AS2.

2006 - 2019

Chemistry

Rewarding Learning

ADVANCED SUBSIDIARY (AS)

General Certificate of Education
2006

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

FRIDAY 23 JUNE, AFTERNOON

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all seventeen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all seven** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **13(a)(ii)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

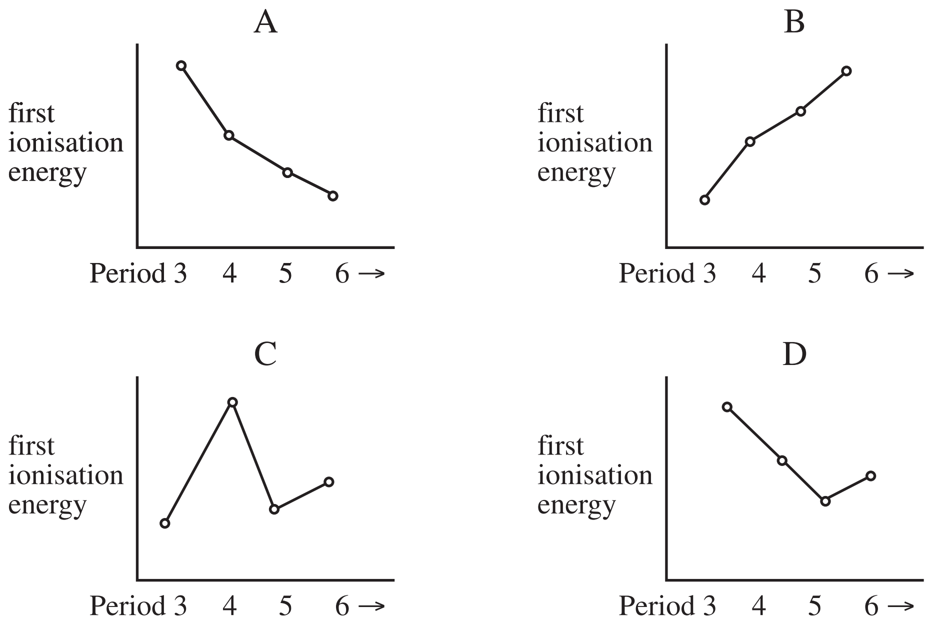
For each of the following questions only **one** of the lettered responses (A – D) is correct.

Select the correct response in each case by connecting the dots as illustrated on the answer sheet.

1 The mechanism for the reaction between methane and chlorine is

A electrophilic addition.
B free radical addition.
C free radical substitution.
D nucleophilic substitution.

2 Which one of the following graphs shows the variation in the first ionisation energy of the Group II elements in periods 3, 4, 5 and 6?



3 A chemist carried out a flame test on a white powder and observed a red colour. When dilute hydrochloric acid was added to the white powder a gas was evolved which gave a white precipitate with calcium hydroxide solution. The powder was

A barium carbonate or calcium carbonate.
B barium hydroxide or strontium hydroxide.
C calcium carbonate or strontium carbonate.
D calcium hydroxide or strontium hydroxide.

4 Which one of the following would **not** give a precipitate of iodoform when reacted with iodine and sodium hydroxide?

A butan-2-ol
B ethanol
C methanol
D propan-2-ol

5 Which one of the following can exist as *cis-trans* isomers?

A but-l-ene
B but-2-ene
C chloroethene
D 2-chlorobut-l-ene

6 Calculate the mass of magnesium chloride produced on neutralising $50\,cm^3$ of $2\,mol\,dm^{-3}$ hydrochloric acid with excess magnesium oxide

A 4.75 g
B 9.50 g
C 20.00 g
D 95.00 g

7 In the reaction between hydrogen bromide and ethene

A the product is unsaturated.
B the transition state is neutral.
C the hydrogen bromide bond splits to form ions.
D the product can exist as two different structural isomers.

8 Which one of the following statements regarding the chemical equilibrium is correct:

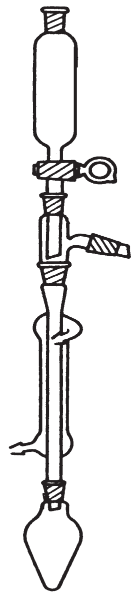
$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -192\ kJ$$

A An increase in the concentration of O_2 will increase the equilibrium amount of SO_2.
B A decrease in the pressure will increase the equilibrium concentration of SO_3.
C An increase in temperature will increase the equilibrium concentration of SO_2.
D Removal of SO_3 from the reaction vessel will increase the equilibrium concentration of SO_2.

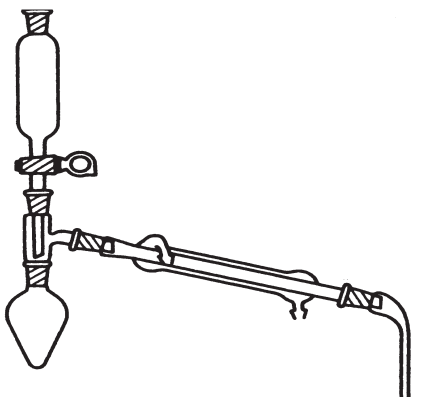
9 Which one of the following sets of apparatus should be selected to separate a mixture of three or more liquids whose boiling points are close together?

A

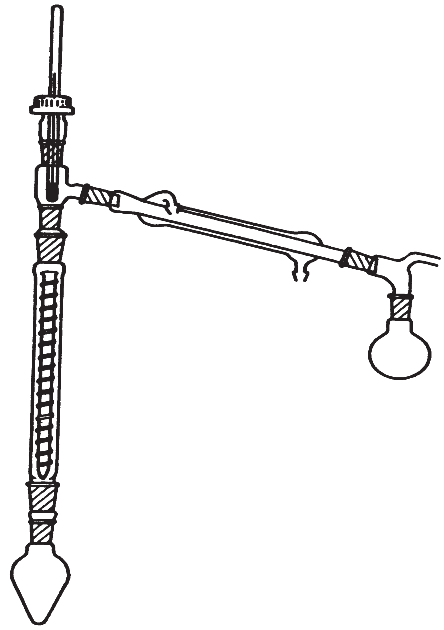
B



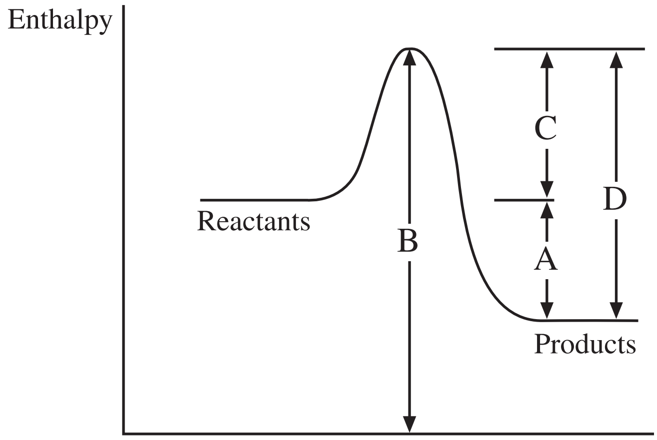
C



D



10 On the reaction profile shown, which one of the letters, A–D, represents the activation energy for the back reaction?



Section B

Answer **all seven** questions in the spaces provided

11 Concentrated orange juice contains a low percentage of dissolved sulphur dioxide as an antioxidant; household bleach contains dissolved chlorine. Both gases can be driven off by gentle warming.

(a) Describe a chemical test for sulphur dioxide and state the observation for a positive result.

Test ____ [1]

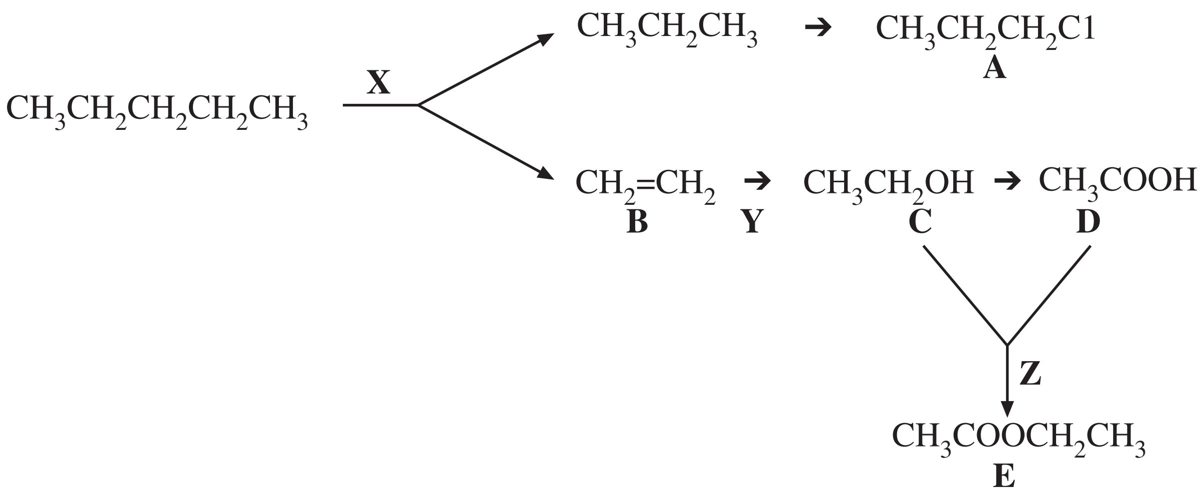
Observation ____ [1]

(b) Describe a chemical test for chlorine and state the observation for a positive result.

Test ____ [1]

Observation ____ [1]

12 (a) Name the processes **X** and **Z** in the following flow scheme:



X ______________________ **Z** ______________________ [2]

(b) Name the compounds **A** and **E**.

A ____ [1]

E ____ [1]

(c) State the temperature and pressure used in the industrial process **Y** and name the catalyst.

temperature ____________________________________ [1]

pressure ____________________________________ [1]

catalyst ____________________________________ [1]

(d) (i) Compounds **C** and **D** react to form compound **E**. Name another compound which will react with **C** to form **E**.

____ [1]

(ii) Write an equation for the reaction between **C** and the compound you have named to form **E**.

____ [2]

(e) Compound **B** can be converted into HD polythene.

(i) State the conditions for the production of HD polythene.

____

____

____ [2]

(ii) Explain the relationship between the flexibility and softening temperature of HD polythene and its structure.

____

____ [2]

13 Samples of 1-iodobutane, 1-bromobutane and 1-chlorobutane are placed in three test tubes labelled A, B and C respectively. Silver nitrate solution is added to each test tube and the mixtures warmed gently.

(a) **(i)** State what you should observe in the test tube A when the reaction is complete.

____ [1]

(ii) Explain the relative rates of hydrolysis in terms of the bond enthalpies and bond polarities of the three carbon–halogen bonds.

____

____

____

____

____ [3]

Quality of written communication [2]

(iii) Write equations for the **two** reactions which occur in test tube B.

1. ____ [1]

2. ____ [1]

(b) 2-bromo-2-methylpropane is an isomer of 1-bromobutane which also undergoes reaction with water or sodium hydroxide.

(i) Explain why 2-bromo-2-methylpropane is an isomer of 1-bromobutane.

____

____ [2]

(ii) Write a flow scheme for the mechanism of the reaction between 2-bromo-2-methylpropane and hydroxide ions.

[3]

(iii) When three drops of phenolphthalein are added to 5 cm^3 of a 0.1 $mol\,dm^{-3}$ solution of sodium hydroxide solution, a pink colour is observed. When 1 cm^3 of 2-bromo-2-methylpropane is then added, the solution eventually turns colourless. Suggest an explanation for this observation.

____

____ [1]

14 5.49 g of a metal oxide of formula MO were completely dissolved in 100 cm^3 of a 2.0 mol dm^{-3} solution of hydrochloric acid (an excess). The remaining acid required 27.5 cm^3 of a 0.20 mol dm^{-3} sodium hydroxide solution to be neutralised. This method is called a ‘back titration’ and is used to determine the amount of the unreacted acid.

(a) Write an equation for the reaction between the oxide, MO, and hydrochloric acid.

____ [1]

(b) Calculate the number of moles of hydrochloric acid added to the metal oxide.

____ [1]

(c) Calculate the number of moles of unreacted hydrochloric acid.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

____ [1]

(d) Calculate the number of moles of hydrochloric acid reacting with the metal oxide.

____ [1]

(e) Calculate the number of moles of the metal oxide that reacted with the hydochloric acid.

____ [1]

(f) Calculate the relative formula mass of the metal oxide.

____ [1]

(g) Calculate the relative atomic mass of M.

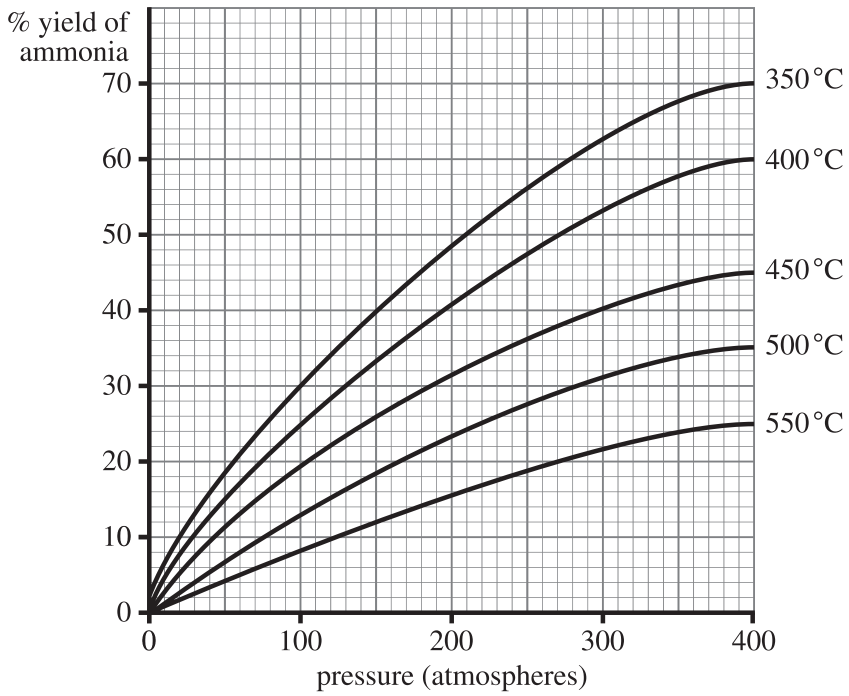
____ [1]

15 Ammonia takes its name from the worshippers of the Egyptian god Amun, the Ammonians, because they heated ammonium chloride with alkali to produce ammonia for use in their religious ceremonies. Today ammonia is made by the Haber–Bosch process.

(a) **(i)** Write an equation for the reaction between nitrogen and hydrogen in the Haber process.

____ [2]

(ii) The graph below shows the percentage of ammonia produced at a series of pressures and temperatures in the Haber–Bosch process.



Explain why a temperature of 450 °C, and not 350 °C, is chosen for the industrial process.

____

____ [1]

(iii) Explain why a pressure of 200 atm, and not 400 atm, is chosen.

____

____ [1]

(iv) State the catalyst used in the Haber–Bosch process.

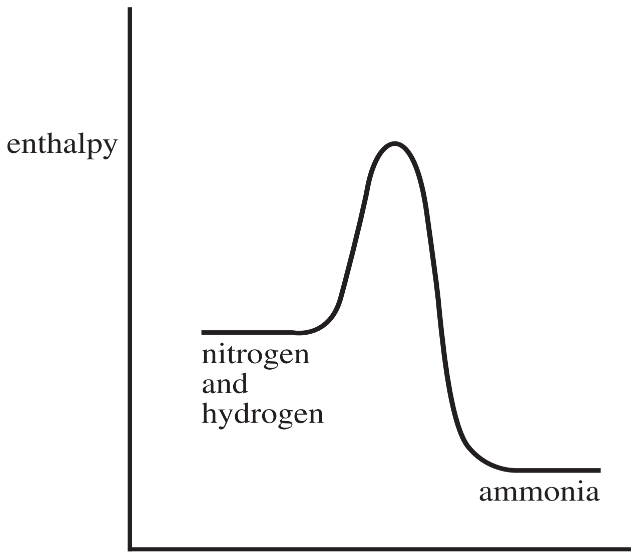
____ [1]

(v) Suggest why the catalyst in the reaction chamber is in the form of pellets rather than as a powder.

____

____ [1]

(vi) The diagram below shows the reaction profile for the uncatalysed reaction between nitrogen and hydrogen. Draw the reaction profile for the catalysed reaction on the diagram.



[1]

(vii) Describe the test for ammonia and state the observation for a positive result.

test ____ [1]

observation _____________________________________ [1]

(b) Excess ammonia reacts with 1,5-dichloropentane to produce cadaverine, a putrid product formed from the decay of flesh:

$$H_2N(CH_2)_5NH_2$$

cadaverine

(i) Suggest an equation for this reaction.

____ [2]

(ii) The smell of cadaverine may be eliminated by adding hydrochloric acid. What does this suggest about the chemical nature of cadaverine?

____ [1]

(c) **(i)** l,5-dichloropentane reacts with sodium hydroxide in ethanol to produce pent-l,4-diene.

$$2NaOH + Cl(CH_2)_5Cl \rightarrow CH_2{=}CHCH_2CH{=}CH_2 + 2NaCl + 2H_2O$$

What is the name given to this type of reaction?

____ [1]

(ii) State the reagent and catalyst needed to convert pent-1,4-diene to pentane.

____

____ [2]

(iii) Write an equation for the conversion of pent-1,4-diene to pentane.

____ [2]

16 Magnesium is being increasingly used in the frames of some modern bicycles. This is due to the discovery of an electrolytic process which puts "Keronite", a thin layer of magnesium oxide, on a surface to prevent oxidation.

(a) **(i)** Write an equation for the reaction between magnesium and oxygen.

____ [1]

(ii) State **one** property of magnesium which makes it suitable for use in bicycle frames.

____ [1]

(b) Group II carbonates show changes in properties as the metal ion changes.

(i) How does the size of the positive ion change from magnesium to barium?

____ [1]

(ii) State the effect on the thermal stability of the carbonate ion as the size of the positive ion changes from magnesium to barium.

____ [1]

(iii) Apart from the changing size of the positive ion, what other factor affects the thermal stability of the carbonate, going from magnesium to barium?

____ [1]

(iv) Write an equation for the thermal decomposition of magnesium carbonate.

____ [1]

(c) Explain, using an equation, how magnesium ions can be used to distinguish between carbonate ions and hydrogencarbonate ions in solution.

____

____

____ [3]

17 Ethanol is produced commercially by the fermentation of sucrose which is initially converted to glucose, $C_6H_{12}O_6$.

(a) **(i)** Explain the term **fermentation**.

____ [1]

(ii) Write an equation for the production of ethanol from glucose.

____ [2]

(b) In the UK it is illegal to drive if the alcohol level in blood is above 80 mg per 100 cm^3. In the original breathalysers, a motorist blew through a tube containing a mixture of sulphuric acid and potassium dichromate on silica gel.

(i) Write an equation for the oxidation of ethanol, using [O] to represent the oxidising agent.

____ [2]

(ii) State the colour change observed in the breathalyser when ethanol is detected.

____ [2]

(iii) If a suspect's breath contains 90 mg of ethanol per 100 cm^3, calculate the concentration of ethanol in mol dm^{-3}.

____

____

____ [3]

(iv) Which organ of the body may be permanently affected by alcohol?

____ [1]

(c) Ethanol is also oxidised when it is burnt in air. In some countries ethanol is used as an alternative to petrol.

(i) Write an equation for the complete combustion of ethanol.

____ [1]

(ii) Write **one** equation for the incomplete combustion of ethanol.

____ [1]

(iii) Explain the environmental advantage of using ethanol rather than petrol in cars.

____

____ [2]

Rewarding Learning

ADVANCED
General Certificate of Education
2006

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

FRIDAY 23 JUNE, AFTERNOON

MARK SCHEME

Section A

1 C

2 A

3 C

4 C

5 B

6 A

7 C

8 C

9 D

10 D

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11 **(a)** acidified (potassium) permanganate [1] purple to colourless [1]
or
acidified (potassium) dichromate [1] orange to green [1] [2]

(b) indicator paper or solution [1] bleached [1] [2] 4

12 **(a)** X cracking Z esterification [2]

(b) A 1-chloropropane E ethyl ethanoate [2]

(c) temperature = 300 °C ± 50 °C [1] pressure = 60–70 atm [1]
catalyst phosphoric acid (on silica) [1] [3]

(d) **(i)** ethanoyl chloride [1]

(ii) $CH_3COCl + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + HCl$ [2]

(e) **(i)** 30–100 °C, 1–50 atm, Ziegler catalyst, $Al(C_2H_5)_3/TiCl_4$ [2]

(ii) high crystallinity, higher softening temperature, more rigid [1]
no branching/close packed/van der Waals [1] [2] 14

13 **(a)** **(i)** yellow precipitate [1]

(ii) from Cl to I the C-X polarity decreases, as does the bond enthalpy [1]. Of these opposing effects, the latter dominates [1]
Statement on rate [1] [3]

Quality of written communication [2]

(iii) $CH_3CH_2CH_2CH_2Br + H_2O \rightarrow CH_3CH_2CH_2CH_2OH + HBr$ [1]
$HBr + AgNO_3 \rightarrow AgBr(s) + HNO_3$ [1] [2]

(b) **(i)** same formula [1] different structure [1] [2]

(ii) $CH_3C(CH_3)_2Br \rightarrow CH_3C^+(CH_3)_2 + Br^- \rightarrow CH_3C(CH_3)_2OH$ [3]

OH^-

(iii) the OH^- concentration decreases as it is used up in the reaction/the solution becomes less alkaline [1] 14

14 **(a)** $MO + 2HCl \rightarrow MCl_2 + H_2O$ [1]

(b) $\dfrac{100 \times 2}{1000} = 0.2$ [1]

(c) $\dfrac{27.5 \times 0.2}{1000} = 0.0055$ [1]

(d) $0.2 - 0.0055 = 0.194$ [1]

(e) moles MO = $\dfrac{0.194}{2} = 0.097$ [1]

(f) 0.097 moles $\rightarrow$ 5.49 g
1 mole $\rightarrow \dfrac{5.49}{0.097} = 56$ [1]

(g) MO = 56 O = 16
M = 56 – 16 = 40 [1] 7

15 **(a)** **(i)** $N_2 + 3H_2 \rightleftharpoons 2NH_3$ [2]

(ii) faster rate [1]

(iii) high pressure is expensive [1]

(iv) iron [1]

(v) spaces between pellets, gas can pass through/less possibility of clogging [1]

(vi) lower curve [1]

(vii) hydrogen chloride/conc. hydrochloric acid [1] white smoke [1] [2]

(b) **(i)** $Cl(CH_2)_5Cl + 2NH_3 \rightarrow H_2N(CH_2)_5NH_2 + 2HCl$ [2]

(ii) cadaverine is alkaline/basic [1]

(c) **(i)** elimination [1]

(ii) finely divided Ni [1] and hydrogen [1] [2]

(iii) $CH_2{=}CHCH_2CH{=}CH_2 + 2H_2 \rightarrow CH_3(CH_2)_3CH_3$ [2] 17

16 **(a)** **(i)** $2Mg + O_2 \rightarrow 2MgO$ [1]

(ii) low density [1]

(b) **(i)** increases [1]

(ii) thermal stability increases [1]

(iii) lattice enthalpy [1]

(iv) $MgCO_3 \rightarrow MgO + CO_2$ [1]

(c) Mg^{2+} and $CO_3^{2-} \rightarrow$ ppt. [1]

Mg^{2+} and $HCO_3^{-} \rightarrow$ no ppt. [1] **or** white ppt. on heating

$Mg^{2+} + CO_3^{2-} \rightarrow MgCO_3$ [1]
or $Mg(HCO_3)_2 \xrightarrow{heat} MgCO_3 + CO_2 + H_2O$ [3] 9

17 **(a)** **(i)** enzymic oxidation/enzymic breakdown [1]

(ii) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ [2]

(b) **(i)** $CH_3CH_2OH + [O] \rightarrow CH_3CHO + H_2O$ [2]

(ii) orange [1] green [1] [2]

(iii) 0.9/46 = 0.0196 mol dm^{-3} [3]

(iv) liver [1]

(c) **(i)** $CH_3CH_2OH + 3O_3 \rightarrow 2CO_2 + 3H_2O$ [1]

(ii) $CH_3CH_2OH + 2O_2 \rightarrow 2CO + 3H_2O$
or $CH_3CH_2OH + \frac{3}{2}O_2 \rightarrow CO + C + 3H_2O$ [1]

(iii) no SO_2 [1] therefore no acid rain [1]/renewable fuel [1] as sugar can be grown [1] [2] 15

Section B	**80**
Total	**100**

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General Certificate of Education
2007

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

MONDAY 18 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all sixteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all six** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **14(c)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following hydrocarbons exhibits *cis-trans* isomerism?

A $CH_3CH_2CH{=}CH_2$
B $(CH_3)_2C{=}CHCH_3$
C $CH_3CH{=}CHCH_2CH_3$
D $CH_2{=}C(CH_3)_2$

2 Which one of the following statements about ethene is correct?

A The π (pi) bond contains two shared electron pairs.
B The π (pi) bond is readily attacked by nucleophiles.
C Rotation of the double bond requires breaking a σ (sigma) bond.
D The carbon to hydrogen σ (sigma) bond can rotate freely.

3 Which one of the following increases on descending Group II from calcium to barium?

A first ionisation energy
B melting point
C solubility of the sulphates
D thermal stability of the hydroxides

4 14.8 g of butan-1-ol (RMM 74) were refluxed with sodium bromide and sulphuric acid, after which 17.8 g of 1-bromobutane (RMM 137) were collected. What is the percentage yield of this conversion?

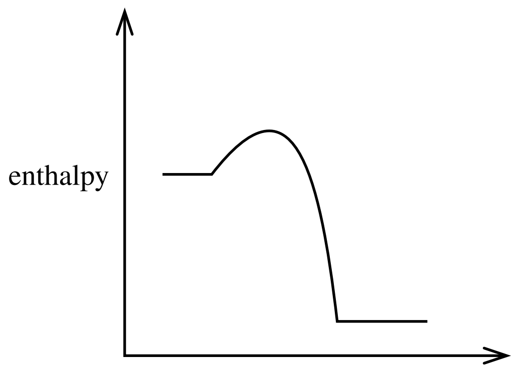
A 54%
B 65%
C 78%
D 83%

5 Which one of the following reactions is **not** found in the mechanism for the photochlorination of methane?

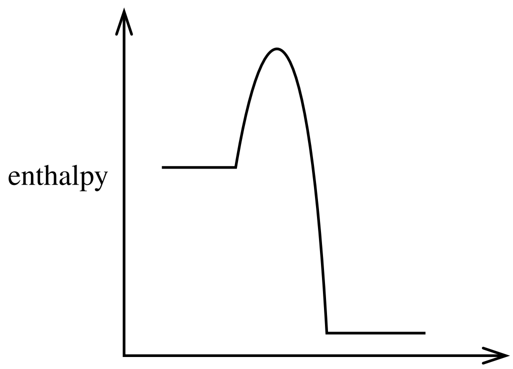
A $Cl_2 \rightarrow 2Cl\bullet$
B $2Cl\bullet \rightarrow Cl_2$
C $CH_4 + Cl\bullet \rightarrow CH_3Cl + H\bullet$
D $CH_3\bullet + Cl\bullet \rightarrow CH_3Cl$

6 Which one of the following reaction profiles represents a reaction in which the reactants are kinetically and thermodynamically unstable compared to the products?

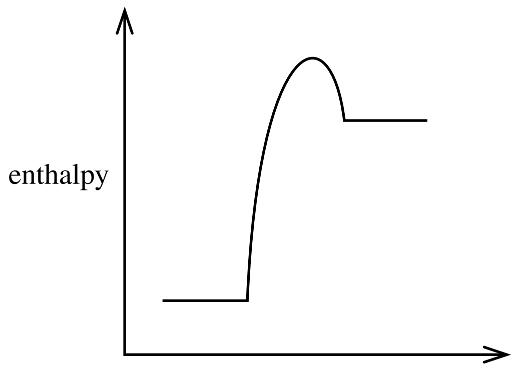
A



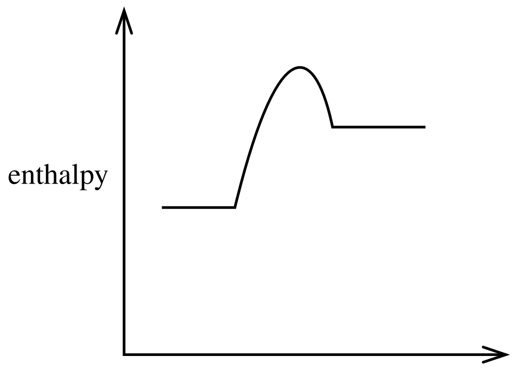
B



C



D



7 Which one of the following alcohols will give a positive result in the iodoform test?

A $CH_3C(CH_3)(OH)CH_3$
B $CH_3CH_2CH_2CH_2OH$
C $CH_3CH(OH)CH_2CH_3$
D $CH_3CH(CH_3)CH_2OH$

8 0.8 mole of a liquid X was found to contain 19.2 g carbon, 3.2 g hydrogen and 56.8 g chlorine. What is the molecular formula of X?

A CH_2Cl
B C_2H_2Cl
C C_2H_4Cl
D $C_2H_4Cl_2$

9 Which one of the following alcohols is **not** oxidised by acidified potassium dichromate solution?

A Propan-1-ol
B Propan-2-ol
C 2-methylpropan-1-ol
D 2-methylpropan-2-ol

10 The molecular structure and flexibility of HD polythene is best described as

A branched and rigid.
B branched and flexible.
C unbranched and rigid.
D unbranched and flexible.

Section B

Answer **all six** questions in the spaces provided.

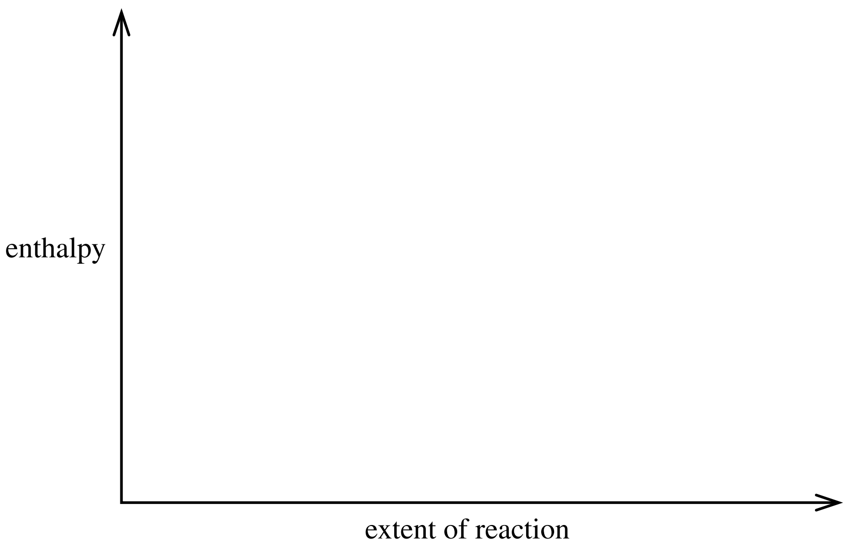
11 Rennin, from calves' stomachs, is an enzyme used in the hydrolysis of protein during cheese manufacture.

(a) Explain the term **hydrolysis**.

____

____ [2]

(b) Protein hydrolysis in cheese manufacture is an exothermic process. Draw a labelled reaction profile to show both the catalysed and uncatalysed reaction pathways for this hydrolysis.



[2]

12 Long chain hydrocarbons may be converted into shorter more useful ones, by catalytic cracking.

(a) **(i)** Write an equation for the cracking of $C_{20}H_{42}$ in which pentane is one of the products.

____ [2]

(ii) Draw the structure of a branched isomer of pentane.

[2]

(b) A mixture of pentane and excess oxygen was ignited. The resultant gases were bubbled through concentrated sodium hydroxide solution which absorbed 115 cm^3. Calculate the volume of pentane in the original mixture.

____

____

____ [2]

13 The synthesis stage in the manufacture of methanol involves the reaction of carbon dioxide with hydrogen as shown below.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \qquad \Delta H = -49\,kJ$$

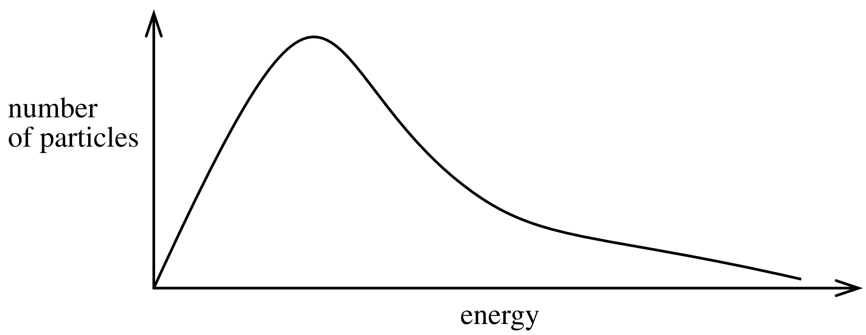
The original process used a chromium oxide/zinc oxide catalyst.

(a) Complete the table below indicating if the condition chosen increases, decreases or has no effect on the rate and yield of methanol.

Condition	**Rate**	**Yield**
catalyst	increase	no effect
high pressure		
high temperature		

[4]

(b) The distribution of molecular energies in the reaction mixture at 350 °C is shown below.



(i) Sketch, on the axes above, the distribution of molecular energies at 340 °C. [1]

(ii) On the axis above, draw the relative positions of the activation energy without a catalyst (E_A) and the activation energy with a catalyst (E_A'). [1]

(iii) Explain whether the manufacture of methanol is an example of homogeneous or heterogeneous catalysis.

[1]

(iv) Use the graph on page 7 to explain the effect of decreasing the temperature on the rate of formation of methanol.

[2]

(c) Name the reagents (A–C) used in the following reactions of methanol.

$$\begin{array}{ccccc} & & CH_3Cl & & \\ & & \uparrow \scriptstyle{B} & & \\ HCOOH & \xleftarrow{\quad A \quad} & CH_3OH & \xrightarrow{\quad C \quad} & CH_3ONa \end{array}$$

A

B

C [3]

(d) Methylated spirits contains ethanol (b.p. 78 °C), methanol (b.p. 64 °C) and water as well as other additives.

(i) Explain why ethanol, methanol and water are miscible.

[2]

(ii) Suggest how these **three** components of methylated spirits could be separated.

[2]

(iii) Methylated spirits is used as a fuel for some camping stoves. Explain why the pots heated by a methylated spirits burner are often covered in a layer of black powder on the outside during use. Write an equation to support your answer.

____

____

____ [3]

(e) Methanol undergoes an esterification reaction when refluxed with ethanoic acid in the presence of concentrated sulphuric acid.

(i) State **two** roles of the concentrated sulphuric acid in this reaction.

____

____ [2]

(ii) Draw the structural formula of the ester formed.

[2]

(iii) Name the ester formed in this reaction.

____ [1]

(iv) Ethanoyl chloride can be used in place of ethanoic acid for this conversion. State **two** advantages of using ethanoyl chloride.

____

____ [2]

14 Magnesium is found in minerals such as dolomite, magnesite and kieserite.

(a) Dolomite has the formula $CaCO_3.MgCO_3$.

(i) State **one** observation when dolomite is treated with dilute hydrochloric acid.

____ [1]

(ii) Write an equation for the reaction of dolomite with dilute hydrochloric acid.

____ [2]

(iii) State the colour expected when a sample of dolomite is used in a flame test.

____ [1]

(iv) Explain why calcium carbonate is more stable to heat than magnesium carbonate.

____

____

____ [2]

(b) Kieserite is hydrated magnesium sulphate. Explain how an aqueous solution of magnesium sulphate may be used to distinguish between **powdered** samples of sodium carbonate and sodium hydrogencarbonate.

____

____

____ [2]

(c) Pure magnesite has the formula $MgCO_3$ but is often contaminated with other minerals. Describe, without details of rinsings or calculations, the practical steps required to determine the percentage purity of a sample of magnesite using a back titration method.

____

____

____

____

____

____

____ [4]

Quality of written communication [2]

(d) It is estimated that each cubic kilometre in the ocean contains 1.2 million tonnes of magnesium. Calculate the concentration of magnesium in the ocean in mol dm^{-3}.
($1\,km^3 = 10^{12}\,dm^3$ and 1 tonne = $10^6\,g$)

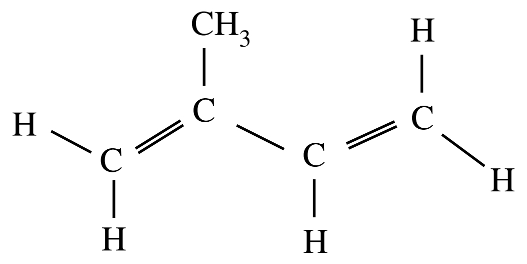
____

____

____

____ [3]

15 The Smoky Mountains in the United States are enveloped by a blue haze which contains simple gaseous hydrocarbons emitted by trees and plants. One such hydrocarbon is isoprene, which has the structure:



Isoprene shows typical reactions of an unsaturated hydrocarbon.

(a) Explain the term **hydrocarbon**.

____ [1]

(b) Isoprene reacts with hydrogen bromide.

(i) Draw a flow scheme for the mechanism of this reaction showing **one** hydrogen bromide molecule reacting with **one** double bond in isoprene.

[3]

(ii) Name the mechanism for this reaction.

____ [2]

(c) Hydrogenation of isoprene, C_5H_8, involves the use of heat and a catalyst.

(i) Name the catalyst used.

____ [1]

(ii) Write an equation for the complete hydrogenation of isoprene and name the product.

____

____ [3]

(iii) State how you would use a chemical test to show that all of the isoprene has been saturated.

____

____

____ [2]

16 The halogenoalkanes are sweet smelling organic compounds which are used as refrigerants, propellants and in fire extinguishers.

(a) Refluxing a tertiary bromoalkane with aqueous sodium hydroxide forms a tertiary alcohol.

(i) Write an equation for the reaction of 2-bromo-2-methylpropane, $(CH_3)_3CBr$ with aqueous sodium hydroxide.

____ [1]

(ii) 1.25 g of a tertiary bromoalkane were refluxed with 50 cm^3 of 0.25 M aqueous sodium hydroxide. On completion, the excess sodium hydroxide required 16.8 cm^3 of 0.25 M hydrochloric acid for neutralisation. Using the steps below, determine the mass of one mole of the bromoalkane, assuming it contains only one bromine atom.

moles of sodium hydroxide reacting with hydrochloric acid.

____

moles of sodium hydroxide used to hydrolyse the bromoalkane

____

moles of the bromoalkane

____

mass of one mole of the bromoalkane

____ [4]

(b) Bromoalkanes react with sodium hydroxide in alcohol to give different products than with the aqueous solution.

(i) Write the equation for the reaction of 1-bromobutane with sodium hydroxide in alcohol, naming the organic product.

____

____ [3]

(ii) Name the type of reaction occurring in part **(i)**.

____ [1]

(c) Ammonia, like halogenoalkanes, is used as a refrigerant.

(i) State a chemical test for ammonia.

____

____ [2]

(ii) Ammonia reacts with halogenoalkanes to form amines. Write an equation for the reaction of ammonia with chloroethane.

____ [1]

(d) Bromochlorodifluoromethane, $BrClF_2C$, is used to extinguish fires.

(i) Draw a dot and cross diagram, using outer electrons only, to show the bonding in $BrClF_2C$.

[2]

(ii) Suggest which carbon–halogen bond is most readily hydrolysed when $BrClF_2C$ is heated with aqueous sodium hydroxide solution.

____ [1]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2007

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

MONDAY 18 JUNE, AFTERNOON

MARK SCHEME

Section A

1	C
2	D
3	D
4	B
5	C
6	A
7	C
8	D
9	D
10	C

[2] for each correct answer	[20]	20
	Section A	**20**

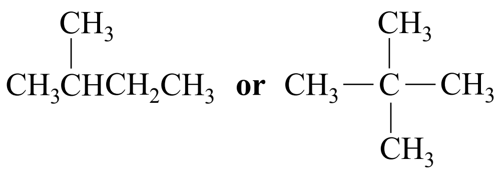
Section B

11 **(a)** Reaction [1]
with water [1] [2]

(b) Any **two**:
Reactants higher (than products) [1]
Correct uncatalysed/catalysed curve labelled [1] [2] 4

12 **(a)** **(i)** $C_{20}H_{42} \rightarrow C_5H_{12} + C_{15}H_{30}$ [2]

(ii)



[2]

(b) 1 mole C_5H_{12} produces 5 moles CO_2
therefore volume of pentane present = 115/5 = 0.023 dm^3 [2] 6

13 **(a)**

increase [1]	increase [1]
increase [1]	decrease [1]

[4]

(b) **(i)** Peak to left, higher and starting at same point [1]

(ii) E_A' to the left of E_A (on the tail portion of graph) [1]

(iii) (Heterogeneous)
reactants gaseous, catalyst solid/different phases [1]

(iv) Smaller number of molecules [1]
possess the activation energy [1] [2]

(c) A acidified (sodium or potassium) dichromate/permanganate [1]
B phosphorus pentachloride/thionyl chloride/hydrogen chloride [1]
C sodium [1] [3]

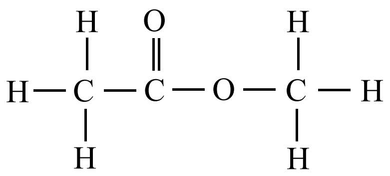
(d) **(i)** All contain OH group [1]
which form hydrogen bonds [1] [2]

(ii) Fractional [1] distillation [1] [2]

(iii) Incomplete combustion [1]
produces carbon [1]
$C_2H_5OH + O_2 \rightarrow 2C + 3H_2O$ [1] [3]

(e) **(i)** Catalyst [1]
Dehydrating agent/improves yield [1] [2]

(ii)



[2]

(iii) Methyl ethanoate [1]

(iv) Faster [1]
Higher yield [1]
Easier to separate [1]
Any **two** from **three** [2] 26

14 **(a)** **(i)** Fizzing/effervescence/solid dissolves [1]

(ii) $CaCO_3.MgCO_3 + 4HCl \rightarrow CaCl_2 + MgCl_2 + 2CO_2 + 2H_2O$ [2]

(iii) Red [1]

(iv) Calcium ion larger than magnesium ion [1]
Change in lattice enthalpy [1] [2]

(b) Dissolve in water [1]
Carbonate gives white ppt [1] hydrogencarbonate does not [1]
Any **two** from **three** [2]

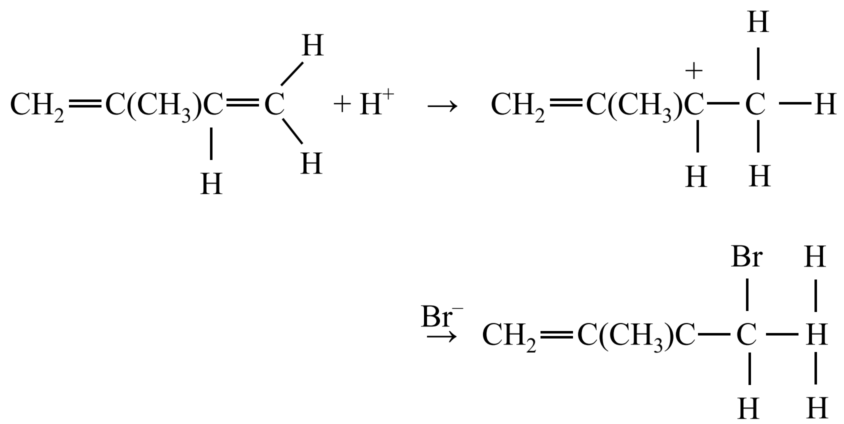
(c) Any **four**:
Take known mass of sample
Add (known volume of standard) named mineral and (an excess)
Titrate (excess acid with standard sodium hydroxide solution)
using phenolphthalein/methyl orange indicator
Colour change colourless to pink or orange to yellow [4]

Quality of written communication [2]

(d) Mass of Mg = $1.2 \times 10^6 \times 10^6 = 1.2 \times 10^{12}$ g
moles Mg = $1.2 \times 10^{12}/24 = 5 \times 10^{10}$
5×10^{10} moles Mg in 10^{12} dm^3
$5 \times 10^{-2} = 0.05$ mol dm^{-3}
Award [3] directly for the correct answer
Each error [–1], carry error through [3] 17

15 **(a)** A compound of carbon and hydrogen [1]

(b) **(i)**



[3]

(ii) Electrophilic [1]
addition [1] [2]

(c) **(i)** (Finely divided) nickel [1]

(ii) $C_5H_8 + 2H_2 \rightarrow C_5H_{12}$ [2]
product name: methylbutane [1] [3]

(iii) Add bromine/bromine water [1]
Remains red/brown/**not** decolourised [1] [2] 12

16 **(a)** **(i)** $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$ [1]

(ii) moles of sodium hydroxide reacting with hydrochloric acid = 4.2×10^{-3}
moles of sodium hydroxide used to hydrolyse the
bromoalkane = $0.0125 - 4.2 \times 10^{-3} = 8.3 \times 10^{-3}$
moles of the bromoalkane = 8.3×10^{-3}
mass of 1 mole of bromoalkane = $\dfrac{1.25}{8.3 \times 10^{-3}}$ = 150.6 g [4]

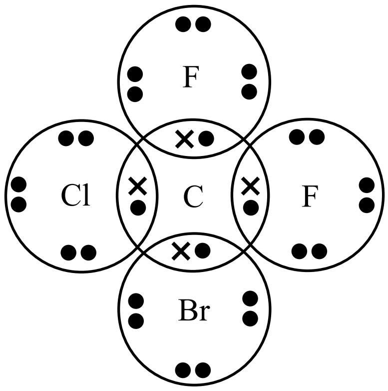
(b) **(i)** $C_4H_9Br + NaOH \rightarrow C_4H_8 + H_2O + NaBr$ [2]
but-1-ene [1] [3]

(ii) Elimination [1]

(c) **(i)** Conc. hydrochloric acid (fumes) [1]
white fumes [1] [2]

(ii) $C_2H_5Cl + NH_3 \rightarrow C_2H_5NH_2 + HCl$ [1]

(d) (i)



Each error [–1] [2]

(ii) C—Br [1] 15

Section B	**80**
Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2008

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

TUESDAY 22 JANUARY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all seventeen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all seven** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **16(b)(iii)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following correctly describes the structure of low density (LD) polythene?

A Branched and crystalline
B Branched and non-crystalline
C Unbranched and non-crystalline
D Unbranched and crystalline

2 Which one of the following does **not** represent a propagation step in the reaction between methane and chlorine in the presence of ultraviolet light?

A $CHCl_3 + Cl\cdot \rightarrow CCl_3\cdot + HCl$
B $CH_3\cdot + Cl\cdot \rightarrow CH_3Cl$
C $CH_3\cdot + Cl_2 \rightarrow CH_3Cl + Cl\cdot$
D $CH_2Cl\cdot + Cl_2 \rightarrow CH_2Cl_2 + Cl\cdot$

3 Which one of the following lists Group II metal carbonates and hydroxides in order of increasing thermal stability?

	Metal carbonates	**Metal hydroxides**
A	$MgCO_3$ $CaCO_3$ $SrCO_3$ $BaCO_3$	$Ba(OH)_2$ $Sr(OH)_2$ $Ca(OH)_2$ $Mg(OH)_2$
B	$BaCO_3$ $SrCO_3$ $CaCO_3$ $MgCO_3$	$Mg(OH)_2$ $Ca(OH)_2$ $Sr(OH)_2$ $Ba(OH)_2$
C	$MgCO_3$ $CaCO_3$ $SrCO_3$ $BaCO_3$	$Mg(OH)_2$ $Ca(OH)_2$ $Sr(OH)_2$ $Ba(OH)_2$
D	$BaCO_3$ $SrCO_3$ $CaCO_3$ $MgCO_3$	$Ba(OH)_2$ $Sr(OH)_2$ $Ca(OH)_2$ $Mg(OH)_2$

4 20 cm^3 of a gaseous hydrocarbon reacts with exactly 90 cm^3 of oxygen producing 60 cm^3 of carbon dioxide (measured at the same temperature and pressure). Which one of the following is the formula of the hydrocarbon?

A C_3H_6
B C_3H_8
C C_6H_{12}
D C_6H_{14}

5 Which one of the following can be used to produce methyl ethanoate?

A Ethanoyl chloride and methanoic acid
B Ethanoyl chloride and methanol
C Methane and ethanoic acid
D Methanoic acid and ethanol

6 Which one of the following lists the fractions from crude oil in order of decreasing boiling point?

A diesel, kerosene, naphtha, gasoline
B gasoline, kerosene, naphtha, diesel
C gasoline, naphtha, kerosene, diesel
D kerosene, diesel, naphtha, gasoline

7 Ethene contains

A 4 sigma (σ) bonds and 2 pi (π) bonds.
B 5 sigma (σ) bonds and 1 pi (π) bond.
C 2 sigma (σ) bonds and 4 pi (π) bonds.
D 1 sigma (σ) bond and 5 pi (π) bonds.

8 3.70 g of butan-1-ol (RMM = 74) was used to prepare 1-bromobutane (RMM = 137) and a 60% yield was achieved. Which one of the following statements is correct?

A The actual yield is 4.11 g.
B The actual yield is 6.85 g.
C The theoretical yield is 2.00 g.
D The theoretical yield is 2.22 g

9 Which one of the following describes the conditions used in the Haber–Bosch process?

	Pressure	**Temperature**	**Catalyst**
A	400–500 atm	200–300 °C	Iron
B	200–300 atm	400–500 °C	Vanadium(V) Oxide
C	1–2 atm	400–500 °C	Vanadium(V) Oxide
D	200–300 atm	400–500 °C	Iron

10 A hydrocarbon contains 85.7% carbon (by mass) and has a relative molecular mass greater than 50 but less than 60. Which one of the following statements is correct?

A The empirical formula is C_2H_4.
B The empirical formula is C_2H_5.
C The molecular formula is C_4H_8.
D The molecular formula is C_4H_{10}.

Section B

Answer **all seven** questions in the spaces provided.

11 But-2-ene exhibits geometric (*cis-trans*) isomerism.

(a) Draw the *cis* and *trans* isomers of but-2-ene

cis *trans* [2]

(b) Explain why but-2-ene exhibits geometric isomerism.

____

____ [2]

12 Halogenoalkanes react with aqueous and alcoholic solutions of sodium hydroxide.

(a) Which one of the following halogenoalkanes would you expect to react most readily with aqueous sodium hydroxide?

1-chlorobutane   1-bromobutane   1-iodobutane

____ [1]

(b) Explain why the halogenoalkane you have chosen in part **(a)** reacts more readily than the other two.

____

____

____

____ [2]

(c) Draw the structure of the organic product obtained when 1-bromo-2-methylbutane is heated with

(i) aqueous sodium hydroxide

[1]

(ii) alcoholic sodium hydroxide

[1]

13 Methanol can be formed from carbon dioxide and hydrogen in a reversible reaction:

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$$

A position of dynamic equilibrium is established if conditions are kept constant.

(a) **(i)** What do you understand by the term **dynamic equilibrium**?

____

____

____ [2]

(ii) State and explain the effect of increasing the pressure on the position of the above equilibrium if the temperature remains constant.

____

____

____ [2]

(iii) If the temperature is increased, the equilibrium yield of methanol decreases. Deduce the sign of the enthalpy change for the forward reaction and explain your reasoning.

____

____

____ [2]

(b) Why would the equilibrium position remain unchanged if a catalyst was added?

____

____ [1]

14 Alkenes, such as ethene, are more reactive than the corresponding alkanes.

(a) Ethene reacts with hydrogen bromide.

(i) Draw a flow scheme to illustrate the mechanism of this reaction.

[3]

(ii) Name the mechanism for this reaction.

____ [2]

(b) Calculate the volume of pure liquid bromine which would be required to react completely with 120 cm^3 of gaseous ethene (measured at 20 °C and 1 atmosphere pressure).

$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

Number of moles of ethene

____

Number of moles of bromine (Br_2)

____

Number of grams of bromine (Br_2)

____

Volume of pure liquid bromine (density = 3.2 $g\,cm^{-3}$)

____ [4]

15 Magnesium is a reactive metal which can form many compounds.

(a) Magnesium burns when heated in air.

(i) Give **one** observation when this reaction is carried out in the laboratory.

______________________________ [1]

(ii) Write an equation for this reaction.

______________________________ [2]

(b) Magnesium also reacts with dilute hydrochloric acid forming a solution of magnesium chloride.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Calculate the volume of hydrogen gas produced (measured at 20 °C and 1 atmosphere pressure) if an excess of magnesium is added to 50.0 cm^3 of 2M hydrochloric acid.

____

____

____

______________________________ [3]

(c) **(i)** What is observed when solutions of magnesium chloride and sodium carbonate are mixed?

______________________________ [2]

(ii) Write an ionic equation, including state symbols, to represent the above reaction.

______________________________ [2]

(d) (i) State and explain the trend in the solubilities of the Group II sulphates as the Group is descended.

____

____

____

____

____ [4]

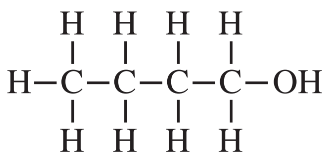
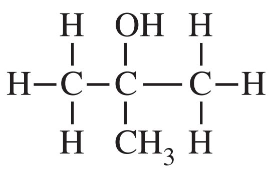
(ii) Name a reagent which can be used to test for the presence of sulphate and sulphite ions in solution.

____ [1]

16 There are four isomeric alcohols with the formula C_4H_9OH.

(a) Complete the following table, giving the missing structures, name and classifications.

(P = Primary, S = Secondary and T = Tertiary)

Structure and Name	**Classification**
 butan-1-ol	P
 2-methylpropan-2-ol	
2-methylpropan-1-ol	

[6]

(b) **(i)** Explain the term **structural isomers**.

____

____ [2]

(ii) What is a **tertiary alcohol**?

____

____ [2]

(iii) Describe a chemical test which could be used to distinguish between 2-methylpropan-2-ol and butan-1-ol.

____

____

____

____

____ [3]

Quality of written communication [2]

(c) **(i)** What structural feature must an alcohol contain to give a positive iodoform test?

____ [1]

(ii) Name or give the structure of the alcohol from part **(a)** which gives a positive iodoform test.

____ [1]

(iii) Describe how you can carry out the iodoform test, stating the result for a positive test.

____

____

____ [3]

17 Carbon monoxide (CO) and nitrogen monoxide (NO) are produced when fuels are burned in car engines, but are then removed in the catalytic converter.

(a) A catalytic converter consists of metals spread very thinly on a ceramic support (the 'honeycomb'). When a catalytic converter is fitted to the exhaust of a car, CO and NO combine to form less harmful products.

(i) Name the less harmful products.

____

____ [2]

(ii) Give the equation for the reaction between CO and NO.

____ [1]

(iii) Name **one** metal used in a catalytic converter.

____ [1]

(iv) Suggest **two** reasons why the metals are spread very thinly on a ceramic support (honeycomb).

____

____ [2]

(v) Why are the reactions occurring in a catalytic converter described as **heterogeneous** catalysis?

____

____ [2]

(vi) Explain, using chemisorption, how the catalyst works.

____

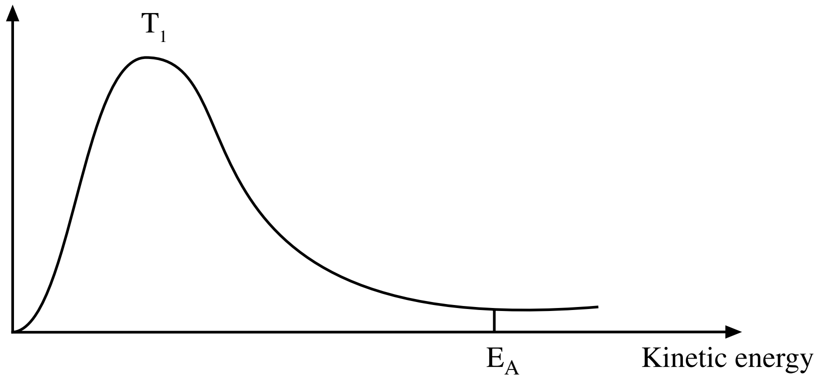
____ [2]

(vii) Explain why leaded petrol should not be used in a car that has a catalytic converter fitted in the exhaust pipe.

____

____ [2]

(b) The diagram below shows the distribution of molecular kinetic energies in a mixture of CO and NO at temperature T_1.



(i) Label the *y* axis on the above diagram. [1]

(ii) The activation energy (E_A) is indicated on the diagram. Explain the term **activation energy**.

____

____ [1]

(iii) Why do most collisions between molecules of CO and NO, at temperature T_1, not result in a reaction?

____

____ [1]

(iv) On the diagram above, draw a curve to show the distribution of molecular kinetic energies at a higher temperature and label it T_2. [3]

(v) Using the distribution curves, explain why the reaction between molecules of CO and NO is faster at the higher temperature T_2.

____

____ [2]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2008

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

TUESDAY 22 JANUARY, MORNING

MARK SCHEME

Section A

1 B

2 B

3 C

4 A

5 B

6 A

7 B

8 A

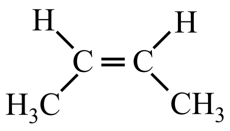
9 D

10 C

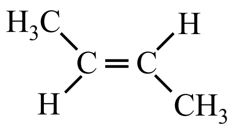
[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11 **(a)**



cis



trans

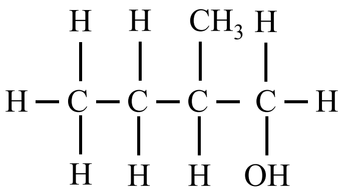
[2]

(b) Restricted rotation [1] about C=C [1] [2] 4

12 **(a)** l-iodobutane [1]

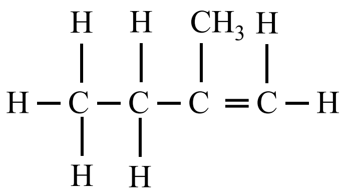
(b) C–I bond [1] is weaker/weakest [1] (than C–Br and C–Cl)
Breaks more easily [1] [2]

(c) **(i)**



[1]

(ii)



[1] 5

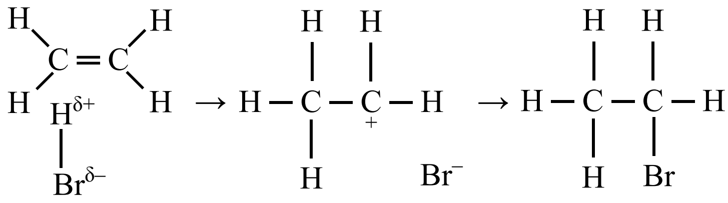
13 **(a)** **(i)** Rate of forward reaction = rate of reverse reaction
Concentration of any reactant or product constant [2]

(ii) Equilibrium shifts to RHS [1]
4 moles (g) LHS → 2 moles (g) RHS [1] [2]

(iii) Negative [1]
When temperature increases shifts in endothermic direction/reverse reaction is endothermic [1] [2]

(b) Increases the rate of the forward reaction and reverse reactions equally [1] 7

14 **(a)** **(i)**



Correct dipole [1] [3]

(ii) electrophilic [1] addition [1] [2]

(b) Moles of ethene = 120 ÷ 24 000 = 0.005 moles
1:1 ratio
Moles of bromine (Br_2) = 0.005 moles
Mass of bromine (Br_2) = 0.005 × 160 = 0.8 g
Volume of pure **liquid** bromine
Volume (cm^3) = mass (g) ÷ density (0.8 ÷ 3.2) = 0.25 cm^3 [4] 9

15 **(a)** **(i)** White flame/white solid [1]

(ii) $2Mg + O_2 \rightarrow 2MgO$ [2]

(b) Moles of HCl = 2 × 0.05 = 0.1 moles
2:1 ratio
Moles of H_2 = 0.05 moles
Volume of H_2 = 0.05 × 24 = 1.2 dm^3 or 1200 cm^3 [3]

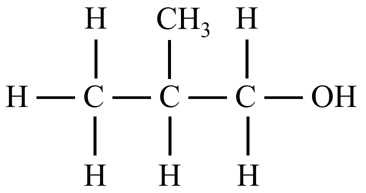
(c) **(i)** White [1] precipitate [1] [2]

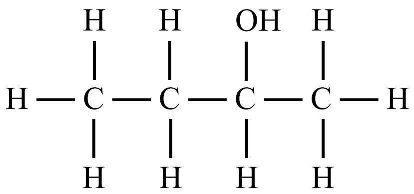
(ii) $Mg^{2+}(aq) + CO_3^{2-}(aq) \rightarrow MgCO_3(s)$ [2]

(d) **(i)** Decreases down the group [1]
Use of lattice enthalpy (X) [1]
Use of hydration enthalpy (Y) [1]
Variation in Y is greater than variation in X down the group [1] [4]

(ii) Barium chloride (or nitrate) [1] 15

16 **(a)** T [1]

 [1] P [1]

 [1] S [1]

Butan-2-ol [1] [6]

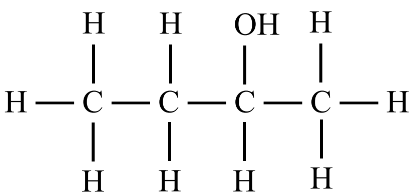
(b) **(i)** Molecules which have the same molecular formula but different structural formula [2]

(ii) An alcohol which has 3 carbons directly attached to the same carbon as the hydroxyl group [2]

(iii) Heat each alcohol (separately) [1]
with acidified (potassium) dichromate (APD)/acidified (potassium) manganate VII [1]
with butan-1-ol APD orange to green/purple to colourless [1]
with 2-methylpropan-2-ol APD remains orange/remains purple [1]
Maximum [3] [3]

Quality of written communication [2]

(c) **(i)** methyl group and a hydrogen attached to the same carbon as the hydroxy group [1]

(ii)  **or** Butan-2-ol [1]

(iii) Alkaline solution [1]
of iodine [1]
yellow ppt [1] [3] 20

17 **(a)** **(i)** carbon dioxide and nitrogen [2]

(ii) $2CO + 2NO \rightarrow N_2 + 2CO_2$ [1]

(iii) Platinum/Rhodium/Palladium [1]

(iv) Maximum surface area/efficiency [1]
minimises cost [1]
better catalysis [1]
Any two from three [2]

(v) The catalyst is in a different physical state (solid) [1]
than the reactants (gases) [1] [2]

(vi) Adsorbs to surface [1]
Weakens bonds (in the reactants)/correct orientation/d-orbitals argument [1] [2]

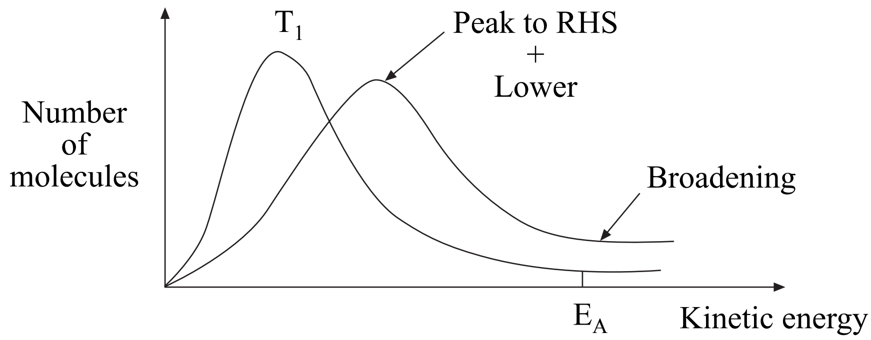
(vii) The lead compounds bond very strongly (chemisorb) to the catalytic surface [1]
poisoning the catalyst/preventing catalysis [1] [2]

(b) (i) *y*-axis = number of molecules [1]

(ii) The minimum amount of energy required for reaction [1]

(iii) Most collisions (between molecules of CO and NO) have energy less than activation energy [1]

(iv)



Peak to RHS + Lower [2]
Broadening [1] [3]

(v) A greater fraction of all collisions (between CO and NO) [1]
have energy greater than or equal to the activation energy [1] [2] 20

Section B	**80**
Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2008

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

THURSDAY 12 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all sixteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all six** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **14(e)(ii)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 What is the order of increasing boiling points for the following fractions when crude oil is distilled?

A Bitumen, lubricating oil, kerosene, gasoline.
B Gasoline, kerosene, lubricating oil, bitumen.
C Kerosene, bitumen, gasoline, lubricating oil.
D Lubricating oil, gasoline, bitumen, kerosene.

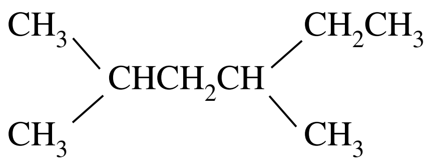
2 Which one of the following molecules exists as *cis-trans* isomers?

A $(CH_3)_2C = C(CH_3)_2$
B $CH_3CH_2CH = CHCH_2CH_3$
C $CH_3CH_2CH = C(CH_3)_2$
D $(CH_3)_2CHCH_2CH = CH_2$

3 Which one of the following represents the conditions used in the Contact Process?

	Catalyst	**Approximate pressure (atm)**	**Approximate temperature (°C)**
A	Iron	1 – 2	250
B	Iron	200 – 1000	450
C	Vanadium(V) oxide	1 – 2	450
D	Vanadium(V) oxide	200 – 1000	250

4 What is the systematic name for the molecule shown below?



A 2,4-dimethylhexane
B 2-ethyl-4-methylpentane
C 2-methyl-4-ethylpentane
D 3,5-dimethylhexane

5 The solubility of ethanol in water is due to

A covalent bonding only.
B hydrogen bonding only.
C permanent dipole attractions.
D van der Waals forces.

6 Which statement describes the pattern of the melting points for the elements in Group II?

A They decrease as the atomic number increases.
B They increase as the atomic number increases.
C They decrease from magnesium to calcium and then increase.
D They increase from magnesium to calcium and then decrease.

7 It is important to minimise the release of sulphur dioxide during the manufacture of sulphuric acid as it can contribute to

A acid rain.
B depletion of the ozone layer.
C global warming.
D increasing smog levels.

8 Which one of the following will give a yellow precipitate in the iodoform test?

A propan-1-ol
B propan-2-ol
C 2-methylpropan-1-ol
D 2-methylpropan-2-ol

9 In propanone, CH_3COCH_3, the attractions between the molecules are

A dipole–dipole attractions.
B dipole–dipole attractions and hydrogen bonds.
C dipole–dipole attractions and van der Waals forces.
D hydrogen bonds and van der Waals forces.

10 Which one of the following is a tertiary alcohol?

A 2-methylbutan-1-ol
B 2-methylbutan-2-ol
C 3-methylbutan-2-ol
D 2,2-dimethylpropan-1-ol

Section B

Answer all **six** questions in this section.

11 Complete the table below by describing an appropriate test and the observation expected to identify each gas.

Gas	**Test**	**Observation**
Hydrogen		
Sulphur dioxide		
Hydrogen chloride		

[6]

12 The chlorination of methane in sunlight occurs by a free radical mechanism.

(a) Explain what is meant by the term **free radical**.

____ [1]

(b) Write the equation for the formation of chloromethane from chlorine and methane.

____ [1]

(c) Write equations for each of the following stages in the reaction mechanism.

(i) The initiation step.

____ [1]

(ii) **Two** propagation steps.

____

____ [2]

(iii) **One** termination step.

____ [1]

13 Deposits of limestone, which is mainly calcium carbonate, $CaCO_3$, are found in Northern Ireland at the Marble Arch Caves and at White Park Bay.

(a) Describe how you could show the presence of calcium ions and carbonate ions in a sample of limestone.

calcium ions:

____

____

____

carbonate ions:

____

____

____ [4]

(b) Calcium carbonate can be decomposed by heat.

(i) Write an equation for the decomposition of calcium carbonate.

____ [1]

(ii) Compare the thermal stability of calcium carbonate with those of magnesium and strontium carbonates, explaining any differences.

____

____

____

____ [3]

(c) The percentage of calcium carbonate in a sample of limestone can be determined as follows:

The sample of limestone is weighed and dissolved in excess hydrochloric acid. The unreacted hydrochloric acid is then titrated with standard sodium hydroxide solution.

$$CaCO_3 \quad + \quad 2HCl \quad \rightarrow \quad CaCl_2 \quad + \quad H_2O \quad + \quad CO_2$$

$$HCl \quad + \quad NaOH \quad \rightarrow \quad NaCl \quad + \quad H_2O$$

1.05 g of limestone were dissolved in 30.0 cm^3 of 1.0 M hydrochloric acid. The solution was then made up to 250 cm^3. 25.0 cm^3 of this solution, when titrated, required exactly 11.6 cm^3 of 0.1 M sodium hydroxide solution.

(i) Name a suitable indicator for the titration and give the colour change observed at the end point.

Indicator: ____

Colour change:

from ____________________ to ____________________ [3]

(ii) Calculate the percentage of calcium carbonate in the sample of limestone.

Number of moles of sodium hydroxide used in the titration:

____

Number of moles of hydrochloric acid in 250 cm^3 of solution:

____

Number of moles of hydrochloric acid in 30.0 cm^3 of 1.0 M solution:

____

Moles of hydrochloric acid which reacted with the limestone:

____

Moles of calcium carbonate in the sample:

____

Mass of calcium carbonate in the sample:

____

Percentage of calcium carbonate in the sample:

____ [5]

14 Alkenes are important raw materials in the chemical industry.

(a) Alkenes can be made from alkanes with high relative molecular masses, e.g. dodecane, $C_{12}H_{26}$.

(i) What is the name given to this process?

____ [1]

(ii) Write an equation for the formation of ethene from dodecane.

____ [1]

(iii) Describe the chemical test to confirm the presence of an alkene in the resulting mixture.

____

____ [2]

(b) Ethene can also be prepared from bromoethane. Write an equation for this reaction, giving the reaction conditions.

____

____ [2]

(c) Consider the following table.

	Ethane	**Ethene**
Bond length/nm	0.154	0.134
Bond energy/kJ mol^{-1}	346	598

(i) Explain the differences in bond length and bond energy in terms of the sigma (σ) and pi (π) bonds present.

____

____

____

____ [3]

(ii) Explain why ethene is more reactive than ethane despite its bond energy being greater.

____

____

____ [2]

(d) Hydrogen bromide, HBr, reacts readily with ethene.

(i) Draw the mechanism for this reaction.

[3]

(ii) What name is used to describe this mechanism?

____ [2]

(e) Ethene may be polymerised to form high density (HD) or low density (LD) polythene.

(i) What conditions are used for the manufacture of HD polythene?

____

____ [2]

(ii) By comparing their structures, explain the differences in softening temperature and flexibility of HD and LD polythene.

____

____

____

____

____

____

____ [4]

Quality of written communication [2]

(iii) Polymer waste may be disposed of in landfill sites or by incineration.

State **one** advantage and **one** disadvantage of each method of disposal.

Landfill: ______________________________________

____

____

Incineration: ___________________________________

____

____ [4]

15 Alcohol (ethanol) continues to play an important role in everyday life and in the laboratory.

(a) Ethanol is considered to be a recreational drug.

State **one** beneficial and **one** harmful effect of alcohol consumption.

[2]

(b) Ethanol produced from sugar cane can be used as a fuel.

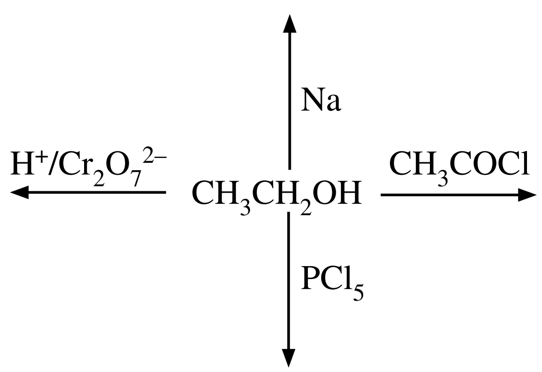
(i) Write an equation for the complete combustion of ethanol.

[2]

(ii) Give **two** environmental advantages of using ethanol as a fuel.

[2]

(c) Complete the diagram below by drawing the structure of each organic product formed.



[4]

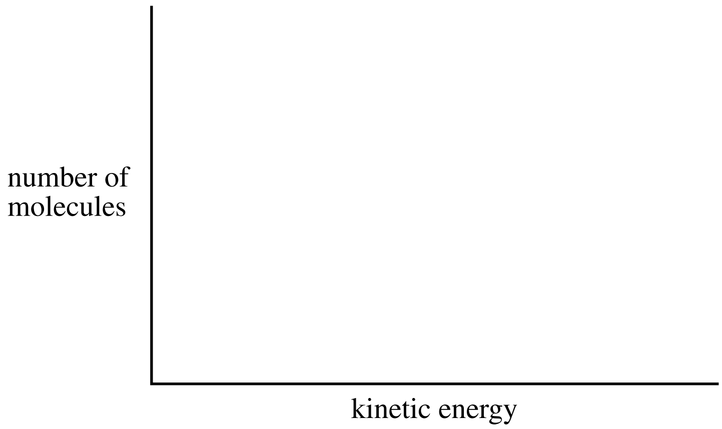
16 Nitrogen(II) oxide, NO, is produced in car engines and may be removed from the exhaust gases to help reduce air pollution.

(a) The catalytic converter in a car exhaust converts the nitrogen(II) oxide to nitrogen by reacting it with carbon monoxide which is also present in the exhaust gases.

(i) Write an equation for the reaction of nitrogen(II) oxide with carbon monoxide.

____ [2]

(ii) On the axes below sketch the distribution of molecular kinetic energies in a gas and mark the activation energy, E_A, of the uncatalysed and catalysed, E_A(cat) reactions.



[3]

(iii) Catalytic converters in car exhaust systems may contain platinum and palladium which act as heterogeneous catalysts.

Using chemisorption, explain their catalytic behaviour.

____

____

____ [3]

(b) Nitrogen(II) oxide reacts with oxygen in the following equilibrium.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \quad \Delta H = -114\,kJ$$

Describe and explain the effect of the following changes on the composition of the equilibrium mixture.

(i) Increasing the temperature.

____

____ [2]

(ii) Increasing the pressure.

____

____ [2]

(iii) Adding a catalyst.

____

____ [2]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2008

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

THURSDAY 12 JUNE, AFTERNOON

MARK SCHEME

Section A

1 B

2 B

3 C

4 A

5 B

6 D

7 A

8 B

9 C

10 B

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11		**Hydrogen:** burning splint [1] (squeaky) pop [1] **Sulphur dioxide:** (acidified) potassium permanganate [1] decolourised [1] **or** changes (acidified) potassium dichromate [1] (from orange) to green [1] **Hydrogen chloride:** with ammonia [1] white fumes [1]	[6]	6
12	**(a)**	An atom or molecule with an unpaired electron	[1]	
	(b)	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$	[1]	
	(c)	**(i)** $Cl_2 \rightarrow 2Cl^{\cdot}$	[1]	
		(ii) $CH_4 + Cl^{\cdot} \rightarrow CH_3^{\cdot} + HCl$ $CH_3^{\cdot} + Cl_2 \rightarrow CH_3Cl + Cl^{\cdot}$ $CH_3Cl + Cl^{\cdot} \rightarrow CH_2Cl^{\cdot} + HCl$ (or any correct alternative, any **two** [1] each)	[2]	
		(iii) $Cl^{\cdot} + Cl^{\cdot} \rightarrow Cl_2$ $CH_3^{\cdot} + CH_3^{\cdot} \rightarrow CH_3CH_3$ $CH_3^{\cdot} + Cl^{\cdot} \rightarrow CH_3Cl$ (or any correct alternative)	[1]	6
13	**(a)**	**Calcium ions:** Description of a flame test [1] gives a brick red flame [1] **Carbonate ions:** Fizzing with hydrochloric acid [1] gas turns lime water milky [1]	[4]	
	(b)	**(i)** $CaCO_3 \rightarrow CaO + CO_2$	[1]	
		(ii) Calcium carbonate is more stable than magnesium carbonate but less stable than strontium carbonate [1] As the Group is descended the cation size increases [1] changing the lattice enthalpy [1]	[3]	
	(c)	**(i)** Indicator: Phenolphthalein [1] **or** methyl orange From: colourless [1] to: pink [1] **or** red to orange	[3]	
		(ii) $\left.\begin{array}{l}(0.1 \times 11.6)/1000 = 11.6 \times 10^{-4} = 1.16 \times 10^{-3}\text{ mol}\\ 11.6 \times 10^{-3} = 1.16 \times 10^{-2}\text{ mol}\end{array}\right\}$ [1] $\left.\begin{array}{l}(1 \times 30)/1000 = 0.030\text{ mol}\\ 0.030 - 0.0116 = 0.0184\text{ mol}\end{array}\right\}$ [1] $0.0184/2 = 0.0092$ mol 0.92 g $(0.92/1.05) \times 100 = 87.6\%$ ([–1] for each mistake, carry error through)	[5]	16

14 **(a)** **(i)** Cracking [1]

(ii) $C_{12}H_{26} \rightarrow C_2H_4 + C_{10}H_{22}$ [1]

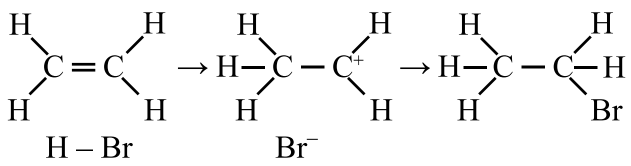
(iii) Add bromine water [1]
decolourised/from orange to colourless [1] [2]

(b) $C_2H_5Br + NaOH \rightarrow C_2H_4 + NaBr + H_2O$ [1]
Alcoholic OH^- [1] [2]

(c) **(i)** Carbons in ethane held by sigma bond only [1]
Carbons in ethene held by sigma and pi bonds [1]
Bonding in ethene stronger making the bond shorter and increasing the bond energy [1] [3]

(ii) Pi bond has overlapping p-orbitals exposing the electrons/high electron density [1]
Attacked by electrophiles/Pi bonds more easily broken [1] [2]

(d) **(i)**



([–1] for each mistake) [3]

(ii) Electrophilic [1] addition [1] [2]

(e) **(i)** About 60 °C [1] and atmospheric pressure [1]
Zeigler-Natla catalyst [1]
All **three** [2]

(ii) HD – little or no branching/extensive crystalline regions [1]
Making it rigid and giving it a higher melting point [1]
LD – lots of branching/little crystalline structure [1]
Making it flexible and giving it a lower melting point [1] [4]

Quality of written communication [2]

(iii) **Landfill**

Advantages	**Disadvantages**
cheap	non-biodegradable
land reclaimed	eyesore
no CO_2/greenhouse gases	destroys habitat
no toxic fumes	waste not recycled

Incineration

Advantages	Disadvantages
Heat reused	Produces greenhouse gases
Removes waste quicker	Waste not recycled
Small amount of residue	Toxic fumes
	Expensive

Cannot use same reason for both disposal methods
([1] each, must have both landfill and incineration for full marks) [4] 28

15 (a) **Beneficial:** socialisation/relaxation/small amounts prevent heart disease
Harmful: damage to liver/depression
(Must have one beneficial and one harmful for comparison and both marks) [2]

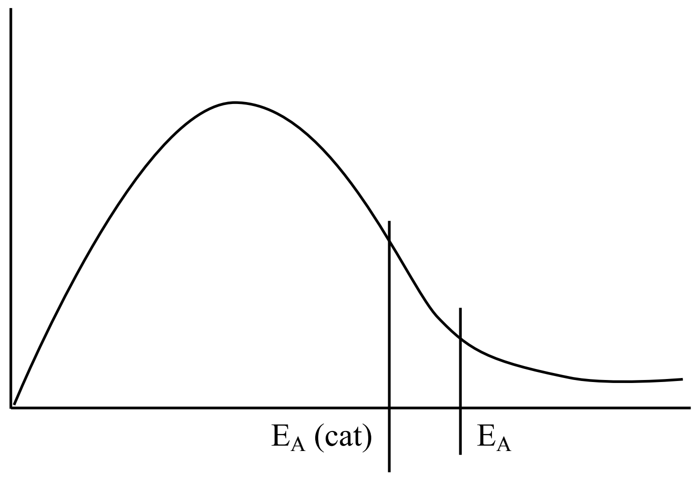
(b) (i) $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ [2]

(ii) Reduces the use of fossil fuels/less CO_2 emissions/ reduces SO_2/CO_2 emissions/renewable [2]

(c) $Na \rightarrow CH_3CH_2ONa$ [1]
$CH_3COCl \rightarrow CH_3COOCH_2CH_3$ [1]
$PCl_5 \rightarrow CH_3CH_2Cl$ [1]
$H^+/Cr_2O_7^{2-} \rightarrow CH_3COOH$ **or** CH_3CHO [1] [4] 10

16 (a) (i) $2NO + 2CO \rightarrow N_2 + 2CO_2$ [2]

(ii)



Curve: starting at 0/0 [1] correct shape not touching *x*-axis [1]
E_A (cat) to left of E_A [3]

(iii) Reactants adsorbed (onto the surface) [1]
Molecules closer together/orientated [1]
Bonds in reactants weakened/broken [1] [3]

(b) (i)	Reaction moves to the left [1] To absorb heat/endothermic process [1]	[2]	
(ii)	Reaction moves to the right [1] Fewer molecules/less volume [1]	[2]	
(iii)	No effect [1] Less time to reach equilibrium [1]	[2]	14
		Section B	**80**
		Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2009

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

TUESDAY 20 JANUARY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all eighteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all eight** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **18(b)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following bonds is the weakest?

A C–C
B C–F
C C–H
D C–I

2 A pi (π) bond is present in a molecule of

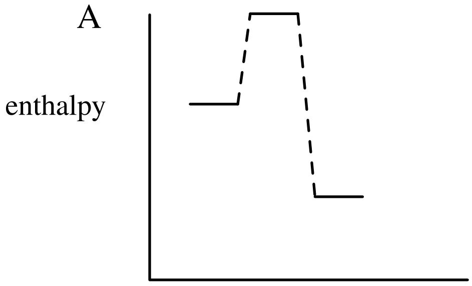
A ethene
B ethanol
C ethane
D polythene

3 Which one of the following reactions involves elimination?

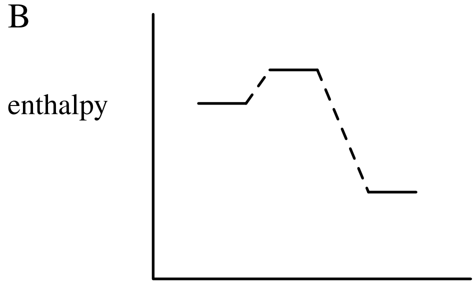
A the reaction of a tertiary bromoalkane with hydroxide ions to form an alcohol
B the reaction of a primary chloroalkane with ammonia to form an amine
C the reaction of a tertiary chloroalkane with cyanide ions to form a nitrile
D the reaction of a primary bromoalkane with hydroxide ions to form an alkene

4 Which one of the following reaction profiles shows a mixture of methane and air as thermodynamically unstable and kinetically stable?

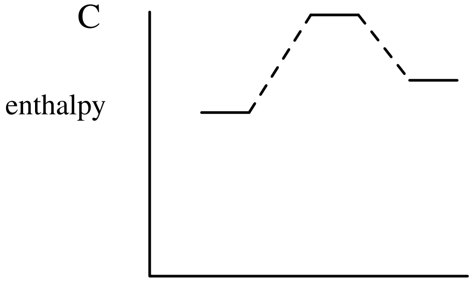
A



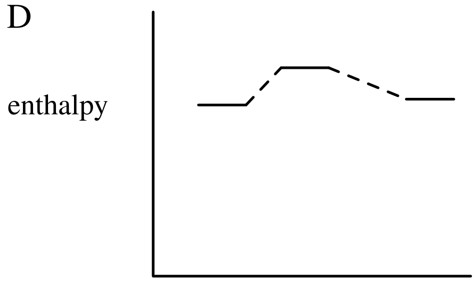
B



C



D



5 Which one of the following is a tertiary alcohol?

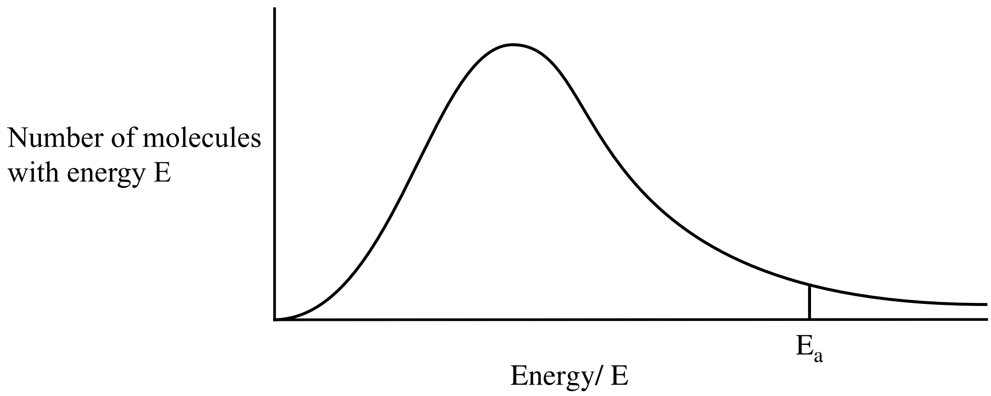
A 2-methylbutan-1-ol
B 2-methylbutan-2-ol
C 3-methylbutan-1-ol
D 3-methylbutan-2-ol

6 Which one of the following equations represents a step in the mechanism for the reaction between hydrogen bromide and ethene?

A $C_2H_4 + Br^+ \rightarrow C_2H_4Br^+$
B $C_2H_4 + HBr \rightarrow C_2H_5^+ + Br^-$
C $C_2H_4 + HBr \rightarrow C_2H_5\bullet + Br\bullet$
D $C_2H_4 + HBr \rightarrow C_2H_4Br^- + H^+$

7 The distribution of energy amongst the molecules involved in the reaction between sulphur dioxide and oxygen to form sulphur trioxide is shown below.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 \qquad \Delta H = -92 \text{ kJ}$$



Which one of the following results in an increase in the proportion of molecules with enough energy to react?

A A decrease in pressure
B A decrease in temperature
C An increase in pressure
D An increase in temperature

8 Which one of the following pairs of aqueous solutions does **not** form a white precipitate on mixing?

A barium chloride and sodium sulphate
B barium nitrate and sodium sulphite
C magnesium chloride and sodium carbonate
D magnesium sulphate and potassium hydrogencarbonate

9 A solution of a salt gives a lilac colour when sprayed into a Bunsen flame and a white precipitate when added to an acidified solution of silver nitrate.
The salt is

A potassium carbonate.
B potassium chloride.
C sodium carbonate.
D sodium sulphate.

10 Which one of the following is **not** an isomer of the ester?

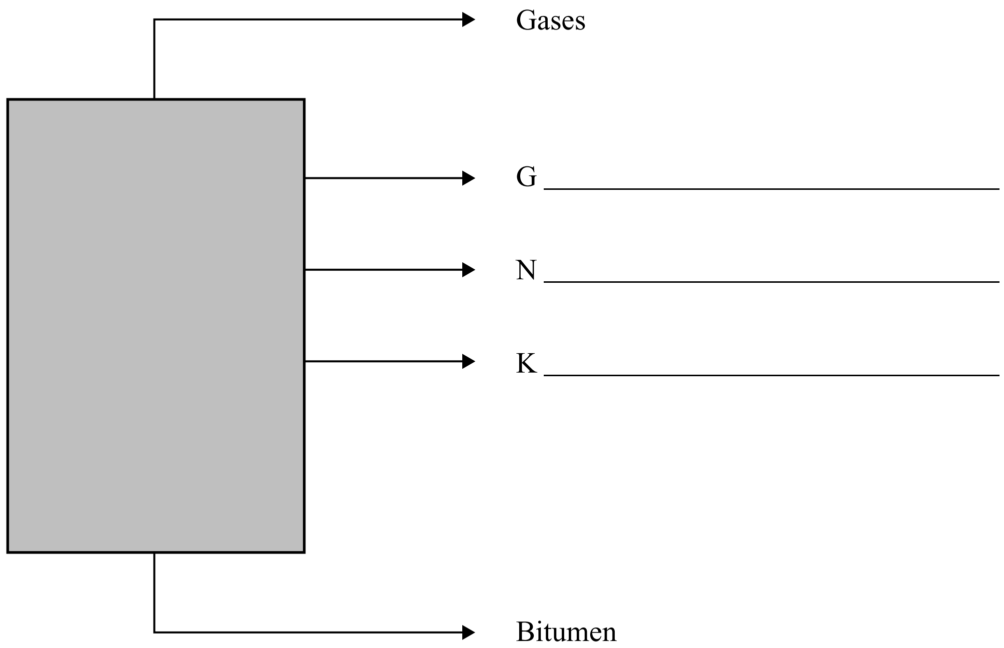
$CH_3CO_2CH(CH_3)_2$

A ethyl ethanoate
B butyl methanoate
C pentanoic acid
D propyl ethanoate

Section B

Answer **all eight** questions in the spaces provided.

11 A fractionation column for the primary fractionation of petroleum is shown below.



Complete the names of the fractions shown. [3]

12 The photochemical reaction between methane and chlorine is an example of free radical substitution. The mechanism below is incomplete because the free radicals are not shown. Using dots (•) identify the free radicals.

$$Cl_2 \rightarrow 2Cl$$

$$Cl + CH_4 \rightarrow CH_3 + HCl$$

$$CH_3 + Cl_2 \rightarrow CH_3Cl + Cl$$

$$CH_3 + CH_3 \rightarrow C_2H_6$$

[3]

13 The Haber process for the manufacture of ammonia involves the equilibrium reaction between nitrogen and hydrogen.

(a) Write the equation for the equilibrium reaction.

____ [2]

(b) Name the catalyst used in the Haber process.

____ [1]

(c) Explain why a combination of high pressure and low temperature would maximise the yield of ammonia.

high pressure

____

____ [2]

low temperature

____

____ [2]

(d) Describe a chemical test for ammonia. State the reagent used and the observation for a positive result.

____

____ [2]

14 Planes "ice-up" when their wings are covered in a layer of ice. The most commonly used de-icing liquid is ethane-1,2-diol known as ethylene glycol.

CH_2OH
|
CH_2OH

ethylene glycol

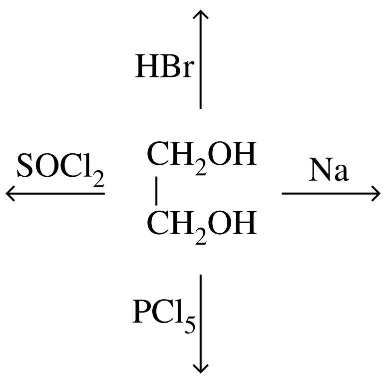
Ethylene glycol can lower the freezing point of water to –13 °C. It is very soluble in water and runs off the plane with the melted ice.

(a) **(i)** Ethylene glycol contains a **primary alcohol** group. Explain this term.

____

____ [2]

(ii) Primary alcohols react with a variety of reagents. Complete the following scheme by drawing the structure of the organic product in each case assuming an **excess** of each reagent in each case.



[4]

(b) Explain why ethylene glycol is very soluble in water.

____

____ [2]

(c) Ethylene glycol causes environmental problems. It may be washed into streams and rivers where it is oxidised by bacteria which lower the oxygen content of the water.

(i) Name an oxidising agent which will cause mild oxidation of a primary alcohol.

____ [1]

(ii) What is a primary alcohol converted to after mild oxidation?

____ [1]

(d) Explain whether ethylene glycol will give a positive iodoform test.

____

____ [2]

(e) Ethylene glycol is far more poisonous than ethanol; 100 cm^3 of ethylene glycol is lethal when swallowed.

(i) State **one** harmful effect of ethanol apart from its poisonous nature.

____

____ [1]

(ii) Calculate the lethal dose of ethylene glycol, in moles, if its density is 0.8 g cm^{-3}.

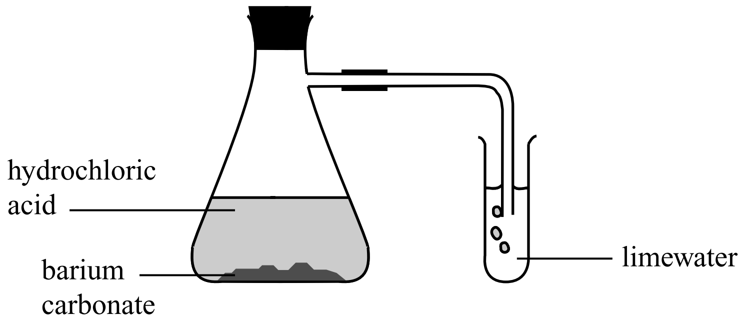
____

____

____ [3]

15 Barium carbonate, $BaCO_3$, occurs naturally as the mineral Witherite. It is a white solid which is insoluble in water but soluble in hydrochloric and nitric acids.

(a) The apparatus below can be used to demonstrate that carbon dioxide is produced when barium carbonate reacts with hydrochloric acid.



(i) Write an equation for the reaction of barium carbonate with hydrochloric acid.

____ [2]

(ii) Describe what is observed in the test tube after a few seconds.

____ [1]

(iii) Calculate the volume of carbon dioxide produced, at 20 °C and one atmosphere pressure, if 0.66 g of barium carbonate is reacted with an excess of acid.

____

____

____

____ [3]

(iv) What colour is seen if the solution left in the conical flask is sprayed into a Bunsen flame?

____ [1]

(b) Barium carbonate and barium sulphate are not poisonous because they are hardly soluble. However, a soluble salt such as barium chloride, is extremely poisonous.

(i) The solubility of barium carbonate is 0.86 mg in 100 cm^3 of water at 18 °C.
Calculate the molarity of this saturated solution.

____

____

____ [3]

(ii) An antidote to barium chloride poisoning is to swallow a solution of magnesium sulphate (Epsom Salts) which reacts to form insoluble barium sulphate.
Write an equation for this reaction.

____ [2]

(c) Barium carbonate is very difficult to decompose, a temperature of 1360 °C is required. Beryllium carbonate decomposes easily at 25 °C.

(i) Write the equation for the decomposition of barium carbonate.

____ [1]

(ii) Suggest why the thermal stability of barium carbonate is higher than that of beryllium carbonate.

____

____

____ [3]

(iii) The decomposition of barium carbonate occurs at a much lower temperature if it is heated with carbon. Barium oxide is formed together with carbon monoxide. Write the equation for the reaction.

____ [2]

16 Hydrocarbon fuels such as butane, C_4H_{10}, are one of our main sources of energy.

(a) Energy is released when hydrocarbon fuels are burnt.

(i) Write the equation for the complete combustion of butane.

____ [2]

(ii) Carbon (soot) can be formed by incomplete combustion. Name two products, other than carbon, produced by the incomplete combustion of butane.

____ [2]

(iii) What causes incomplete combustion to occur?

____

____ [1]

(b) The two isomers which have the formula C_4H_{10} are butane and 2-methylpropane.

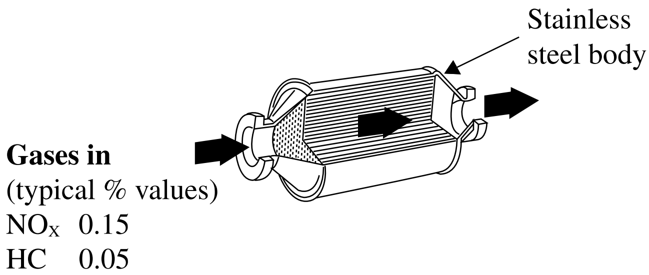
(i) Draw the structure of 2-methylpropane.

[2]

(ii) Name the products from the complete combustion of 2-methylpropane.

____ [2]

17 The diagram below shows a catalytic converter.



Inside is a metal or ceramic honeycomb coated with finely divided metals.

(a) The metals used are platinum, palladium and rhodium.

(i) Suggest why the metals are finely divided.

____

____ [2]

(ii) Explain how chemisorption takes place on the surface of the metals and leads to a reaction.

____

____

____ [3]

(b) Explain why lead-free petrol must be used with a catalytic converter.

____

____ [2]

(c) Complete the following table which summarises the conversions taking place in the converter.

Gas In	**Gases Out**
carbon monoxide	
hydrocarbon	
nitrogen monoxide	

[3]

18 The annual UK production of polythene is about half a million tonnes. Ethene needed for the process is obtained from the catalytic cracking of naphtha.

(a) Explain the term **catalytic cracking**.

____

____ [2]

(b) Explain the flexibility and softening temperature of HD polythene in terms of its structure.

____

____

____

____

____

____ [4]

Quality of written communication. [2]

(c) Polythene is chemically inert. Its non-biodegradability leads to the need to develop waste management strategies.

(i) Explain the meaning of the term **non-biodegradability**.

____

____ [2]

(ii) State **two** reasons why the disposal of polythene by incineration may be preferred to dumping in landfill sites.

____

____ [2]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2009

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

TUESDAY 20 JANUARY, MORNING

MARK SCHEME

Section A

1 D

2 A

3 D

4 A

5 B

6 B

7 D

8 D

9 B

10 A

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11			gasoline	[1]	
			naphtha	[1]	
			kerosene	[1]	3
12			$Cl_2 \rightarrow 2Cl^{\bullet}$ $Cl^{\bullet} + CH_4 \rightarrow CH_3^{\bullet} + HCl$ $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ $CH_3^{\bullet} + CH_3^{\bullet} \rightarrow C_2H_6$	[3]	3
13	**(a)**		$N_2 + 3H_2 \rightleftharpoons 2NH_3$	[2]	
	(b)		iron	[1]	
	(c)		more molecules on the left hand side	[1]	
			equilibrium moves to the right	[1]	
			reaction is exothermic	[1]	
			hence low temperature to move equilibrium to right	[1]	
	(d)		concentrated hydrochloric acid	[1]	
			white smoke/fumes	[1]	9
14	**(a)**	**(i)**	carbon attached to two hydrogens and an OH group	[2]	
		(ii)	CH_2Br-CH_2Br $CH_2ONa-CH_2ONa$ CH_2Cl-CH_2Cl CH_2Cl-CH_2Cl	[4]	
	(b)		H bonding between	[1]	
			OH groups and water	[1]	
	(c)	**(i)**	acidified (potassium) dichromate/formula acidified (potassium) manganate(VII)/formula	[1]	
		(ii)	aldehydes	[1]	
	(d)		no (dependent on explanation)	[1]	
			because CH_3CHOH- is not present	[1]	
	(e)	**(i)**	liver damage/affects behaviour	[1]	
		(ii)	$100\,cm^3$ is $80\,g$ $CH_2OHCH_2OH = 24 + 6 + 32 = 62$ $80\,g = 80/62 = 1.29$ mol	[3]	16

15 **(a)** **(i)** $BaCO_3 + 2HCl \rightarrow BaCl_2 + CO_2 + H_2O$ [2]

(ii) milky/chalky/white [1]

(iii) $BaCO_3 = 137 + 12 + 48 = 197$
$0.66\,g = 0.66/197 = 0.00335$ mol
0.00335 mol $= 0.00335 \times 24\,dm^3 = 0.0804\,dm^3$ or $80.4 / 80\,cm^3$ [3]

(iv) green [1]

(b) **(i)** $0.86\,mg = 0.86 \times 10^{-3}\,g$
mol of barium carbonate $= 0.86 \times 10^{-3}/197 = 0.00436 \times 10^{-3}$
$= 4.4 \times 10^{-6}$ mol in 100 cm^3
solubility $= 4.4 \times 10^{-5}$ mol dm^{-3} [3]

(ii) $BaCl_2 + MgSO_4 \rightarrow MgCl_2 + BaSO_4$ [2]

(c) **(i)** $BaCO_3 \rightarrow BaO + CO_2$ [1]

(ii) cation size of Ba is greater than that of Be [1]
lattice enthalpy of $BaCO_3$ greater than $BeCO_3$ [2]

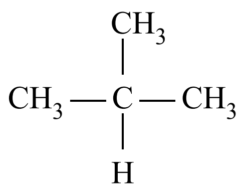
(iii) $BaCO_3 + C \rightarrow BaO + 2CO$ [2] 18

16 **(a)** **(i)** $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ [2]

(ii) water [1]
carbon monoxide [1]

(iii) limited supply of oxygen/air [1]

(b) **(i)**



[2]

(ii) water and carbon dioxide [2] 9

17	**(a)**	**(i)** greater surface area	[1]	
		faster reaction/more economical	[1]	
		(ii) molecules adsorbed on the surface/interaction with d orbitals of metal	[1]	
		activation energy lowered	[1]	
		bonds weakened or broken	[1]	
		orientation of molecules on the surface	[1]	
		to a maximum of [3]		
	(b)	lead (or compounds) coats the surface	[1]	
		stops catalysis/reaction taking place	[1]	
	(c)	carbon dioxide	[1]	
		carbon dioxide and water	[1]	
		nitrogen	[1]	10
18	**(a)**	(vapour of hydrocarbon passed over hot) catalyst	[1]	
		molecule broken down into smaller parts	[1]	
	(b)	flexibility of HD polythene is low	[1]	
		softening temperature of HD polythene is high	[1]	
		polythene molecule is not branched	[1]	
		packing is closer/intermolecular forces greater/more crystalline	[1]	
		Quality of written communication	[2]	
	(c)	**(i)** molecules do not break down	[1]	
		by the action of microbes/bacteria/microorganisms	[1]	
		(ii) provides energy – essential	[1]	
		not sufficient landfill sites etc	[1]	12
			Section B	**80**
			Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2009

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

THURSDAY 11 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all seventeen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all seven** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **17(e)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following statements about polythene is correct?

	type of polythene	**crystallinity**	**flexibility**
A	HD	high	low
B	HD	low	high
C	LD	low	low
D	LD	high	low

2 A free radical is a particle with

A a lone pair of electrons.
B a negative charge.
C a positive charge.
D an unpaired electron.

3 In the Contact process, sulphur dioxide is prevented from escaping because it

A increases global warming.
B leads to acid rain.
C reduces ozone in the upper atmosphere.
D reacts with oxygen in the atmosphere.

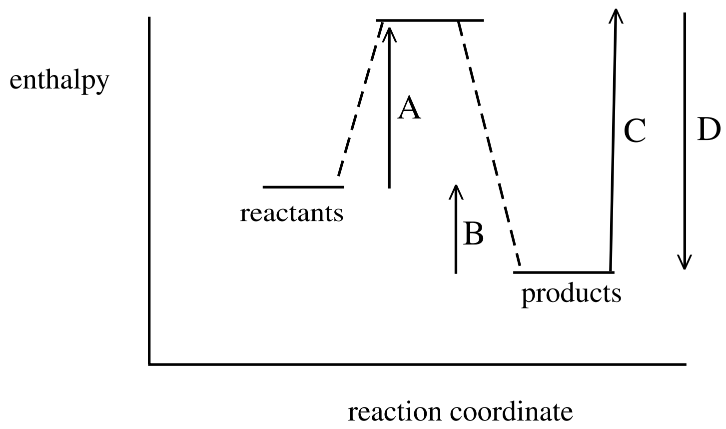
4 Which one of the following is not a source of ethanol?

A Manufacture from sugar cane
B Catalytic hydration of ethene
C Hydrolysis of bromoethane with alkali
D Reaction of iodoethane with ammonia

5 Which one of the following hydrocarbons contains a double bond?

A CH_4
B C_2H_4
C C_2H_6
D C_3H_8

6 In the reaction profile below, which letter represents the activation energy for the conversion of reactants to products?



7 Which one of the following describes the reaction between hydrogen bromide and ethene?

A Electrophilic addition
B Electrophilic substitution
C Nucleophilic addition
D Nucleophilic substitution

8 2.8 g of a metal, M, combines with 0.8 g of oxygen to form the oxide MO. The metal, M, also forms an oxide in which the metal and oxygen are present in the ratio 7:3 by mass. What is the formula of the second oxide?

A MO_2
B M_2O
C M_2O_3
D M_3O_2

9 The manufacture of sodium carbonate is represented by the equation below:

$$2NaCl + CaCO_3 \rightarrow CaCl_2 + Na_2CO_3$$

Which one of the following shows the masses of reactants (in tonnes) needed to produce 2 tonnes of sodium carbonate?

	NaCl	$CaCO_3$
A	1.00	1.00
B	1.00	0.92
C	2.20	1.89
D	2.34	2.00

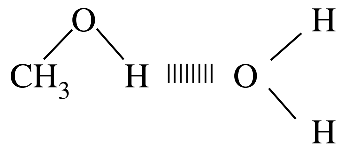
10 Which one of the following ions, in aqueous solution, reacts with magnesium ions to form a colourless solution which deposits a white precipitate on boiling?

A carbonate
B hydrogencarbonate
C hydroxide
D sulphite

Section B

Answer all **seven** questions in this section.

11 The diagram below shows the formation of a bond between molecule A and molecule B.



(a) Name the molecules and the type of bond formed between them.

(i) molecule A ____ [1]

(ii) molecule B ____ [1]

(iii) bond ____ [1]

(b) State a physical property of A affected by this type of bond.

____ [1]

12 Petroleum is a mixture of hydrocarbons. It is separated into a number of fractions by fractional distillation.

(a) Give the names of **three** fractions.

____

____ [3]

(b) Explain the process of fractional distillation.

____

____ [2]

(c) Name the elements present in a hydrocarbon.

____ [2]

13 The Group II elements, together with their electron structures, are listed below:

beryllium	$1s^2 2s^2$
magnesium	$1s^2 2s^2 2p^6 3s^2$
calcium	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
strontium	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^2$
barium	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s^2$

(a) Explain why they are regarded as s-block elements.

____ [1]

(b) **(i)** State and explain the trend in ionic radius down the group.

____

____

____ [2]

(ii) State and explain the trend in ionisation energy down the group.

____

____

____

____ [2]

(c) Giving observations, compare the chemistry of calcium with that of magnesium using the following headings:

combustion

____

____

____ [2]

reaction with water

____

____

____ [2]

reaction with hydrochloric acid

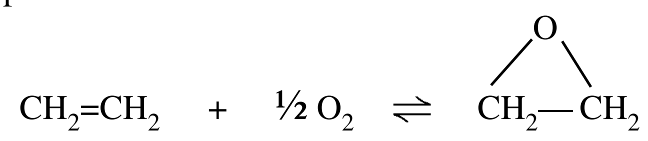
____

____

____ [2]

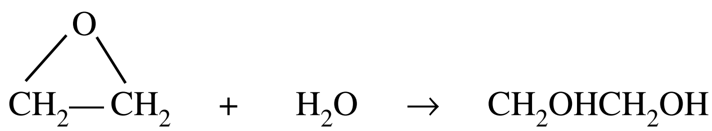
14 Ethylene glycol is manufactured industrially via ethylene oxide.

Step 1



ethylene oxide

Step 2



(a) The first step, which is an equilibrium reaction, is carried out by passing ethene and air over silver metal at a high temperature and pressure.

(i) Suggest the purpose of the silver.

____[1]

(ii) Explain the process of chemisorption on the surface of silver.

____

____

____

____

____[3]

(iii) Using an equilibrium argument, explain why a high pressure is used.

____

____[2]

(iv) Using an equilibrium argument, suggest why a high temperature is used.

____

____ [2]

(b) Calculate the number of tonnes of ethylene glycol produced in step 2 by the reaction of 2 tonnes of ethylene oxide with an excess of water.

____

____

____ [3]

15 Natural rubber is a polymer of isoprene (2-methylbut-1,3-diene).

$$\begin{array}{ccccccc} & & CH_3 & & H & & \\ & & | & & | & & \\ CH_2 & = & C & — & C & = & CH_2 \end{array}$$

isoprene

(a) What is the molecular formula of isoprene?

______________________________ [1]

(b) **(i)** Explain the meaning of the term **polymer**.

____

______________________________ [2]

(ii) State the functional group which enables isoprene to polymerise.

______________________________ [1]

(c) Isoprene may be catalytically hydrogenated to form a saturated alkane.

(i) Draw the structure of the alkane produced.

[1]

(ii) State the systematic name for the alkane.

______________________________ [2]

(iii) Name a suitable catalyst for the hydrogenation.

______________________________ [1]

(d) Isoprene burns in air to produce carbon dioxide and water.

(i) Write an equation for the combustion.

____ [2]

(ii) Name **one** substance which is produced during the incomplete combustion of isoprene, but **not** during complete combustion.

____ [1]

(e) It is best not to incinerate waste rubber, but to seek another means of disposal.

(i) State **two** reasons why the incineration of waste rubber causes serious environmental problems.

____

____ [2]

(ii) State an alternative means of disposal.

____ [1]

16 Lime (calcium oxide) is added to increase the pH of soil and to improve the yield of certain crops. Calcium oxide is manufactured by the thermal decomposition of calcium carbonate.

(a) **(i)** Write the equation for the decomposition of calcium carbonate.

____ [1]

(ii) State **two** factors which affect the thermal decomposition of Group II carbonates.

____

____ [2]

(b) Calcium oxide is basic and reacts with water to form calcium hydroxide.

(i) Explain the term **basic**.

____

____ [1]

(ii) Write the equation for the reaction of calcium oxide with water.

____ [1]

(iii) If the solubility of calcium hydroxide is 0.021 mol dm^{-3} at 20 °C, calculate the number of grams of calcium hydroxide which would dissolve in 250 cm^3 of water at this temperature.

____

____

____ [3]

(c) Calcium hydroxide reacts with hydrochloric acid to form calcium chloride and water.

(i) Write the equation for this reaction.

____ [2]

(ii) State the colour produced when a solution of calcium chloride is sprayed into a Bunsen flame.

____ [1]

17 Chloroethane has a boiling point of 12 °C and has been used as a local anaesthetic. When sprayed on the skin it evaporates quickly cooling the surface tissue and reducing pain.

(a) **(i)** Draw the structure of chloroethane showing all the bonds present.

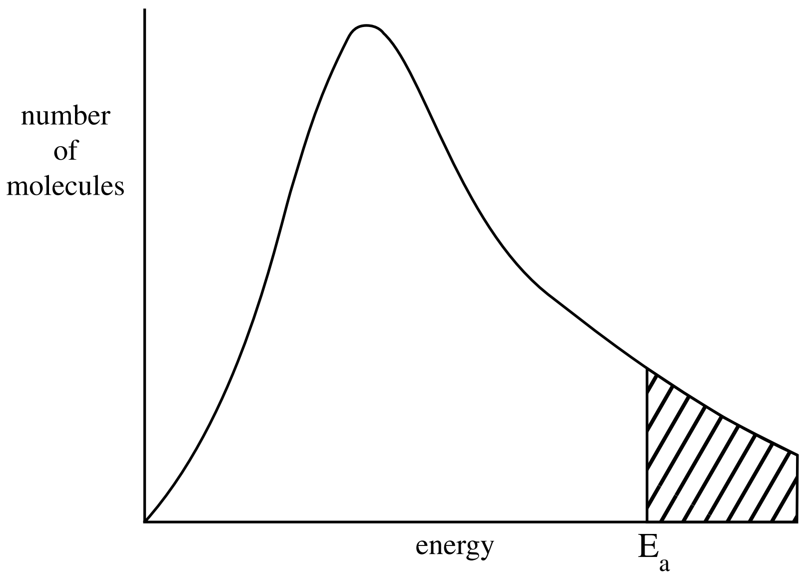
[2]

(ii) Ethanol has a boiling point of 78 °C. Explain why ethanol has the higher boiling point despite the greater molecular mass of chloroethane.

____

____ [2]

(b) Chloroethane reacts with nucleophiles such as ammonia. The distribution of molecular energies for a gaseous mixture of chloroethane and ammonia, at 20 °C , is shown below.



(i) Explain the significance of the shaded area, if E_a represents the activation energy.

____

____ [2]

(ii) Sketch on the axes above, the distribution of molecular energies at approximately 30 °C. [2]

(iii) Use the graphs of the distribution of molecular energies to explain the difference in the reaction rates at 20 °C and 30 °C.

____

____ [2]

(c) **(i)** Show the polarity of the carbon-chlorine bond in chloroethane using the diagram below

C — Cl

[1]

(ii) Explain why the bond is polar.

____

____ [2]

(d) Explain why an ammonia molecule can act as a nucleophile whereas an ammonium ion cannot.

____

____ [2]

(e) The comparative ease of hydrolysis of the halogenoalkanes can be demonstrated by adding 1-chlorobutane, 1-bromobutane and 1-iodobutane to three test tubes containing ethanol, heating and adding silver nitrate solution. State what would be observed and explain the relative rates of reaction in terms of bond enthalpies.

____

____

____

____

____

____ [5]

Quality of written communication [2]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2009

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[ASC21]

THURSDAY 11 JUNE, AFTERNOON

MARK SCHEME

Section A

1 A

2 D

3 B

4 D

5 B

6 A

7 A

8 C

9 C

10 B

[2] for each correct answer	[20]	20
		20

Section B

11	**(a)**	**(i)** methanol	[1]	
		(ii) water	[1]	
		(iii) hydrogen bond	[1]	
	(b)	solubility/melting point/boiling point	[1]	4
12	**(a)**	e.g. gasoline (petrol)/diesel/naphtha/lubricating oil/kerosine/bitumen/ refinery gas	[3]	
	(b)	oil boiled and fraction evaporates and is condensed	[1]	
		fractions obtained at a specific temperature/range of temperature	[1]	
	(c)	carbon	[1]	
		hydrogen	[1]	7
13	**(a)**	the outside shell contains s electrons	[1]	
	(b)	**(i)** the ionic radius increases down the group	[1]	
		the number of shells of electrons increases	[1]	
		(ii) the ionisation energy decreases down the group	[1]	
		the outer electron is further from the nucleus/more shielding	[1]	
	(c)	combustion		
		magnesium gives a white/bright light/calcium red light	[1]	
		white solids are formed	[1]	
		reaction with water		
		magnesium slow/no gas given off; calcium fizzes/bubbles	[1]	
		magnesium gives no heat; calcium is exothermic	[1]	
		magnesium stays shiny, dull, grey; calcium gives a white solid/ppt	[1]	
		to a maximum of [2]		
		reaction with hydrochloric acid		
		both magnesium and calcium fizz/bubbles	[1]	
		both magnesium and calcium dissolve/disappear	[1]	
		both reactions are exothermic	[1]	
		to a maximum of [2]		11

14 **(a)** **(i)** catalyst [1]

(ii) molecules adsorbed on the surface/weak temporary bonds with surface [1]
activation energy lowered [1]
bonds weakened/broken [1]
interaction with d-orbitals of metal [1]
orientation of molecules on the surface [1]

to a maximum of [3]

(iii) more molecules on the left hand side [1]
increased yield at high pressure/moves to RHS [1]

(iv) reaction must be endothermic [1]
increased yield at high temperature/moves to RHS [1]

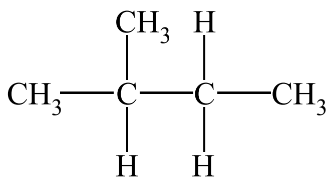
(b) $CH_2OCH_2 = 24 + 4 + 16 = 44$
$CH_2OHCH_2OH = 24 + 6 + 32 = 62$
44 tonnes of ethylene oxide produce 62 tonnes of ethylene glycol
1 tonne of ethylene oxide produce 1.41 tonnes of ethylene glycol
2 tonnes of ethylene oxide produce 2.82 tonnes of ethylene glycol [3] 11

15 **(a)** C_5H_8 [1]

(b) **(i)** monomers/short chain molecules [1]
join together [1]
or long chain structure with repeating pattern [2]

(ii) double bond [1]

(c) **(i)**



[1]

(ii) 2-methylbutane [2]

(iii) nickel [1]

(d) **(i)** $C_5H_8 + 7O_2 \rightarrow 5CO_2 + 4H_2O$ [2]

(ii) carbon/carbon monoxide [1]

(e) **(i)** smoke produced because of carbon [1]
carbon dioxide causes greenhouse effect [1]
carbon monoxide poisonous
to a maximum of [2]

(ii) landfill/recycling. [1] 14

16 (a) (i) $CaCO_3 \rightarrow CaO + CO_2$ [1]

(ii) cation size/charge density [1]
lattice enthalpy [1]

(b) (i) reacts with an acid (to produce a salt)/neutralised by acids/
proton acceptor [1]

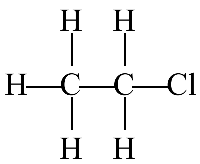
(ii) $CaO + H_2O \rightarrow Ca(OH)_2$ [1]

(iii) $Ca(OH)_2 = 40 + 2 + 32 = 74$
0.021 mol $= 0.021 \times 74 = 1.554$ g
1.554 g dissolved in 1 dm^3/1000 cm^3
0.3885/0.39 g dissolved in 250 cm^3 [3]

(c) (i) $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$ [2]

(ii) red/brick red [1] 11

17 (a) (i)



[2]

(ii) hydrogen bonding forces greater than van der Waals/dipole–dipole [2]

(b) (i) represents the number of molecules [1]
with (an energy greater than) the activation energy [1]

(ii) peak moved to the right [1]
peak lower than the previous peak [1]

(iii) more molecules have energy greater than the activation energy [2]

(c) (i) $\overset{\delta+}{C}—\overset{\delta-}{Cl}$ [1]

(ii) chlorine is more electronegative than carbon [1]
the electrons in the bond are closer to chlorine [1]

(d) ammonia has a lone pair [1]
in the ammonium ion the lone pair forms a dative bond [1]

(e)	chlorobutane gives a white precipitate	[1]	
	bromobutane gives a cream precipitate	[1]	
	iodobutane gives a yellow precipitate	[1]	
	iodobutane forms precipitate first/chlorobutane last	[1]	
	the C—I bond is the weakest	[1]	
	Quality of written communication	[2]	22
		Section B	**80**
		Total	**100**

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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2009

Chemistry

Assessment Unit AS 2

assessing

Module 2: Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry

[AC121]

THURSDAY 11 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all sixteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10.
Keep in sequence when answering.
Answer **all six** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **15(d)(iii)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 A free radical is a particle with

A an unpaired electron.
B a negative charge.
C a positive charge.
D a lone pair of electrons.

2 Which one of the following hydrocarbons contains a double bond?

A CH_4
B C_2H_2
C C_2H_4
D C_2H_6

3 Which one of the following describes the reaction between hydroxide ions and 1-bromopentane?

A Electrophilic addition
B Electrophilic substitution
C Nucleophilic addition
D Nucleophilic substitution

4 Which one of the following equations corresponds to a standard enthalpy of formation?

A $2NO(g) \rightarrow N_2(g) + O_2(g)$
B $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
C $Na(s) + Cl(g) \rightarrow NaCl(s)$
D $Mg(s) + Br_2(l) \rightarrow MgBr_2(s)$

5 Which one of the following reagents could detect the presence of ethanol in Gasohol which can be regarded as a mixture of alkanes, alkenes and ethanol?

A bromine
B hydrogen chloride
C sodium
D universal indicator

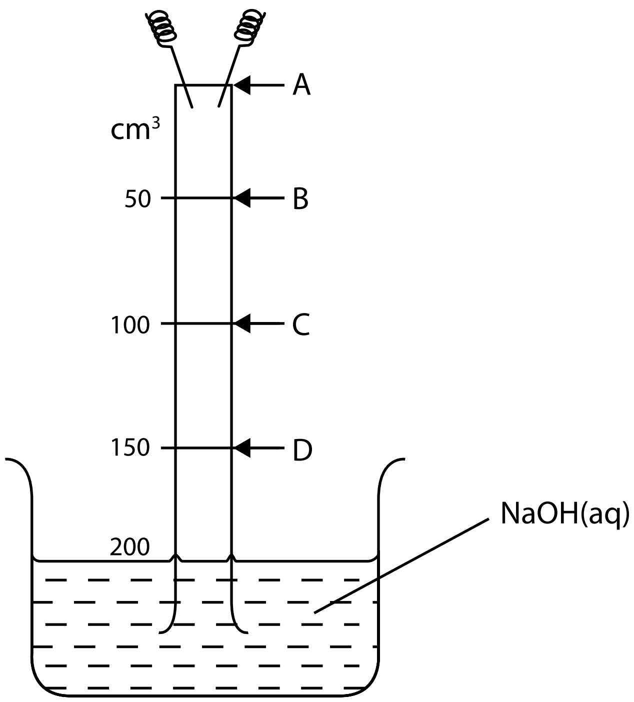
6 How many structural isomers exist with the formula, C_4H_{10}?

A 1
B 2
C 3
D 4

7 A tube is filled with 50 cm^3 of methane and 150 cm^3 of oxygen at room temperature over a beaker containing NaOH(aq) as shown.
The following reaction took place when a spark was applied to the mixture:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

When the tube is cooled to room temperature, what level will the liquid have reached?



8 In which one of the following pairs will **neither** of the hydroxides dissolve in an excess of aqueous sodium hydroxide?

A $Al(OH)_3$ and $Fe(OH)_2$
B $Al(OH)_3$ and $Zn(OH)_2$
C $Fe(OH)_2$ and $Mg(OH)_2$
D $Mg(OH)_2$ and $Zn(OH)_2$

9 Which one of the following substances has the highest boiling point?

A CH_3CH_2Cl
B $CH_3CH_2CH_2OH$
C $CH_3CH_2CH_2CH_3$
D $CH_3CH_2CH_2CH_2CH_3$

10 In the laboratory preparation of a halogenoalkane, any acidic impurities present are removed using

A sodium chloride
B sodium hydrogencarbonate
C sodium hydroxide
D sodium sulphate

Section B

Answer all **six** questions in this section

11 The table below shows the results of analysing four aqueous solutions.

compound	**colour of aqueous solution**	**addition of aqueous barium chloride**	**other information**
A	blue	white precipitate	blue-green flame test
B	colourless	white precipitate	pH = 1
C	yellow	yellow precipitate	yellow/orange flame test
D	colourless	white precipitate	lilac flame test

Name the four compounds.

A ____

B ____

C ____

D ____ [4]

12 Hydrogen is produced on an industrial scale by the reaction between methane and steam. The reaction is endothermic.

$$CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$$

The reaction is carried out at 1023 K and a pressure of 40 atmospheres in the presence of a nickel catalyst.

(a) Explain the use of a temperature of 1023 K.

____

____

____ [3]

(b) Calculate the atom economy for the reaction assuming that the carbon dioxide is a waste product and comment on the value obtained.

____

____

____

____ [4]

(c) Use the following bond energies to calculate ΔH for the reaction.

	$kJ\ mol^{-1}$
C–H	413
O–H	464
C=O	805
H–H	436

____

____

____ [3]

(d) Although the raw materials are cheap, the running costs of this reaction are significant. Suggest **two** reasons for this.

____

____ [2]

(e) Another reaction which can occur is

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$$

(i) Explain why this reaction is environmentally undesirable.

____ [1]

(ii) Suggest how the occurrence of this reaction could be prevented.

____

____ [1]

(iii) Calculate the volume of hydrogen produced at 20 °C and 1 atmosphere pressure from the reaction of 4 tonnes of methane with steam.

____

____

____ [3]

13 Chloromethane, CH_3Cl, is the largest natural source of ozone-depleting chlorine compounds in the atmosphere. Some common tropical plants emit considerable quantities of chloromethane.

(a) Chloromethane may be prepared in the laboratory by the reaction of methanol with a mixture of sodium chloride and concentrated sulphuric acid which generates hydrogen chloride.

(i) Describe the chemical test to show that hydrogen chloride is produced.

____ [2]

(ii) Write the equation for the reaction of methanol with hydrogen chloride.

____ [1]

(iii) The preparation of chloromethane is difficult because it is a gas at room temperature and pressure.
Suggest how this would cause problems during the preparation.

____ [1]

(b) Another method of preparing chloromethane is by the reaction of methane with chlorine in the presence of ultra violet light. The reaction proceeds by a free radical mechanism.

(i) Write the equation for the reaction of methane with chlorine to form chloromethane.

____ [1]

(ii) Give the electronic structure of a chlorine radical.

____ [1]

(iii) What is the role of the ultra violet light?

____

____ [2]

(iv) Ethane is formed as an impurity during the reaction. Explain how it is formed.

____

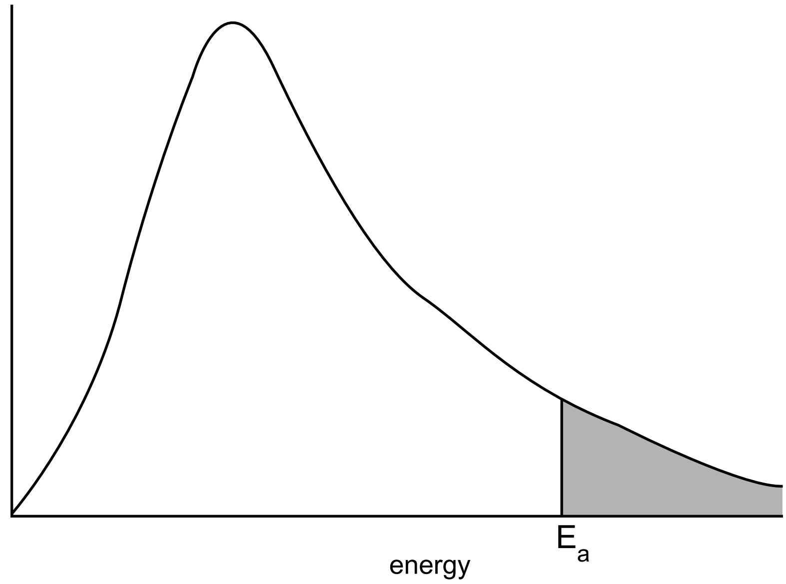
____ [1]

(c) Complete the scheme below writing the formulae of the organic products.

$$\xleftarrow{\quad NH_3 \quad} CH_3Cl \xrightarrow{\quad NaOH(aq) \quad}$$

[2]

14 The diagram shows the distribution curve for the energies of the molecules of a gas in a given system. E_a is the activation energy for a particular reaction.



(a) (i) Label the vertical axis on the diagram. [1]

(ii) Explain why the curve starts at the origin.

____

____ [1]

(iii) Why does the curve not intersect the horizontal axis at higher energies?

____

____ [1]

(iv) What does the shaded area represent?

____

____ [2]

(b) **(i)** Draw a curve on the graph representing the distribution of energies for the same molecules at a higher temperature. [2]

(ii) By reference to the curve you have drawn in part **(i)**, explain the effect of the higher temperature on the rate of a chemical reaction.

____

____

____ [1]

(c) By reference to the distribution curve, explain the effect of a catalyst on the rate of a chemical reaction.

____

____

____ [2]

15 Magnesium sulphate occurs as the mineral Epsom salts, $MgSO_4.7H_2O$. Calcium sulphate occurs as gypsum, $CaSO_4.2H_2O$. Barium sulphate contains no water of crystallisation.

(a) Magnesium, calcium and barium are regarded as **s-block** elements. Explain this term.

____ [1]

(b) Hydration of the sulphate is related to the trend in solubility of the Group II sulphates. State this trend.

____ [1]

(c) When heated, the hydrated salts lose water to form the anhydrous sulphate. Further heating causes the sulphate to decompose to form the oxide and sulphur trioxide.

(i) Calculate the percentage yield of $CaSO_4$ when 34.4 g gypsum is heated to form 26.0 g of anhydrous calcium sulphate.

____

____

____ [3]

(ii) Write the equation for the decomposition of anhydrous calcium sulphate.

____ [1]

(iii) The thermal stability of the Group II sulphates may be explained in a similar way to that of the carbonates. Explain the relative stability of the sulphates with reference to the cations involved.

____

____

____ [3]

(d) The enthalpy change for the hydration of magnesium sulphate may be determined using Hess's law.

$$MgSO_4(s) + 7H_2O(l) \rightarrow MgSO_4.7H_2O(s)$$

(i) State Hess's law.

____

____ [2]

(ii) Use the following data to calculate the molar enthalpy of hydration of magnesium sulphate. You may wish to construct an enthalpy cycle.

When 0.10 mol of anhydrous $MgSO_4$ was dissolved in 100 g of water, the temperature rose by 9 °C. When 0.10 mol of $MgSO_4.7H_2O$ was dissolved in 100 g of water, the temperature dropped 3 °C. (The specific heat capacity for water is 4.2 J °C^{-1}g^{-1}.)

[4]

(iii) Suggest how you would carry out this experiment in the laboratory, stating the equipment used, the measurements made and the possible sources of error. Explain how these errors can be minimised.

____

____

____

____

____

____ [5]

Quality of written communication [2]

16 Propenonitrile, $CH_2{=}CHCN$, can be polymerised to form a fibre known as Orlon, used for making clothes.

(a) Propenonitrile is manufactured from propene, ammonia and oxygen in the presence of molybdenum. Water is produced together with propenonitrile.

(i) Write an equation for the reaction.

____ [2]

(ii) Suggest the role of the molybdenum.

____ [1]

(iii) Suggest how you could use infra-red spectroscopy to show that no propene was present in the product from the reaction.

____

____

____ [2]

(b) Propenonitrile may be prepared in the laboratory using chloroethene and sodium cyanide. Write the equation for the reaction.

____ [2]

(c) **(i)** What is the molecular formula for propenonitrile?

____ [1]

(ii) What is the empirical formula for propenonitrile?

____ [1]

(iii) Draw the structure of a propenonitrile molecule, showing **all** the bonds present.

[2]

(iv) Explain whether propenonitrile is able to exist in *cis* and *trans* (E–Z) forms.

____

____ [2]

(d) Propenonitrile polymerises to form poly(propenonitrile) known as Orlon.

(i) Draw a diagram to represent the structure of Orlon, showing two of the repeating units.

[2]

(ii) State the type of polymerisation taking place.

____ [1]

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2009

Chemistry

Assessment Unit AS 2

assessing

Module 2: Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry

[AC121]

THURSDAY 11 JUNE, AFTERNOON

MARK SCHEME

Section A

1	A		
2	C		
3	D		
4	D		
5	C		
6	B		
7	B		
8	C		
9	B		
10	B		
[2] for each correct answer		[20]	20
		Section A	**20**

Section B

11 copper sulphate [1]
sulphuric acid [1]
sodium chromate [1]
potassium sulphate [1] [4] 4

12 **(a)** reaction is endothermic + mention of high temperature [1]
reaction moves to RHS to absorb heat [2]
increased temperature speeds up reaction [1]
To a maximum of [3] [3]

(b) Comment/statement on formula for % atom economy [2]
$CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4H_2(g)$
16 36 44 8

$$\frac{8}{52} \times 100 = 15.4\% \quad [2]$$

atom economy very low [1]
(no problem with disposal of carbon dioxide [1])
except that it causes global warming [1]
need to find a use for the carbon dioxide [1]
large amount of waste produced [1]
To a maximum of [4] [4]

(c) energy needed to break bonds in reactants
4C—H = 4 × 413 = 1652
4O—H = 4 × 464 = 1856 total = 3508

energy needed to break bonds in products
2C═O = 2 × 805 = 1610
4H—H = 4 × 436 = 1744 total = 3354

+3508 – 3354 = (+)154 kJ [3]

(d) high pressure (is expensive to maintain/thicker pipes needed) [1]
high temperature/endothermic (needs fuel which is expensive) [1] [2]

(e) **(i)** carbon monoxide is poisonous [1]

(ii) use an excess of water/steam [1]

(iii) $1CH_4 \rightarrow 3H_2$
$16\,g \rightarrow 3 \times 24\,dm^3$
16 tonnes $\rightarrow 10^6 \times 3 \times 24\,dm^3$
4 tonnes $\rightarrow 10^6 \times 3 \times 6\,dm^3$
$= 1.8 \times 10^7\,dm^3$ [3] 17

13 **(a)** **(i)** conc. ammonia [1]
white smoke [1] [2]

(ii) $CH_3OH + HCl \rightarrow CH_3Cl + H_2O$ [1]

(iii) the gas would escape from the reaction flask/needs to be condensed/difficult to collect [1]

(b) **(i)** $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ [1]

(ii) $1s^2 2s^2 2p^6 3s^2 3p^5$ [1]

(iii) provides the energy [1]
to break the Cl—Cl bond [1] [2]

(iv) $^{\bullet}CH_3 + {}^{\bullet}CH_3 \rightarrow C_2H_6$ [1]

(c) CH_3NH_2/$CH_3\overset{+}{N}H_3\ Cl^-$ [1]
CH_3OH [1] [2] 11

14 **(a)** **(i)** number of molecules [1]

(ii) no molecules hence no energy [1]

(iii) there are always some molecules with (a higher/some) energy [1]

(iv) the number of particles [1]
with (energy greater than) the activation energy [1] [2]

(b) **(i)** peak moves to the RHS [1]
and is lower [1] [2]

(ii) more particles have (energy greater than) the activation energy [1]

(c) the activation energy is less [1]
the number of particles with the required activation energy is greater [1] [2] 10

15 **(a)** the outer shells contain s electrons [1]

(b) the solubility of the sulphates decreases down the group [1]

(c) **(i)** $CaSO_4.2H_2O = 40 + 32 + 64 + 2 \times 18 = 172$
$CaSO_4 = 40 + 32 + 64 = 136$
172 g of gypsum gives 136 g of anhydrous calcium sulphate
34.4 g of gypsum gives $136/172 \times 34.4$ g of anhydrous calcium sulphate = 27.2 g
percentage yield = $26.0/27.2 \times 100 = 95.588 = 95.6\%$ [3]

(ii) $CaSO_4 \rightarrow CaO + SO_3$ [1]

(iii) the size of the cation increases down the group [1]
the polarising power of the cation is decreased [1]
charge density less [1]
anion is "deformed" [1]
Any three from four [3]

(d) **(i)** the enthalpy change in a reaction is independent of the route taken [2]

(ii)

$$\begin{tikzcd}
MgSO_4(s) + 7H_2O(l) \arrow[rr, "\Delta H_1"] \arrow[dr, "\Delta H_2"'] & & MgSO_4.7H_2O(s) \arrow[dl, "\Delta H_3"] \\
& MgSO_4(aq) &
\end{tikzcd}$$

$$\Delta H_1 + \Delta H_3 = \Delta H_2$$

$\Delta H_2 = 10 \times 100 \times 4.2 \times 9 = 37.8 \times 10^3$ J = –37.8 kJ (exothermic)
$\Delta H_3 = 10 \times 100 \times 4.2 \times 3 = 12.6 \times 10^3$ J = +12.6. kJ (endothermic)

$\Delta H_1 + 12.6 = -37.8 \quad \Delta H_1 = -50.4$ kJ [4]

(iii) Any **three** from **four**:
- insulated container/plastic cup [1]
- add solid to water [1] with stirring [1]
- measure temperature before and after with thermometer [1]

major error is heat loss [1]
increase insulation/use lid/stop draughts [1]
(Maximum [5]) [5]

Quality of written communication [2] 22

16 **(a)** **(i)** $C_3H_6 + NH_3 + 1.5O_2 \rightarrow CH_2{=}CHCN + 3H_2O$ [2]

(ii) catalyst [1]

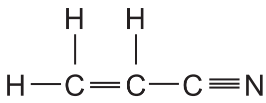
(iii) the IR spectra are unique for a compound they will differ [1]
because of the different position of the C=C absorption [1]/
fingerprint regions of each don't match
or
superimpose the spectra of each compound
they will be different [2]

(b) $CH_2{=}CHCl + NaCN \rightarrow CH_2{=}CHCN + NaCl$ [2]

(c) **(i)** C_3H_3N [1]

(ii) C_3H_3N [1]

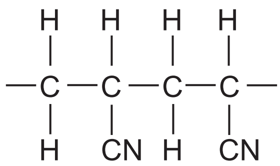
(iii)



[2]

(iv) no [1]
propenonitrile contains CH_2 group/explain by drawing structures [1] [2]

(d) **(i)**



[2]

(ii) addition polymerisation [1] 16

Section B	**80**
Total	**100**

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January 2010

Chemistry

Assessment Unit AS 2

assessing

Module 2: Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry

[AC121]

THURSDAY 21 JANUARY, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10.
Keep in sequence when answering.
Answer **all five** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **14(e)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 The reaction of hydrogen bromide with ethene is an example of

A electrophilic addition.
B electrophilic substitution.
C nucleophilic addition.
D nucleophilic substitution.

2 Which one of the chlorides described below, all of formula MCl_2, is a chloride of a Group II element?

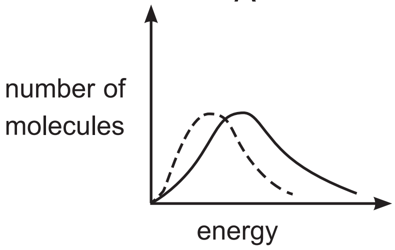
A white solid, melting point 280 °C, boiling point 304 °C, fairly soluble in water to give a colourless neutral solution with poor electrical conductivity
B white solid, melting point 815 °C, readily soluble in water to give a green-blue solution with good electrical conductivity
C white solid, melting point 875 °C, readily soluble in water to give a colourless neutral solution with good electrical conductivity
D white solid, melting point 672 °C, gives pale green solution with good electrical conductivity

3 Which one of the following is a chain propagation step in the chlorination of methane?

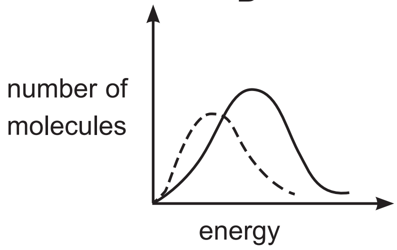
A $H\bullet + Cl_2 \rightarrow HCl + Cl\bullet$
B $Cl\bullet + CH_4 \rightarrow CH_3Cl + H\bullet$
C $CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$
D $CH_3\bullet + HCl \rightarrow CH_3Cl + H\bullet$

4 Which one of the graphs below most accurately represents the distribution of molecular energies in a gas at 500 K if the dotted curve represents the distribution for the same gas at 300 K?

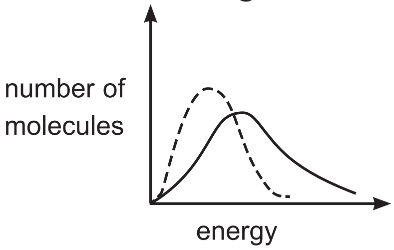
A



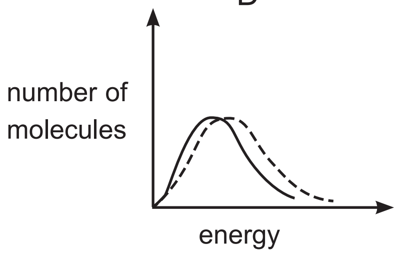
B



C



D



5 A pure hydrocarbon was isolated from bottled gas used for heating. 10 cm^3 of the hydrocarbon was completely combusted in 70 cm^3 of oxygen (an excess). The final gaseous mixture contained 30 cm^3 of carbon dioxide and 20 cm^3 of unreacted oxygen. All volumes were measured under identical conditions.
Which one of the the following is the molecular formula of the hydrocarbon?

A C_2H_4
B C_2H_6
C C_3H_6
D C_3H_8

6 Which one of the following occurs when a molecule absorbs infra-red radiation?

A Electrons in the bonds are excited.
B The bonds bend and eventually break.
C The bonds rotate.
D The bonds vibrate.

7 Which one of the following will **not** give a yellow precipitate with a solution of iodine in sodium hydroxide?

A butan-1-ol
B butan-2-ol
C ethanol
D propan-2-ol

8 The formula of the precipitate produced when solutions of magnesium chloride and sodium hydrogencarbonate are mixed and boiled is:

A $Mg(OH)_2$
B $Mg(HCO_3)_2$
C $MgCO_3$
D MgO

9 5.0 g of butan-1-ol (RMM 74) reacted with an excess of hydrogen bromide and 6.4 g of 1-bromobutane (RMM 137) were obtained after purification. The percentage yield of 1-bromobutane was:

A 42%
B 54%
C 69%
D 78%

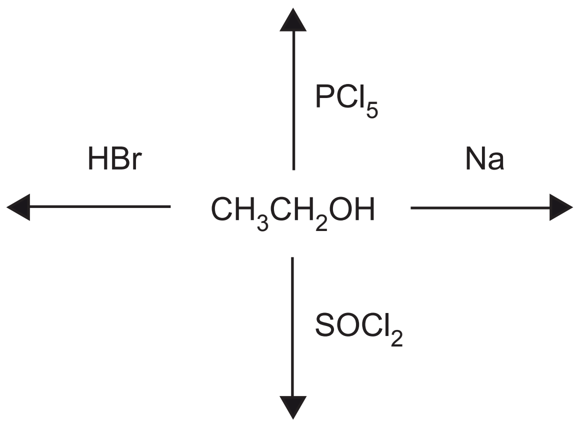
10 A solution of a salt gives a yellow/orange colour when sprayed into a blue Bunsen flame and a white precipitate when added to acidified barium chloride solution. The salt is

A potassium carbonate.
B potassium sulphate.
C sodium carbonate.
D sodium sulphate.

Section B

Answer **all five** questions in the spaces provided.

11 Complete the following flow scheme showing the organic compound formed in each reaction.



[4]

12 Poly(tetrafluoroethene) is made in a two stage reaction from chlorodifluoromethane.

(a) In the first stage chlorodifluoromethane is cracked to give tetrafluoroethene.

$$2CHClF_2(g) \rightleftharpoons CF_2{=}CF_2(g) + 2HCl(g) \qquad \Delta H = +128 \text{ kJ mol}^{-1}$$

(i) Explain what is meant by the term **thermal cracking**.

____

____ [2]

(ii) Explain, using the ΔH value, whether the reaction is exothermic or endothermic.

____ [1]

(iii) Explain, in terms of reaction rate and equilibrium, whether a high or low pressure should be used.

[3]

(iv) Explain, in terms of reaction rate and equilibrium, whether a high or low temperature should be used.

[3]

(v) Hydrogen chloride is a product of the reaction. Describe a chemical test for hydrogen chloride gas.

[2]

(b) The second stage involves the polymerisation of tetrafluoroethene.

(i) Complete the following equation which represents the polymerisation reaction.

$$n\ CF_2{=}CF_2 \ \rightarrow$$

[2]

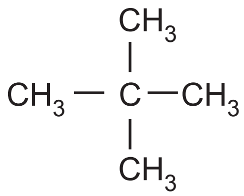
(ii) Why is tetrafluoroethene able to polymerise?

[1]

(iii) What type of polymerisation does tetrafluoroethene undergo?

[1]

13 Three pentanes are possible theoretically and all occur in natural gas and petroleum gas. Their structures, "trivial" names and boiling points are shown below.

structure	**name**	**boiling point/°C**
$CH_3CH_2CH_2CH_2CH_3$	normal pentane	36°
	isopentane	28°
	neopentane	9°

(a) Write the general formula for an alkane.

____ [1]

(b) The three pentanes are regarded as **structural isomers**. Explain this term.

____

____ [2]

(c) How would the pentanes be obtained from petroleum?

____ [2]

(d) Deduce the IUPAC names for isopentane and neopentane.

isopentane ______________________________________ [1]

neopentane ______________________________________ [1]

(e) Explain why the pentanes have different boiling points.

____

____

____ [2]

(f) All three pentanes burn in a limited and in a plentiful supply of air.

(i) Write the equation for the complete combustion of pentane.

____ [2]

(ii) Write an equation for the incomplete combustion of pentane to form carbon monoxide.

____ [2]

(g) **(i)** A pentane reacts with chlorine to form a chlorinated pentane. The percentage composition of the chlorinated pentane is shown below.

	% by mass
chlorine	60.7
carbon	34.2
hydrogen	5.1

Deduce the empirical formula of the chlorinated pentane.

____

____

____

____ [3]

(ii) Explain whether this chlorinated pentane has a higher or lower boiling point than the three pentanes.

____

____ [1]

14 The world production of calcium oxide is currently 280 million tonnes annually. It is used extensively in steel making and the construction industries.
The production of calcium oxide involves heating limestone (calcium carbonate) in a kiln at a temperature of 1200 °C.

$$CaCO_3 \rightarrow CaO + CO_2$$

The heat needed to sustain the reaction is provided by the combustion of fossil fuels.

(a) Compare the thermal stability of calcium carbonate with the other Group II metal carbonates.

____

____ [2]

(b) Explain how the thermal stability of a Group II carbonate is related to the charge and size of the cation.

____

____ [2]

(c) Explain how the manufacture of calcium oxide contributes to global warming.

____

____ [2]

(d) The calcium oxide produced is basic and reacts with water and dilute acids.

(i) Write the equation for the reaction of calcium oxide with hydrochloric acid.

____ [2]

(ii) Write the equation for the reaction of calcium oxide with water to form calcium hydroxide.

____ [1]

(e) A saturated solution of calcium hydroxide is known as limewater. Describe how you would prepare limewater and use it to test for carbon dioxide, stating the result of a positive test.

[4]

Quality of written communication [2]

(f) Write the equation for the reaction of aqueous calcium hydroxide with carbon dioxide including state symbols.

[2]

(g) 5 dm^3 of polluted air containing an excess of carbon dioxide was passed through limewater so that all the carbon dioxide present was precipitated as calcium carbonate. The mass of calcium carbonate formed was 0.05 g. Use the following headings to calculate the percentage by volume of carbon dioxide in the air sample.
All measurements were carried out at 20°C and 1 atmosphere pressure.

Mass of one mole of $CaCO_3$ in grams

Number of moles of $CaCO_3$ in 0.05 g of calcium carbonate

Number of moles of CO_2 required to produce 0.05 g of calcium carbonate

Volume of CO_2 in dm^3 required to produce 0.05 g of calcium carbonate

Percentage of carbon dioxide in the polluted air

15 Ethanol is produced in large quantities for use as a fuel. The mixture of ethanol with gasoline (petrol) is known as gasohol.

(a) (i) Explain, using an equation, how ethanol is manufactured from ethene.

____

____

____ [3]

(ii) Explain another industrial method of producing ethanol.

____

____ [2]

(b) Explain how you would carry out a chemical test to show that ethanol was present in a sample of gasohol.

____

____

____ [3]

(c) The equation for the combustion of ethanol is shown below:

$$CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

Use the following bond energies to calculate the enthalpy change for the combustion.

	$kJ\ mol^{-1}$
C—O	360
C—H	413
O—H	464
C=O	805
O=O	498
C—C	347

____

____

____ [4]

(d) The gases produced by the combustion of the gasohol can be passed through a catalytic converter.

(i) What are carbon monoxide, unburnt hydrocarbons and nitrogen oxides converted to in the converter?

carbon monoxide .... [1]

unburnt hydrocarbons .... [1]

nitrogen oxides .... [1]

(ii) Occasionally the catalyst is poisoned. Explain how this occurs and how the catalyst is affected.

....

....

.... [3]

(iii) Explain the role of the catalyst using a simple labelled enthalpy level diagram. Assume the reactions catalysed are exothermic.

....

.... [4]

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January 2010

Chemistry

Assessment Unit AS 2

assessing

Module 2: Further Organic, Physical and Inorganic Chemistry and Introduction to Organic Chemistry

[AC121]

THURSDAY 21 JANUARY, AFTERNOON

MARK SCHEME

Section A

1	A
2	C
3	C
4	C
5	D
6	D
7	A
8	C
9	C
10	D

[2] marks for each correct answer	[20]	20
	Section A	**20**

Section B

11 **(a)** CH_3CH_2Cl

CH_3CH_2ONa

CH_3CH_2Cl

CH_3CH_2Br [4] 4

12 **(a)** **(i)** molecule broken down (into a smaller molecule) [1]
using heat (and a catalyst) [1]

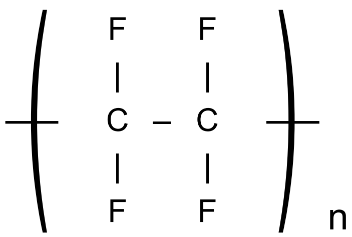
(ii) endothermic as ΔH is +ve [1]

(iii) low pressure [1]
more molecules on RHS [1]
but reaction rate is (slightly) slower [1]

(iv) high temperature
reaction is endothermic/ absorbs heat → RHS
and rate is increased [3]

(v) conc ammonia (solution) [1]
white smoke/fumes [1]

(b) **(i)**



[2]

(ii) contains a double bond/ C = C/ unsaturated [1]

(iii) addition [1] 15

13 **(a)** C_nH_{2n+2} [1]

(b) same molecular formula [1]
different arrangement of atoms etc [1]

(c) fractional distillation [2]

(d) 2 – methylbutane or methylbutane [1]
2, 2 – dimethylpropane or dimethylpropane [1]

(e) van der Waals forces greatest between chains
more branched lower b.pt [2]

(f) **(i)** $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ [2]

(ii) $2C_5H_{12} + 11O_2 \rightarrow 10CO + 12H_2O$ [2]

(g) **(i)**

$$\left.\begin{array}{llll} Cl & \frac{60.7}{35.5} & = 1.71 & 1 \\ C & \frac{34.2}{12} & = 2.85 & 1.66 \quad 1\frac{2}{3} = \frac{5}{3} \\ H & \frac{5.1}{1} & = 5.1 & 3 \end{array}\right\} [1]$$

$1 : \frac{5}{3} : 3$

$\therefore\ 3 : 5 : 9$

$C_5H_9Cl_3$ or $Cl_3C_5H_9$ [3]

(ii) has a higher b.pt. because chloropentane has a greater
mass than pentane/ polar /more van der Waals [1] 17

14 **(a)** more stable than ($BeCO_3$), $MgCO_3$ [1]

less stable than $SrCO_3$/ $BaCO_3$ [1]

(b) the size of cation increases down Gp = Group passim [1]
charge density decreases down Gp
polarisation power decreases down Gp [2]
max of 2

(c) produces CO_2 $CaCO_3 \rightarrow CaO + CO_2$ [1]
and CO_2 from combustion of fossil fuels [1]

(d) **(i)** $CaO + 2HCl \rightarrow CaCl_2 + H_2O$ [2]

(ii) $CaO + H_2O \rightarrow Ca(OH)_2$ [1]

(e) add $Ca(OH)_2$ to water
stir / until no more dissolves
filter
blow CO_2 through limewater/collect CO_2 in pipette/
add to container of CO_2 seal and shake
goes milky/chalky/cloudy [4]
max of 4
QWC [2]

(f) $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$ [2]

(g) 100g of $CaCO_3$

$\frac{0.05}{100} = 5 \times 10^{-4}$ mol of $CaCO_3$

5×10^{-4} mol CO_2

$5 \times 10^{-4} \times 24\ dm^3 = 0.012\ dm^3$

$\% \ CO_2 = \frac{0.012}{5} \times 100 = 0.24\%$ [5] 22

15 **(a)** **(i)** $C_2H_4 + H_2O \rightarrow C_2H_5OH$ [1]

steam/ high temp [1]

H_3PO_4 [1]

(ii) fermentation [1]
sugars [1]

(b)

acidified dichromate		Iodine	[1]
warm	**or**	alkali	[1]
(orange) → green		yellow solid	[1]

(c)

bonds broken	5C—H	= 5 × 413	= 2065
	1C—C	= 1 × 347	= 347
	1C—O	= 1 × 360	= 360
	1O—H	= 1 × 464	= 464
	3O=O	= 3 × 498	= 1494
bonds formed	4C=O	= 4 × 805	= 3220
	6O—H	= 6 × 464	= 2784

bonds broken = +4730
bonds formed = –6004

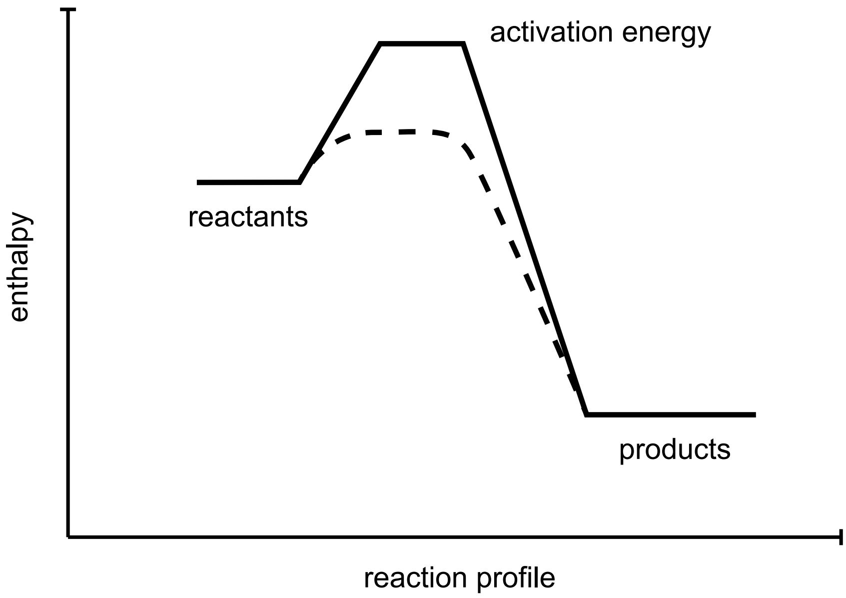
$\Delta H = -\ 1274\ \text{kJ mol}^{-1}$ [4]

(d) **(i)** $CO \rightarrow CO_2$ [1]

$CxHy \rightarrow CO_2 + H_2O$ [1]

$NO_x \rightarrow N_2\ (+CO_2)$ [1]

(ii) lead [1]
covers the surface [1]
molecules prevented from chemisorption/ catalyst effect reduced [1]



activation energy lowered by the catalyst [4] 22

Section B	**80**
Total	**100**

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2010

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC121]

THURSDAY 17 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all seventeen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all seven** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

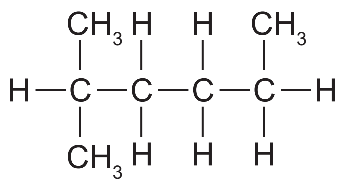
The total mark for this paper is 100.
Quality of written communication will be assessed in question **16(b)(i)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 The correct name for the compound with the following structure



is

A 1,1,4-trimethylbutane.
B 1,4-dimethylpentane.
C 1,4,4-trimethylbutane.
D 2-methylhexane.

2 A mixture of two salts (X and Y) produced the following results.

Test	**Observation**
Flame test	Yellow/orange colour
Addition of $HNO_3(aq)$	No effervescence
Addition of $AgNO_3(aq)$	Yellow precipitate
Addition of $BaCl_2(aq)$	White precipitate

X and Y could be

A potassium iodide and potassium carbonate
B sodium chloride and sodium carbonate
C sodium chloride and sodium sulphate
D sodium iodide and sodium sulphate

3 When heated with acidified potassium dichromate solution, which one of the following alcohols does **not** cause the solution to change from orange to green?

A butan-1-ol
B butan-2-ol
C 2-methylpropan-1-ol
D 2-methylpropan-2-ol

4 0.05 moles of a liquid fuel was used to increase the temperature of 200 g of water by 10 K. The heat capacity of water is 4.2 J $g^{-1} K^{-1}$.
What is the molar enthalpy of combustion of the fuel?

A -8.4 kJ mol^{-1}
B -168 kJ mol^{-1}
C -420 kJ mol^{-1}
D -8400 kJ mol^{-1}

5 The reaction between bromoethane and ethanolic potassium hydroxide is described as

A electrophilic addition
B elimination
C free radical substitution
D nucleophilic substitution

6 Which one of the following lists both sets of compounds in order of increasing solubility (least soluble first, most soluble last)?

	Sulphates	**Hydroxides**
A	$MgSO_4$, $CaSO_4$, $SrSO_4$, $BaSO_4$	$Ba(OH)_2$, $Sr(OH)_2$, $Ca(OH)_2$, $Mg(OH)_2$
B	$MgSO_4$, $CaSO_4$, $SrSO_4$, $BaSO_4$	$Mg(OH)_2$, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$
C	$BaSO_4$, $SrSO_4$, $CaSO_4$, $MgSO_4$	$Mg(OH)_2$, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$
D	$BaSO_4$, $SrSO_4$, $CaSO_4$, $MgSO_4$	$Ba(OH)_2$, $Sr(OH)_2$, $Ca(OH)_2$, $Mg(OH)_2$

7 Which one of the following alcohols gives a positive iodoform test?

A butan-1-ol
B butan-2-ol
C 2-methylpropan-1-ol
D 2-methylpropan-2-ol

8 Which one of the following hydrocarbons has the empirical formula C_3H_5?

A $CH_3CH{=}CH_2$
B $CH_3(CH_2)_3CH{=}CH_2$
C $(CH_3)_3CCH_2CH_2CH_3$
D $CH_2{=}CHCH_2CH_2CH{=}CH_2$

9 Which one of the following substances is **not** formed when methane reacts with chlorine in the presence of ultraviolet light?

A dichloromethane
B ethane
C hydrogen
D hydrogen chloride

10 An aqueous solution produced a precipitate on addition of a few drops of aqueous sodium hydroxide. The precipitate dissolved on addition of excess sodium hydroxide but not on addition of excess ammonia. The solution contains

A Al^{3+}(aq).
B Fe^{3+}(aq).
C Mg^{2+}(aq).
D Zn^{2+}(aq).

Section B

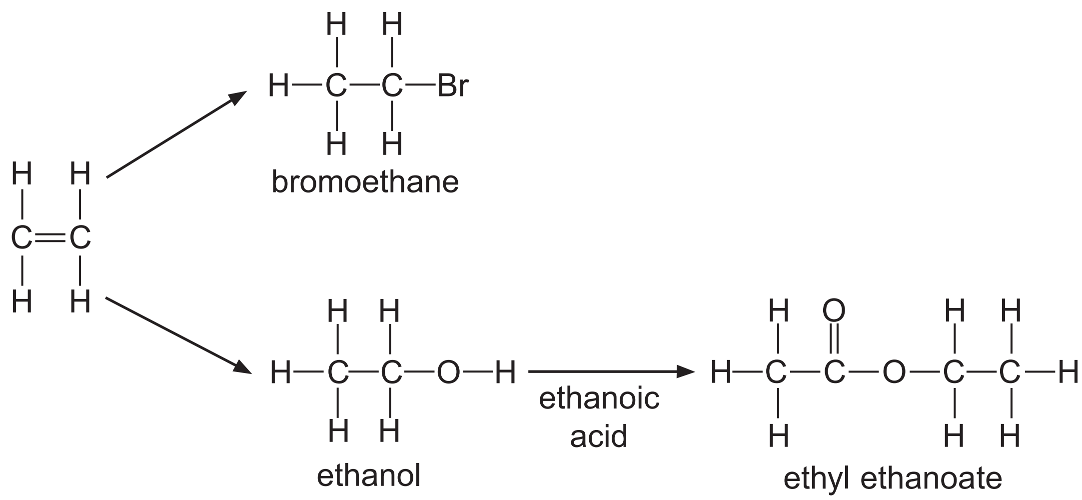
Answer **all seven** questions in the spaces provided.

11 Analysis of a compound, which contains carbon, hydrogen and bromine only, showed that 22.2% of its mass is carbon and 3.7% is hydrogen. The relative molecular mass of the compound is 216.

Calculate the molecular formula of the compound.

[3]

12 Consider the following sequence of reactions:



(a) (i) Name the mechanism for the conversion of ethene to bromoethane.

____ [2]

(ii) Draw a flow scheme to represent the mechanism for the conversion of ethene to bromoethane.

[3]

(b) (i) Name the type of reaction which occurs when ethanoic acid and ethanol react to form ethyl ethanoate.

____ [1]

(ii) Name another reagent which reacts with ethanol to form ethyl ethanoate.

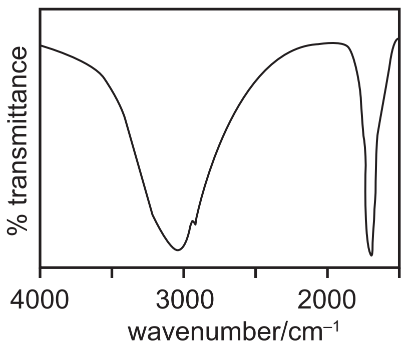
____ [1]

(iii) Part of three infra-red spectra A, B and C are given below. The spectra are those of ethanol, ethanoic acid and ethyl ethanoate but not necessarily in that order.

- O—H bonds produce deep, broad absorptions between 2500–3500 cm^{-1}.
- C=O bonds produce deep, sharp absorptions between 1650–1750 cm^{-1}.

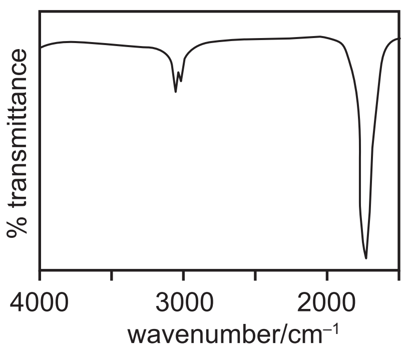
Identify each compound from its spectrum.

A



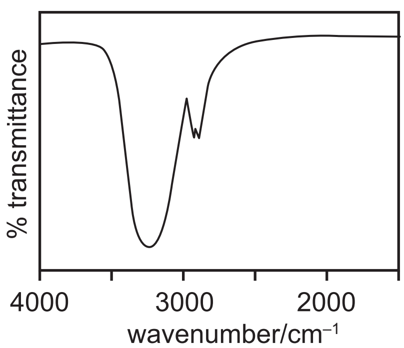
____

B



____

C



____

[2]

13 Fractional distillation of crude oil is used to produce hydrocarbon fuels. The diesel fraction contains heptadecane molecules which have the formula $C_{17}H_{36}$. Incomplete combustion of diesel produces carbon monoxide.

(a) (i) Write an equation for the incomplete combustion of heptadecane to form carbon monoxide.

____ [2]

(ii) What is fitted to the exhaust system of a car to change carbon monoxide into carbon dioxide?

____ [1]

(b) Thermal cracking of long chain hydrocarbons produces shorter chain hydrocarbons.

Write an equation for the thermal cracking of heptadecane in which ethene and propene are produced in a 2:1 ratio with only one other product.

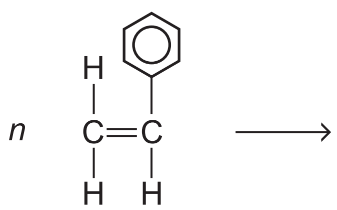
____ [2]

(c) Ethene and propene can be converted into polythene and polypropene respectively.

(i) Name the type of reaction involved in the conversion of propene to polypropene.

____ [2]

(ii) Suggest the equation for the conversion of styrene to polystyrene:



styrene

[1]

(d) Ethene and propene do not exhibit geometric isomerism.

(i) Draw the structure and give the name of a **branched** alkene, with molecular formula C_6H_{12}, which exhibits geometric isomerism.

____ [2]

(ii) Draw the structures of the geometric isomers for the molecule identified in **d(i)**.

[2]

14 Many enthalpy changes, including enthalpies of combustion, can be determined by experiment. Others can be deduced using Hess's Law.

(a) (i) State Hess's Law.

____

____ [2]

(ii) Define the term **standard enthalpy of combustion**.

____

____

____ [2]

(iii) Use the standard enthalpies of formation given in the table below to calculate the enthalpy change for the complete combustion of methane:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Compound	$\Delta H_f^\ominus$**/kJ mol^{-1}**
CO_2	–394
H_2O	–286
CH_4	–75

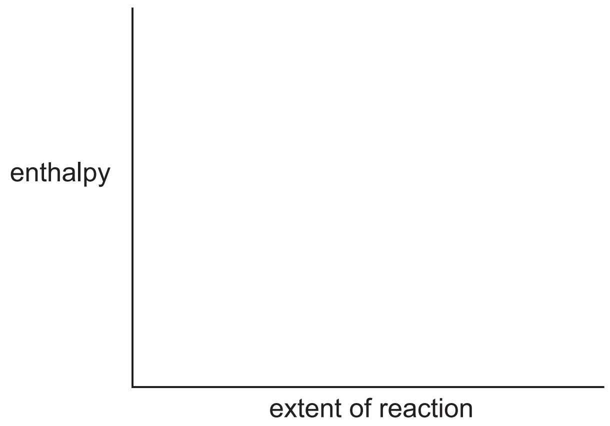
____

____

____ [2]

(b) Enthalpy changes can also be calculated using average bond enthalpies. When bond enthalpies were used to estimate the enthalpy of reaction for the complete combustion of methane, it was found to have a value of $-698\ \text{kJ mol}^{-1}$.

(i) Complete the enthalpy level diagram for this reaction.



[1]

(ii) What is meant by the term **average bond enthalpy**?

[2]

(iii) Using the estimated enthalpy of reaction and the bond enthalpies given in the table below, calculate the bond enthalpy of the C—H bond in methane.

bond	bond enthalpy/kJ mol^{-1}
C═O	743
O═O	496
O—H	463

[3]

15 The second stage in the production of nitric acid involves the reaction of nitrogen monoxide with oxygen to form nitrogen dioxide. When nitrogen monoxide and oxygen are mixed under suitable conditions a dynamic equilibrium is established.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = -116\ kJ\ mol^{-1}$$

(a) Explain what is meant by the term **dynamic equilibrium**.

____

____ [2]

(b) State and explain how increasing the pressure will affect the equilibrium yield of nitrogen dioxide.

____

____

____

____ [2]

(c) State and explain how increasing the temperature will affect the equilibrium yield of nitrogen dioxide.

____

____

____

____ [2]

(d) State and explain the effect a catalyst has on the equilibrium yield of nitrogen dioxide.

____

____

____ [2]

(e) The first stage in the production of nitric acid involves ammonia.

(i) State the temperature and pressure used in the production of ammonia by the Haber process.

____

____ [2]

(ii) Why is the temperature used in the Haber process described as a compromise temperature?

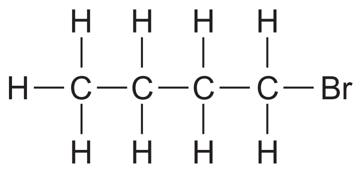
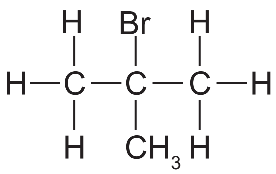
____

____ [1]

16 There are four bromoalkanes with the formula C_4H_9Br.

(a) Complete the following table by drawing the missing structures, giving the missing name and indicating the classification for each.

(P = Primary, S = Secondary and T = Tertiary)

Structure and Name	Classification
 1-bromobutane	P
 2-bromo-2-methylpropane	
1-bromo-2-methylpropane	
______________________	

[6]

(b) (i) 1-bromobutane can be prepared by refluxing a mixture containing butan-1-ol, water, sodium bromide and concentrated sulphuric acid for 45 minutes. Describe the remaining steps required to produce a pure, dry sample of this haloalkane.

____

____

____

____

____

____

____

____ [4]

Quality of written communication [2]

(ii) 11.1 g of butan-1-ol was used to prepare 1-bromobutane and 12.3 g was obtained.

$$C_4H_9OH + HBr \rightarrow C_4H_9Br + H_2O$$

Calculate the percentage yield.

____

____

____ [3]

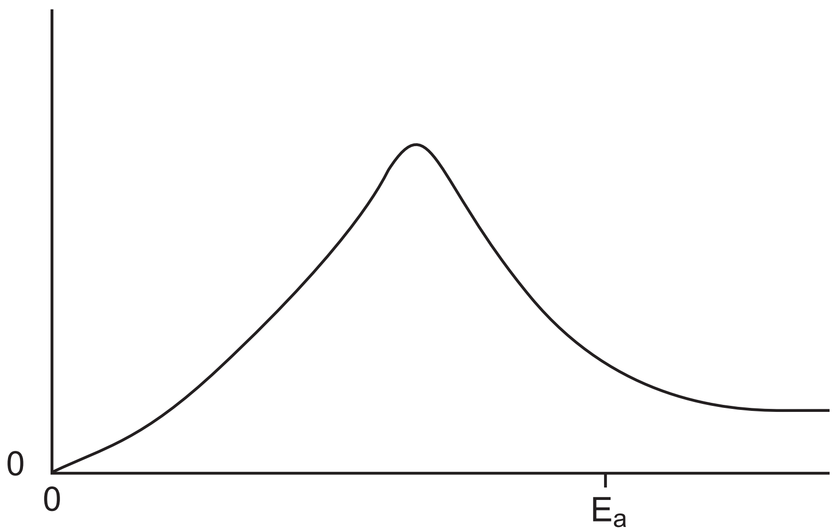
(c) When heated with aqueous sodium hydroxide 1-bromobutane was converted into butan-1-ol.

How could the resulting solution be tested to prove that it contains bromide ions?

____

____ [2]

17 The Maxwell-Boltzmann distribution for a mixture of SO_2 and O_2 which react to form SO_3 at 450 K is shown below.



(a) **(i)** Label the axes on the above diagram. [2]

(ii) Suggest why the curve starts at the origin.

____

____ [1]

(iii) Draw a second curve, on the same axes, for the same mixture of gases at 440 K. [2]

(iv) By making reference to the two curves, state and explain the effect of reducing the temperature on the rate of reaction.

____

____

____

____ [2]

(b) Catalysts are used in many industrial processes. Name the catalyst used in each of the following processes.

(i) the Contact process

____ [1]

(ii) the conversion of sunflower oil to margarine

____ [1]

(iii) the Haber process

____ [1]

(iv) the reaction of steam with ethene

____ [1]

(c) Manganese(IV) oxide catalyses the decomposition of hydrogen peroxide solutions:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

(i) Explain, in terms of activation energy and reaction pathway, how a catalyst works.

____

____

____ [2]

(ii) Calculate the volume of oxygen gas (measured at 20 °C and 1 atmosphere of pressure) which would be produced when a 50.0 cm^3 sample of 2 mol dm^{-3} hydrogen peroxide solution undergoes complete decomposition.

____

____

____

____ [3]

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Chemistry

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Module 2: Organic, Physical and Inorganic Chemistry

[AC121]

THURSDAY 17 JUNE, AFTERNOON

MARK SCHEME

Section A

1 D

2 D

3 D

4 B

5 B

6 C

7 B

8 D

9 C

10 A

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

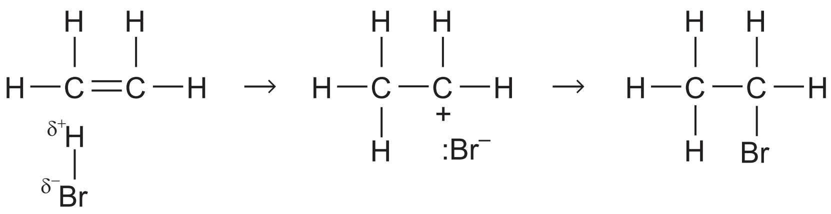
11

Element	Moles	Ratio
C	22.2 ÷ 12 = 1.85	2
H	3.7 ÷ 1 = 3.70	4
Br	74.1 ÷ 80 = 0.93	1

	Moles	[1]	
	Empirical Formula = C_2H_4Br	[1]	
216 ÷ 108 = 2	Molecular Formula = $C_4H_8Br_2$	[1]	3

12 **(a)** **(i)** Electrophilic [1] addition [1] [2]

(ii)



Dipole/H in HBr approaches the C═C [1]
Structure of carbocation intermediate [1]
bromide ion(Br^-) [1]

(b) **(i)** esterification [1]

(ii) ethanoyl chloride [1]

(iii) A = Ethanoic acid [1]
B = Ethyl ethanoate [1] 9
C = Ethanol

13 **(a)** **(i)** Either: $C_{17}H_{36} + 17\frac{1}{2}O_2 \rightarrow 17CO + 18H_2O$

Or: $2C_{17}H_{36} + 35O_2 \rightarrow 34CO + 36H_2O$ [2]

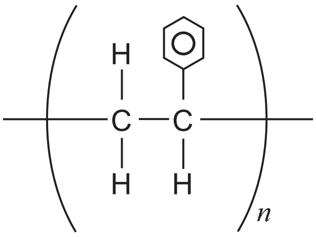
(ii) catalytic converter [1]

(b) Either: $C_{17}H_{36} \rightarrow 2C_2H_4 + C_3H_6 + C_{10}H_{22}$

Or: $C_{17}H_{36} \rightarrow 4C_2H_4 + 2C_3H_6 + C_3H_8$ [2]

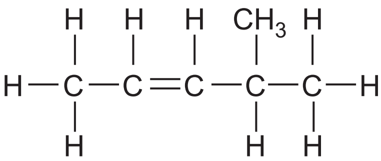
(c) **(i)** addition [1] polymerisation [1] [2]

(ii)



[1]

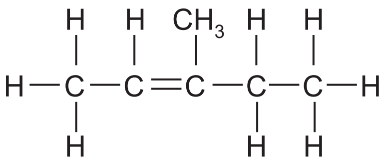
(d) **(i)** Either:



[1]

4-methylpent-2-ene [1]

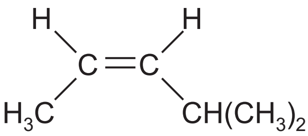
Or:

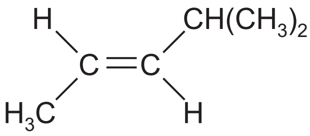


[1]

3-methylpent-2-ene [1] [2]

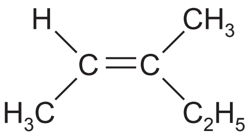
(ii) Either:

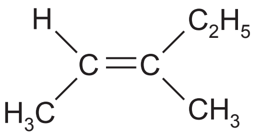




Distinction between *cis* and *trans* not necessary

Or:





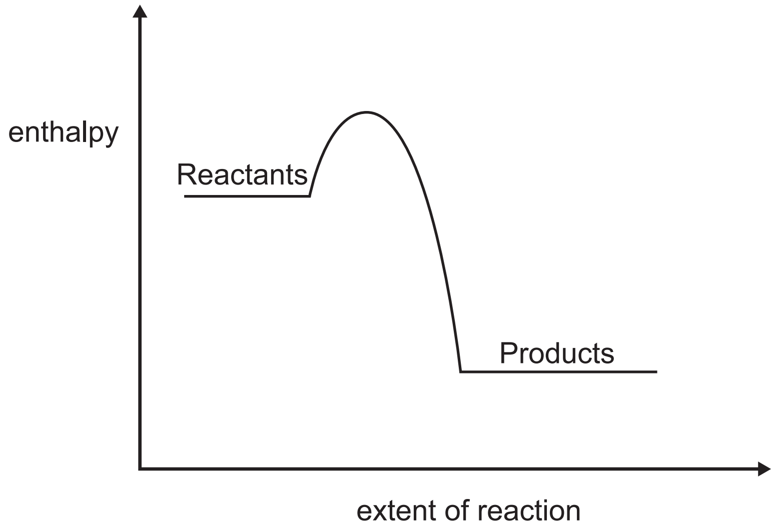
Distinction between *E* and *Z* not necessary [2] 12

14 **(a)** **(i)** Enthalpy change(s) [1]
is/are independent of the route taken [1]

(ii) Enthalpy change which occurs when 1 mole of a substance undergoes complete combustion in oxygen under standard conditions. [2]

(iii) $(-394) + (-286 \times 2) + (+75)$ [1]
$-891\ \text{kJ mol}^{-1}$ [1]

(b) **(i)**



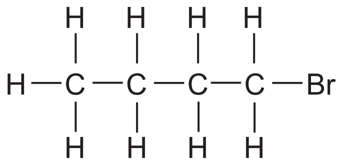
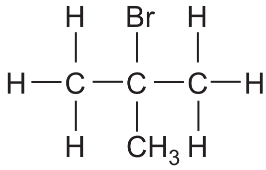
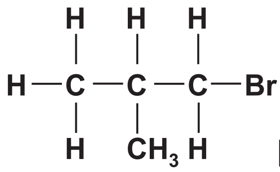
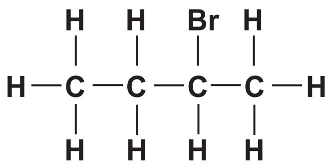
[1]

(ii) Energy required to break one mole of a given bond averaged over many compounds. Error [–1] [2]

(iii) $-698 = 4(\text{C—H}) - 2346$
$4(\text{C—H}) = 1648$
$412\ \text{kJ mol}^{-1}$ [3] 12

15	**(a)**	Rate of forward reaction = Rate of reverse reaction The amount of any given reactant or product remains constant	[1] [1]	
	(b)	Increase 3 moles (g) LHS 2 moles (g) RHS Equilibrium shifts to RHS to oppose the change	[1] [1]	
	(c)	Decrease (Forward) reaction is exothermic Equilibrium shifts to LHS to oppose the change/cool the system	[1] [1]	
	(d)	No effect on yield Increases the rate of the forward and reverse reactions equally	[1] [1]	
	(e)	**(i)** 400–500 °C [1] 200–300 atm [1]	[2]	
		(ii) Compromise between rate and yield [1]	[1]	11

16 (a)

Structure and Name	**Classification**
 1-bromobutane	P
 2-bromo-2-methylpropane	**T** [1]
 [1] 1-bromo-2-methylpropane	**P** [1]
 [1] **2-bromobutane** [1]	**S** [1]

[6]

(b) (i) Distil and collect the 1-bromobutane at its boiling point [1]
Shake crude product with a solution of sodium carbonate in a separating funnel [1]
Release pressure [1]
Separate the organic layer [1]
Shake with a drying agent, e.g. anhydrous calcium chloride [1]
Filter [1]
(max = [4])

Quality of written communication

2 marks The candidate expresses ideas clearly and fluently through well-linked sentences and paragraphs. Arguments are generally relevant and well-structured. There are few errors of grammar, punctuation and spelling.

1 mark The candidate expresses ideas clearly, if not always fluently Arguments may sometimes stray from the point. There may be some errors of grammar, punctuation and spelling, but not such as to suggest a weakness in these areas.

0 marks The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage.

Quality of written communication [2]

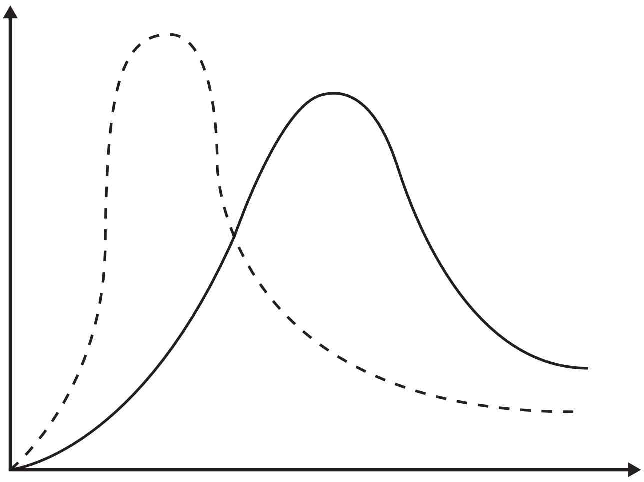
(ii) $11.10 \div 74 = 0.15$ moles of butan-1-ol [1]
$12.33 \div 137 = 0.09$ moles of 1-bromobutane [1]
$(0.09 \div 0.15) \times 100 = 60\%$ [1]

(c) Add an aqueous solution of silver nitrate [1]
A cream precipitate forms [1] 17

17 **(a)** **(i)** *y* axis = number of molecules [1]
x axis = (kinetic) energy [1]

(ii) Either: all molecules have some energy/are moving
Or: no molecules have zero (kinetic) energy [1]

(iii)



maximum to LHS of original and higher [1]
lower number of molecules at higher energies [1]

(iv) Number of molecules with energy greater than the activation energy decreases as temperature drops [2]

(b) **(i)** vanadium(V) oxide [1]

(ii) nickel [1]

(iii) iron [1]

(iv) phosphoric acid [1]

(c) **(i)** provides an alternative pathway [1]
with lower activation energy [1]

(ii) moles of hydrogen peroxide = $2 \times 0.05 = 0.1$ mole [1]
2:1 ratio so moles of oxygen = 0.05 [1]
Volume (dm^3) = $0.05 \times 24 = 1.2$ dm^3 (1200 cm^3) [1] 16

Section B	**80**
Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2011

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC121]

THURSDAY 20 JANUARY, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all seventeen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all seven** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **17(b)**.

In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following colours do barium ions give in a flame test?

A Blue–green
B Green
C Red
D Yellow

2 Which one of the following represents a propagation step in the chlorination of methane?

A $CH_4 + Cl_2 \rightarrow CH_3Cl^{\bullet} + HCl$
B $CH_4 + Cl^{\bullet} \rightarrow CH_3^{\bullet} + HCl$
C $CH_3^{\bullet} + Cl^{\bullet} \rightarrow CH_3Cl$
D $CH_4 + Cl^{\bullet} \rightarrow CH_3Cl + H^{\bullet}$

3 CFC–114, used as a refrigerant, contains 14.0% carbon, 44.4% fluorine and the remainder is chlorine. Which one of the following is the empirical formula of CFC–114?

A $CFCl$
B CF_2Cl
C $C_2F_4Cl_5$
D $C_3F_6Cl_4$

4 A solution of a sulphate gave a white precipitate when both sodium hydroxide and ammonia solutions were separately added to it. The white precipitate was soluble in excess of both sodium hydroxide and ammonia solutions.
Which one of the following is the sulphate?

A $Al_2(SO_4)_3$
B $MgSO_4$
C Na_2SO_4
D $ZnSO_4$

5 Which one of the following molecules can exist as *cis* and *trans* (E–Z) isomers?

A $CH_2{=}CHCH(CH_3)CH_3$
B $CH_2{=}CHCH_2CH_2CH_3$
C $CH_3CH{=}CHCH_2CH_3$
D $CH_3C(CH_3){=}CHCH_3$

6 Copper can be extracted by heating copper(II) oxide with carbon.

$$2CuO(s) + C(s) \rightarrow 2Cu(s) + CO_2(g)$$

Which one of the following is the atom economy of the reaction?

A 40.0%
B 69.5%
C 74.4%
D 80.0%

7 Which one of the following represents the standard enthalpy change for the formation of ethanol?

A $2C(g) + 6H(g) + O(g) \rightarrow C_2H_5OH(g)$
B $2C(s) + 3H_2(g) + O(g) \rightarrow C_2H_5OH(l)$
C $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(g)$
D $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

8 The following table shows the enthalpy change of neutralisation for some acid-base reactions:

Acid	**Base**	**Enthalpy change of neutralisation/kJ mol^{-1}**
HCl	NaOH	–57.2
X	NaOH	–55.2
HCl	**Y**	–52.2
HNO_3	KOH	**Z**

The identities of X, Y and Z are:

	X	**Y**	**Z**
A	ethanoic acid	ammonia solution	–57.2
B	sulphuric acid	ammonia solution	–55.2
C	ethanoic acid	sodium hydroxide	–52.2
D	sulphuric acid	sodium hydroxide	–57.2

9 Which one of the following alcohols will give a positive result in the iodoform test?

A $CH_3CH_2CH_2CH_2CH_2OH$
B $CH_3CH_2CH_2CH(OH)CH_3$
C $CH_3CH_2CH(OH)CH_2CH_3$
D $CH_3C(CH_3)_2CH_2OH$

10 The standard enthalpies of combustion for carbon, hydrogen and ethyne, C_2H_2, are given below.

	Standard enthalpy of combustion (kJ mol^{-1})
$C(s) + O_2(g) \rightarrow CO_2(g)$	–394
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	–286
$C_2H_2(g) + 2\frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(l)$	–1300

Which one of the following is the standard enthalpy of formation of ethyne?

A –226 kJ mol^{-1}
B +226 kJ mol^{-1}
C –620 kJ mol^{-1}
D +620 kJ mol^{-1}

Section B

Answer **all seven** questions in this section.

11 **(a)** Airbags used in cars contain sodium azide, NaN_3. During a crash the airbag rapidly fills with nitrogen gas from the following reaction:

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

ΔH for the reaction is positive.

(i) What name is given to reactions in which ΔH is positive?

____ [1]

(ii) Label the axes below and draw an enthalpy level diagram for the reaction.

[3]

(iii) When fully inflated the airbag contains 50 dm^3 of nitrogen at 20 °C and one atmosphere pressure. What mass of sodium azide is needed to produce this volume of nitrogen?

____

____

____ [3]

(b) Catalytic converters help to reduce environmental damage due to vehicle exhaust emissions.

(i) Give an equation to show how unburnt heptane, C_7H_{16}, is removed from the exhaust emissions.

____ [2]

(ii) In the catalytic converter, carbon monoxide can react with nitrogen(II) oxide to form nitrogen. Write an equation for this reaction.

____ [2]

12 Magnesium, calcium and barium are found in Group II of the Periodic Table.

(a) Explain why the Group II elements are regarded as s-block elements.

____

____ [1]

(b) **(i)** Write an equation, including state symbols, for the first ionisation energy of magnesium.

____ [2]

(ii) State and explain the change in the value of the first ionisation energy from magnesium to barium.

____

____

____

____

____ [3]

(c) Calcium hydroxide can be decomposed by heating.

(i) Write an equation for the decomposition of calcium hydroxide.

____ [1]

(ii) Compare and explain the thermal stability of magnesium hydroxide with barium hydroxide.

____

____

____

____ [3]

(iii) Explain the difference in pH value when 0.1 mole of magnesium hydroxide and 0.1 mole of barium hydroxide are stirred with separate 100 cm^3 portions of water.

____

____

____ [2]

13 Crude petroleum is the source of hydrocarbons such as alkanes.

(a) How are alkanes obtained from crude petroleum?

____ [1]

(b) Octane, C_8H_{18}, is an alkane which is a constituent of petrol.

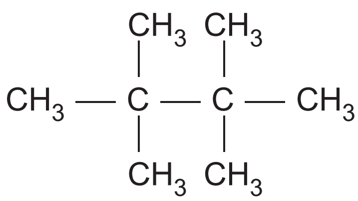
(i) Octane is a saturated hydrocarbon.
What is meant by the terms **saturated** and **hydrocarbon**?

____

____

____ [2]

(ii) Give the systematic name for the isomer of octane shown below.



____ [1]

(c) Alkenes, such as propene, can be obtained from alkanes such as octane.

(i) What name is given to the process of forming alkenes from alkanes?

____ [1]

(ii) State **one** condition which is necessary for this process.

____ [1]

(iii) Write an equation for the formation of propene from octane.

____ [1]

(iv) Describe a chemical test for an unsaturated hydrocarbon such as propene.

[2]

(v) Write an equation for the reaction involved in the test described in part **(iv)**.

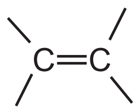
[1]

(d) Explain why alkenes are more reactive than alkanes.

[1]

(e) Alkenes such as propene react with hydrogen bromide.

(i) Use a flow diagram to suggest the mechanism for the reaction between an alkene and hydrogen bromide.

You may represent the alkene as: 

[3]

(ii) What name is given to the type of reaction between propene and hydrogen bromide?

[2]

14 Some “ice packs” used to treat sports injuries contain ammonium nitrate and water. A capsule containing the water is broken, the ammonium nitrate dissolves and the temperature falls.

(a) The following results were obtained when ammonium nitrate was added to some water.

Mass of water = 100 g
Mass of ammonium nitrate = 5.0 g
Initial temperature = 25.0 °C
Final temperature = 24.1 °C

Specific heat capacity of water = 4.2 J g^{-1} $°C^{-1}$

(i) Calculate the enthalpy change taking place.

____

____ [2]

(ii) How many moles of ammonium nitrate were used?

____

____ [1]

(iii) Calculate the molar enthalpy change for dissolving the ammonium nitrate in 100 g of water.

____

____ [1]

(b) One manufacturer makes an “ice pack” containing 120 g of water. What mass of ammonium nitrate will be needed to produce a temperature fall of 25.0 °C?

____

____

____ [2]

15 The Birkeland-Eyde process for the manufacture of nitric acid was developed in 1903. In the first step of the process nitrogen and oxygen react as follows:

$$N_2(g) \quad + \quad O_2(g) \quad \rightleftharpoons \quad 2NO(g) \qquad \Delta H = +180 \text{ kJ mol}^{-1}$$

Explain the effect, if any, of each of the following changes on the **yield** of nitrogen(II) oxide and on **the rate of the reaction**.

(a) Increasing the temperature.

____

____

____

____ [3]

(b) Adding more nitrogen.

____

____

____

____ [3]

(c) Increasing the pressure.

____

____

____

____ [3]

(d) Adding a catalyst.

____

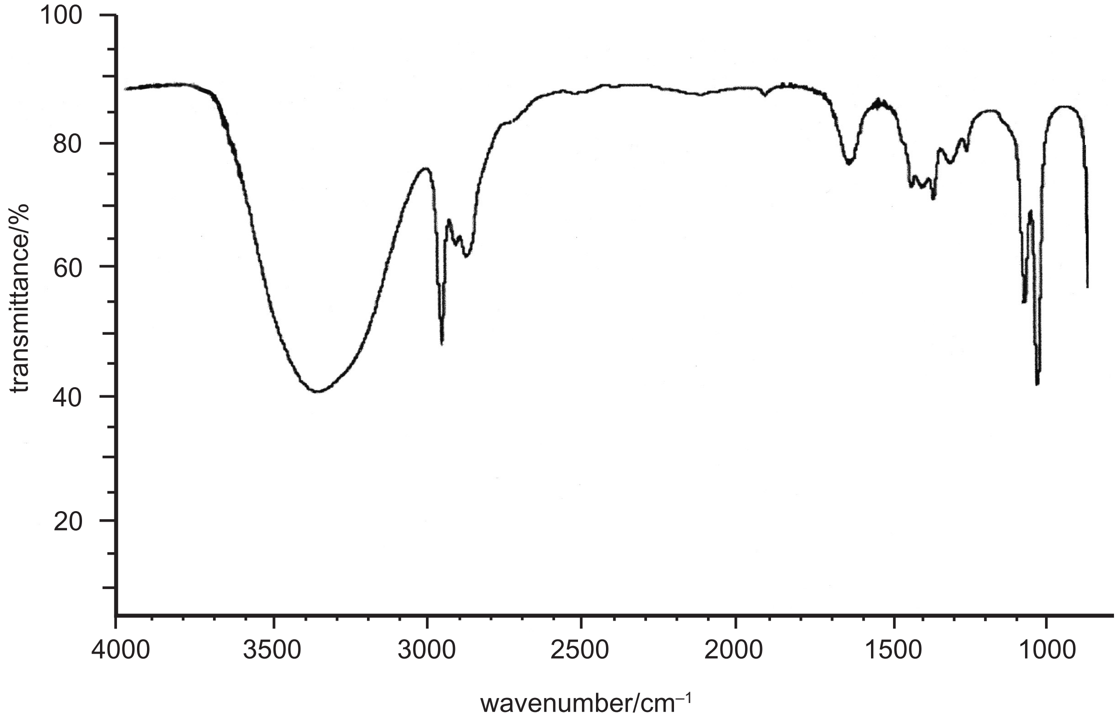
____

____ [2]

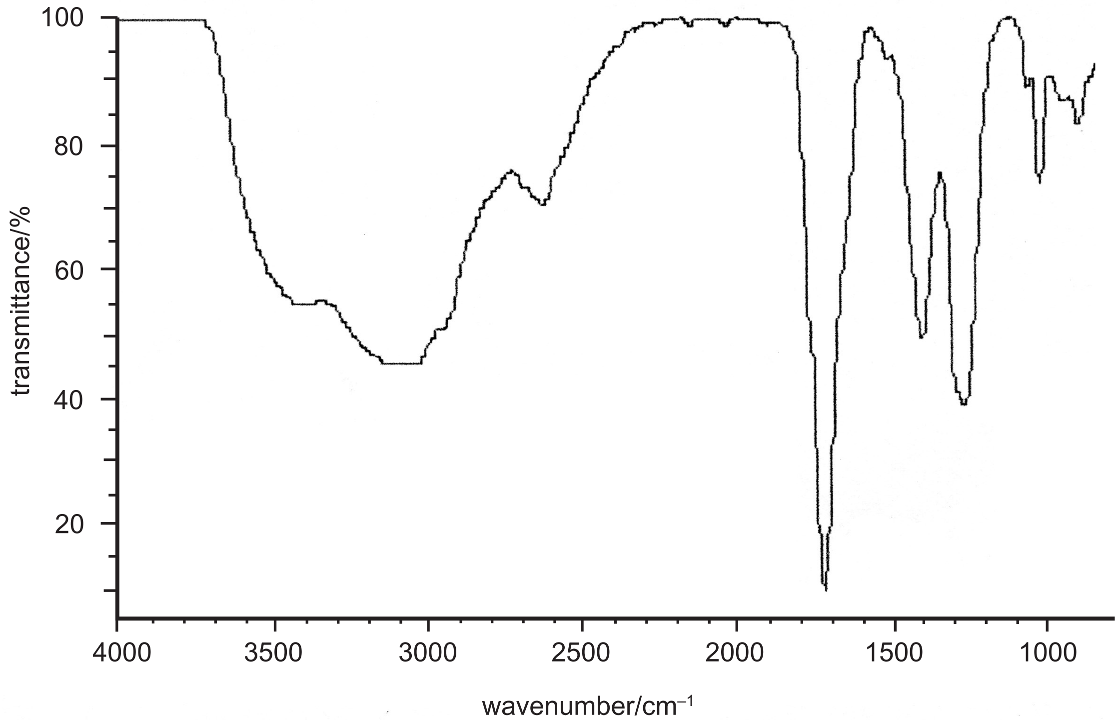
16 Some wine is thought to be contaminated by ethanal and ethanoic acid.

(a) A sample of the wine was subjected to infra-red spectroscopy and the results compared to the spectra for ethanol, ethanal and ethanoic acid. The infra-red spectra for ethanol, ethanal and ethanoic acid are shown below (not necessarily in that order).

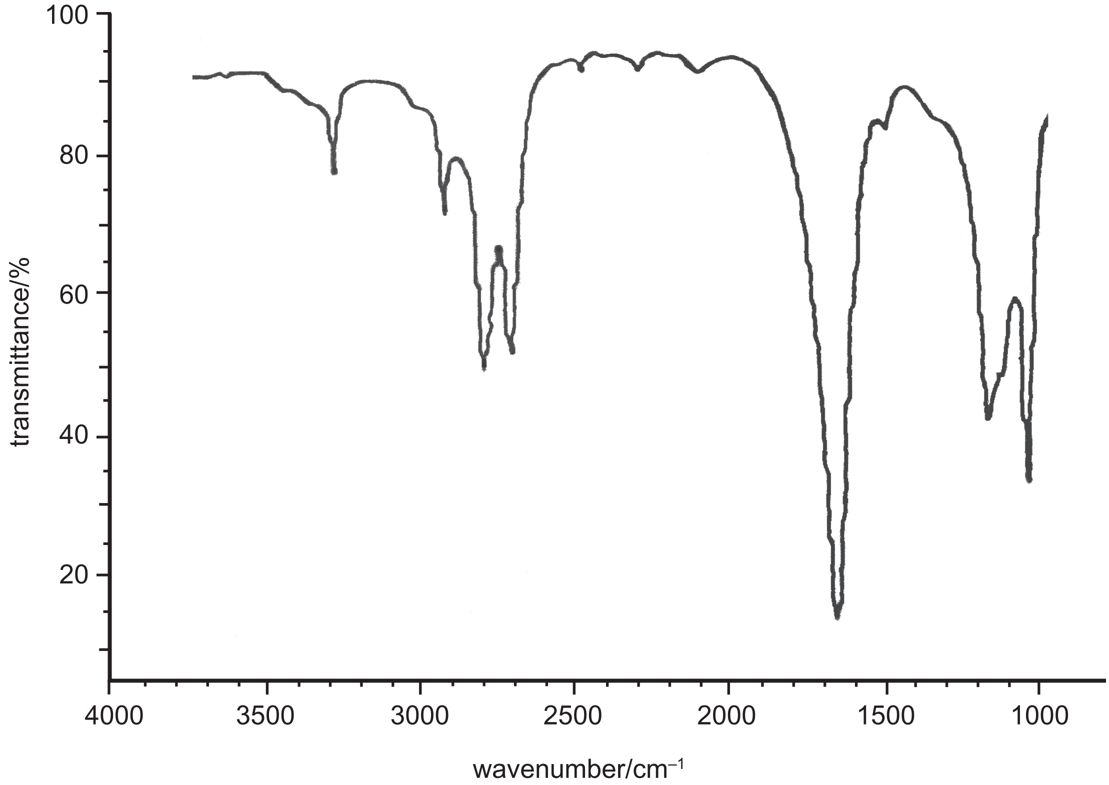
Spectrum A



Spectrum B



Spectrum C



(i) Explain how the absorption of infra-red radiation arises in molecules.

____

____ [1]

(ii) The table below gives some infra-red absorption data.

Bond	Wavenumber/cm^{-1}
C — H	2850–3300
C ═ C	1620–1680
C ═ O	1680–1750
C — O	1000–1300
(alcohols) O — H	3230–3550
(acids) O — H	2500–3000

Use this data to identify the absorptions at:

Spectrum A: (broad) 3000 cm^{-1} ____________________________

Spectrum C: 1000 cm^{-1} _________________________________ [2]

(iii) Identify the molecule responsible for:

Spectrum B: ____

Spectrum C: ____ [2]

(b) Ethanol can be oxidised to ethanal or ethanoic acid depending on the experimental technique used.

(i) Name a suitable oxidising agent.

____ [1]

(ii) Give the formula of the ion formed by reduction of this oxidising agent.

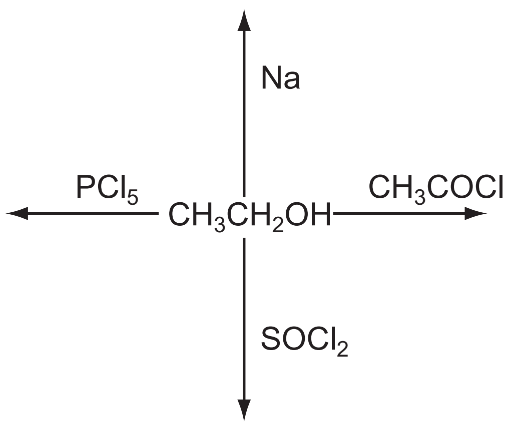
____ [1]

(iii) Give the experimental techniques required to form

Ethanal: ____ [1]

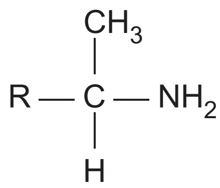
Ethanoic acid: ____ [1]

(c) Complete the diagram below giving the formula of the organic compound formed in each case.

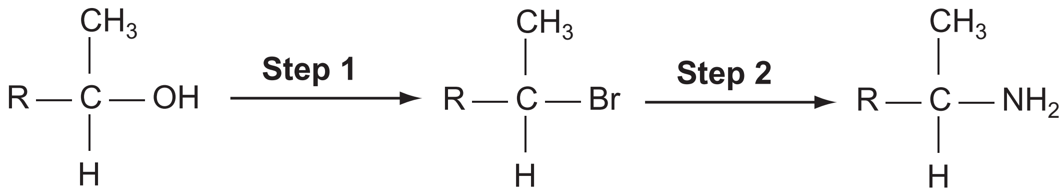


[4]

17 Amphetamines were once used to treat obesity, mild depression and some behavioural disorders.
The general formula for an amphetamine can be represented as:



Amphetamines can be synthesised in the following steps.



(a) (i) Suggest a suitable reagent for **Step 1**.

____ [1]

(ii) What type of reaction is taking place in **Step 1**?

____ [2]

(iii) Suggest a suitable reagent and conditions for carrying out **Step 2**.

____

____ [2]

(b) The liquid product obtained from **Step 1** is impure. Giving experimental details explain how it can be separated, dried and purified.

____

____

____

____

____

____

____ [4]

Quality of written communication [2]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2011

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC121]

THURSDAY 20 JANUARY, AFTERNOON

MARK SCHEME

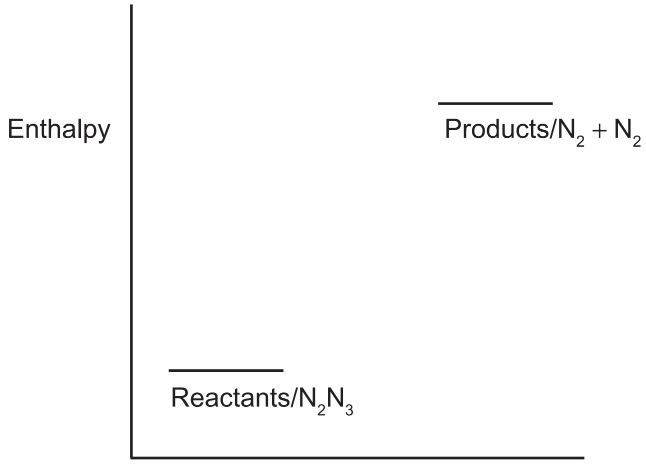
Section A

1	B	[2]	
2	B	[2]	
3	B	[2]	
4	D	[2]	
5	C	[2]	
6	C	[2]	
7	D	[2]	
8	A	[2]	
9	B	[2]	
10	B	[2]	20

Section B

11 **(a)** **(i)** Endothermic [1]

(ii)



Reaction path/reaction co-ordinate/extent of reaction/progress

([–1] for each mistake) [3]

(iii) Moles of N_2 = 50/24 = 2.083 mole
Moles of NaN_3 = 2.083 × 2/3 = 1.389 mole
Mass of NaN_3 = 1.389 × 65 = 90.28 g
([–1] for each mistake) [3]

(b) **(i)** $C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$ [2]

(ii) $2CO + 2NO \rightarrow 2CO_2 + N_2$ [2] 11

12 **(a)** The outer electrons are in the s-subshell/orbital/shell [1]

(b) **(i)** $Mg(g) \rightarrow Mg^{+}(g) + e^{-}$
(equation [1], state symbols [1]) [2]

(ii) 1st ionisation energy decreases going down the group [1]
Increased shielding (from inner electrons) [1]
Outer electrons further from the nucleus [1] [3]

(c) **(i)** $Ca(OH)_2 \rightarrow CaO + H_2O$ [1]

(ii) $Mg(OH)_2$ less stable than $Ba(OH)_2$ [1]
Mg^{2+} smaller/high charge density [1]
Polarisation of OH^-/Comparison in size to O^{2-}/OH^- [1] [3]

(iii) pH of $Ba(OH)_2 > Mg(OH)_2$ [1]
Solubility of the hydroxides increases going down the group [1] [2] 12

13 **(a)** Fractional distillation [1]

(b) **(i)** **Hydrocarbon** – compound containing carbon and hydrogen only [1]
Saturated – contains no C=C bonds [1] [2]

(ii) 2,2,3,3-tetramethylbutane [1]

(c) **(i)** Cracking [1]

(ii) High temperature/catalyst [1]

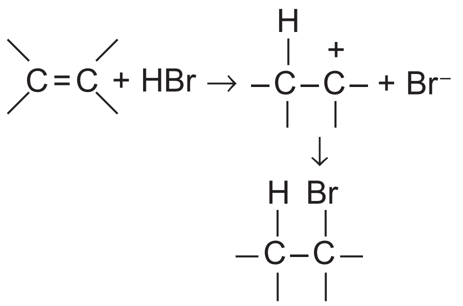
(iii) $C_8H_{18} \rightarrow C_5H_{12} + C_3H_6$ **or**
$C_8H_{18} \rightarrow C_2H_6 + 2C_3H_6$ [1]

(iv) Shake propene gas with bromine water
Decolourises [1] bromine water [1] [2]

(v) $C_3H_6 + Br_2 \rightarrow C_3H_6Br_2$ [1]

(d) High electron density around the double bond [1]

(e) **(i)**



[3]

(ii) Electrophilic [1] addition [1] [2] 16

14 **(a)** **(i)** $\Delta H = mc\Delta T = 100 \times 4.2 \times 0.9$ [1]
$= 378$ J [1] [2]

(ii) $5/80 = 0.0625$ [1]

(iii) $378/0.0625 = 6048$ (J mol^{-1}) [1]

(b) 5 g produces 0.9 °C change

$\frac{5}{0.9} \times 25$ g produces 25 °C change

$\frac{5}{0.9} \times 25 \times \frac{120}{100}$ in 120 g water = 166.7 g [2] 6

15 **(a)** Rate of reaction increases as more molecules will have enough energy to react when they collide [1]
(Equilibrium moves to the right) increasing the yield of NO [1]
The forward reaction is endothermic/removes the extra heat [1] [3]

(b) Rate of the reaction will increase due to increased concentration [1]
Equilibrium moves to the right increasing the yield of NO [1]
This removes the additional N_2 (restoring the equilibrium) [1] [3]

(c) Rate of the reaction will increase as this increases the concentration of the gases [1]
Equilibrium position is unaffected [1]
Same volume/number of molecules on each side [1] [3]

(d) Rate of the reaction increases as the catalyst provides an alternative pathway with a lower energy [1]
The catalyst will not affect the position of the equilibrium and the yield will not change [1] [2] 11

16 **(a)** **(i)** Molecular vibrations [1]

(ii) **Spectrum A:** C—H bond [1]
Spectrum C: C—O bond [1] [2]

(iii) **Spectrum B:** ethanoic acid [1]
Spectrum C: ethanal [1] [2]

(b) **(i)** $H^+/Cr_2O_7^{2-}$ acidified dichromate [1]

(ii) Cr^{3+} [1]

(iii) Ethanal: Heat under distillation [1]
Ethanoic acid: Heat under reflux [1] [2]

(c) $Na \rightarrow CH_3CH_2ONa$ [1]
$CH_3COCl \rightarrow CH_3COOCH_2CH_3$ [1]
$SOCl_2 \rightarrow CH_3CH_2Cl$ [1]
$PCl_5 \rightarrow CH_3CH_2Cl$ [1] [4] 13

17	**(a)**	**(i)** HBr	[1]	
		(ii) Nucleophilic [1] substitution [1]	[2]	
		(iii) Heat [1] with (concentrated) ammonia [1]	[2]	
	(b)	Use of separating funnel [1] Use of $NaHCO_3$ solution (to remove acid impurities) – release pressure [1] Use of anhydrous Na_2SO_4 or $CaCl_2$ (for drying) – filter [1] Distil (product for final purification) [1]	[4]	
		Quality of written communication	[2]	11
			Section B	**80**
			Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2011

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

FRIDAY 24 JUNE, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all sixteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all six** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

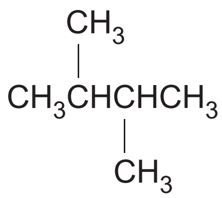
The total mark for this paper is 100.
Quality of written communication will be assessed in question **12(b)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following is the IUPAC name for the hydrocarbon shown below?



A 1,4-dimethylbutane
B 2,3-dimethylbutane
C 1,4-dimethylhexane
D 2,3-dimethylhexane

2 1.4 g of an alkene gives 3.8 g of a dichloroalkane on reaction with chlorine. Which one of the following is the molecular formula of the alkene?

A C_2H_4
B C_3H_6
C C_4H_8
D C_6H_{12}

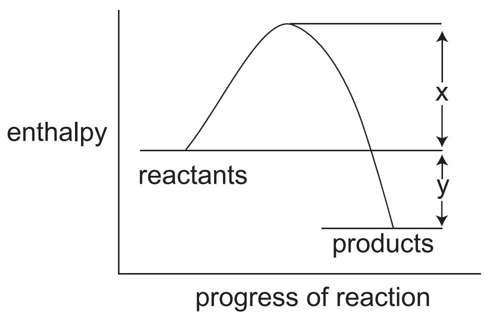
3 Which one of the following lists the products of hydrolysis of chloromethane with "heavy water", D_2O?
(The symbol D represents an atom of deuterium, an isotope of hydrogen)

A $CH_3OH + HCl$
B $CH_3OH + DCl$
C $CH_3OD + HCl$
D $CH_3OD + DCl$

4 The enthalpy change for the combustion of graphite is $-393.5\,kJ\,mol^{-1}$ and that of diamond is $-395.4\,kJ\,mol^{-1}$.
Which one of the following is the enthalpy change for the reaction C(graphite) $\rightarrow$ C(diamond)?

A $-1.9\,kJ\,mol^{-1}$
B $+1.9\,kJ\,mol^{-1}$
C $-788.9\,kJ\,mol^{-1}$
D $+788.9\,kJ\,mol^{-1}$

5 The energy level diagram for a reversible reaction is shown below.



Which one of the following is correct?

A The activation energy of the forward reaction is x
B The activation energy of the reverse reaction is y
C The forward reaction is endothermic
D The enthalpy change for the reverse reaction is y–x

6 The reaction of bromine with water can be represented by the following equation:

$$Br_2 + H_2O \rightleftharpoons Br^- + OBr^- + 2H^+$$

Which one of the following reagents would move the equilibrium position to the right?

A nitric acid
B sodium carbonate
C sodium bromide
D sulfuric acid

7 What is the number of moles of oxygen required for the complete combustion of one mole of butane?

A 5.5
B 6
C 6.5
D 7

8 When bromobutane is prepared by the reaction of butanol with concentrated hydrobromic acid in the presence of concentrated sulfuric acid which one of the following is **not** found in the reaction flask?

A bromine
B butanol
C butane
D hydrogen bromide

9 The mechanism of the reaction between ethene and hydrogen bromide is

A electrophilic addition.
B electrophilic substitution.
C nucleophilic addition.
D nucleophilic substitution.

10 In ethanol the attractions between adjacent molecules are

A covalent bonds only.
B hydrogen bonds only.
C hydrogen bonds and van der Waals forces only.
D van der Waals forces only.

Section B

Answer **all six** questions in the spaces provided.

11 Complete the following table:

Formula	**Name**
SCN^-	
	potassium dichromate
CHI_3	
	thionyl chloride

[4]

12 Crude petroleum is the major source of hydrocarbons. They are obtained by fractional distillation.

Whilst the use of petroleum products is of major benefit to mankind there are many environmental problems caused by the spillage and combustion of hydrocarbons. The recent spillage of crude petroleum onto the shores of the USA was a serious event in world economics.

(a) What are the products from the incomplete combustion of hydrocarbons?

____ [2]

(b) Discuss the environmental problems associated with spillage and the combustion of hydrocarbons.

____

____

____

____

____

____

____

____

____ [5]

Quality of written communication [2]

13 The table below shows some information about the Group II elements.

	magnesium	**calcium**	**strontium**	**barium**
atomic number	12	20	38	56
atomic radius/nm	0.160	0.197	0.215	
density/g cm^{-3}	1.74	1.54	2.6	3.5

(a) Explain why none of the Group II elements are found on the Earth's surface as free elements.

____

____ [1]

(b) Use the atomic number to determine the electronic configuration of calcium.

____ [1]

(c) The atomic radius of the Group II elements shows a trend as the group is descended.

(i) Explain why the atomic radius increases down the group.

____

____ [1]

(ii) Suggest whether the values of the atomic radii of the Group I elements are larger or smaller than those of the Group II elements.

____

____ [2]

(iii) Predict a value for the atomic radius of barium.

____ [1]

(iv) Use the values in the table to suggest why barium has the highest density of the group.

____

(d) All of the Group II elements form ions from their atoms.

(i) If the symbol for a Group II element is M what is the symbol for its ion?

______________________________ [1]

(ii) Explain what is meant by the term **first ionisation energy**.

____

______________________________ [1]

(iii) Write the equation for the first ionisation energy of magnesium including state symbols.

______________________________ [2]

(e) The density of the Group II elements relative to water indicates whether the metal should float or sink as it is reacting.

(i) State and explain whether calcium floats or sinks.

____

______________________________ [2]

(ii) State **two** further observations when calcium reacts with water.

____

______________________________ [2]

(iii) Write the equation for the reaction of calcium with water.

______________________________ [2]

(iv) Draw a labelled diagram, to show how the gas given off when calcium reacts with water can be collected. Use a test tube and a beaker.

[3]

(f) Barium carbonate is roasted with carbon to produce barium oxide according to the equation below.

$$BaCO_3 \rightarrow BaO + CO_2$$

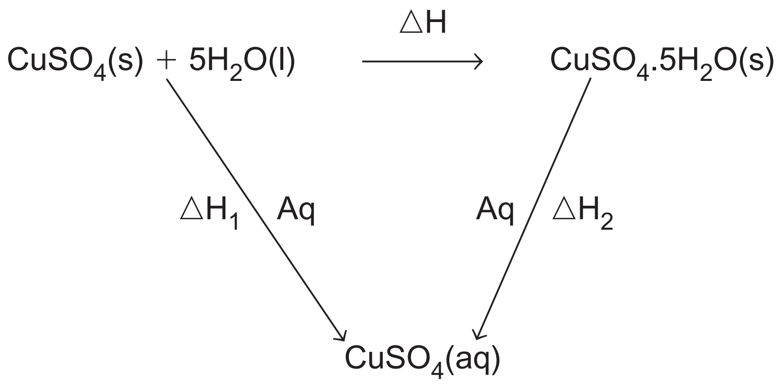
Calculate the atom economy of the reaction.

____

____

____ [3]

14 The following diagram shows the enthalpy changes that occur during the determination of the enthalpy change of the reaction of copper(II) sulfate with water to form copper(II) sulfate pentahydrate i.e.



(a) **(i)** 8.0 g of anhydrous copper(II) sulfate ($CuSO_4$) added to 100 g of water caused the temperature to rise by 1.2 °C. Calculate the enthalpy change, ΔH_1.
(Assume that the specific heat capacity of water is $4.2\,J\,g^{-1}\,{}^{o}C^{-1}$.)

[1]

(ii) 12.5 g of hydrated copper(II) sulfate ($CuSO_4.5H_2O$) added to 100 g of water caused the temperature to fall by 1.4 °C. Calculate the enthalpy change ΔH_2.
(Assume that the specific heat capacity of water is $4.2\,J\,g^{-1}\,{}^{o}C^{-1}$.)

[1]

(b) State Hess's law.

[2]

(c) Use the values calculated in parts **(a)(i)** and **(a)(ii)** to calculate the molar enthalpy of reaction $\triangle H$.

____

____

____ [3]

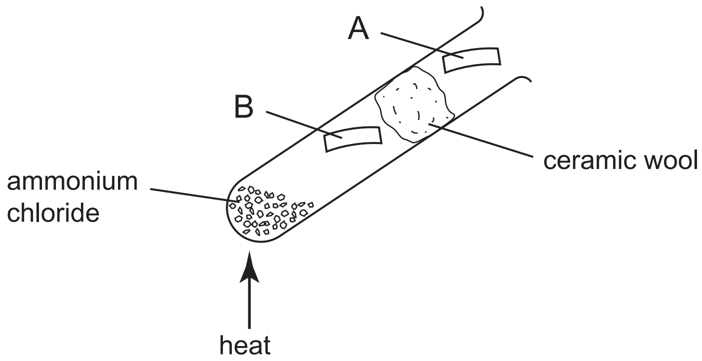
(d) At the end of the experiment a test was carried out to show that the solution produced contained Cu^{2+} ions.

Describe how you would use aqueous ammonia to test and confirm the presence of Cu^{2+}.

____

____ [2]

15 Crystals of ammonium chloride were heated in a test tube as shown below.



The pH paper placed at A turns blue and the pH paper placed at B turns red.

The ammonium chloride, when heated, dissociates to form an equilibrium mixture.

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

(a) **(i)** Explain why the pH paper changes to a blue colour at A.

______________________________ [1]

(ii) Explain why the pH paper changes to a red colour at B.

______________________________ [1]

(b) Suggest the purpose of the ceramic wool.

______________________________ [1]

(c) Heat is needed to decompose the ammonium chloride. Explain whether the forward reaction is exothermic or endothermic.

____

______________________________ [2]

(d) Ammonium chloride dissolves in water to form aqueous ammonium and chloride ions.

$$NH_4Cl(s) \quad + \quad Aq \quad \longrightarrow \quad NH_4^{\ +}(aq) \quad + \quad Cl^-(aq)$$

(i) Describe how you would test for aqueous ammonium ions.

____

____ [3]

(ii) Describe how you would test for aqueous chloride ions.

____

____ [3]

(e) Ammonium chloride is quite soluble in water, 37.2 g dissolve in 100 cm^3 of water at 20 °C. Calculate the maximum volume of ammonia gas that could be obtained from this solution at 20 °C and one atmosphere pressure.

____

____

____ [3]

16 The structure of t-butyl chloride (tertiary chlorobutane) one of the isomers of the chlorobutanes is shown below.

$$(CH_3)_3CCl$$

t-butyl chloride

(a) Deduce the systematic name for t-butyl chloride

____ [2]

(b) There are three other isomers of t-butyl chloride which are known. They are shown in the table below.

butyl chloride	structure	boiling point/°C
t-butyl chloride	$(CH_3)_3CCl$	51–52
n-butyl chloride	$CH_3CH_2CH_2CH_2Cl$	78–79
sec-butyl chloride	$CH_3CH_2CHClCH_3$	68–70
iso-butyl chloride	$(CH_3)_2CHCH_2Cl$	68–69

(i) What is the general formula for chloroalkanes?

____ [1]

(ii) What is the general molecular formula for the chlorobutanes?

____ [1]

(iii) Suggest, in terms of intermolecular forces, why the boiling point of t-butyl chloride is so different from the other chlorobutanes.

____

____ [2]

(iv) Explain what is meant by the term **isomer**.

____

____ [2]

(v) Suggest the meaning of the term **sec**.

(c) t-butyl chloride is easily made from the corresponding alcohol according to the following reaction.

$$(CH_3)_3COH + HCl \rightarrow (CH_3)_3CCl + H_2O$$

The preparation is carried out in a separating funnel. 25 g of t-butyl alcohol and 85 cm^3 of concentrated hydrochloric acid (an excess) are shaken from time to time over 20 minutes. The mixture is allowed to stand for a few minutes and the lower acid layer removed. The crude t-butyl chloride is washed with sodium hydrogencarbonate solution and then with water. Anhydrous calcium sulfate is swirled with the t-butyl chloride in a conical flask. The liquid is decanted, 2–3 chips of porous porcelain added and distilled to collect 28 g of t-butyl chloride at 51–52 °C.

(i) After each shaking the separating funnel is inverted and the tap opened. Explain the reason for this procedure.

______________________________ [1]

(ii) Explain why the t-butyl chloride is shaken with sodium hydrogencarbonate solution.

______________________________ [1]

(iii) Explain why the t-butyl chloride is shaken with water.

______________________________ [1]

(iv) Explain why the t-butyl chloride is swirled with anhydrous calcium sulfate.

______________________________ [1]

(v) Explain why porous porcelain is added before distillation.

______________________________ [1]

(vi) Calculate the percentage yield of t-butyl chloride.

____

____

____

______________________________ [3]

(d) When added to water t-butyl chloride undergoes “spontaneous solvation”. Hydrolysis immediately occurs to produce the alcohol. Compare the speed of this hydrolysis to that of n-butyl chloride and suggest why there is such a difference in speed.

____

____

____

____ [3]

THIS IS THE END OF THE QUESTION PAPER

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2011

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical
and Inorganic Chemistry

[AC121] [AC122]

FRIDAY 24 JUNE, MORNING

MARK SCHEME

Section A

1 B

2 B

3 D

4 B

5 A

6 B

7 C

8 C

9 A

10 C

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11 thiocyanate (ion) [1]
$K_2Cr_2O_7$ [1]
iodoform/triiodomethane [1]
$SOCl_2$ [1] 4

12 **(a)** H_2O, C, CO or names [2]

(b) <u>spillage</u> aesthetic aspects [1]
oil on birds/animals (explained) [1] oil on plants (explained) [1]
non-biodegradable [1]
<u>combustion</u> CO_2 – greenhouse effect/global warming [1]
problems with particulates (smoke, carbon) explained –
respiratory problems [1]
carbon monoxide is poisonous [1]
sulfur dioxide – acid rain [1]
or oxides of nitrogen
hydrocarbons – non renewable [1] [5]

Quality of written communication [2] 9

13 **(a)** metals are (very) reactive/react with O or S/form compounds [1]

(b) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ [1]

(c) **(i)** increased number of shells [1]

(ii) larger atomic radius in Group 1 due to smaller nuclear charge [2]

(iii) 0.160 0.197 0.215 0.224
0.037 0.018 0.009 [1]

(iv) size of strontium similar/close to barium [1]
mass of barium larger than strontium [1] [2]

(d) **(i)** M^{2+} [1]

(ii) energy needed to convert 1 mole of gaseous atoms into gaseous ions with a charge of 1+ [1]

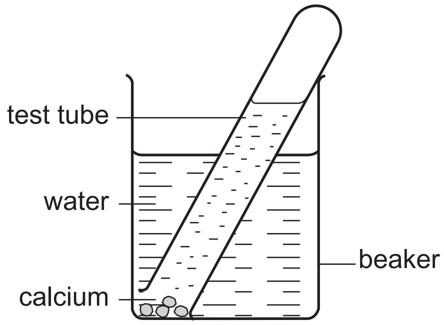
(iii) $Mg(g) \rightarrow Mg^{+}(g) + e^{-}$ [2]

(e) **(i)** calcium heavier/denser than water [1]
sinks [1] [2]

(ii) bubbles [1]
white solid appears [1]
heat evolved [1]
Ca gets smaller [1] any 2 [2]

(iii) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ [2]

(iv)



[3]

(f) $BaCO_3 \rightarrow BaO + CO_2$

$BaCO_3 = 137 + 12 + 48 = 197$
$BaO = 137 + 16 = 153$

atom economy $= 153/197 \times 100 = 77.7\%$
$= 78\%$ [3] 24

14 **(a)** **(i)** $100 \times 1.2 \times 4.2 = -504\,J$ $(-10.08\,kJ\,mol^{-1})$ [1]

(ii) $100 \times 1.4 \times 4.2 = +588\,J$ $(+11.76\,kJ\,mol^{-1})$ [1]

(b) enthalpy change is independent of route [2]
(in a series of reactions)

(c) $CuSO_4 = 64 + 32 + 64 = 160$
$5H_2O = 5 \times 18 = 90$
$CuSO_4.5H_2O = 160 + 90 = 250$

$12.5\,g = 12.5/250 = 0.05\,mol$
$8.0\,g = 8.0/160 = 0.05\,mol$

$\Delta H + \Delta H_2 = \Delta H_1$

$\Delta H + 588 = -504$
$\Delta H = -588 - 504 = -1092\,J$

For one mol $-1092/0.05 = -21840\,J\,mol^{-1}$
$-21.84\,kJ\,mol^{-1}$ [3]

(d) blue precipitate [1]
in xs ammonia dissolves to give dark/deep blue solution [1] [2] 9

15 **(a)** **(i)** ammonia present which is alkaline [1]

(ii) hydrogen chloride present which is acidic [1]

(b) to separate NH_3 from HCl [1]

(c) endothermic [1]
equilibrium absorbs heat/to reduce temperature [1]/heat is needed [2]

(d) **(i)** add sodium hydroxide (essential) [1]/heat [1]
stopper/glass rod with conc HCl giving white fumes/
smoke [1] [3]

(ii) add silver nitrate solution (essential) [1]
white [1]
precipitate [1] [3]

(e) $NH_4Cl = 14 + 4 + 35.5 = 53.5$
$37.2/53.5 = 0.695\,\text{mol}$
$0.695 \times 24\,\text{dm}^3 = 16.69\,\text{dm}^3 = 16.7\,\text{dm}^3$ [3] 14

16 **(a)** 2-chloro(-2-)methylpropane [2]

(b) **(i)** $C_nH_{2n+1}Cl$ [1]

(ii) C_4H_9Cl [1]

(iii) less van der Waals forces [1]
spherical molecule/branching [1]
or
linear molecules greater attractive forces [1] [2]

(iv) same molecular formula [1]
different structure [1] [2]

(v) secondary [1]

(c) **(i)** release the pressure/gases [1]

(ii) remove acids/hydrogen chloride/hydrochloric acid [1]

(iii) remove inorganic material/NaCl/$NaHCO_3$/alcohol/soluble
impurities [1]

(iv) dry the butyl chloride [1]

(v) smooth boiling [1]

(vi) $(CH_3)_3COH = C_4H_9OH = C_4H_{10}O$
$= 48 + 10 + 16 = 74$

$25/74 = 0.34\,\text{mol}$

$(CH_3)_3CCl = C_4H_9Cl$
$= 48 + 9 + 35.5 = 92.5$

$28/92.5 = 0.30\,\text{mol}$

percentage yield $= 0.30/0.34 \times 100 = 88\%$ [3]

(d) faster [1]
reference to tertiary versus primary structure [1]
weaker (C — Cl) bond or correct reference to S_N1/S_N2 [1] [3] 20

Section B	**80**
Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2012

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

THURSDAY 19 JANUARY, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all sixteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all six** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **12(c)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 The standard enthalpy of formation of water is $-286\,kJ\,mol^{-1}$. Which one of the following is the enthalpy change when hydrogen reacts with oxygen to form 1 g of water?

A $+15.9\,kJ$
B $-15.9\,kJ$
C $+31.8\,kJ$
D $-31.8\,kJ$

2 Which one of the following statements about the alcohol shown below

$$CH_3CH_2CHOHCH_3$$

is **not** correct?

A It takes part in the iodoform reaction
B It is oxidised to an aldehyde
C It has the molecular formula $C_4H_{10}O$
D It has the systematic name butan–2–ol

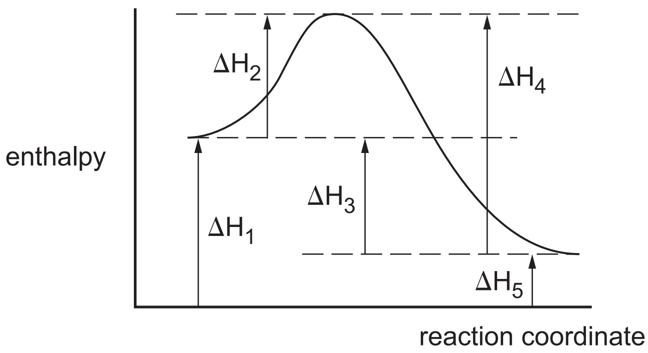
3 X and Y are two atoms which are joined together to form a covalent bond, X–Y. X is more electronegative than Y. Which one of the following pairs of species is produced by homolytic fission of this bond?

A $X^+ + Y^-$
B $X^- + Y^+$
C $X^\bullet + Y^\bullet$
D $X{:} + Y$

4 In which one of the following pairs will **neither** hydroxide dissolve in an excess of aqueous sodium hydroxide?

A aluminium hydroxide and magnesium hydroxide
B aluminium hydroxide and zinc hydroxide
C magnesium hydroxide and iron(II) hydroxide
D zinc hydroxide and calcium hydroxide

5 The diagram represents the enthalpy of a reversible reaction plotted against the reaction co-ordinate.



Which one of the listed enthalpies would be altered by the use of a catalyst?

A $\Delta H_1 + \Delta H_5$
B $\Delta H_2 + \Delta H_3$
C $\Delta H_2 + \Delta H_4$
D $\Delta H_3 + \Delta H_4$

6 Which one of the following is the number of possible isomers of formula $C_2H_3Cl_3$?

A 2
B 3
C 4
D 5

7 Which one of the following processes is endothermic?

A $Ba \rightarrow Ba^+ + e^-$
B $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
C $H^+ + OH^- \rightarrow H_2O$
D $N_2 + 3H_2 \rightarrow 2NH_3$

Which one of the following equations represents the standard enthalpy change of formation of barium chloride?

A $Ba(g) + Cl_2(g) \rightarrow BaCl_2(s)$
B $Ba(s) + Cl_2(g) \rightarrow BaCl_2(s)$
C $Ba^{2+}(g) + 2Cl^-(g) \rightarrow BaCl_2(s)$
D $Ba^{2+}(s) + 2Cl^-(g) \rightarrow BaCl_2(s)$

9 Which one of the following molecules can **not** act as a nucleophile?

A CH_3NH_2
B CH_4
C H_2O
D NH_3

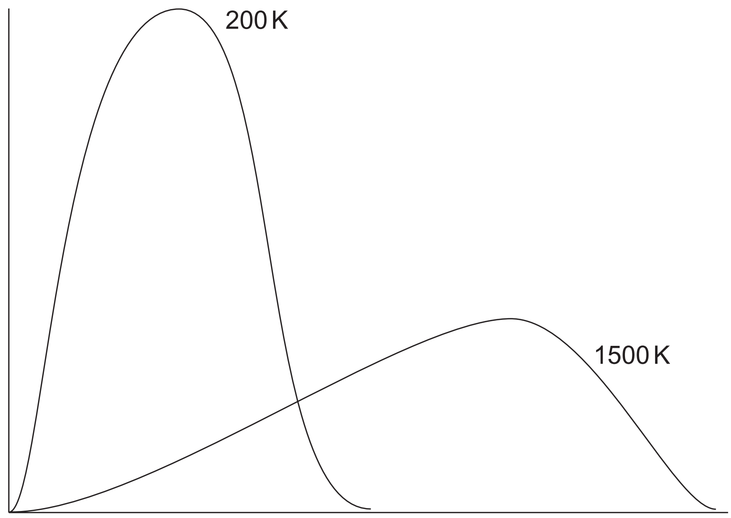
10 Which one of the following is the volume of oxygen required for the complete combustion of $100\,cm^3$ of butane at room temperature and pressure?

A $400\,cm^3$
B $500\,cm^3$
C $650\,cm^3$
D $1300\,cm^3$

Section B

Answer **all six** questions in this section.

11 The diagram below shows the Maxwell-Boltzmann distribution curves for the molecules in a gas at temperatures of 200 K and 1500 K.



(a) Label the axes. [2]

(b) Draw the shape of the distribution curve for 500 K on the same graph. [2]

(c) Explain why all the graphs start at point (0, 0).

____

____ [2]

12 Strontium sulfate, $SrSO_4$, is a white solid which occurs in nature as the mineral celestine. It closely resembles barium sulfate in many of its properties.

(a) Strontium sulfate is moderately soluble in water.

$$SrSO_4(s) + aq \rightleftharpoons Sr^{2+}(aq) + SO_4^{2-}(aq)$$

The table below shows the solubility of strontium sulfate at different temperatures.

solubility/g dm^{-3}	**temperature/°C**
0.0111	18
0.0135	25

(i) Explain whether the dissolving of strontium sulfate is an exothermic or endothermic process.

____

____ [2]

(ii) Compare the solubility of strontium sulfate with that of calcium and barium sulfates.

____

____ [2]

(b) Strontium sulfate may be prepared in the laboratory by reacting strontium with water and then mixing the strontium hydroxide produced with dilute sulfuric acid.

(i) Write the equation for the reaction of strontium with water.

____ [2]

(ii) Write the equation for the reaction of strontium hydroxide with sulfuric acid.

____ [2]

(c) Celestine and barite, $BaSO_4$, are two minerals which may be distinguished from each other using a flame test. Describe how a flame test can be carried out and state the colour expected for barite. Celestine produces a red flame.

____

____

____

____

____ [4]

Quality of written communication [2]

(d) Strontium sulfate decomposes on heating to form the oxide and sulfur trioxide. Its thermal stability can be explained in a similar way to that of the carbonate.

(i) Write the equation for the decomposition of strontium sulfate.

____ [1]

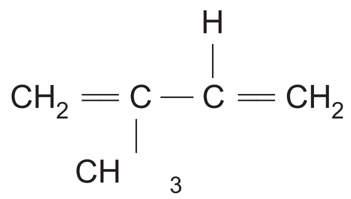
(ii) Explain the thermal stability of strontium sulfate.

____

____

____

13 Rubber is a polymer of isoprene, C_5H_8, whose structural formula is shown below.



(a) **(i)** Draw the full structure of isoprene showing **all** the bonds present.

[1]

(ii) Explain whether isoprene is capable of forming *cis* and *trans* (E–Z) isomers.

[2]

(b) Deduce the systematic name for isoprene.

[1]

(c) Isoprene is fully hydrogenated when it reacts with hydrogen in the presence of a metal catalyst.

(i) Write the equation for the reaction.

[1]

(ii) Name the metal catalyst.

[1]

(iii) In what form is the solid metal used?

[1]

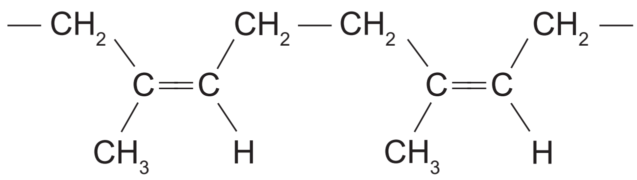
(iv) Isoprene has a boiling point of 34 °C. The product, pentane, has a boiling point of 24 °C. What does this suggest about the intermolecular forces between the molecules in pentane compared to isoprene?

____

____

____ [2]

(d) Isoprene polymerises to form rubber. A section of the polymer is shown below.



One important artificial rubber is neoprene, a polymer of chloroprene, $CH_2{=}CClCH{=}CH_2$.

Draw a section of the neoprene structure.

[2]

(e) Isoprene reacts with bromine to form a bromo-derivative with the following percentage composition:

carbon	26.3%
hydrogen	3.5%
bromine	70.2%

(i) Deduce the empirical formula for the bromo-derivative.

____

____

____ [3]

(ii) Draw a structural formula for the bromo-derivative.

[1]

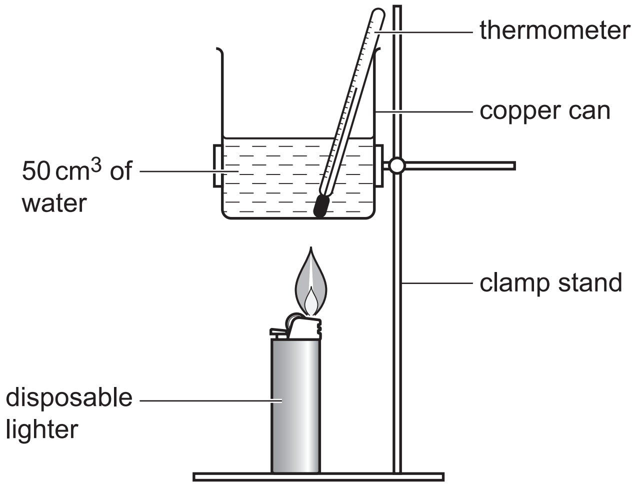
(f) Mixtures of isoprene vapour and air are potentially explosive. Name **two** products which are formed during the incomplete combustion but not during the complete combustion of isoprene.

1. ____

2. ____ [2]

14 Disposable lighters contain liquid butane. When the pressure is released the butane forms a gas and escapes. A spark from the flint ignites the gas which burns to release heat.

The following experiment was carried out to determine the molar enthalpy of combustion of butane.



The lighter was weighed before the butane was ignited and weighed again after the butane had burned to raise the temperature of the water in the copper can by 55 °C.

Specific heat capacity of water is $4.2\,J\,g^{-1}\,°C^{-1}$)

The following results were obtained:

mass of lighter before ignition	= 15.00 g
mass of lighter after burning	= 14.53 g
temperature of water before heating	= 25 °C
temperature of water after heating	= 80 °C
mass of water	= 50 g

(a) Calculate the molar enthalpy of combustion of butane using the following headings.

number of grams of butane burned

______________________________ [1]

relative formula mass of butane

______________________________ [1]

number of moles of butane burnt

______________________________ [1]

heat received by 50 g of water

______________________________ [1]

molar enthalpy of combustion of butane

____

______________________________ [1]

(b) A similar experiment was carried out to determine the molar enthalpy of combustion of ethanol. A value of half the theoretical value of $-1367\,kJ\,mol^{-1}$ was obtained.
State **three** reasons for the low experimental value.

____

____

____

______________________________ [3]

(c) Explain why the molar enthalpy of combustion of butane is theoretically more than that of ethanol.

____

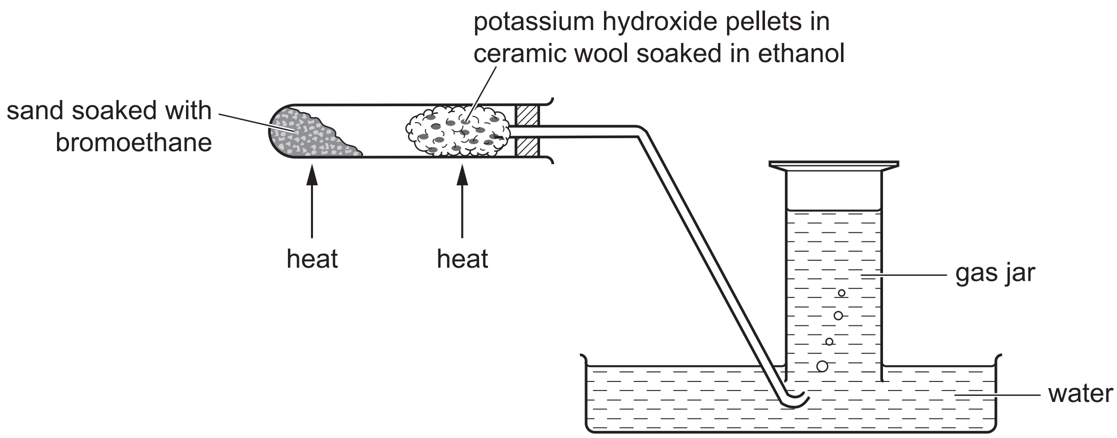
______________________________ [2]

(d) The butane is ignited using a spark from the lighter. State and explain whether the spark acts as a catalyst.

____

15 Bromoethane is a colourless liquid which boils at 38 °C. 9.1 g of bromoethane dissolve in one litre of water at room temperature. It undergoes an elimination reaction with ethanolic potassium hydroxide.

(a) The following experiment shows the reaction of bromoethane with ethanolic potassium hydroxide.



(i) Write the equation for the reaction of bromoethane with ethanolic potassium hydroxide.

____ [1]

(ii) Name the gas collected in the gas jar.

____ [1]

(iii) Describe a chemical test to confirm the identity of the gas.

____

____ [2]

(iv) How does the collection of this gas prove that an *elimination* reaction has taken place?

____

____ [1]

(b) Bromoethane reacts differently with aqueous potassium hydroxide, as nucleophilic substitution takes place.

(i) Write the equation for the reaction.

____ [1]

(ii) Explain the meaning of the term **nucleophilic substitution**.

____

____ [2]

(iii) Draw a flow scheme to illustrate the mechanism for the reaction of bromoethane with hydroxide ions.

[3]

(iv) Explain, in terms of bond enthalpy and polarity why the hydrolysis of chloroethane is slower than that of bromoethane.

____

____

____ [3]

16 Ammonia is made industrially from nitrogen and hydrogen. It does not burn in air but it will burn in oxygen.

$$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$$

(a) **(i)** Name the industrial process used to make ammonia.

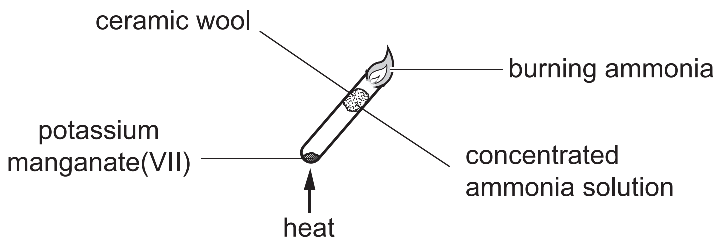
____ [1]

(ii) Suggest why neither ammonia nor hydrogen burns during the manufacture of ammonia.

____

____ [1]

(b) The apparatus shows how ammonia can be burnt in a stream of oxygen provided by the decomposition of heated potassium manganate(VII).



(i) Potassium manganate(VII) thermally decomposes according to the following equation.

$$2KMnO_4 \rightarrow K_2MnO_4 + O_2 + MnO_2$$

Calculate the volume of oxygen produced at 20 °C and one atmosphere pressure when 2.5 g of potassium manganate(VII) are heated.

____

____

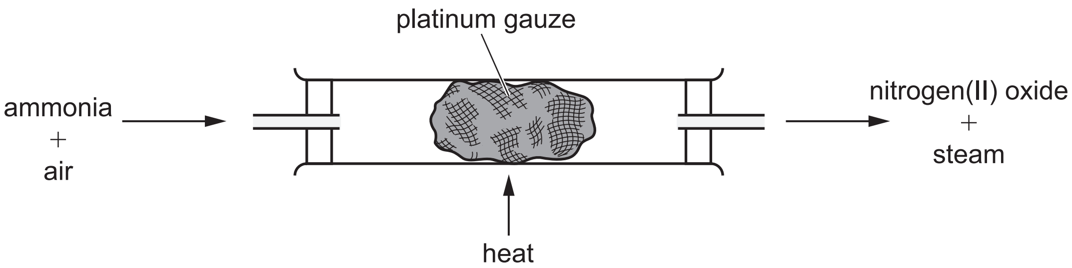
____ [3]

(ii) Before the ceramic wool is placed in the test tube the gas may be tested to see that oxygen is being given off. Describe the chemical test for oxygen.

____

____ [2]

(c) When mixed with air and passed through a heated platinum gauze ammonia forms nitrogen(II) oxide and steam.



$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

(i) Suggest the purpose of the platinum gauze.

____ [1]

(ii) Explain why gauze is used rather than a pile of platinum powder.

____

____ [1]

(iii) Explain why the laws of chemical equilibrium cannot be applied to this particular mixture of ammonia and oxygen.

____ [1]

(iv) Using the bond energies below calculate the enthalpy change per mole of ammonia and state whether the reaction is exothermic or endothermic.

bond	**bond energy/kJ mol^{-1}**
N–H	391
O=O	498
N=O	587
H–O	464

____

____

____

____ [4]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2012

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

THURSDAY 19 JANUARY, AFTERNOON

MARK SCHEME

Section A

1 B

2 B

3 C

4 C

5 C

6 A

7 A

8 B

9 B

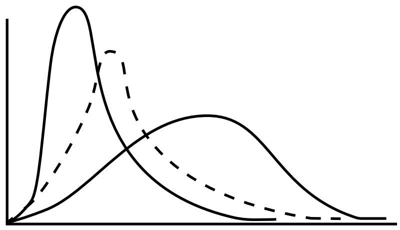
10 C

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11 **(a)** number of particles – *y* axis [1]
(kinetic) energy – *x* axis [1] [2]

(b)



[2]

(c) 0 particles [1]
0 energy [1] [2] 6

12 **(a)** **(i)** solubility increases with increase in temperature/
goes to the RHS as temperature increases [1]
∴ endothermic [1] [2]

(ii) less soluble than $CaSO_4$ [1]
more soluble than $BaSO_4$ [1] [2]

(b) **(i)** $Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$ [2]

(ii) $Sr(OH)_2 + H_2SO_4 \rightarrow SrSO_4 + 2H_2O$ [2]

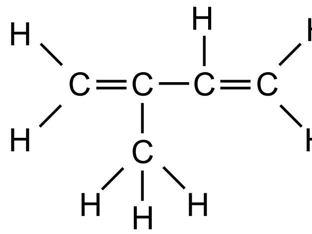
(c) nichrome/platinum wire [1]
blue flame [1]
conc. hydrochloric acid [1]
green [1] [4]

Quality of written communication [2]

(d) **(i)** $SrSO_4 \rightarrow SrO + SO_3$ [1]

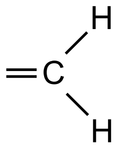
(ii) size of cation/charge on cation
sulfate ion distorted/deformed by Sr^{2+}
(Any **two**) [2] 17

13 (a) (i)



error [–1] [1]

(ii) no

because of  [1]

groups the same i.e. H and H

(reference to both C═C) [1] [2]

(b) 2-methylbut(a)-1,3-diene **or** 2-methyl-1,3-butadiene [1]

(c) (i) $C_5H_8 + 2H_2 \rightarrow C_5H_{12}$ [1]

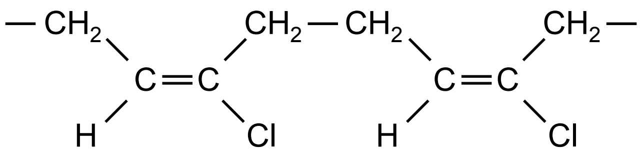
(ii) nickel [1]

(iii) finely divided [1]

(iv) van der Waals forces [1]

greater in isoprene [1] [2]

(d)



[2]

(e) (i)

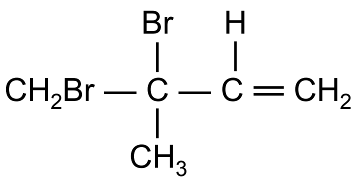
C	26.3	$\frac{26.3}{12}$	=	2.19	$\frac{2.19}{0.88}$	=	2.5
H	3.5	$\frac{3.5}{1}$	=	3.5	$\frac{3.5}{0.88}$	=	3.97
Br	70.2	$\frac{70.2}{80}$	=	0.88	$\frac{0.88}{0.88}$	=	1

×2 $C_5H_8Br_2$

error [–1]

[3]

(ii)



or bromine on double bond [1]

(f) carbon [1]

carbon monoxide (either order) [1] [2]

17

14 (a) 0.47g [1]
C_4H_{10} = 58 [1]
$\frac{0.47}{58}$ = 0.0081 mol [1]
50 × 4.2 × 55 = 11550 J [1]
$\frac{11550}{0.0081}$ = (–)1425.9 kJ [1] [5]

(b) draughts [1]
incomplete combustion [1]
loss heat to the copper can [1] [3]

(c) more bonds produced in combustion of butane [1]
forming bonds gives out heat [1] [2]

(d) no [1]
the spark is heat/not a chemical [1] [2] 12

15 (a) (i) $C_2H_5Br + KOH \rightarrow KBr + H_2O + C_2H_4$ [1]

(ii) ethene [1]

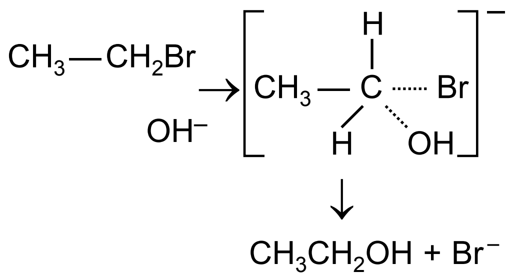
(iii) bromine water [1]
goes colourless [1] [2]

(iv) gas is not one of the reactants [1]

(b) (i) $C_2H_5Br + KOH \rightarrow C_2H_5OH + KBr$ [1]

(ii) nucleophile – ion or molecule with lone pair of electrons/ attracted to an area of low electron density [1]
substitution – one (functional) group replaced by another [1] [2]

(iii)



[3]

(iv) bond enthalpy of C—Cl greater [1]
C—Cl is more polar [1]
bond enthalpy more important [1] [3] 14

16 **(a)** **(i)** Haber Process [1]

(ii) no oxygen present [1]

(b) **(i)** $KMnO_4 = 39 + 55 + 64 = 158$

$2.5\,g = \frac{2.5}{158} = 0.0158$ mol

1 mol $\rightarrow$ 0.5 mol O_2

$\therefore \frac{0.0158}{2} \times 24\ dm^3 = 0.1896$

$= 190\ cm^3$

error [–1] [3]

(ii) glowing splint [1]
relights [1] [2]

(c) **(i)** catalyst/speeds up the reaction [1]

(ii) gas passes through [1]

(iii) not in a sealed container/reaction not reversible [1]

(iv) bonds before

bonds before	12 N—H =	12 × 391 = 4692
	5 O═O =	5 × 498 = <u>2490</u>
		<u>7182</u>
bonds after	4 N═O =	4 × 587 = 2348
	12 O—H =	12 × 464 = <u>5568</u>
		<u>7916</u>

$\Delta H = +7182 - 7916$

$= -734 \div 4 = 183.5$

$\therefore$ –ve

exothermic

error [–1] [4] 14

Section B	**80**
Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2012

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

TUESDAY 19 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all five** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in question **14(b)(iv)**.

In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 The forces of attraction between ethanol molecules are

A permanent dipole-dipole attractions only.
B permanent dipole-dipole attractions and hydrogen bonds.
C hydrogen bonds.
D hydrogen bonds and van der Waals' forces.

2 Which one of the following is a propagation step in the chlorination of methane?

A $Cl_2 \rightarrow 2Cl^{\bullet}$
B $CH_4 + Cl^{\bullet} \rightarrow CH_3Cl + H^{\bullet}$
C $CH_4 \rightarrow CH_3^{\bullet} + H^{\bullet}$
D $CH_4 + Cl^{\bullet} \rightarrow CH_3^{\bullet} + HCl$

3 0.47 g of a hydrocarbon was completely burnt in air. The heat produced raised the temperature of 200 g of water by 28.2 °C. The standard enthalpy of combustion of the hydrocarbon is $-2220\,\text{kJ mol}^{-1}$.
The specific heat capacity of water is $4.2\,\text{J g}^{-1}\,°\text{C}^{-1}$
Which one of the following is the molar mass of the hydrocarbon?

A 40
B 44
C 185
D 199

4 Which one of the following **decreases** as Group II is descended from magnesium to barium?

A Atomic radius
B First ionisation energy
C Reactivity with water
D Solubility of the hydroxides

5 A solution of a white solid gives a white precipitate with concentrated ammonia solution. This precipitate is soluble in excess concentrated ammonia solution. The solution of the white solid also gives a white precipitate with barium chloride solution. Which one of the following does the solution contain?

A Aluminium chloride
B Aluminium sulfate
C Zinc chloride
D Zinc sulfate

6 Absorption of infra-red radiation by molecules is caused by

A electronic transitions.
B electronic vibrations.
C molecular transitions.
D molecular vibrations.

7 An organic compound consists of 40.7% carbon, 5.1% hydrogen and 54.2% oxygen and has a relative molecular mass of 118.
Which one of the following is the molecular formula of the compound?

A $C_3H_2O_5$
B $C_4H_6O_4$
C $C_5H_{10}O_3$
D $C_6H_{14}O_2$

8 Calcium nitrate undergoes thermal decomposition as follows:

$$2Ca(NO_3)_2(s) \rightarrow 2CaO(s) + 4NO_2(g) + O_2(g)$$

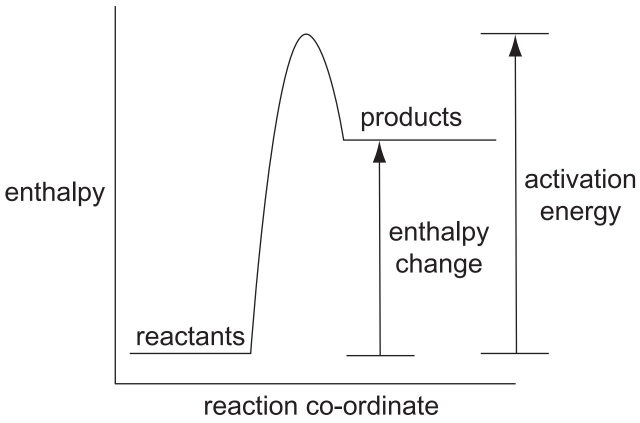
Which one of the following is the total volume of gas formed when 8.20 g of calcium nitrate are completely decomposed at room temperature and pressure?

A 0.6 dm^3
B 2.4 dm^3
C 3.0 dm^3
D 6.0 dm^3

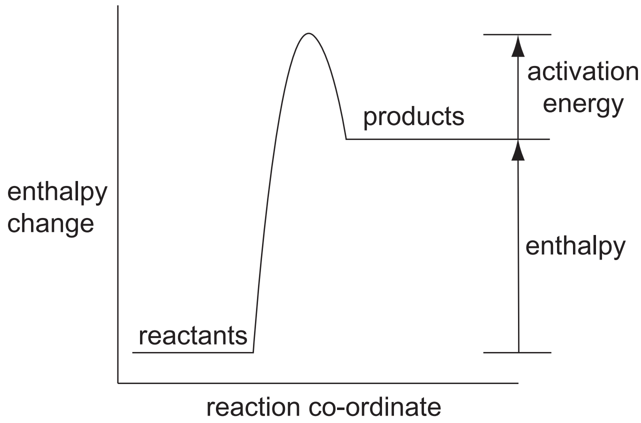
9 The reaction between bromobutane and aqueous sodium hydroxide is an example of

A electrophilic addition.
B electrophilic substitution.
C nucleophilic addition.
D nucleophilic substitution.

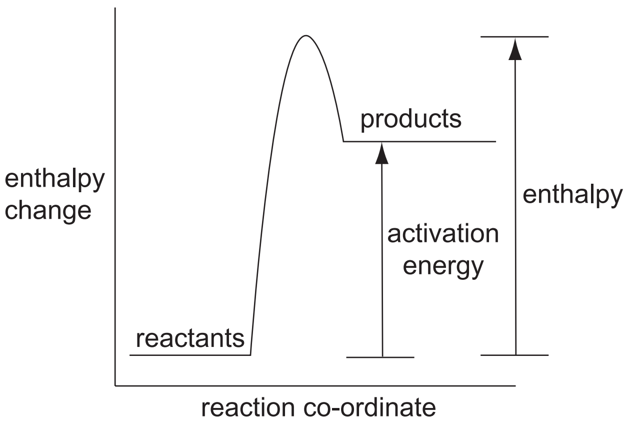
10 Which one of the following represents a correctly labelled enthalpy level diagram?



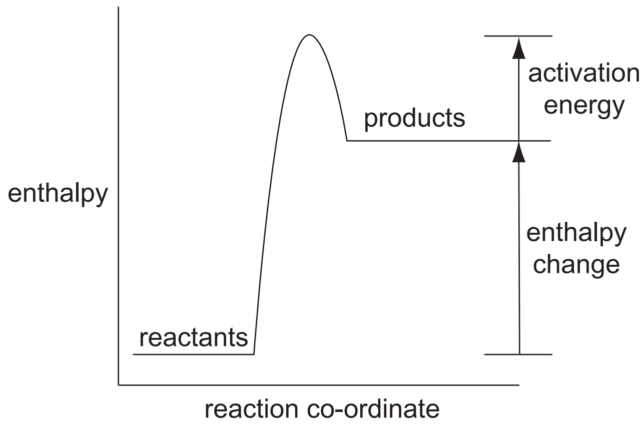
A



B



C



D

Section B

Answer **all five** questions in this section.

11 Salicylic acid, extracted from willow bark, was used as a painkiller. Today salicylic acid is used to manufacture aspirin.

Aspirin can be prepared in the laboratory by reacting salicylic acid with ethanoic anhydride according to the following equation:

$$C_6H_4(OH)COOH + (CH_3CO)_2O \rightarrow HOOCC_6H_4OCOCH_3 + CH_3COOH$$

salicylic acid	ethanoic anhydride	aspirin	ethanoic acid

(a) A student reacted 3.00 g of salicylic acid with 6.0 cm^3 of ethanoic anhydride.

(i) How many moles of salicylic acid were used?

______________________________ [1]

(ii) What mass of ethanoic anhydride was used?
(Density of ethanoic anhydride = 1.08 $g\,cm^{-3}$)

______________________________ [1]

(iii) How many moles of ethanoic anhydride were present?

______________________________ [1]

(iv) What is the maximum number of moles of aspirin which could be formed?

______________________________ [1]

(v) Calculate the maximum mass of aspirin which could be formed.

______________________________ [1]

(vi) The student isolated 3.08 g of aspirin. Calculate the percentage yield of aspirin obtained by the student.

____

______________________________ [1]

(b) **(i)** Explain what is meant by the term **atom economy** of a reaction.

____

____ [1]

(ii) Calculate the atom economy of the reaction to prepare aspirin.

____

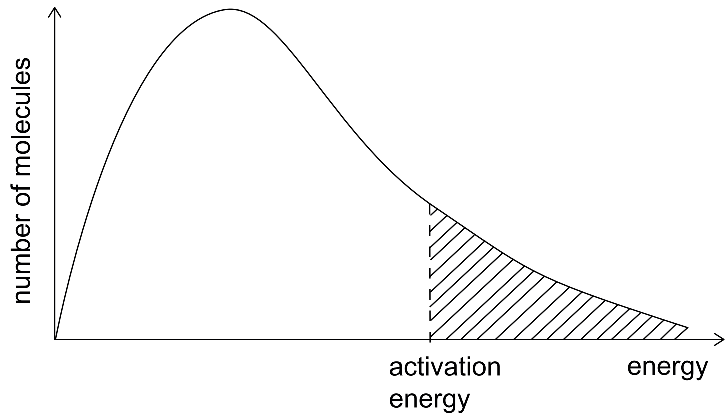
____ [2]

12 The first step in the Ostwald Process for the manufacture of nitric acid is the oxidation of ammonia.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \triangle H = -950\,kJ\,mol^{-1}$$

(a) The reaction is carried out at approximately 900 °C.

The diagram below shows the distribution of molecular energies in the reaction mixture at 900 °C.



(i) What is the name given to this distribution of molecular energies in gases?

____ [1]

(ii) Draw on the diagram the distribution of the molecular energies at 1500 °C. [2]

(iii) Use the diagram to explain why the rate of the reaction is faster at 1500 °C.

____

____

____ [2]

(iv) Explain how the yield of nitrogen(II) oxide is affected by increasing the temperature to 1500 °C.

____

____

____ [2]

(b) The reaction is carried out at 4 – 10 atmospheres pressure.

(i) Explain how increasing the pressure to 100 atmospheres would affect the rate of the reaction.

[2]

(ii) Explain how increasing the pressure to 100 atmospheres would affect the yield of the nitrogen(II) oxide.

[2]

(c) The catalyst used in the reaction contains rhodium and platinum.

(i) Explain, referring to the diagram, how the catalyst increases the rate of the reaction.

[2]

(ii) Explain the effect, if any, the catalyst has on the yield of the nitrogen(II) oxide.

[2]

13 But-1-ene and but-2-ene are gaseous isomers of C_4H_8.

(a) But-1-ene contains a carbon-carbon double bond, C=C, as well as carbon-carbon single bonds, C—C.

(i) Compare and explain the difference in bond strength and bond length of C=C and C—C.

____

____

____

______________________________ [3]

(ii) Explain why but-1-ene is more reactive than butane.

____

____

______________________________ [2]

(iii) Describe a test, including any observations, to show the presence of C=C in but-1-ene.

____

____

______________________________ [3]

(b) But-2-ene exists as E—Z isomers.

(i) Draw and label the E and Z isomers of but-2-ene.

[2]

(ii) Explain why but-2-ene can exist as E and Z isomers.

____

____ [2]

(c) But-1-ene can be polymerised to form poly(but-1-ene).

(i) What type of polymerisation does but-1-ene undergo?

____ [1]

(ii) Draw a section of poly(but-1-ene) showing **two** repeating units.

[2]

14 Barium carbonate has a variety of uses which include ceramic glazes and rat poisons.

(a) Barium carbonate can be prepared by heating barium sulfide, BaS, with sodium carbonate. Write an equation for this reaction.

____ [1]

(b) Barium carbonate is decomposed at 1360 °C.

(i) Write the equation for the decomposition of barium carbonate.

____ [1]

(ii) In industry coke (carbon) is added. Suggest the role of coke in this process.

____ [1]

(iii) Compare the thermal stability of barium carbonate to calcium carbonate, explaining any difference.

____

____

____

____ [3]

(iv) Describe how you would carry out a flame test to distinguish between barium carbonate and calcium carbonate, giving the result for each compound.

____

____

____

____

____

____ [5]

Quality of written communication [2]

(c) Describe a chemical test to distinguish between sodium carbonate and sodium hydrogencarbonate solids.

[3]

15 C_4H_9OH can be produced by fermentation of a sugar solution using the bacterium *clostridium acetobutylicum*.

(a) **(i)** Suggest **two** conditions necessary for this fermentation process.

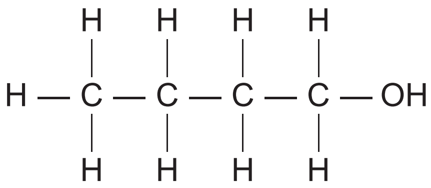
____

____ [2]

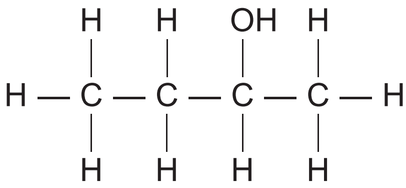
(ii) The fermentation process produces a mixture of alcohols and propanone. Suggest how the mixture may be separated.

____ [1]

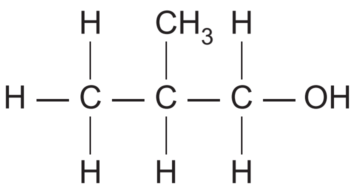
(b) C_4H_9OH has four isomers; butan-1-ol, butan-2-ol and two others, **A** and **B**.



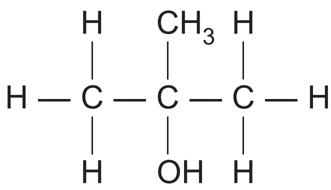
Butan-1-ol



Butan-2-ol



A



B

(i) Give the systematic names of isomers **A** and **B**.

A ____

B ____ [2]

(ii) Describe, giving experimental details and any observations, how you would use the iodoform test to distinguish between butan-1-ol and butan-2-ol.

____

____

____

____ [4]

(iii) Name a reagent you could use to distinguish between isomers **A** and **B**. Include any observations that occur when it is reacted with **A** and **B**.

____

____

____

____ [3]

(c) Butan-1-ol has potential as a biofuel, which is an alternative fuel.

(i) Suggest why butan-1-ol can be considered as an alternative fuel.

____

____ [1]

(ii) The equation for the combustion of butan-1-ol is given below.

$$C_4H_9OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(g)$$

Use the standard enthalpies of formation given in the table below to calculate the standard enthalpy of combustion for butan-1-ol.

	Standard enthalpy of formation kJ mol^{-1}
Butan-1-ol	−327
Carbon dioxide	−394
Water	−286

____

____

____ [3]

(iii) What are the conditions used for measuring standard enthalpies of formation?

____

____ [2]

(iv) Why is no value given for the standard enthalpy of formation of oxygen?

____ [1]

(d) Ethanol can also be used as a biofuel. The enthalpy of combustion of ethanol can be calculated using bond enthalpies.

(i) Explain what is meant by the term **bond enthalpy**.

____

____

____ [2]

(ii) Use the bond enthalpies given in the table below to calculate the enthalpy of combustion of ethanol.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

Bond	**Bond enthalpy $kJ\,mol^{-1}$**
C—C	+347
C—H	+413
C—O	+358
O—H	+464
O=O	+498
C=O	+805

____

____

____

____ [3]

(iii) Using experimental data the standard enthalpy of combustion of ethanol is found to be $-1407\,kJ\,mol^{-1}$.
Explain the difference between this value and that obtained using bond enthalpies.

____

____ [1]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2012

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

TUESDAY 19 JUNE, AFTERNOON

MARK SCHEME

Section A

1 D

2 D

3 B

4 B

5 D

6 D

7 B

8 C

9 D

10 A

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

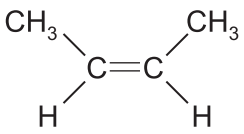
11	**(a)**	**(i)**	Moles of salicylic acid = 3/138 = 0.0217	[1]	
		(ii)	Mass of ethanoic anhydride = 1.08 × 6 = 6.48 (g)	[1]	
		(iii)	Moles of ethanoic anhydride = 6.48/102 = 0.0635	[1]	
		(iv)	0.0217 mole	[1]	
		(v)	0.0217 × 180 = 3.91(g)	[1]	
		(vi)	(3.08/3.91) × 100 = 78.8%	[1]	
	(b)	**(i)**	$\frac{\text{Mass of desired product}}{\text{Total mass of reactants}} \times 100$	[1]	
		(ii)	180/240 × 100 = 75%	[2]	9
12	**(a)**	**(i)**	Maxwell-Boltzmann distribution	[1]	
		(ii)	Same shape: peak to the right [1] peak lower [1]	[2]	
		(iii)	More of the molecules will have energy greater than the activation energy [1] More of the collisions will be successful [1]	[2]	
		(iv)	(The reaction is exothermic so) the equilibrium will move to the left (to reduce the temperature) [1] The yield of NO will decrease [1]	[2]	
	(b)	**(i)**	Increasing the pressure reduces the volume/the molecules are closer together/conc. increases [1] More collisions will increase the rate of the reaction [1]	[2]	
		(ii)	There are more molecules/greater volume of gas on the right hand side so equilibrium moves to the left to reduce the volume [1] Yield of NO decreases [1]	[2]	
	(c)	**(i)**	(The catalyst) provides (an alternative pathway of) lower activation energy [1] More of the collisions will be successful (and the rate of the reaction increases) [1]	[2]	
		(ii)	(The catalyst) speeds up the forward and reverse reactions equally [1] (There is no effect on the equilibrium so there is) no change in the yield of NO [1]	[2]	15

13 **(a)** **(i)** C=C contains sigma and pi bond [1]
C—C contains only a sigma bond [1]
C=C is stronger and shorter than C—C [1] [3]

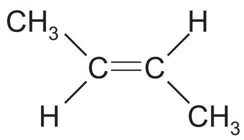
(ii) C=C is a centre of high electron density [1]
can undergo addition reactions/attracted by electrophiles [1] [2]

(iii) Add bromine water [1] * essential
changes colour from orange/brown/yellow [1]
to colourless [1] [3]

(b) **(i)**



Z



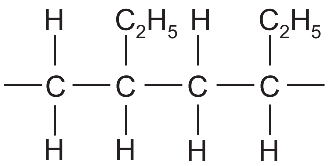
E

[1] for diagram [1] for labels [2]

(ii) No free rotation about the C=C [1]
Both C in C=C have two different atoms/gps attached [1] [2]

(c) **(i)** Addition [1]

(ii)



([–1] for each mistake) [2] 15

14 **(a)** $BaS + Na_2CO_3 \rightarrow BaCO_3 + Na_2S$ [1]

(b) **(i)** $BaCO_3 \rightarrow BaO + CO_2$ [1]

(ii) The coke burns to produce heat [1]

(iii) $BaCO_3$ is more stable [1]
Ba^{2+} is larger [1]
Less polarising/lower charge density [1]
(or converse) [3]

(iv) Dip (nichrome) wire in conc. HCl [1]
Dip in solid [1]
and hold in blue (Bunsen) flame [1]
Barium gives a green flame [1]
Calcium gives a brick red flame [1] [5]

Quality of written communication [2]

(c) Dissolve in water [1]
add Mg^{2+} ions(aq) [1] CO_3^{2-} forms white ppt [1]
or add Mg^{2+} ions(aq) [1] HCO_3^- no ppt formed [1] [3] 16

15	**(a)**	**(i)**	Warmth/heat [1] Absence of air/oxygen [1]/anaerobic	[2]	
		(ii)	(Fractional) distillation	[1]	
	(b)	**(i)**	**A**: (2-) methylpropan-1-ol [1] **B**: (2-) methylpropan-2-ol [1]	[2]	
		(ii)	Add iodine (solution) (I_2 dissolved in KI solution) [1] and NaOH solution [1] warm [1] butan-2-ol will form yellow crystals [1] antiseptic smell [1] any 4 from 5	[4]	
		(iii)	Add acidified potassium dichromate [1] A will turn the solution (from orange to) green [1] B no change [1]	[3]	
	(c)	**(i)**	Renewable/clean fuel/instead of a fossil fuel	[1]	
		(ii)	$\Delta H + (-327) = 4(-394) + 5(-286)$ $\Delta H = -1576 - 1430 + 327$ $\Delta H = -2679$ (kJ mol^{-1}) ([–1] for each mistake)	[3]	
		(iii)	1 atmosphere pressure [1] 298 K [1]	[2]	
		(iv)	Oxygen is an element	[1]	
	(d)	**(i)**	Energy required to break [1] one mole of a (covalent) bond [1]	[2]	
		(ii)	Bonds broken – Bonds formed (347 + 358 + 5(413) + 464 + 3(498)) – (4(805) + 6(464)) 4728 – 6004 = –1276 kJ ([–1] for each mistake)	[3]	
		(iii)	Bond enthalpies are average values (and so this value is only an estimate)	[1]	25
				Section B	**80**
				Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2013

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

WEDNESDAY 16 JANUARY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all sixteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all six** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **15(c)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following hydroxides is the most soluble in water?

- **A** Barium hydroxide
- **B** Calcium hydroxide
- **C** Magnesium hydroxide
- **D** Strontium hydroxide

2 How many structural isomers have the formula C_5H_{12}?

- **A** Two
- **B** Three
- **C** Four
- **D** Five

3 Which one of the following is a tertiary alcohol?

- **A** pentan-2-ol
- **B** pentan-3-ol
- **C** 2-methylpentan-1-ol
- **D** 2-methylpentan-2-ol

4 Propan-1-ol can be dehydrated to form propene:

$$CH_3CH_2CH_2OH \rightarrow CH_3CH{=}CH_2 + H_2O$$

30.0 g of propan-1-ol produces 16.8 g of propene. Which one of the following is the percentage yield?

- **A** 50.0
- **B** 60.0
- **C** 70.0
- **D** 80.0

Which one of the following metal chlorides gives a green colour in a flame test?

A $BaCl_2$

B $CaCl_2$

C KCl

D NaCl

6 Which one of the following is the mass of magnesium oxide required to neutralise 25.0 cm^3 of 0.1 mol dm^{-3} hydrochloric acid?

A 0.025 g

B 0.050 g

C 0.100 g

D 0.250 g

7 Which one of the following is the number of π (pi) bonds present in propene?

A One

B Two

C Three

D Six

8 Which one of the following is formed by the complete oxidation of propan-2-ol?

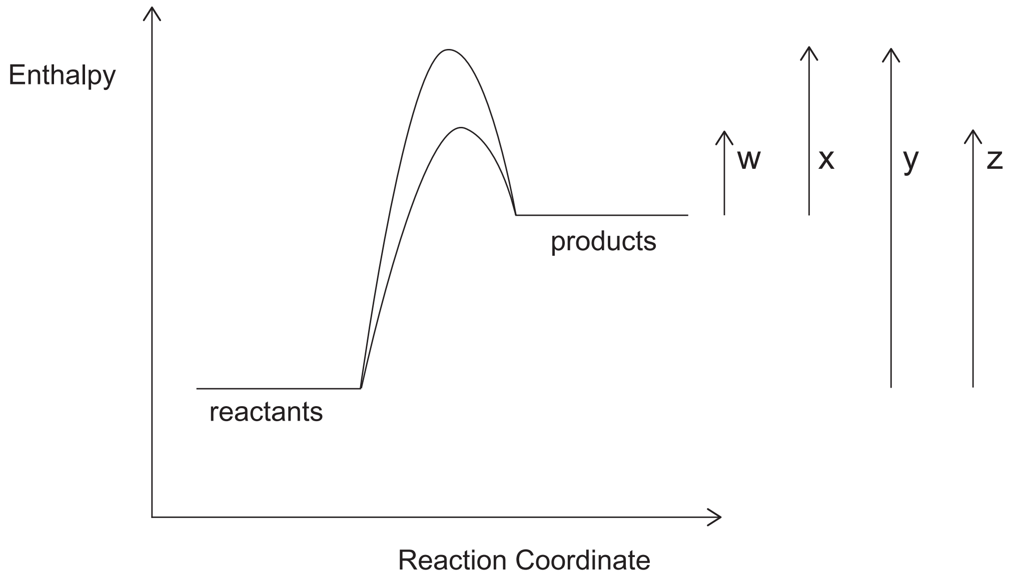
A a carboxylic acid

B a ketone

C a secondary alcohol

D an aldehyde

9 Which one of the following pairs of enthalpy changes shows how a catalyst works in an endothermic reaction?



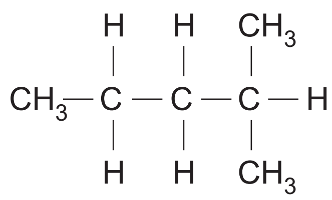
A w and x

B w and z

C x and y

D y and z

10 Which one of the following is the IUPAC name for the hydrocarbon shown below?



A 1,1-dimethylbutane

B 4,4-dimethylbutane

C 2-methylpentane

D 1,1,3-trimethylpropane

Section B

Answer **all six** questions in this section in the spaces provided.

11 An excess of methane reacts with chlorine, in the presence of light, to form chloromethane as the main product.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

(a) Name the type of mechanism for this reaction.

____ [2]

(b) Write an equation for the initiation step.

____ [1]

(c) Write **two** equations for the propagation steps.

____

____ [2]

(d) Write an equation for the termination step which results in the formation of ethane.

____

12 The empirical formula of a molecular covalent compound can be calculated using percentage composition by mass.

(a) Explain the term **empirical formula** as applied to a molecular covalent compound.

____

____ [1]

(b) Explain the term **molecular formula** as applied to a molecular covalent compound.

____

____ [1]

(c) An oxide of phosphorus contains 43.7% by mass of phosphorus. The relative molecular mass of the oxide is 284. This oxide reacts with sodium hydroxide to form sodium phosphate (Na_3PO_4) and water as the only products.

(i) Calculate the empirical and molecular formulae of the oxide.

____

____

____

____

____

empirical formula: ____

molecular formula: ____ [4]

(ii) Write an equation for the reaction of the oxide with sodium hydroxide.

____ [2]

13 3-methylpent-2-ene, $CH_3CH{=}C(CH_3)CH_2CH_3$, exists as stereoisomers.

(a) **(i)** Explain the meaning of the term **stereoisomers**.

____

____

____ [2]

(ii) Give **two** reasons why 3-methylpent-2-ene exists as stereoisomers.

____

____

____ [2]

(iii) Draw the E-isomer of 3-methylpent-2-ene.

[1]

(iv) Draw and name a structural isomer of 3-methylpent-2-ene which cannot form stereoisomers.

____ [2]

(b) 3-methylpent-2-ene is an unsaturated hydrocarbon. It can be converted into a saturated hydrocarbon by catalytic hydrogenation.

(i) Name the catalyst used in the hydrogenation reaction and describe its state.

____ [2]

(ii) Write an equation for the reaction and use it to calculate the percentage atom economy for the equation.

____

____

____ [2]

(c) 3-methylpent-2-ene can undergo addition polymerisation. Draw a section of the resulting polymer chain showing **two** repeating units.

[1]

14 Recently chemists have developed alternatives to fossil fuels. Ethanol obtained from a biological source may have a significant role to play, e.g. some of the petrol sold in the UK and Ireland contains up to 10% ethanol. In Brazil the percentage is even higher.

(a) The standard enthalpy of combustion of ethanol can be calculated using Hess's Law.

(i) State Hess's Law.

____

____ [2]

(ii) Define the term **standard enthalpy of combustion**.

____

____

____ [2]

(iii) Use the standard enthalpies of formation given in the table below to calculate the standard enthalpy of combustion of ethanol.

Compound	$\Delta H_f^{\ominus}$/kJ mol^{-1}
$C_2H_5OH(l)$	-277
$CO_2(g)$	-394
$H_2O(l)$	-286

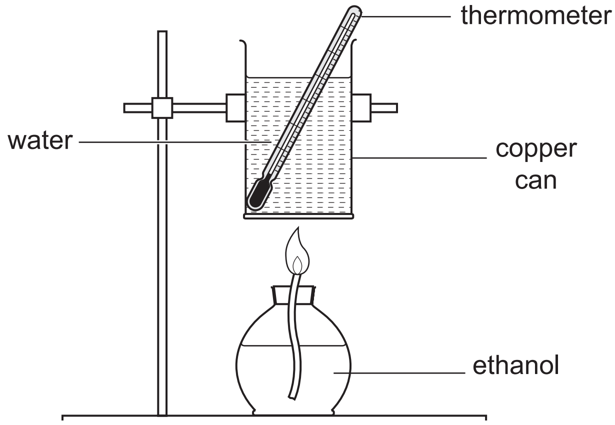
$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

____

____

____ [3]

(b) The enthalpy of combustion for ethanol can also be obtained experimentally by using the apparatus shown below:



The results of the experiment are summarised in the table below:

Mass of water in the copper can	200.0 g
Mass of spirit burner + ethanol (before burning)	150.0 g
Mass of spirit burner + ethanol (after burning)	148.6 g
Initial temperature of water	18.0 °C
Final temperature of water	42.0 °C

(i) Calculate the heat energy released by the combustion of the ethanol using the equation:

heat energy released (J) = mass of water × 4.18 × temperature rise

____

____ [1]

(ii) Calculate the enthalpy of combustion of ethanol in kJ mol^{-1}.

heat energy released (in kJ) ___________________________

moles of ethanol ___________________________

enthalpy of combustion ___________________________ [3]

(iii) State **two** reasons to explain the difference between this experimental value and the theoretical value obtained in **(a)(iii)**.

____

____

____ [2]

15 Group II carbonates and nitrates decompose when heated. Magnesium carbonate decomposes to form magnesium oxide and carbon dioxide. Magnesium nitrate forms magnesium oxide, nitrogen(IV) oxide and oxygen.

(a) (i) Write an equation for the decomposition of magnesium nitrate.

____ [2]

(ii) Suggest whether or not strontium nitrate would be more or less stable than magnesium nitrate when heated. Explain your reasoning.

____

____

____ [2]

(b) Nitrogen(IV) oxide is a brown gas which can form the colourless gas, dinitrogen tetroxide, N_2O_4, in a dynamic equilibrium.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -58\ kJ\,mol^{-1}$$

(i) Explain the term **dynamic equilibrium**.

____

____ [2]

(ii) What is observed when the pressure on the equilibrium mixture is increased? Explain your answer.

____

____

____ [3]

(iii) What is observed when the equilibrium mixture is cooled? Explain your answer.

____

____

____ [3]

(c) Describe how a solution of magnesium nitrate can be used to distinguish between solid samples of potassium carbonate and potassium hydrogencarbonate. Give experimental details, observations and include an ionic equation, with state symbols, for any reaction which occurs.

____

____

____

____

____

____

____

____ [4]

Ionic equation

____ [2]

Quality of written communication [2]

(d) Sodium nitrate decomposes when heated to produce sodium nitrite and oxygen:

$$2NaNO_3 \rightarrow 2NaNO_2 + O_2$$

Calculate the volume of oxygen produced, at 20 °C and a pressure of 1 atmosphere, when 4.25 g of sodium nitrate decomposes.

Moles of sodium nitrate

____ [1]

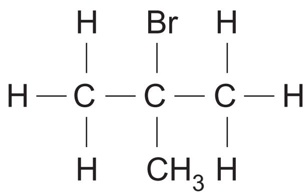
Moles of oxygen produced

____ [1]

Volume of oxygen, cm^3

____ [1]

16 2-bromo-2-methylpropane is a tertiary halogenoalkane.



(a) What is the general formula for a bromoalkane?

[1]

(b) Why is 2-bromo-2-methylpropane classified as a tertiary halogenoalkane?

[2]

(c) 2-bromo-2-methylpropane reacts with aqueous potassium hydroxide to produce a tertiary alcohol.

(i) Name the type of mechanism for this reaction.

[1]

(ii) Write an equation for the first step in the mechanism.

[1]

(iii) Draw the structure of the organic product in the first step.

[1]

(iv) Write an equation for the second step in the mechanism.

[1]

(d) How could infrared spectroscopy be used to distinguish between 2-bromo-2-methylpropane and the tertiary alcohol produced in this reaction?

____

____

____ [2]

(e) 2-bromo-2-methylpropane reacts with ethanolic potassium hydroxide to produce a different product.

(i) Write an equation for this reaction.

____ [2]

(ii) Name the organic product.

____ [1]

(iii) Name the type of reaction.

____ [1]

(f) 1-bromobutane is a structural isomer of 2-bromo-2-methylpropane.

(i) Define the term **structural isomer**.

____

____ [2]

(ii) State, giving reasons for your choice, which of these two compounds would be expected to have the higher boiling point.

____

____

____

____ [3]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2013

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

WEDNESDAY 16 JANUARY, MORNING

MARK SCHEME

Section A

1	A
2	B
3	D
4	D
5	A
6	B
7	A
8	B
9	D
10	C

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11 **(a)** free radical [1]
substitution [1] [2]

(b) $Cl_2 \rightarrow 2\,Cl^\bullet$ [1]

(c) $CH_4 + Cl^\bullet \rightarrow CH_3^\bullet + HCl$ [1]
$CH_3^\bullet + Cl_2 \rightarrow CH_3Cl + Cl^\bullet$ [1]

(d) $CH_3^\bullet + CH_3^\bullet \rightarrow C_2H_6$ [1] 6

12 **(a)** A formula which shows the simplest whole number ratio of atoms of each element in a compound [1]

(b) A formula which shows the actual number of atoms of each element in a molecule [1]

(c) **(i)**

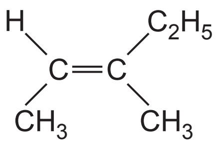
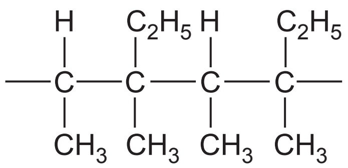
P	O
43.7	56.3
1.410	3.519
1	2.5
2	5

empirical formula P_2O_5

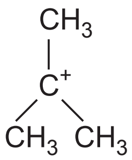
$284 \div 142 = 2$

molecular formula P_4O_{10} [4]

(ii) $12NaOH + P_4O_{10} \rightarrow 4Na_3PO_4 + 6H_2O$ [2] 8

13	**(a)**	**(i)**	Same structural formula	[1]		
			Different arrangement in (3D) space – dependent on first statement	[1]	[2]	
		(ii)	Restricted rotation about C═C	[1]		
			Both carbons in C═C have 2 different atoms/groups attached	[1]	[2]	
		(iii)			[1]	
		(iv)	e.g. $CH_2 = CH(CH_2)_3CH_3$	[1]		
			Correct name, e.g. hex-1-ene	[1]	[2]	
	(b)	**(i)**	Finely divided	[1]		
			nickel	[1]	[2]	
		(ii)	$C_6H_{12} + H_2 \rightarrow C_6H_{14}$	[1]		
			100%	[1]	[2]	
	(c)				[1]	12
14	**(a)**	**(i)**	Enthalpy change	[1]		
			independent of route taken	[1]	[2]	
			(provided the initial and final conditions are the same)			
		(ii)	Enthalpy change when one mole of a substance is completely burnt in oxygen under standard conditions		[2]	
		(iii)	$[(2 \times -394) + (3 \times -286)] - [(-277)]$			
			$-1646 + 277 = -1369$ kJ mol^{-1}		[3]	
	(b)	**(i)**	20064 J		[1]	
		(ii)	20.064 kJ	[1]		
			moles of ethanol = 0.0304	[1]		
			-659 kJ mol^{-1}	[1]	[3]	
		(iii)	heat lost to surroundings	[1]		
			Incomplete combustion	[1]	[2]	13

15	**(a)**	**(i)**	$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$		[2]	
		(ii)	More stable	[1]		
			Sr^{2+} is larger than Mg^{2+}/less polarising/smaller charge density	[1]	[2]	
	(b)	**(i)**	Rate of forward reaction = rate of backward reaction	[1]		
			Amount of any given reactant or product remains constant	[1]	[2]	
		(ii)	Brown to colourless	[1]		
			2 moles (g) on LHS 1 mole (g) on RHS	[1]		
			Equilibrium shifts to RHS to reduce pressure	[1]	[3]	
		(iii)	Brown to colourless	[1]		
			(forward) reaction is exothermic	[1]		
			equilibrium shifts to RHS (to increase temperature)	[1]	[3]	
	(c)		Dissolve samples in water	[1]		
			Add solution of magnesium nitrate to each	[1]		
			Solution of potassium carbonate – white [1] precipitate [1]	[1]		
			Solution of potassium hydrogencarbonate – no ppt	[1]	[4]	
			Any 4 from 5			
			$Mg^{2+}(aq) + CO_3^{2-}(aq) \rightarrow MgCO_3(s)$		[2]	
			Quality of written communication		[2]	
	(d)		0.050		[1]	
			0.025		[1]	
			600		[1]	23

16	**(a)**	$C_nH_{2n+1}Br$		[1]	
	(b)	Three carbons (directly) attached to the same carbon as Br	[1] [1]	[2]	
	(c)	**(i)** Nucleophilic substitution		[1]	
		(ii) $(CH_3)_3CBr \rightarrow (CH_3)_3C^+ + Br^-$		[1]	
		(iii) 		[1]	
		(iv) $(CH_3)_3C^+ + OH^- \rightarrow (CH_3)_3COH$		[1]	
	(d)	Absence of O–H absorption	[1] [1]	[2]	
	(e)	**(i)** $(CH_3)_3CBr + KOH \rightarrow CH_2{=}C(CH_3)_2 + H_2O + KBr$		[2]	
		(ii) 2–methylpropene or methylpropene		[1]	
		(iii) Elimination		[1]	
	(f)	**(i)** Same molecular formula Different structural formula	[1] [1]	[2]	
		(ii) 1-bromobutane No branching/greater contact between molecules Greater van der Waals forces	[1] [1] [1]	[3]	18
				Section B	**80**
				Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2013

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

WEDNESDAY 19 JUNE, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all five** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **12(c)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of the Elements, containing some data, is included in this question paper.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following compounds has the highest boiling point?

A 2,3-dimethylbutane

B Hexane

C 2-methylpentane

D 3-methylpentane

2 When a solution of potassium chromate is added to a solution containing barium ions

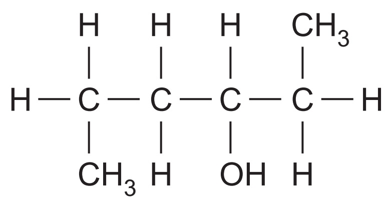
A a yellow precipitate forms.

B a white precipitate forms.

C an orange to green colour change occurs.

D the potassium chromate solution remains orange.

3 Which one of the following is the name of the alcohol below?



A 1,4-dimethylbutan-2-ol

B 1,4-dimethylbutan-3-ol

C Hexan-3-ol

D Hexan-4-ol

4 Methane reacts with excess chlorine to form tetrachloromethane.

$$CH_4 + 4Cl_2 \rightarrow CCl_4 + 4HCl$$

Which one of the following is the atom economy for the formation of CCl_4?

A 25.7%

B 44.2%

C 51.3%

D 80.8%

5 Which one of the following is a tertiary alcohol?

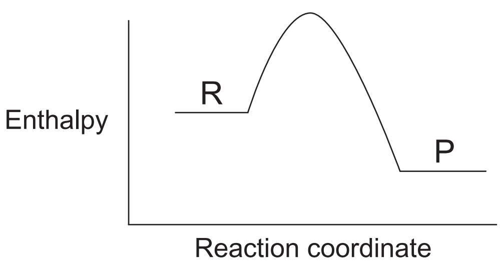
A 2-methylbutan-2-ol

B 2-methylbutan-3-ol

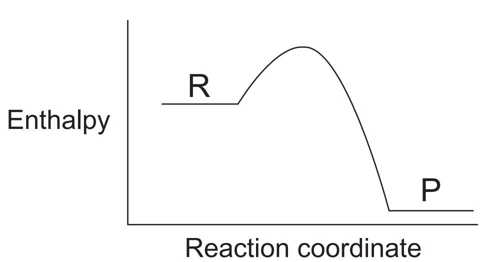
C Pentan-2-ol

D Pentan-3-ol

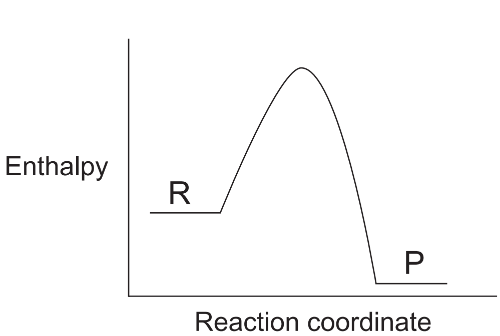
6 Which one of the following reaction profiles represents a reaction for which the enthalpy change is numerically greater than the activation energy?



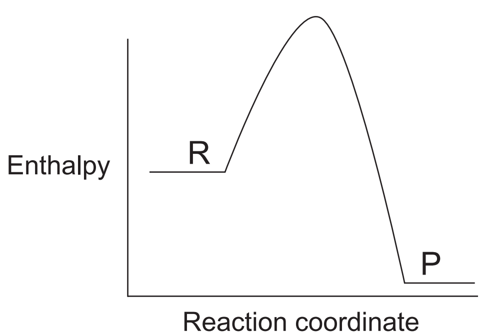
A



B

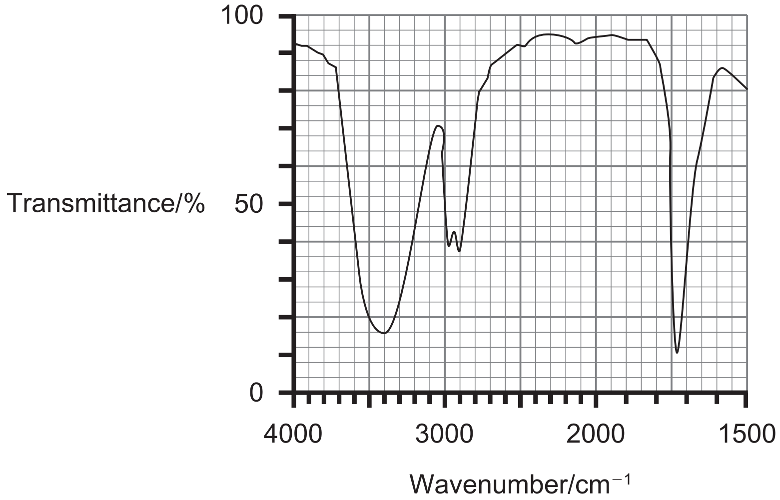


C



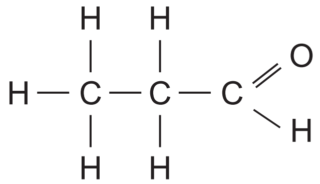
D

7 Which one of the following molecules produces the infrared spectrum shown below?

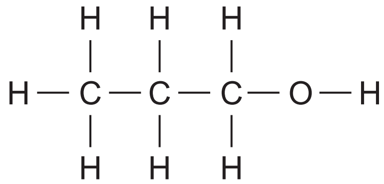


Bond	**Wavenumber (cm^{-1})**
O — H (alcohols)	3200–3700 strong broad
C — H	2700–3300 medium sharp
O — H (carboxylic acids)	2500–3200 strong broad
C ═ O	1680–1780 strong sharp

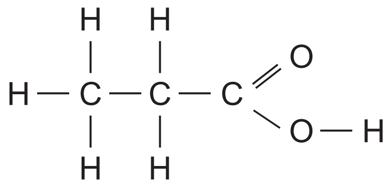
A



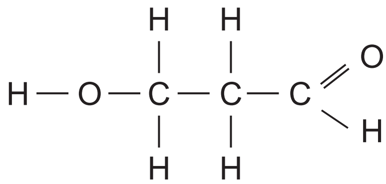
B



C



D



8 Which one of the following alkenes may be formed when 3-bromo-2-methylpentane reacts with ethanolic potassium hydroxide?

A 1,1-dimethylbut-1-ene

B 2-methylpent-3-ene

C 4-methylpent-2-ene

D 4-methylpent-3-ene

9 The standard enthalpies of combustion of carbon (C), hydrogen (H_2) and propane (C_3H_8) are -394, -286 and $-2219\,kJ\,mol^{-1}$ respectively. Which one of the following is the standard enthalpy of formation of propane in $kJ\,mol^{-1}$?

A -1539

B -107

C $+107$

D $+1539$

10 Which one of the following alcohols can be oxidised to form a ketone?

A Butan-1-ol

B Butan-2-ol

C 2-methylpropan-1-ol

D 2-methylpropan-2-ol

Section B

Answer **all five** questions in this section.

11 The elements in Group II of the Periodic Table, from magnesium to barium, have similar chemical properties and are known as the alkaline earth metals.

(a) The s-block of the Periodic Table consists of the elements in Groups I and II.

(i) Give the electronic configuration of a calcium atom.

____ [1]

(ii) In terms of electronic configuration, what do s-block elements have in common?

____

____ [1]

(iii) Write an equation, including state symbols, to represent the first ionisation energy of calcium.

____ [2]

(iv) State and explain the trend in the first ionisation energies as Group II is descended.

____

____

____ [3]

(b) Magnesium reacts vigorously with both hydrochloric and sulfuric acids to form solutions of magnesium chloride and magnesium sulfate.

(i) Write the equation for the reaction of magnesium with hydrochloric acid.

____ [2]

(ii) State **two** observations when this reaction is carried out.

____

____ [2]

(iii) Name a reagent which can be used to distinguish between solutions of magnesium chloride and magnesium sulfate.

____ [1]

(iv) What is observed when this reagent is added to each solution?

____

____ [2]

(v) Write the ionic equation, including state symbols, for any reaction which occurs when the reagent named in **(iii)** above is used.

____ [2]

(c) The hydroxides and sulfates of Group II show significant variations in solubility.

(i) Give the formula of the most soluble Group II hydroxide.

____ [1]

(ii) Give the formula of the least soluble Group II sulfate.

____ [1]

(iii) State and explain the trend in the thermal stability of the hydroxides as Group II is descended.

____

____

____ [2]

(iv) Write the equation for the thermal decomposition of magnesium hydroxide.

____ [1]

(d) The elements in Group II react with water.

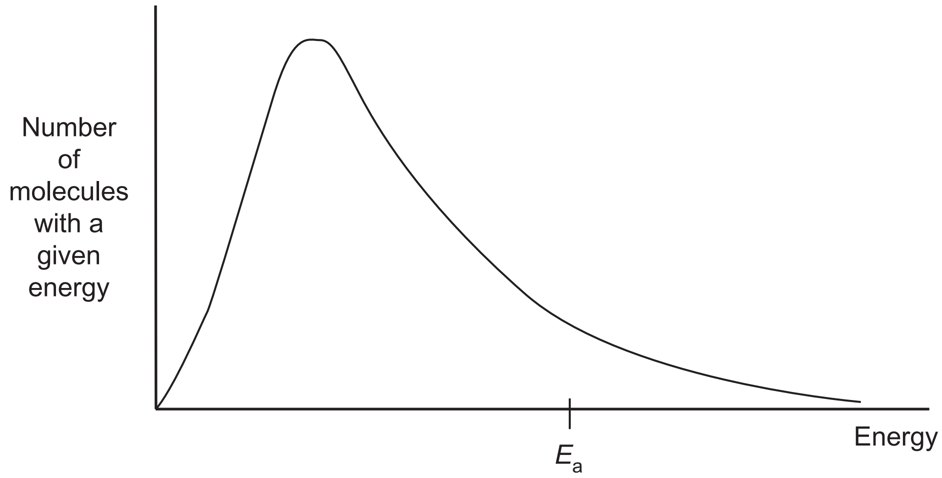
(i) State the trend in reactivity with water of the elements from magnesium to barium.

____ [1]

(ii) Write the equation for the reaction of barium with water.

____ [2]

12 The diagram shows a Maxwell–Boltzmann distribution curve for a mixture of sulfur dioxide and oxygen at temperature T.
E_a = activation energy



(a) On the diagram, sketch the distribution curve for the same mixture at a higher temperature. [2]

(b) Use these distribution curves to explain why the reaction between sulfur dioxide and oxygen is faster at the higher temperature.

____

____ [2]

(c) Use the distribution curve to explain the role of a catalyst and why the reaction between sulfur dioxide and oxygen is faster in the presence of a catalyst.

____

____

____

____

____

____

____ [4]

Quality of written communication [2]

13 There are several compounds with the molecular formula C_6H_{12}. The molecules present in these compounds are described as structural isomers. Some compounds, with molecular formula C_6H_{12}, exist as geometric isomers.

(a) What are **structural isomers**?

____

____ [2]

(b) Give the name and structural formula for an isomer of C_6H_{12} which does not exist as a geometric isomer.

____ [2]

(c) **(i)** What are **geometric isomers**?

____

____ [2]

(ii) Name an isomer of C_6H_{12} which exists as geometric isomers.

____ [1]

(iii) Give **two** reasons why this isomer exists as geometric isomers.

____

____

____ [2]

(iv) Draw the **two** geometric isomers and identify the Z isomer.

[3]

(d) Give the empirical formula of all the compounds with molecular formula C_6H_{12}.

____ [1]

14 Ethene reacts with steam in a reversible reaction to form ethanol:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

The reaction establishes a position of dynamic equilibrium.

(a) What is meant by the term **dynamic equilibrium**?

____

____ [2]

(b) Use the following average bond enthalpy values to calculate the enthalpy change for the reaction.

Bond	**Average Bond Enthalpy ($kJ\,mol^{-1}$)**
C — C	347
C ═ C	612
C — H	413
C — O	358
O — H	464

____

____

____

____ [3]

(c) (i) State and explain the effect of an increase in pressure on the yield of ethanol.

____

____ [2]

(ii) State and explain the effect of an increase in temperature on the yield of ethanol.

____

____

____

____ [2]

(iii) State the effect of using a catalyst on the yield of ethanol.

____ [1]

(d) State the conditions and a catalyst used in the industrial production of ethanol from ethene and steam.

____

____ [3]

(e) Assuming an 80% yield, what mass of ethene would be required to produce 460 kg of ethanol?

____

____

____ [3]

15 Methylpropene reacts with hydrogen bromide to form two products, the major product being 2-bromo-2-methylpropane.

(a) Hydrogen bromide is a polar molecule.

(i) Using the diagram below, show the polarity of the hydrogen bromide molecule.

H — Br

[1]

(ii) Use the polarity of the hydrogen bromide molecule to explain why it is attracted to methylpropene molecules.

____

____ [2]

(b) The formation of 2-bromo-2-methylpropane occurs in two steps.

(i) Write an equation for the first step of the mechanism showing the structure of the intermediate.

____ [2]

(ii) Write an equation for the second step of the mechanism showing the structure of 2-bromo-2-methylpropane.

____ [1]

(iii) Name the mechanism of the reaction.

____ [1]

(iv) Suggest the name of the minor product.

____ [1]

(c) Methylpropene is an unsaturated hydrocarbon.

(i) What is an **unsaturated hydrocarbon**?

____

____ [2]

(ii) Calculate the volume of hydrogen gas, measured at 20 °C and one atmosphere pressure, required to saturate 4.2 g of methylpropene.

____

____

____ [3]

(d) Under suitable conditions, methylpropene can be converted into poly(methylpropene).

(i) Name the type of reaction occurring.

____ [2]

(ii) Draw the structure of poly(methylpropene) showing three repeating units.

____ [2]

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2013

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

WEDNESDAY 19 JUNE, MORNING

MARK SCHEME

Section A

1	B
2	A
3	C
4	C
5	A
6	B
7	D
8	C
9	B
10	B

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11	**(a)**	**(i)**	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$		[1]	
		(ii)	Highest energy electron in an s-subshell		[1]	
		(iii)	$Ca(g) \rightarrow Ca^+(g) + e^-$		[2]	
		(iv)	Decreases Electron further from nucleus/higher in energy More shielded	[1] [1] [1]	[3]	
	(b)	**(i)**	$Mg + 2HCl \rightarrow MgCl_2 + H_2$		[2]	
		(ii)	Magnesium gets smaller/disappears Heat produced Bubbles/fizz/effervescence Any **two** from three		[2]	
		(iii)	Barium chloride (**or** silver nitrate) (aq)		[1]	
		(iv)	White precipitate with magnesium sulfate No precipitate with magnesium chloride (**or** opposite way round with silver nitrate)	[1] [1]	[2]	
		(v)	$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ **Or** $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$		[2]	
	(c)	**(i)**	$Ba(OH)_2$		[1]	
		(ii)	$BaSO_4$		[1]	
		(iii)	Increases Cation gets bigger/charge density of cation decreases	[1] [1]	[2]	
		(iv)	$Mg(OH)_2 \rightarrow MgO + H_2O$		[1]	
	(d)	**(i)**	Increases		[1]	
		(ii)	$Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$		[2]	24
12	**(a)**		Peak shifts to right and peak is lower Other drawing errors [–1]		[2]	
	(b)		Number of molecules with energy greater than E_a increases	[1] [1]	[2]	
	(c)		Catalyst provides an alternative route of lower activation energy E_a More molecules have energy greater than E_a Number/frequency of successful collisions (between SO_2 and O_2 molecules) increases	[1] [1] [1] [1]	[4]	
			Quality of written communication		[2]	10

13 **(a)** Same molecular formula [1]
Different structural formula [1] [2]

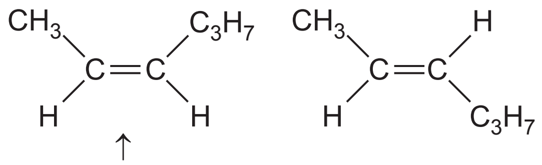
(b) Correct structure, e.g. $CH_2{=}CH_2(CH_2)_3CH_3$ [1]
Correct name, e.g. hex-1-ene [1] [2]

(c) **(i)** Same structural formula [1]
Non-superimposable/different 3D spatial arrangement [1] [2]

(ii) e.g. hex-2-ene, hex-3-ene, 3-methylpent-2-ene,
4-methylpent-2-ene [1]

(iii) Restricted rotation about C=C [1]
Both carbons in the C=C have two different atoms/groups attached [1] [2]

(iv)



Z

[2]
Correct identification of Z isomer [1] [3]

(d) CH_2 [1] 13

14 **(a)** Rate of forward reaction = rate of backward reaction [1]
Amount of any given reactant or product remains constant [1] [2]

(b) Bonds broken 3192
Bonds formed 3234
Enthalpy change $-42\ kJ\,mol^{-1}$ [3]

(c) **(i)** Increases [1]
2 moles of gas on LHS, 1 mole of gas on RHS [1] [2]

(ii) Decreases [1]
Reaction is exothermic [1] [2]

(iii) No effect [1]

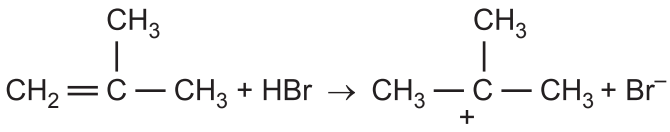
(d) 330 °C/(300–400 °C) [1]
60 atm/(50–75 atm) [1]
Phosphoric acid/H_3PO_4 [1] [3]

(e) Moles of ethanol = 10 000 moles (actual yield)
Moles of ethene = 12 500 moles (theoretical yield)
Mass of ethene = 350 kg units needed [3]
Each error [–1] 16

15 (a) (i) $\overset{\delta+}{H}-\overset{\delta-}{Br}$ [1]

(ii) C=C centre of high electron density [1]
H end of HBr is electrophilic [1] [2]

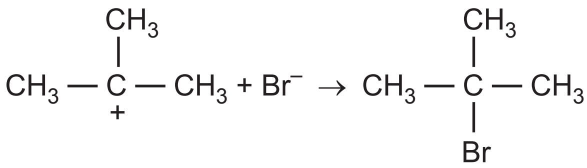
(b) (i)



[1]

Correct structure for carbocation [1] [2]

(ii)



[1]

(iii) Electrophilic addition [1]

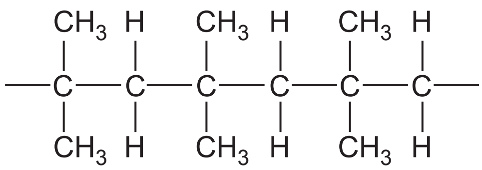
(iv) 1-bromo-2-methylpropane [1]

(c) (i) Contains hydrogen and carbon only [1]
Contains a C=C/C≡C [1] [2]

(ii) Moles of methylpropene = $\frac{4.2}{56}$ = 0.075
Moles of hydrogen = 0.075
Volume of hydrogen = 1.8 dm^3 [3]
each error [–1]

(d) (i) Addition [1]
polymerisation [1] [2]

(ii)



[2] 17

Section B	**80**
Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2014

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

THURSDAY 16 JANUARY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all five** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **11(d)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of the Elements, containing some data, is included in this question paper.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 A solution of an unknown solid when sprayed into the blue flame of a Bunsen burner produced a crimson colour. When silver nitrate solution was added to this solution a white precipitate was observed. The solution contained

A calcium chloride.

B calcium sulfate.

C lithium chloride.

D lithium sulfate.

2 Which one of the following can act as a free radical?

A Cl

B Cl^-

C Cl^+

D Cl_2

3 Propan-2-ol is produced from the reaction of propene and steam. Assuming a 65% yield, which one of the following is the mass of propene required to produce 390 g of propan-2-ol?

A 253.5 g

B 273.0 g

C 420.0 g

D 600.0 g

4 Which one of the following is the molecular formula of methyl propanoate?

A $CH_3CH_2COOCH_3$

B C_2H_4O

C $C_4H_8O_2$

D $HCOOCH_2CH_2CH_3$

5 Which one of the following reagents could be used to distinguish between propan-1-ol and propan-2-ol?

A Acidified potassium dichromate

B Alkaline iodine

C Ethanoic acid

D Thionyl chloride

6 Which one of the following is the atom economy for the production of iron in the Thermite Process?

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$$

A 25.2%

B 26.2%

C 50.1%

D 52.3%

7 Which one of the following sets of observations is **not** correct for the addition of dilute ammonia solution to a solution of the metal ion?

	metal ion solution	**addition of drops of dilute ammonia solution**	**addition of excess dilute ammonia solution**
A	Al^{3+}	precipitate formed	precipitate remains
B	Cu^{2+}	precipitate formed	precipitate remains
C	Mg^{2+}	precipitate formed	precipitate remains
D	Zn^{2+}	precipitate formed	precipitate redissolves

Which one of the following alkenes will exhibit *cis* and *trans* (E-Z) isomerism?

A $(CH_3)_2C{=}CH_2$

B $CH_3CH{=}CHCH_3$

C $H_2C{=}CHCl$

D $C_2H_5(CH_3)C{=}C(CH_3)_2$

9 Using the bond enthalpies below calculate which one of the following is the enthalpy of combustion of propane.

bond	bond enthalpy/kJ mol^{-1}
C — C	347
C — H	413
O — H	464
O ═ O	498
C ═ O	805

A -198 kJ mol^{-1}

B -361 kJ mol^{-1}

C -1707 kJ mol^{-1}

D -2054 kJ mol^{-1}

10 Which one of the following compounds will produce equal volumes of carbon dioxide and water vapour when burnt completely in oxygen?

A C_2H_2

B C_2H_4

C C_2H_6

D C_2H_5OH

Section B

Answer **all five** questions in the spaces provided.

11 Barium oxide is formed by the thermal decomposition of barium carbonate.

(a) **(i)** Write an equation for the decomposition of barium carbonate.

____ [1]

(ii) Explain why calcium carbonate will decompose at a lower temperature than barium carbonate.

____

____

____

____ [3]

(b) Barium oxide can also be formed from the combustion of barium. What colour is the flame when barium is burned?

____ [1]

(c) Barium hydroxide can be formed from barium oxide.

(i) How would you convert barium oxide into barium hydroxide?

____ [1]

(ii) State the trend in solubility of the Group II hydroxides.

____ [1]

(iii) Write an equation for the reaction between barium hydroxide and sulfuric acid.

____ [1]

(iv) What colour is the solid product in the reaction in part **(c)(iii)**?

____ [1]

(d) Describe tests, other than a flame test, to confirm the presence of barium ions and carbonate ions in separate solutions.

____

____

____

____

____

____ [4]

Quality of written communication [2]

12 Paraffin wax is a mixture of alkanes containing 20–40 carbon atoms. The alkane with 20 carbon atoms is known as icosane.

(a) **(i)** What is the general formula for an alkane?

______________________________ [1]

(ii) What is the molecular formula of icosane?

______________________________ [1]

(iii) Alkanes are **saturated**. What does this term mean?

______________________________ [1]

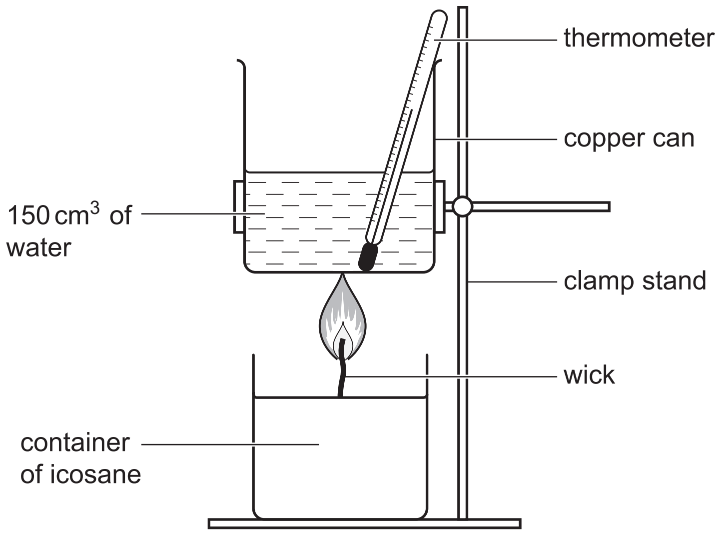
(b) Explain why icosane is a solid at room temperature whereas ethane is a gas.

____

____

______________________________ [2]

(c) A calorimeter is set up as shown in the diagram below using a container of icosane with a wick in it. A student carried out an experiment and recorded all measurements in a table.



(i) Complete the table.

Initial mass of icosane	26.2 g
Final mass of icosane	25.3 g
Mass of icosane burned	
Initial water temperature	19 °C
Final water temperature	80 °C
Temperature change	
Mass of water	150 g

[1]

(ii) Use the following headings to calculate the enthalpy of combustion of icosane (RMM = 282).

Calculate the number of moles of icosane burned.

____ [1]

Calculate the amount of heat energy in joules transferred to the water as the icosane is burned (the specific heat capacity of water is $4.18\,J\,g^{-1}\,°C^{-1}$).

____

____ [1]

Calculate the enthalpy of combustion of icosane in $kJ\,mol^{-1}$.

____

____

____ [3]

(iii) Give one practical reason why the experimental value you calculated is significantly different from a value quoted in a data book.

____

____ [1]

(d) Icosane needs a plentiful supply of air to burn completely.

(i) Write an equation for the complete combustion of icosane.

____ [2]

(ii) Give the chemical formula of a different compound that is formed in the incomplete combustion of icosane.

____ [1]

13 A catalytic converter is a device in a car exhaust system in which a catalyst is spread thinly over a honeycomb structure.

(a) Explain, in terms of energy, what is meant by the term **catalyst**.

____

____ [2]

(b) The following equilibrium reaction takes place in a catalytic converter.

$$2CO + 2NO \rightleftharpoons 2CO_2 + N_2 \qquad \Delta H = -745\,kJ\,mol^{-1}$$

(i) State and explain the effect of a decrease in temperature on the above equilibrium.

____

____ [2]

(ii) State and explain the effect of an increase in pressure on the above equilibrium.

____

____ [2]

(iii) Use the following headings to calculate the total volume of gas produced when 5.6 g of carbon monoxide passes through a catalytic converter.

Relative molecular mass of carbon monoxide

____

Number of moles of carbon monoxide

____

Number of moles of gas produced

____

Volume of gas produced

____ [4]

(c) Explain why cars fitted with catalytic converters must not be fuelled with leaded petrol.

____

____ [1]

14 Ethanol is the main alcohol found in alcoholic drinks. It is produced by the fermentation of sugars.

(a) Ethanol is a **primary** alcohol. What does this term mean?

____

____ [1]

(b) State **one** effect of alcohol on an individual's ability to drive.

____

____ [1]

(c) Early breathalysers involved the motorist blowing into a tube containing crystals of potassium dichromate mixed with concentrated sulfuric acid.

(i) What colour change occurs when acidified potassium dichromate reacts with ethanol?

____ [2]

(ii) Write an equation for the oxidation of ethanol using [O] to represent the acidified potassium dichromate.

____ [2]

(d) In the case of a positive breathalyser test the motorist is tested a second time using infrared spectroscopy.

(i) State and explain the effect of infrared radiation on molecules.

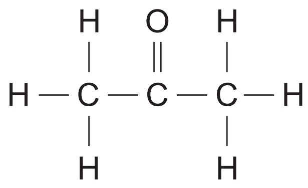
____

____

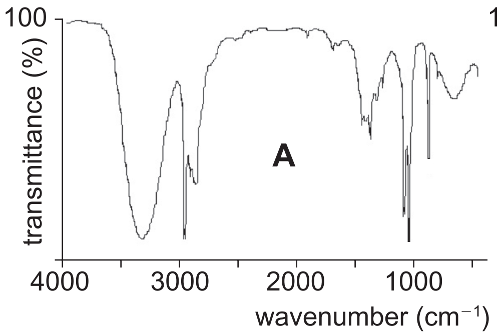
____ [2]

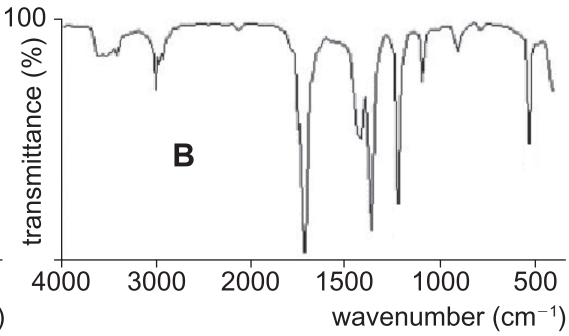
(ii) The infrared spectrum must be carefully read to distinguish between ethanol and propanone, which is found in the breath of diabetics. Use the data in the following table to determine which spectrum, A or B, is for ethanol. Explain your choice and refer to both spectra in your answer.

bond	wavenumber (cm^{-1})
C — H	2850–3300
C = O	1680–1750
C — O	1000–1100
O — H	3230–3550



propanone





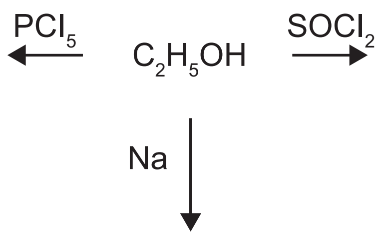
____

____

____

____ [3]

(e) Give the structure of the organic product formed when ethanol reacts with each of the following reagents.



(f) Ethanol reacts with propanoic acid in a dynamic equilibrium to form an ester according to the following equation.

$$C_2H_5OH \quad + \quad C_2H_5COOH \quad \rightleftharpoons \quad C_2H_5COOC_2H_5 \quad + \quad H_2O$$

(i) Name the ester that is formed in the reaction.

____ [1]

(ii) Name the catalyst used in the reaction.

____ [1]

(iii) Explain the term **dynamic equilibrium**.

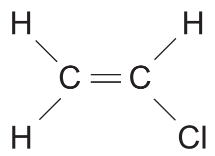
____

____ [2]

(iv) Suggest another reagent that could be used in place of propanoic acid to produce the same ester.

____ [1]

15 Vinyl chloride, CH_2CHCl, is an important compound as it is used to manufacture polyvinylchloride (PVC).



vinyl chloride

(a) The first stage in the production of vinyl chloride is the reaction of ethene with chlorine. The product from this reaction then undergoes thermal cracking to form vinyl chloride.

(i) Write an equation for the reaction of ethene with chlorine.

____ [1]

(ii) Name the product formed when ethene reacts with chlorine.

____ [2]

(iii) What is meant by the term **thermal cracking**?

____

____ [2]

(iv) When the product of the reaction in **(a)(i)** is thermally cracked to produce vinyl chloride what is the other product formed?

____ [1]

(v) What type of polymerisation is used to convert the monomer vinyl chloride to the polymer PVC?

____ [1]

(b) A by-product of PVC production is chloroethane.

(i) Draw a dot and cross diagram showing all the outer shell electrons in a chloroethane molecule.

[1]

(ii) Draw a flow scheme to show the mechanism for the reaction of hydrogen chloride with ethene which is similar to the reaction of hydrogen bromide with ethene.

[3]

(iii) What is the name given to this mechanism?

____ [2]

(iv) What type of covalent bond in ethene is broken during this reaction?

____ [1]

(c) Chloroethane can also be made by reacting chlorine with ethane in a reaction that is similar to that of chlorine with methane.

(i) Name the experimental condition required for this reaction to take place.

____ [1]

(ii) Write equations for the propagation steps for this reaction.

____

____ [2]

(iii) Name the alkane produced in a termination step of this reaction.

____ [1]

(d) Chloroethane will react with ammonia in solution. Write an equation for this reaction and name the organic product.

Equation ______________________________________ [1]

Name ____ [1]

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January 2014

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

THURSDAY 16 JANUARY, MORNING

MARK SCHEME

Section A

1 C

2 A

3 C

4 C

5 B

6 D

7 B

8 B

9 D

10 B

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11	(a)	(i)	$BaCO_3 \rightarrow BaO + CO_2$		[1]	
		(ii)	Ca^{2+} is smaller (than Ba^{2+})/Ca^{2+} has greater charge density	[1]		
			causes more polarisation of carbonate	[1]		
			so less heat is required to decompose	[1]	[3]	
	(b)		green (flame)		[1]	
	(c)	(i)	add water		[1]	
		(ii)	increases down Group		[1]	
		(iii)	$Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$		[1]	
		(iv)	white		[1]	
	(d)		add potassium chromate solution	[1]		
			yellow precipitate confirms barium ion	[1]		
			add magnesium ions solution	[1]		
			white precipitate confirms carbonate ion	[1]	[4]	
			Quality of written communication		[2]	15

12	(a)	(i)	C_nH_{2n+2}		[1]	
		(ii)	$C_{20}H_{42}$		[1]	
		(iii)	contains no $C = C$ or $C \equiv C$ bond		[1]	
	(b)		icosane has larger RMM/more electrons	[1]		
			and therefore stronger van der Waals forces	[1]	[2]	
	(c)	(i)	0.9 g 61 °C		[1]	
		(ii)	0.9/282 = 0.0032	[1]		
			$\Delta H = mc\Delta T = 150 \times 4.18 \times 61 = 38\,247$ J	[1]		
			$(38\,247/0.0032)/1000 = 11\,952$ kJ mol^{-1}	[2]		
			insertion of negative sign	[1]	[5]	
		(iii)	heat loss to surroundings/can is not insulated/incomplete combustion		[1]	
	(d)	(i)	$C_{20}H_{42} + 30.5\,O_2 \rightarrow 20\,CO_2 + 21\,H_2O$ **or** $2\,C_{20}H_{42} + 61\,O_2 \rightarrow 40\,CO_2 + 42\,H_2O$		[2]	
		(ii)	CO		[1]	15

13	**(a)**		it provides a different reaction pathway	[1]		
			of lower (activation) energy	[1]	[2]	
	(b)	**(i)**	equilibrium shifts to RHS	[1]		
			in exothermic direction/to produce heat	[1]	[2]	
		(ii)	equilibrium shifts to RHS	[1]		
			where there are fewer molecules	[1]	[2]	
		(iii)	28	[1]		
			0.2	[1]		
			0.3	[1]		
			$7.2\,dm^3$ ($7200\,cm^3$)	[1]	[4]	
	(c)		lead would poison/coat the surface of the catalyst		[1]	11
14	**(a)**		RCH_2OH/one alkyl group/other carbon bonded to the carbon which is bonded to the O—H		[1]	
	(b)		impaired judgment/slow reactions		[1]	
	(c)	**(i)**	orange [1] to green [1]		[2]	
		(ii)	$C_2H_5OH + [O] \rightarrow CH_3CHO + H_2O$		[2]	
			or $C_2H_5OH + 2[O] \rightarrow CH_3COOH + H_2O$			
	(d)	**(i)**	the molecule absorbs infrared radiation	[1]		
			and the bonds vibrate	[1]	[2]	
		(ii)	A is ethanol [1] because the peak for O—H/C—O is present	[1]		
			(B is) propanone as the peak for C═O is present	[1]	[3]	
	(e)		C_2H_5Cl [1] C_2H_5ONa [1] C_2H_5Cl [1]		[3]	
	(f)	**(i)**	ethyl propanoate		[1]	
		(ii)	concentrated sulfuric acid		[1]	
		(iii)	rate of forward reaction is equal to the rate of the backward reaction	[1]		
			amount of each reactant/product remains constant	[1]	[2]	
		(iv)	propanoyl chloride		[1]	19

15 (a) (i) $C_2H_4 + Cl_2 \rightarrow CH_2ClCH_2Cl$ (allow $C_2H_4Cl_2$ for product) [1]

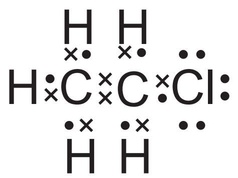
(ii) 1,2-dichloroethane [2]

(iii) using heat [1]
to break large molecules into smaller molecules [1] [2]

(iv) HCl/hydrogen chloride [1]

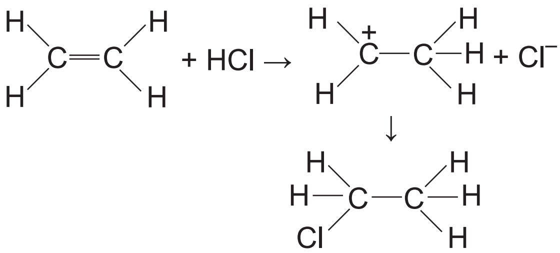
(v) addition [1]

(b) (i)



[1]

(ii) [3]



([–1] each error)

(iii) electrophilic [1] addition [1] [2]

(iv) pi/π [1]

(c) (i) ultraviolet light [1]

(ii) $C_2H_6 + Cl\bullet \rightarrow C_2H_5\bullet + HCl$ [1]

$C_2H_5\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl\bullet$ [1] [2]

(iii) butane [1]

(d) $C_2H_5Cl + 2NH_3 \rightarrow C_2H_5NH_2 + NH_4Cl$
or $C_2H_5Cl + NH_3 \rightarrow C_2H_5NH_2 + HCl$ [1]
ethylamine/aminoethane [1] [2] 20

Section B **80**

Total **100**

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2014

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

TUESDAY 17 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all seventeen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all seven** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **13(b)(ii)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of the Elements, containing some data, is included in this question paper.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Equal volumes of 1-chlorobutane and 1-iodobutane are warmed with aqueous silver nitrate in the presence of ethanol. Which one of the following is the reason why the 1-chlorobutane reacts more slowly?

A The C–Cl bond is more polar than the C–I bond

B The C–Cl bond is stronger than the C–I bond

C The C–I bond is more polar than the C–Cl bond

D The C–I bond is stronger than the C–Cl bond

2 Which one of the following is correct as Group II is descended?

	Solubility of hydroxides	**Solubility of sulfates**
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

3 Which one of the following is the colour of the flame produced when a barium compound is placed in a blue Bunsen burner flame?

A Crimson

B Green

C Lilac

D Orange

4 Which one of the following shows the effect on the yield of ammonia in the Haber process?

	Pressure increase	**Temperature increase**
A	yield decreases	yield decreases
B	yield decreases	yield increases
C	yield increases	yield decreases
D	yield increases	yield increases

5 Which one of the following mixtures will react to produce a compound with molecular formula C_4H_7N?

A 1-bromobutane and ammonia

B 1-bromobutane and potassium cyanide

C 1-bromopropane and ammonia

D 1-bromopropane and potassium cyanide

6 The reaction shown below

$$C_2H_5Br + KOH \rightarrow C_2H_4 + KBr + H_2O$$

is an example of

A dehydration.

B elimination.

C free radical substitution.

D nucleophilic substitution.

7 Which one of the following is the mass of magnesium required to react with 50.0 cm^3 of 0.1 mol dm^{-3} hydrochloric acid?

A 0.005 g

B 0.060 g

C 0.120 g

D 0.240 g

8 Which one of the following lists the compounds in order of increasing boiling point?

A	$CH_3CH_2CH_3$	CH_3CH_2F	CH_3CH_2OH
B	$CH_3CH_2CH_3$	CH_3CH_2OH	CH_3CH_2F
C	CH_3CH_2F	CH_3CH_2OH	$CH_3CH_2CH_3$
D	CH_3CH_2OH	CH_3CH_2F	$CH_3CH_2CH_3$

9 When an organic compound was reacted with chlorine, the organic product was found to have a relative molecular mass which had increased by 69. Which one of the following is the reaction mechanism?

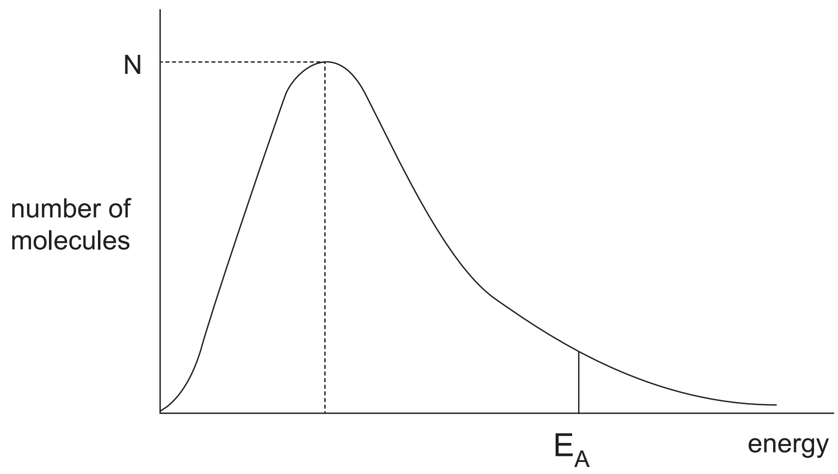
A elimination

B electrophilic addition

C free radical substitution

D nucleophilic substitution

10 The Maxwell–Boltzmann distribution for a reaction mixture is shown below. N is the number of molecules with the most probable energy and E_A is the activation energy.



Which one of the following shows the effect on E_A and on N of increasing the temperature?

	E_A	N
A	constant	decreases
B	constant	increases
C	decreases	decreases
D	decreases	increases

Section B

Answer all **seven** questions in the spaces provided.

11 Butan-1-ol is used to prepare 1-bromobutane according to the following equation:

$$C_4H_9OH + HBr \rightarrow C_4H_9Br + H_2O$$

(a) (i) Give an equation to explain the term **percentage yield**.

percentage yield =

[1]

(ii) Assuming a 40% yield, what mass of butan-1-ol would be required to produce 5.48 g of 1-bromobutane?

moles of 1-bromobutane

____

moles of butan-1-ol

____

mass of butan-1-ol

______________________________ [3]

(b) (i) Give an equation to explain the term **atom economy**.

atom economy =

[1]

(ii) Calculate the atom economy for the formation of 1-bromobutane from butan-1-ol.

____

______________________________ [1]

12 Qualitative analysis can be used to distinguish between aqueous solutions containing different metal ions.

(a) For each of the following pairs of metal ions, give an aqueous reagent which can be used to distinguish between the aqueous solutions and state the expected observations for each ion.

(i) Iron(II) ions and iron(III) ions.

Reagent ______________________________ [1]

Observations ______________________________

____

______________________________ [2]

(ii) Aluminium ions and zinc ions.

Reagent ______________________________ [1]

Observations ______________________________

____

______________________________ [2]

(b) Addition of an aqueous solution of potassium chromate can be used to test for the presence of barium ions.

(i) What is observed when barium ions react with chromate ions?

______________________________ [1]

(ii) Write an ionic equation, including state symbols, for the reaction of barium ions with chromate ions.

______________________________ [2]

13 The fluorohydrocarbon below exists in two stereoisomeric forms.

$$CH_3CH_2CH{=}CFCH_2CH_3$$

(a) Name this fluorohydrocarbon using IUPAC rules.

______________________________ [2]

(b) **(i)** Draw and label the structures of the E and Z isomers of this fluorohydrocarbon.

[1]

(ii) Explain why one of the structures you have drawn is classified as the Z isomer.

____

____

____

____

______________________________ [3]

Quality of written communication [2]

(c) **(i)** Draw a structural isomer of the fluorohydrocarbon which does **not** exist as stereoisomers.

[1]

(ii) Explain, in terms of the structure of this molecule, why it does not exist as stereoisomers.

____

____ [2]

14 Propene reacts with hydrogen bromide to form two isomers, the major product being 2-bromopropane.

(a) Explain why hydrogen bromide is attracted to propene.

____

____

____ [2]

(b) Suggest flow schemes for the mechanisms of the reaction of hydrogen bromide with propene to form 1-bromopropane and 2-bromopropane, showing the structure of both intermediates.

[4]

(c) **(i)** Suggest how you would separate a mixture of 1-bromopropane and 2-bromopropane.

____ [1]

(ii) Suggest how you would use infra-red spectroscopy to identify an unknown sample of bromopropane as either 1-bromopropane or 2-bromopropane.

____

____ [1]

(d) Suggest why 2-bromopropane is the major product.

____ [1]

(e) Name the mechanism of these reactions.

____ [1]

(f) Propene undergoes addition polymerisation to form polypropene.
Draw the structure of polypropene showing **three** repeating units.

[2]

15 Under a particular set of conditions incomplete combustion of propane occurred according to the following equation:

$$C_3H_8(g) + 4O_2(g) \rightarrow CO_2(g) + 2CO(g) + 4H_2O(l)$$

The total volume of gases produced occupied a volume of 9000 dm^3. The molar gas volume, under these conditions, is 30 dm^3.

(a) Define the term **molar gas volume**.

____

______________________________ [2]

(b) **(i)** Calculate the number of moles of carbon monoxide produced in this combustion.

____

______________________________ [2]

(ii) Calculate the number of moles of oxygen used in this combustion.

____

______________________________ [1]

(iii) Calculate the mass of propane, in kg, burned.

____

______________________________ [3]

(iv) Calculate the number of molecules of propane burned.

____

______________________________ [1]

(c) Under a different set of conditions, methane undergoes incomplete combustion to produce carbon dioxide and carbon monoxide in a 2:1 ratio. Write an equation for this incomplete combustion.

______________________________ [2]

16 Butane is sold commercially as “bottled gas”. It undergoes complete combustion according to the following equation:

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

and has a standard enthalpy of combustion of –2876.5 kJ mol^{-1}.

(a) Calculate the amount of energy released for every kilogram of carbon dioxide released.

____

____

____ [3]

(b) Hess’s Law can be used to calculate enthalpy changes, such as the standard enthalpy of formation of butane, which cannot be measured by experiment.

(i) Define the term **standard enthalpy of formation**.

____

____ [3]

(ii) Write an equation, with state symbols, which represents the standard enthalpy of formation of butane.

____ [2]

(iii) Use the standard enthalpy of combustion of butane and the following data to calculate the standard enthalpy of formation of butane.

	Standard enthalpy of combustion (kJ mol^{-1})
Carbon (C)	–393.5
Hydrogen (H_2)	–285.8

____

____

____

____ [3]

17 The formula for ethylene glycol is shown below:

$$
\begin{array}{l}
CH_2OH \\
| \\
CH_2OH
\end{array}
$$

(a) Use IUPAC rules to give the systematic name of ethylene glycol.

______________________________ [1]

(b) What is the empirical formula of ethylene glycol?

______________________________ [1]

(c) Ethylene glycol reacts vigorously with an *excess* of ethanoyl chloride.

(i) Suggest **two** observations in this reaction.

____

______________________________ [2]

(ii) Name the type of reaction occurring.

______________________________ [1]

(iii) Draw the structure of the organic product.

[2]

(iv) Suggest a test for the inorganic product formed in this reaction.

____

______________________________ [2]

(d) Ethylene glycol contains primary alcohol groups. When heated under reflux with excess acidified potassium dichromate the solution changes from orange to green.

(i) Why are the alcohol groups in ethylene glycol classified as primary?

____

____ [1]

(ii) Name the type of reaction occurring.

____ [1]

(iii) Draw the structure of the organic product.

[1]

(iv) Name the functional group present in the organic product.

____ [1]

(v) What would be the most significant difference between the infra-red spectrum of the organic product and that of ethylene glycol?

____

____ [1]

(e) Write an equation for the reaction of ethylene glycol with an excess of phosphorus pentachloride.

[2]

(f) Explain, in terms of structure, why an iodoform test does not give a positive result with ethylene glycol.

____

____ [1]

(g) The boiling point of ethylene glycol is 197 °C and that of ethanol is 78 °C. Explain this large difference in boiling points.

____

____

____ [3]

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General Certificate of Education
2014

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

TUESDAY 17 JUNE, AFTERNOON

MARK SCHEME

Section A

1 B

2 C

3 B

4 C

5 D

6 B

7 B

8 A

9 C

10 A

[2] for each correct answer	[20]	20
	Section A	**20**

Section B

11 **(a)** **(i)** % Yield = $\dfrac{\text{actual yield}}{\text{theoretical yield}} \times 100$ [1]

(ii) moles 1-bromobutane = 5.48/137 = 0.04
moles butan-1-ol = 0.1
mass butan-1-ol = 7.4 g [3]

(b) **(i)** atom economy = $\dfrac{\text{mass of desired product}}{\text{total mass of products}} \times 100$ [1]

(ii) 88.4% [1] 6

12 **(a)** **(i)** NaOH((aq)/NH_3(aq))/potassium thiocyanate
– no change with Fe(II) ions
blood red solution with fe(III) ions [1]

Green precipitate with iron(II)
Rust/brown precipitate with iron(III) [2]

(ii) NH_3(aq) [1]

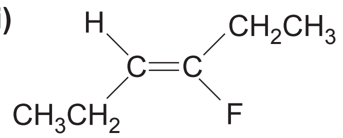
White precipitate with zinc (ions) soluble in excess
White precipitate with aluminium (ions) insoluble in excess [2]

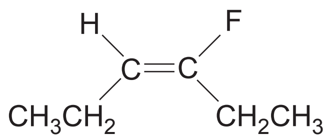
(b) **(i)** yellow precipitate [1]

(ii) $Ba^{2+}(aq) + CrO_4^{2-}(aq) \rightarrow BaCrO_4(s)$ [2] 9

13 **(a)** 3-fluorohex-3-ene [2]

(b) **(i)**





Z isomer E isomer [1]

(ii) Two highest priority groups are on the same side of C═C
C of ethyl group has higher priority than H
F has higher priority than C of ethyl group [3]

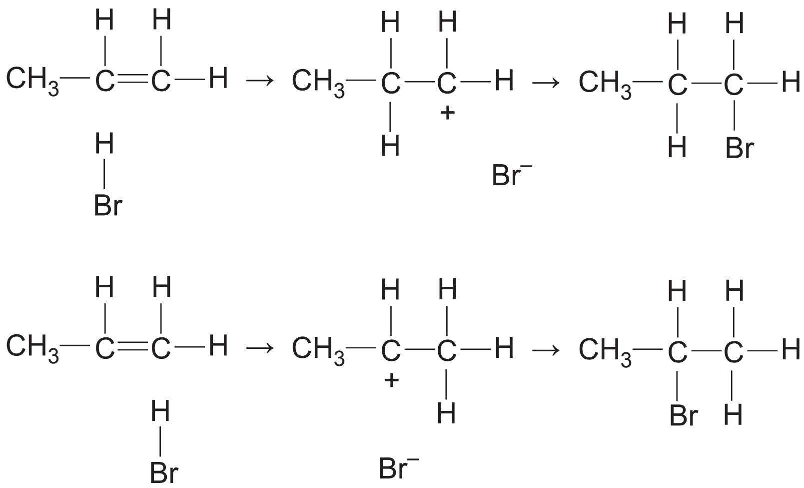
Quality of written communication [2]

(c) **(i)** a correct structure, e.g. 2-fluorohex-1-ene [1]

(ii) One of the carbons in the C═C bond has two identical atoms/groups attached [2] 11

14 **(a)** C=C/propene is a centre of high electron density
H end of HBr has a partial positive charge [2]

(b)



[4]

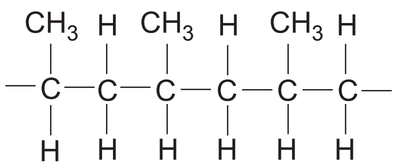
(c) **(i)** (fractional) distillation [1]

(ii) compare unknown spectra with spectra of each isomer [1]

(d) intermediate is (more) stable [1]

(e) electrophilic addition [1]

(f)



[2] 12

15 **(a)** the volume of one mole of gas
under specified conditions of temperature and pressure [2]

(b) **(i)** total moles of gases = 300
moles of CO = 200 [2]

(ii) 400 [1]

(iii) moles of propane = 100
mass of propane = 4400 g
mass of propane = 4.4 kg [3]

(iv) 6.02×10^{25} [1]

(c) $6\ CH_4 + 11\ O_2 \rightarrow 4\ CO_2 + 2\ CO + 12\ H_2O$ [2] 11

16 **(a)** moles of carbon dioxide = 22.7
moles of butane = 5.68
energy released = 16 344 (kJ) [3]

(b) **(i)** The enthalpy change when one mole of a compound is formed from its elements under standard conditions [3]

(ii) $4\ C(s) + 5\ H_2(g) \rightarrow C_4H_{10}(g)$ [2]

(iii) $[(4 \times -393.5) + (5 \times -285.8)] - [(-2876.5)] = -126.5\ (kJ\,mol^{-1})$ [3] 11

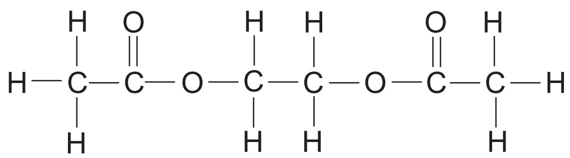
17 **(a)** ethane-1,2-diol [1]

(b) CH_3O [1]

(c) **(i)** steamy fumes
goes warm
hissing sound/bubbles [2]
changed smell

(ii) esterification [1]

(iii)



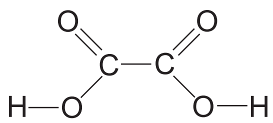
[2]

(iv) glass rod dipped into conc. ammonia solution
white smoke/fumes [2]

(d) **(i)** only one carbon directly attached to the same carbon as the —OH group [1]

(ii) oxidation [1]

(iii)



[1]

(iv) carboxyl [1]

(v) presence of C═O absorption [1]

(e) $C_2H_6O_2 + 2PCl_5 \rightarrow C_2H_4Cl_2 + 2POCl_3 + 2HCl$ [2]

(f) Does not have an H and a methyl group attached to the same C as the OH [1]

(g) more OH groups in ethylene glycol
more hydrogen bonding ethylene glycol
more energy needed to break hydrogen bonds [3] 20

Section B	**80**
Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2015

Centre Number

Candidate Number

Chemistry

Assessment Unit AS 2
assessing
Module 2: Organic, Physical and Inorganic Chemistry

AC122

[AC122]

MONDAY 15 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided.
Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all five** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **14(d)(i)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of the Elements, containing some data, is included in this question paper.

For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
Total Marks	

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following is the general formula of an alkyl group?

A C_nH_{2n}

B C_nH_{2n-1}

C C_nH_{2n+1}

D C_nH_{2n+2}

2 1.4 g of a pure alkene forms 3.8 g of a dichloroalkane on reaction with chlorine. Which one of the following is the molecular formula for the alkene?

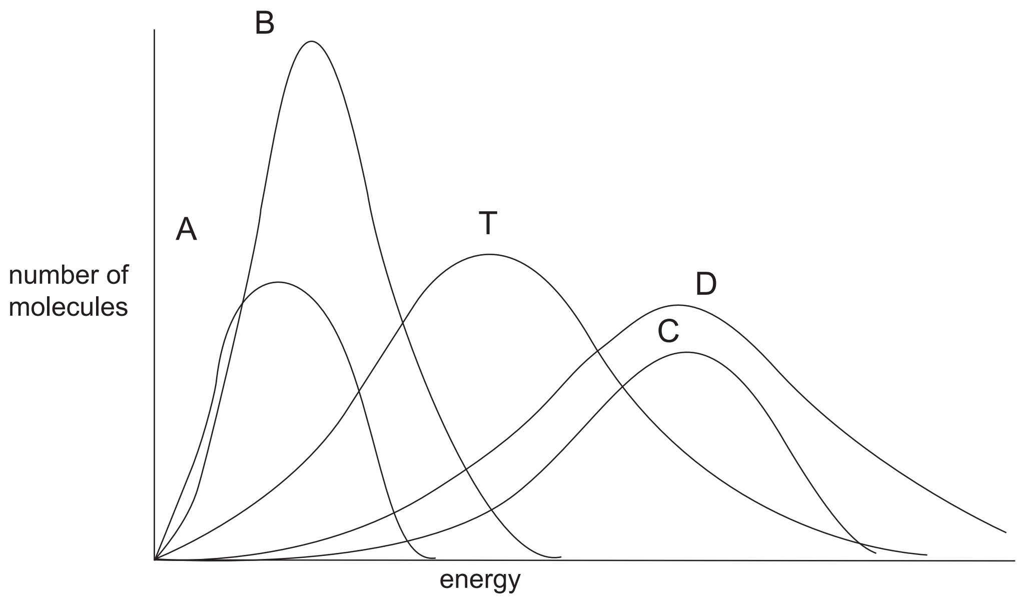
A C_2H_4

B C_3H_6

C C_4H_8

D C_6H_{12}

3 The diagram below represents the Maxwell–Boltzmann distribution curves for methane under various conditions. Curve T is that of methane at temperature T.



Which one of the curves is that of methane at a higher temperature than T?

4 The hydrolysis of a bromoalkane is shown below.

$$C_3H_7Br(l) + NaOH(aq) \rightarrow C_3H_7OH(aq) + NaBr(aq)$$

Which one of the following describes the mechanism of this reaction?

A Electrophilic addition

B Electrophilic substitution

C Nucleophilic addition

D Nucleophilic substitution

5 The dibromoalkene shown below exists in E and Z forms.

$$CHBr{=}CH{-}CH{=}CHBr$$

Which one of the following is the number of E–Z isomers that this molecule can form?

A 2

B 3

C 4

D 6

6 Which one of the following is **not** used in the laboratory preparation of a pure chloroalkane from the corresponding alcohol?

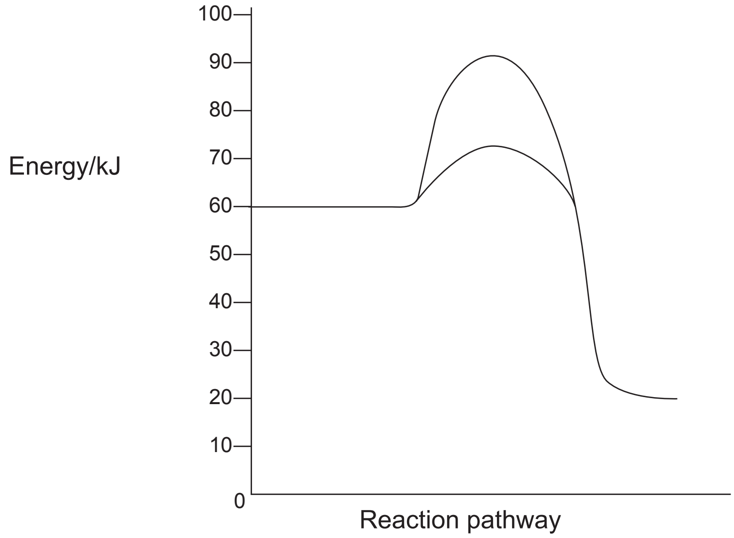
A Aqueous sodium chloride

B Aqueous hydrogencarbonate ions

C Distillation

D Refluxing

7 The enthalpy level diagram below is for a catalysed and uncatalysed reversible reaction.



Which one of the following is the activation enthalpy for the reverse reaction without a catalyst?

A 10 kJ

B 30 kJ

C 40 kJ

D 70 kJ

8 When crude oil undergoes fractional distillation which one of the following fractions is **not** distilled?

A Bitumen

B Low mass alkanes

C Lubricating oil

D Waxes

9 The bond between atoms I and Br consists of two electrons, I**:**Br. Which one of the following equations represents homolytic fission?

A $IBr \rightarrow I^+ + Br^-$

B $IBr \rightarrow I^- + Br^+$

C $IBr \rightarrow I\bullet + Br\bullet$

D $IBr \rightarrow I\!: + Br$

10 Which one of the following is a correct statement for the homologous series of hydrocarbons called alkenes?

A Each member of the series has a different empirical formula and different molecular formula

B Each member of the series has the same empirical formula and same molecular formula

C Each member of the series has a different empirical formula and different structural formula

D Each member of the series has the same empirical formula and the same general formula

Section B

Answer **all five** questions in this section in the spaces provided.

Examiner Only	
Marks	Remark

11 The reaction between methane and chlorine involves free radicals created by the action of light. Free radicals can also be created by the use of high temperatures which is known as pyrolysis. The following reactions occur when ethane is pyrolysed at 700 °C.

P $C_2H_6 \rightarrow 2CH_3\bullet$

Q $CH_3\bullet + C_2H_6 \rightarrow C_2H_5\bullet + CH_4$

R $C_2H_5\bullet \rightarrow C_2H_4 + H\bullet$

S $H\bullet + C_2H_6 \rightarrow H_2 + C_2H_5\bullet$

T $2C_2H_5\bullet \rightarrow C_2H_6 + C_2H_4$

U $2C_2H_5\bullet \rightarrow C_4H_{10}$

(a) Write the formulae of the species, in these equations, which are free radicals.

____ [2]

(b) Classify these reactions, using the letters P–U, under the headings initiation, propagation and termination.

Initiation

____

Propagation

____

Termination

____ [3]

12 Hex-1-ene reacts rapidly with bromine in a solvent such as 1,1,1-trichloroethane (TCE). The reaction is carried out in a glass beaker and is exothermic. Using experimental data it is possible to determine the enthalpy of bromination of hex-1-ene and to determine the C—Br bond enthalpy.

(a) (i) Draw the structure of hex-1-ene.

____ [1]

(ii) Draw the structure of TCE.

[1]

(iii) Write the equation for the reaction of hex-1-ene with bromine.

____ [2]

(iv) The reaction of hex-1-ene with bromine is not an equilibrium reaction. Describe a simple experiment to show this fact.

____

____

____ [2]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

(b) 100 cm^3 of a solution of bromine in TCE is placed in an insulated glass beaker and its temperature is measured. 2 cm^3 of hex-1-ene is added to the beaker. The mixture is stirred and the temperature is measured again.

(i) Calculate the quantity of heat energy produced, per mole of hex-1-ene, according to the following headings:

the mass of 2.0 cm^3 of hex-1-ene if the density of hex-1-ene is 0.68 g cm^{-3}

____

the rise in temperature if the initial temperature of the TCE is 24.9 °C and the final temperature is 32.1 °C

____

the mass of 100 cm^3 of TCE if the density of TCE is 1.33 g cm^{-3}

____

the heat energy received by the 100 cm^3 of TCE if the specific heat capacity of TCE is 1.30 J $°C^{-1}$ g^{-1}.

____

the molar mass of hex-1-ene

____

the number of moles of hex-1-ene in 2.0 cm^3

____

the molar enthalpy of bromination of hex-1-ene

______________________________ [5]

(ii) In the reaction of hex-1-ene with bromine a carbon-carbon double bond is broken requiring 612 kJ mol^{-1} and a bromine-bromine bond requiring 193 kJ mol^{-1}. At the same time a carbon-carbon single bond is formed releasing 348 kJ mol^{-1} and two C—Br bonds are formed. Using the molar enthalpy of bromination calculated in part **(i)** determine the molar C—Br bond enthalpy.

____

____

____

______________________________ [3]

(c) The product from the bromination of hex-1-ene is a dibromoalkane with the following structure.

$$CH_3CH_2CH_2CH_2CHBrCH_2Br$$

(i) Draw the structure of the product when the dibromoalkane is reacted with an *excess* of aqueous alkali.

______________________________ [1]

(ii) Draw the structure of the product when the dibromoalkane is reacted with an *excess* of ammonia.

______________________________ [1]

(iii) Draw the structure of the product when the dibromoalkane is reacted with an *excess* of cyanide ions.

______________________________ [1]

(d) When the dibromohexane produced from the reaction of hex-1-ene with bromine is reacted with *excess* ethanolic potassium hydroxide an organic product is formed. Suggest the structure of the product.

______________________________ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

13 Magnesium is the eighth most abundant metal in the earth's crust but if its presence in seawater is taken into account it is the most abundant metal. Manufacture of magnesium is usually from calcined (heated) dolomite.

(a) Dolomite, a mixture of calcium and magnesium carbonates, has the formula $CaCO_3.MgCO_3$. When calcined dolomite decomposes it forms the metal oxides.

(i) Write the equation for the decomposition of dolomite.

______________________________ [1]

(ii) State the order of thermal stability of the Group II metal carbonates starting with the least stable.

______________________________ [1]

(iii) Explain the thermal stability of the Group II carbonates in terms of the cations.

____

____

______________________________ [3]

(b) The calcined dolomite is slaked (reacted with water) to form the hydroxides. Seawater, which contains magnesium chloride, can be treated with an excess of slaked calcined dolomite.

$$MgCl_2 + Ca(OH)_2.Mg(OH)_2 \rightarrow 2Mg(OH)_2 + CaCl_2$$

The magnesium hydroxide is filtered off and calcined.

(i) Write the equation for the reaction of calcined dolomite with water.

______________________________ [1]

(ii) Magnesium hydroxide is precipitated. What is the solubility trend of the Group II hydroxides?

____

______________________________ [1]

(iii) Calculate the atom economy of $Mg(OH)_2$ from the reaction of magnesium chloride with slaked calcined dolomite.

____

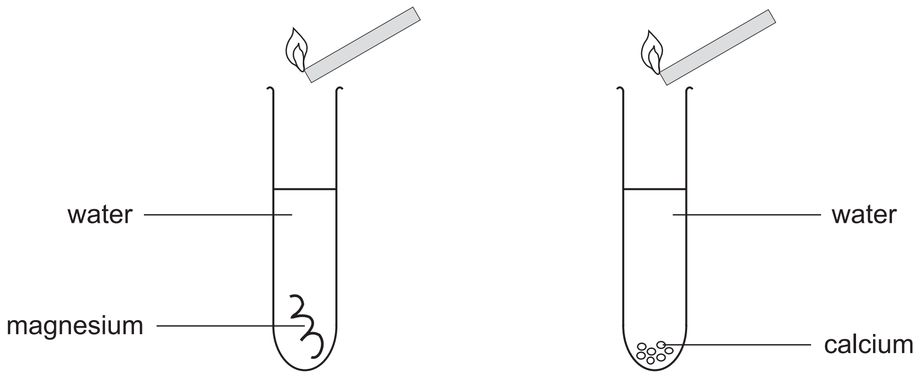
____

____ [2]

(iv) Write the equation for the calcination of magnesium hydroxide.

____ [1]

(c) Magnesium ribbon and calcium turnings were added to water in separate boiling tubes as shown in the diagram below. A lit splint was held above each boiling tube.



(i) Describe what is observed in each boiling tube.

Magnesium

____

____ [2]

Calcium

____

____ [2]

Examiner Only	
Marks	Remark

(ii) Describe what happens around the lit splint for each boiling tube.

Magnesium

____ [1]

Calcium

____ [1]

(iii) Describe and explain what happens when Universal Indicator is added to the boiling tubes after thirty minutes.

Magnesium

____

____ [2]

Calcium

____

____ [2]

Examiner Only	
Marks	Remark

14 In a car engine, petrol vapour, a mixture of C_5 to C_{10} alkanes, and air are ignited by an electric spark. It is important that the mixture explodes smoothly. This is achieved by using branched chain alkanes.

(a) (i) What is the molecular formula for a C_8 alkane?

____ [1]

(ii) Write an equation for the complete combustion of octane.

____ [2]

(iii) Draw the structure of a branched chain isomer of octane.

[1]

(b) One-fifth of air by volume is oxygen. What volume of air is required for the complete combustion of 28.5 g of octane vapour at 20 °C?

____

____

____ [3]

Examiner Only	
Marks	Remark

(c) A typical composition of the gases in petrol engine exhaust fumes is:

Substance	**%**
Water vapour	9
Carbon dioxide	8
Carbon monoxide	4–6
Oxygen	4
Hydrogen	2
Hydrocarbons	0.2
Oxides of nitrogen	0.3

(i) Which gas in the exhaust fumes is a consequence of incomplete combustion?

____ [1]

(ii) The percentage of gases does not add up to 100%. Suggest the names of the **two** missing gases.

____ [1]

(iii) One of the oxides of nitrogen formed is nitrogen(II) oxide which is produced at a high temperature from nitrogen and oxygen. Write an equation for its formation.

____ [1]

Examiner Only	
Marks	Remark

(d) Catalytic converters are used in reducing the environmental damage due to vehicle emissions.

(i) Discuss the environmental problems associated with the combustion of hydrocarbons.

____

____

____

____

____

____

____

____ [3]

Quality of written communication [2]

(ii) Write equations for the conversion of carbon monoxide and nitrogen monoxide to less polluting products in the catalytic converter.

____

____ [2]

(iii) Explain the effect of leaded petrol on the catalytic converter.

____

____ [1]

Examiner Only	
Marks	Remark

15 The haloform reaction is one of the oldest known organic reactions. Serultas made iodoform in 1822 by the reaction of potassium with a mixture of iodine and aqueous ethanol. All of the trihalogenomethanes have been prepared.

name	**formula**	**state at 25 °C**	**boiling point/°C**
fluoroform	CHF_3	gas	−82
chloroform	$CHCl_3$	liquid	61
bromoform	$CHBr_3$	liquid	149
iodoform	CHI_3	solid	218

(a) (i) Suggest the role of potassium in the formation of iodoform.

____ [1]

(ii) What structure is present in ethanol which leads to the formation of iodoform?

____ [1]

(iii) State the colour of iodoform.

____ [1]

(iv) Describe the smell of iodoform.

____ [1]

(b) Explain why chloroform is a liquid and iodoform is a solid.

____

____

____ [2]

Examiner Only

Marks	Remark

(c) There are four butanols which are shown below together with their boiling points.

compound	**formula**	**boiling point/°C**
butan-1-ol	$CH_3CH_2CH_2CH_2OH$	118°
butan-2-ol	$CH_3CH_2CHOHCH_3$	99°
2-methylpropan-1-ol	$(CH_3)_2CHCH_2OH$	108°
2-methylpropan-2-ol	$(CH_3)_3COH$	83°

(i) Classify the butanols as primary, secondary or tertiary alcohols.

____

____ [2]

(ii) Explain which one of these butanols will give a positive iodoform test.

____

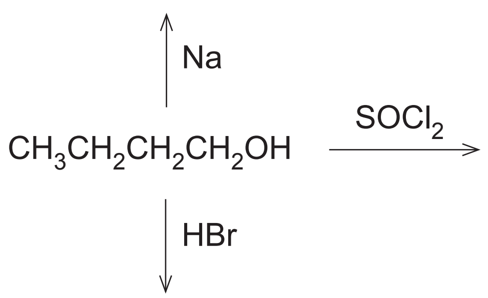
____ [1]

(iii) Explain why butan-1-ol has the highest boiling point.

____

____ [2]

(iv) Complete the diagram below for the reactions of butan-1-ol with the following reagents showing the organic products formed.



[3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(d) Today, the identification of compounds is carried out using spectroscopic methods rather than test tube reactions.

(i) Explain why molecules absorb infrared radiation.

____

____ [1]

(ii) Which group of atoms in the butanol molecule is used to identify alcohols in infrared spectroscopy?

____ [1]

(iii) If you had infrared spectra of the four butanols how would you use them to identify an unknown butanol?

____

____ [1]

(e) Butan-2-ol reacts with carboxylic acids to form volatile esters which are used as perfumes or flavourings. Write the equation for the reaction of butan-2-ol with ethanoic acid showing the structures of the reactants and products.

____ [2]

THIS IS THE END OF THE QUESTION PAPER

182292

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2015

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

MONDAY 15 JUNE, AFTERNOON

MARK SCHEME

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finished.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published; the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

Section A

			AVAILABLE MARKS
1	C		
2	B		
3	D		
4	D		
5	B		
6	A		
7	D		
8	A		
9	C		
10	D		
[2] for each correct answer		[20]	20
		Section A	**20**

Section B

AVAILABLE MARKS

11 **(a)** $CH_3\bullet$ $C_2H_5\bullet$ $H\bullet$ [2]

(b)

Initiation	P			
Propagation	Q			
	R			
	S			
Termination	T			
	U	error [–1]	[3]	5

12 **(a)** **(i)** $CH_3CH_2CH_2CH_2CH{=}CH_2$ [1]

(ii) CCl_3CH_3 [1]

(iii) $CH_3CH_2CH_2CH_2CH{=}CH_2 + Br_2 \rightarrow CH_3CH_2CH_2CH_2CHBrCH_2Br$ [2]

(iv) Starting from product [1]
No bromine colour appears [1] [2]
or
Equimolar quantities of reactants/hex-1-ene in excess [1]
Bromine colour disappears completely [1]

(b) **(i)** the mass of 2 cm^3 of hex-1-ene
= 2 × 0.68 = 1.36 g

the rise in temperature
= 32.1 – 24.9 = 7.2 °C

the mass of 100 cm^3 of TCE
= 100 × 1.33 g = 133 g

the heat energy received by the 100 cm^3 of TCE
= 133 × 1.30 × 7.2 = 1245 J

the molar mass of hex-1-ene
= 6 × 12 + (12 × 1) = 72 + 12 = 84 g

the number of moles of hex-1-ene in 2 cm^3
= 1.36/84 = 0.01619

the molar enthalpy of bromination of hex-1-ene
= 1245/0.016 = –77.8 kJ or kJ mol^{-1} [5]
Missing or incorrect units penalise once

(ii) bonds broken = 612 + 193 = +805
bonds formed = 2 C–Br + 348
ΔH = –77.8 = +805 – (2C–Br + 348) = +457 – 2C–Br
2C–Br = 457 + 77.8 = 534.8
C–Br = 267 kJ mol^{-1} [3]

(c) **(i)** $CH_3CH_2CH_2CH_2CHOHCH_2OH$ [1]

(ii) $CH_3CH_2CH_2CH_2CHNH_2CH_2NH_2$ [1]

(iii) $CH_3CH_2CH_2CH_2CHCNCH_2CN$ [1]

(d) $CH_3CH_2CH_2CH{=}C{=}CH_2$ **or** $CH_3CH_2CH_2CH_2\ C{\equiv}CH$ [1] 18

					AVAILABLE MARKS
13	**(a)**	**(i)**	$CaCO_3.MgCO_3 \rightarrow CaO + MgO + 2CO_2$ **Or** $CaCO_3.MgCO_3 \rightarrow CaO.MgO + 2CO_2$	[1]	
		(ii)	$MgCO_3$ $CaCO_3$ $SrCO_3$ $BaCO_3$	[1]	
		(iii)	as the size/radius of the cation increases polarising power/charge density (of the cation) decreases the carbonate ion is less polarised/distorted	[3]	
	(b)	**(i)**	$CaO.MgO + 2H_2O \rightarrow Ca(OH)_2 + Mg(OH)_2$	[1]	
		(ii)	solubility increases as the Group is descended	[1]	
		(iii)	$MgCl_2 + Ca(OH)_2.Mg(OH)_2 \rightarrow 2Mg(OH)_2 + CaCl_2$ 95 74 58 2 × 58 111 mass of reactants = 95 + 74 + 58 = 227 mass of magnesium hydroxide = 116 atom economy = 116/227 × 100 = 51.10% = 51%	[2]	
		(iv)	$Mg(OH)_2 \rightarrow MgO + H_2O$	[1]	
	(c)	**(i)**	Any two from four: Magnesium magnesium remains [1] the water/solution remains/colourless [1] (small number of) bubbles [1] on the surface [1]	[2]	
			Any two from five: Calcium calcium sinks then rises [1] the mass of calcium gets less [1] there are lots of bubbles around the calcium [1] a white solid/milky solution produced [1] heat produced/steamy fumes [1]	[2]	
		(ii)	Magnesium the splint stays the same/eventually goes out/no pop	[1]	
			Calcium the hydrogen pops/explodes	[1]	
		(iii)	Magnesium the solution stays green – neutral/pH 7 **or** green/blue – alkaline/pH 8/9	[2]	
			Calcium the solution goes blue/violet/purple – alkaline/pH 10–14	[2]	20

	AVAILABLE MARKS

14 (a) (i) C_8H_{18} [1]

(ii) $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ [2]

(iii) e.g.

$$\begin{array}{l} \quad CH_3 \\ \quad | \\ CH_3CHCH_2CH_2CH_2CH_2CH_3 \end{array}$$ [1]

(b) $C_8H_{18} = 8 \times 12 + 18 \times 1 = 96 + 18 = 114$
28.5 g = 28.5/114 = 0.25 mol
2 moles of octane react with 25 moles of oxygen
0.25 mole reacts with 0.25 × 25/2 = 3.125 mols of oxygen
= 3.125 × 24 dm^3 = 75 dm^3
Volume of air needed = 5 × 75 dm^3 = 375 dm^3 [3]
units needed error [–1]

(c) (i) carbon monoxide [1]

(ii) nitrogen and sulfur dioxide/any named noble gas [1]

(iii) $N_2 + O_2 \rightarrow 2NO$ [1]

(d) (i) particulate matter/soot causes damage to the lungs/respiratory problems
the carbon dioxide creates a greenhouse effect/global warming
Incomplete combustion → carbon monoxide → toxic [3]

Quality of written communication [2]

(ii) $2NO \rightarrow N_2 + O_2$
$2CO + O_2 \rightarrow 2CO_2$
$2CO + 2NO \rightarrow 2CO_2 + N_2$ any 2 [2]

(iii) lead covers the surface of the catalyst and stops the catalyst working or poisons the catalyst [1] 18

				AVAILABLE MARKS
15	**(a)**	**(i)** potassium (reacts with water) to form potassium hydroxide/give alkaline conditions/is a reducing agent	[1]	
		(ii) ethanol contains the $CH_3CH(OH)$ group	[1]	
		(iii) yellow	[1]	
		(iv) antiseptic	[1]	
	(b)	chloroform has a lower mass/number of electrons than iodoform hence the van der Waals forces are greater in iodoform	[2]	
	(c)	**(i)** butan-1-ol and 2-methylpropan-1-ol are primary butan-2-ol is secondary 2-methylpropan-2-ol is tertiary error [–1]	[2]	
		(ii) butan-2-ol contains the $CH_3CH(OH)$ group	[1]	
		(iii) butan-1-ol is a linear molecule/unbranched the van der Waals forces between the chains attract more	[2]	
		(iv) Na: $CH_3CH_2CH_2CH_2ONa$	[1]	
		$SOCl_2$: $CH_3CH_2CH_2CH_2Cl$	[1]	
		HBr: $CH_3CH_2CH_2CH_2Br$	[1]	
	(d)	**(i)** bonds vibrate and absorb the infrared radiation	[1]	
		(ii) the –OH group	[1]	
		(iii) the infrared spectrum of the unknown butanol is matched to one of the butanol spectra	[1]	
	(e)	$CH_3CHOHCH_2CH_3 + CH_3COOH \rightleftharpoons CH_3COOCH(CH_3)CH_2CH_3 + H_2O$	[2]	19
			Section B	**80**
			Total	**100**

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2016

Centre Number

Candidate Number

Chemistry

Assessment Unit AS 2

assessing
Module 2: Organic, Physical and Inorganic Chemistry

AC122

[AC122]

WEDNESDAY 22 JUNE, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all five** questions in **Section B**. **You must answer the questions in the spaces provided.**
Do not write outside the boxed area on each page or on blank pages.
Complete in blue or black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **15(c)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of the Elements, containing some data, is included in this question paper.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Industrially, ammonia is converted to nitric acid according to the following equation:

$$NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$$

Which one of the following is the atom economy for the production of nitric acid?

A 20.1%

B 22.2%

C 77.8%

D 79.0%

2 The boiling points of the halogenoethanes are shown below.

halogenoethane	**boiling point/°C**
fluoroethane	–37
chloroethane	16
bromoethane	39
iodoethane	73

The change in boiling point is due to an increase in

A hydrogen bonding.

B hydrogen bonding and van der Waals' forces.

C polarity of the carbon halogen bond.

D van der Waals' forces.

3 Which one of the following molecules does **not** have E–Z isomers?

A $CH_3CH_2CHCH_2$

B $CH_3CHCHCH_3$

C $CH_3CClCHCH_3$

D $CH_3CClCClCH_3$

4 Which one of the following correctly describes the properties of barium hydroxide compared to calcium hydroxide?

	thermal stability	**solubility in water**	**pH of solution**
A	higher	higher	higher
B	higher	lower	lower
C	lower	higher	higher
D	lower	lower	lower

5 42 g of sodium hydrogencarbonate were heated to constant mass producing 0.5 mole of gas. Which one of the following is the equation for this decomposition?

A $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$

B $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

C $2NaHCO_3(s) \rightarrow NaOH(s) + NaO(s) + CO_2(g)$

D $2NaHCO_3(s) \rightarrow Na_2O(s) + H_2O(g) + 2CO_2(g)$

6 The thermal cracking of alkanes

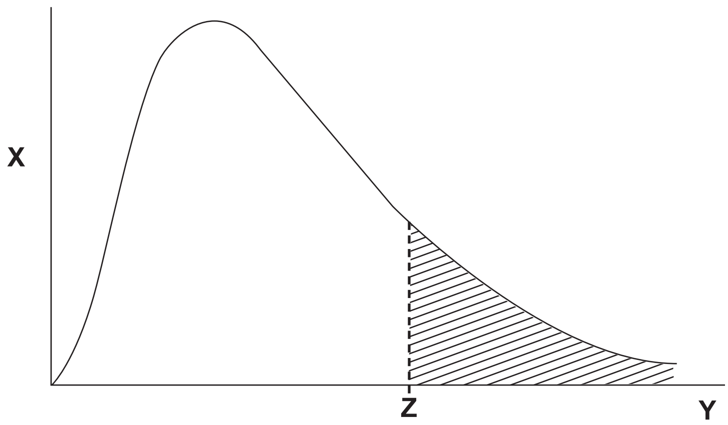
A involves decomposition.

B is an exothermic process.

C produces only small alkanes.

D requires hydrogen.

7 The diagram below shows the Maxwell–Boltzmann distribution of molecular energies for a gas.



Which one of the following is the correct labelling for the diagram?

	X	Y	Z
A	activation energy	kinetic energy	number of molecules
B	kinetic energy	number of molecules	activation energy
C	number of molecules	activation energy	kinetic energy
D	number of molecules	kinetic energy	activation energy

8 Which one of the following will **not** react with ethanol to form 1-chloroethane?

A Cl_2 in sunlight at 100°C

B NaCl and concentrated sulfuric acid

C PCl_5

D $SOCl_2$ at room temperature

9 A white crystalline solid produced a crimson colour in a flame test. A solution of the solid formed a white precipitate with silver nitrate solution. Which one of the following is the white solid?

A Calcium bromide

B Calcium chloride

C Lithium bromide

D Lithium chloride

10 Aspirin can be produced from salicylic acid according to the following equation:

$$\underset{\text{salicylic acid}}{HOC_6H_4COOH} + CH_3COOH \rightarrow \underset{\text{aspirin}}{CH_3COOC_6H_4COOH} + H_2O$$

Which one of the following is the mass of salicylic acid needed to produce 8.4 g of aspirin assuming a 40% yield?

A 2.8 g

B 7.0 g

C 6.4 g

D 16.1 g

[Turn over

Section B

Answer all **five** questions in the spaces provided

11 Methane reacts with steam at 200 °C in a closed container to produce the following equilibrium:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +210\ \text{kJ mol}^{-1}$$

Suggest and explain how each of the following changes affects the position of the equilibrium and the rate of the reaction.

(a) The temperature is reduced to 120 °C.

The position of the equilibrium.

____

____

____ [1]

The rate of the reaction.

____

____

____ [1]

(b) The volume of the container is doubled.

The position of the equilibrium.

____

____

____ [1]

The rate of the reaction.

____

____

____ [1]

(c) The addition of a catalyst.

The position of the equilibrium.

____

____

____ [1]

The rate of the reaction.

____

____

____ [1]

12 Hess's Law can be used to calculate enthalpy changes that cannot be measured by experiment.

(a) State **Hess's Law**.

____

____

____ [2]

(b) Carbon dioxide and hydrogen can react to form methane according to the following equation:

$$CO_2(g) + 4H_2(g) \rightarrow CH_4(g) + 2H_2O(l)$$

Standard enthalpies of formation are given in the table below.

	standard enthalpy of formation/kJ mol^{-1}
carbon dioxide	–393.5
methane	–74.8
water	–241.8

(i) What is meant by the term **standard enthalpy of formation**?

____

____

____ [2]

(ii) Explain why no value is given for the standard enthalpy of formation of hydrogen.

____

____ [1]

(iii) Calculate the enthalpy change for the reaction between carbon dioxide and hydrogen.

____

____

____

____

____ [3]

(c) The average bond enthalpy of each of the bonds involved in the reaction are shown in the table below.

bond	average bond enthalpy /kJ mol^{-1}
C═O	803
H—H	436
C—H	413
O—H	463

(i) Calculate the enthalpy change for the reaction between carbon dioxide and hydrogen using the average bond enthalpies.

____

____

____

____

____ [3]

(ii) What is meant by the term **average bond enthalpy**?

____

____

____ [2]

(iii) Compare the enthalpy change obtained using average bond enthalpies to that using Hess's Law and explain the difference.

____

____

____ [1]

13 In nature, magnesium occurs as magnesite, $MgCO_3$, and barium as witherite, $BaCO_3$.

(a) Explain why magnesium and barium are regarded as s-block elements.

____ [1]

(b) Explain the difference in thermal stability between magnesite and witherite.

____

____

____

____ [3]

(c) Barium can be extracted from witherite. The witherite is heated to form barium oxide which is then reacted with aluminium forming barium and barium aluminate, $Ba(AlO_2)_2$.

(i) Write the equation for the decomposition of witherite.

____ [1]

(ii) Write the equation for the reaction of barium oxide with aluminium.

____ [1]

(d) Magnesium can be extracted by electrolysis of magnesium chloride. The magnesium ions form magnesium atoms at the cathode. The chloride ions form chlorine molecules at the anode.

(i) Write the equation for the reaction at the cathode.

____ [1]

(ii) Write the equation for the reaction at the anode.

____ [1]

(iii) Describe a chemical test for chlorine.

____

____ [2]

(e) Magnesium is also found as hydrated magnesium sulfate in Epsom salts. Explain how Epsom salts could be used to distinguish between sodium carbonate and sodium hydrogencarbonate solutions.

____

____

____

____ [2]

(f) The first ionisation energy of barium is 500 kJ mol^{-1} and that of magnesium is 740 kJ mol^{-1}.

(i) Write an equation, including state symbols, for the first ionisation energy of barium.

____ [2]

(ii) The second ionisation energy of barium is 1000 kJ mol^{-1}.
Explain why the second ionisation energy is greater than the first ionisation energy.

____

____

____ [2]

(iii) Explain why the first ionisation energy of barium is less than the first ionisation energy of magnesium.

____

____

____ [2]

14 1,2-dichloroethane can be made either by the chlorination of ethane or the addition of chlorine to ethene.

(a) The photochlorination of ethane is carried out using electromagnetic radiation and produces 1,2-dichloroethane together with other chlorinated products.

(i) What type of electromagnetic radiation is used?

____ [1]

(ii) What is the name of the mechanism for photochlorination?

____ [1]

(iii) Draw and name the structure of the other dichloroethane.

____ [2]

(iv) Suggest why photochlorination is not used to produce 1,2-dichloroethane commercially.

____

____ [2]

(b) 1,2-dichloroethane is manufactured in high yield by the addition of chlorine to ethene in the presence of iron(III) chloride.

$$CH_2{=}CH_2 + Cl_2 \rightarrow CH_2ClCH_2Cl$$

(i) Suggest the purpose of the iron(III) chloride.

____ [1]

(ii) Suggest how you would obtain the 1,2-dichloroethane from the reaction mixture.

____

____ [2]

(c) Vinyl chloride, $CH_2{=}CHCl$, is used to manufacture PVC (polyvinyl chloride). It is obtained from 1,2-dichloroethane.

(i) Vinyl chloride was discovered in 1835 by Justus von Liebig. He heated 1,2-dichloroethane with potassium hydroxide in ethanol. Write the equation for the reaction.

____ [2]

(ii) Explain why it is important not to use an excess of potassium hydroxide when heating it with 1,2-dichloroethane.

____

____ [1]

(iii) Today, vinyl chloride is manufactured by the thermal cracking of 1,2-dichloroethane. Explain what is meant by the term **thermal cracking**.

____

____ [1]

(d) Vinyl chloride reacts with hydrogen bromide in a similar way to ethene forming two isomers.

(i) Draw the structures of the two isomers.

[2]

(ii) Name the two isomers.

____

____ [2]

(iii) Draw the two intermediates in the mechanisms for the formation of the two isomers.

[2]

(e) Vinyl chloride may be polymerised to form PVC. Draw three repeating units of PVC.

[2]

15 Butanol, C_4H_9OH, can be produced by the fermentation of sugars using the bacterium *Clostridium acetobutylicum*. It is mixed with petrol and used as a fuel for cars.

(a) Butanol produced by fermentation is described as a biofuel. Suggest what is meant by the term **biofuel**.

____

____ [1]

(b) State the conditions required for fermentation.

____

____

____ [2]

(c) Butanol produces fewer harmful environmental emissions from cars than petrol. Explain, without using equations, the role of catalytic converters in reducing the harmful environmental emissions from petrol engines.

____

____

____

____

____

____

____ [4]

Quality of written communication [2]

(d) There are four alcohols which have the formula C_4H_9OH.

(i) Draw the structures for each of these alcohols and name them.

[4]

(ii) Some of these alcohols can be oxidised.
State the reagent necessary for the oxidation and name the organic products formed in each complete oxidation.

Reagent:

____

Names of products:

____

____ [4]

(e) The enthalpy of combustion of a butanol is –2675 kJ mol^{-1}.

(i) Write the equation for the complete combustion of butanol, C_4H_9OH.

____ [1]

(ii) Calculate the mass of butanol required to raise the temperature of 250 g of water by 80 °C, assuming complete combustion.
(The specific heat capacity of water is 4.2 J g^{-1} $°C^{-1}$)

Energy required:

____

____

Moles of butanol required:

____

____

Mass of butanol:

____

____ [3]

THIS IS THE END OF THE QUESTION PAPER

DO NOT WRITE ON THIS PAGE

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
Total Marks	

Rewarding Learning

Periodic Table of the Elements

For the use of candidates taking

Advanced Subsidiary and Advanced Level
Chemistry Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations.

gce A/AS examinations

chemistry

(advanced)

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THE PERIODIC TABLE OF ELEMENTS

One mole of any gas at 20 °C and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3.

Planck Constant = 6.63×10^{-34} J s

Gas Constant = 8.31 J mol^{-1} K^{-1}

Avogadro Constant = 6.02×10^{23} mol^{-1}

I	II	Group										III	IV	V	VI	VII	0
1 **H** Hydrogen 1																	4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	99 **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La*** Lanthanum 57	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	210 **Po** Polonium 84	210 **At** Astatine 85	222 **Rn** Radon 86
223 **Fr** Francium 87	226 **Ra** Radium 88	227 **Ac**† Actinium 89															

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	147 **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	237 **Np** Neptunium 93	242 **Pu** Plutonium 94	243 **Am** Americium 95	247 **Cm** Curium 96	245 **Bk** Berkelium 97	251 **Cf** Californium 98	254 **Es** Einsteinium 99	253 **Fm** Fermium 100	256 **Md** Mendelevium 101	254 **No** Nobelium 102	257 **Lr** Lawrencium 103

* 58–71 Lanthanum series
† 90–103 Actinium series

a b	x

a = relative atomic mass (approx.)
x = atomic symbol
b = atomic number

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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2016

Chemistry

Assessment Unit AS 2

assessing

Module 2: Organic, Physical and Inorganic Chemistry

[AC122]

WEDNESDAY 22 JUNE, MORNING

MARK SCHEME

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finished.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published; the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

Section A

			AVAILABLE MARKS
1	C		
2	D		
3	A		
4	A		
5	B		
6	A		
7	D		
8	A		
9	D		
10	D		
[2] for each correct answer		[20]	20
		Section A	**20**

Section B

AVAILABLE MARKS

11 **(a)** Moves to the left since the forward reaction is endothermic [1]

Decreases, fewer collisions with the activation energy [1]

(b) Moves to the right since more molecules on right hand side [1]

Decreases, the molecules are further apart and so fewer successful collisions [1]

(c) No change, the catalyst speeds up the forward and reverse reactions equally [1]

Faster as it provides alternative pathway of lower activation energy [1] 6

12 **(a)** The enthalpy change for a reaction is independent of the route taken provided the initial and final conditions remain the same [2]

(b) **(i)** The enthalpy change when one mole of a compound is formed from its elements under standard conditions/25 °C and 1 atmosphere pressure [2]
([–1] for each mistake)

(ii) Hydrogen is an element [1]

(iii) $-393.5 + 0 + \Delta H = -74.8 + 2(-241.8)$
$\Delta H = -558.4 + 393.5$
$\Delta H = -164.9 \text{ kJ mol}^{-1}$
([–1] for each mistake) [3]

(c) **(i)** $\{(2 \times 803) + (4 \times 436)\} - \{(4 \times 413) + (4 \times 463)\}$
$\{1606 + 1744\} - \{1652 + 1852\}$
$3350 - 3504 = -154 \text{ kJ mol}^{-1}$
([–1] for each mistake) [3]

(ii) The energy required to break one mole of a given bond averaged over many compounds [2]

(iii) Average bond enthalpy values give an estimate of the value as they are not specific to the compounds involved in the reaction [1] 14

			AVAILABLE MARKS
13 **(a)**	The outer electrons are in the s-subshell	[1]	
(b)	Witherite is more stable [1] Cation is larger/has lower charge density [1] Cation has less polarising effect on the carbonate ion [1] (or converse using magnesite)	[3]	
(c) **(i)**	$BaCO_3 \rightarrow BaO + CO_2$	[1]	
(ii)	$4BaO + 2Al \rightarrow 3Ba + Ba(AlO_2)_2$	[1]	
(d) **(i)**	$Mg^{2+} + 2e^- \rightarrow Mg$	[1]	
(ii)	$2Cl^- \rightarrow Cl_2 + 2e^-$	[1]	
(iii)	Bleaches damp litmus/universal indicator paper	[2]	
(e)	Solution of Epsom salts [1] White precipitate with carbonate and no change with hydrogencarbonate [1]	[2]	
(f) **(i)**	$Ba(g) \rightarrow Ba^+(g) + e^-$ (equation [1], state symbols [1])	[2]	
(ii)	More protons than electrons/greater effective nuclear charge [1] Nucleus has a greater attraction for the outer electron [1]	[2]	
(iii)	Outer electron is further from the nucleus [1] Greater shielding from the inner electrons [1]	[2]	18

AVAILABLE MARKS

14 (a) (i) ultraviolet light [1]

(ii) (free) radical substitution [1]

(iii) Cl_2CHCH_3 [1]

1,1-dichloroethane [1]

(iv) many chlorinated products are formed
low yield or poor atom economy
product is explosive/difficult to separate/takes time/extra cost
(any two) [2]

(b) (i) catalyst [1]

(ii) cool the mixture [1]

ethene and chlorine are gases, 1,2-dichloroethane is a liquid [1]

(c) (i) $ClCH_2CH_2Cl + KOH \rightarrow CH_2{=}CHCl + KCl + H_2O$ [2]

(ii) both of the chlorine atoms will be eliminated/removed [1]

(iii) breaking down (large) molecules into smaller molecules using heat [1]

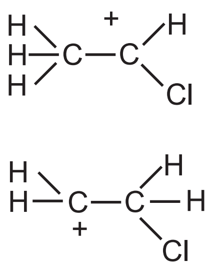
(d) (i) $CH_3CHClBr$ [1]

CH_2BrCH_2Cl [1]

(ii) 1-bromo-1-chloroethane [1]

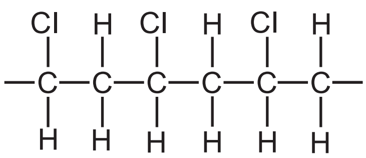
1-bromo-2-chloroethane [1]

(iii)



[2]

(e)



[2]

21

AVAILABLE MARKS

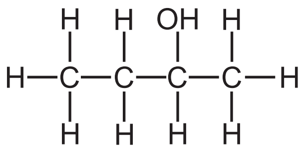
15 **(a)** Derived from biological material which burns to release energy [1]

(b) Anaerobic/no oxygen [1]
20–40°C [1] [2]

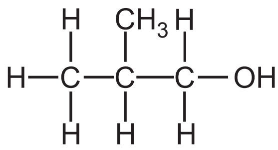
(c) Facilitates/speeds up the following conversions [1]
Carbon monoxide converted to carbon dioxide [1]
Hydrocarbons converted to CO_2 and H_2O [1]
Nitrogen oxides converted to nitrogen [1] [4]

Quality of written communication [2]

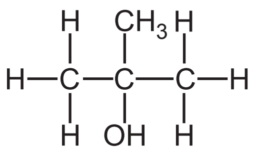
(d) **(i)**



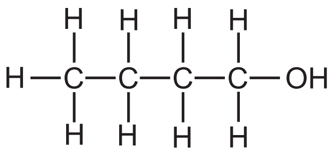
butan-2-ol



2-methylpropan-1-ol



2-methylpropan-2-ol



butan-1-ol

(error [–1]) [4]

(ii) Reagent acidified potassium dichromate/H^+ and $Cr_2O_7^{2-}$ [1]
Names of products:
butanoic acid, butanone, 2-methylpropanoic acid [3] [4]

(e) **(i)** $C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O$ [1]

(ii) Energy required:
$\Delta H = mc\,\Delta T = 250 \times 4.2 \times 80 = 84\,000\,J$ (84 kJ) [1]
Moles of butan-1-ol required = 84/2675 = 0.0314 [1]
Mass of butan-1-ol required = $0.0314 \times 74 = 2.32\,g$ [1]
([–1] for each mistake) [3] 21

Section B **80**

Total **100**

New Specification

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2017

Centre Number

Candidate Number

Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry and an Introduction to Organic Chemistry

[SCH22]

SCH22

MONDAY 5 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all seventeen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all seven** questions in **Section B**. **You must answer the questions in the spaces provided.**
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in Question **14(c)**.
In Section A all questions carry equal marks, i.e. **one** mark for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements, containing some data, is included with this question paper.

10766

Section A – Multiple Choice

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

Each multiple choice question is worth 1 mark.

1 The mechanism for the reaction of halogenoalkanes with ethanolic potassium hydroxide is

A electrophilic addition.

B elimination.

C nucleophilic addition.

D substitution.

2 Which electronic configuration is that of a Group II ion?

A $1s^2 2s^2 2p^2$

B $1s^2 2s^2 2p^6$

C $1s^2 2s^2 2p^6 3s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$

3 Which substance occupies the largest volume at 293 K and 1 atmosphere of pressure?

A 4.0 g of ethane

B 4.4 g of propane

C 5.8 g of butane

D 6.4 g of methanol

4 When methane reacts with excess chlorine, in the presence of UV light, the organic product is

A chloromethane.

B dichloromethane.

C trichloromethane.

D tetrachloromethane.

5 What mass of magnesium oxide is required to neutralise $40.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ hydrochloric acid?

A 0.80 g

B 1.60 g

C 2.40 g

D 3.20 g

6 Which bromoalkane is a secondary bromoalkane?

A 1-bromobutane

B 1-bromo-2-methylpropane

C 2-bromobutane

D 2-bromo-2-methylpropane

7 The table shows some average bond enthalpies.

	average bond enthalpy/kJ mol^{-1}
C–C	348
C–H	413
O=O	496
C=O	743
O–H	463

What is the enthalpy change for the following reaction?

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

A $-1334\,kJ\,mol^{-1}$

B $-1585\,kJ\,mol^{-1}$

C $-1682\,kJ\,mol^{-1}$

D $-1962\,kJ\,mol^{-1}$

8 Assuming a 50.0% yield, what is the minimum mass of butan-1-ol required to produce 13.7 g of 1-bromobutane?

A 6.85 g

B 7.40 g

C 14.8 g

D 68.5 g

10766

9 A radical is

A a particle which acts as an electron pair acceptor.

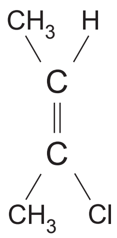
B a particle which acts as an electron pair donor.

C a particle with a lone pair of electrons.

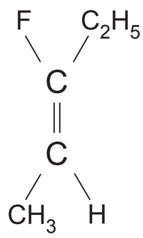
D a particle with an unpaired electron.

10 Which of the following is a Z isomer?

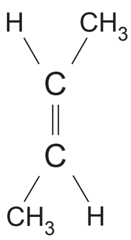
A



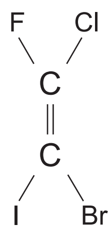
C



B



D



Section B

Answer all seven questions in the spaces provided.

11 A student carried out a series of activities to investigate the chemistry of Group II elements and compounds.

(a) The student heated magnesium carbonate in a boiling tube and bubbled the gas produced through a suitable reagent to identify the gas.

(i) Draw a diagram of the assembled apparatus and name the reagent used.

[2]

(ii) Write an equation for the thermal decomposition of magnesium carbonate.

____ [1]

(iii) Explain why magnesium carbonate decomposes much more readily than calcium carbonate when heated.

____

____

____ [2]

(b) The student added a solution of sodium hydroxide to a solution of magnesium nitrate. A white precipitate was formed.

(i) Name the precipitate.

____ [1]

(ii) Write an ionic equation, without state symbols, for the formation of the precipitate.

____ [1]

(c) The student added a solution of potassium sulfate to a solution of barium nitrate. A white precipitate was formed.

(i) Name the precipitate.

____ [1]

(ii) Write an ionic equation, including state symbols, for the formation of the precipitate.

____ [2]

(d) The student then burnt magnesium using a Bunsen burner.

(i) Give **two** observations.

____

____ [2]

(ii) Write an equation for the reaction.

____ [1]

12 There are five structural isomers with molecular formula C_6H_{14}.

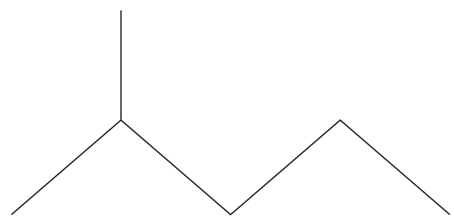
(a) What is meant by the term **structural isomers**?

____

____

____ [2]

(b) Four of the structural isomers are described as having branched structures. Complete the table below.

name of branched isomer	skeletal formula
2-methylpentane	

[3]

(c) Explain why the unbranched isomer, hexane, has a higher boiling point than any of the branched isomers.

____

____

____ [2]

(d) **(i)** Write an equation for the complete combustion of hexane.

____ [2]

(ii) Write an equation for the incomplete combustion of hexane.

____ [2]

13 Ammonia is produced by a reversible exothermic reaction between nitrogen and hydrogen:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) **(i)** Write an expression for the equilibrium constant, K_c, and deduce its units.

[2]

(ii) What does a small value of K_c indicate about this equilibrium?

____

____ [1]

(b) The Haber process, for the production of ammonia, uses a temperature between 400 °C and 500 °C, a pressure of approximately 200 atm and an iron catalyst.

(i) Explain why the yield improves at a temperature of 300 °C at constant pressure.

____

____

____ [2]

(ii) Explain why the production of ammonia is **not** carried out at 300 °C.

____

____

____ [1]

(iii) Explain why the yield improves when the pressure is 1000 atm at a constant temperature.

____

____

____ [2]

(iv) Explain why the production of ammonia is **not** carried out at 1000 atm.

____

____

____ [1]

14 It is often possible to distinguish between organic molecules by using infrared spectroscopy or simple test tube reactions.

(a) Explain why, without access to a database of infrared spectra, it is difficult to distinguish between butan-2-ol and 2-methylpropan-2-ol using infrared spectroscopy.

____

____

____

____ [2]

(b) Butan-2-ol and 2-methylpropan-2-ol give the same observations when reacted with phosphorus pentachloride.

(i) Write an equation for the reaction of 2-methylpropan-2-ol with phosphorus pentachloride.

____ [2]

(ii) Name the organic product.

____ [1]

(c) Describe how you could use simple test tube reactions to distinguish between butan-2-ol and 2-methylpropan-2-ol. Your answer should include reagents, conditions, observations and an explanation of the chemistry involved.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

[6]

15 Enthalpies of neutralisation can be determined using experimental methods.

(a) What is meant by the term **enthalpy of neutralisation**?

____

____

____ [2]

(b) An enthalpy of neutralisation was determined using the following method.

Add 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid to a polystyrene cup. Add 50 cm^3 of 2.0 mol dm^{-3} sodium hydroxide solution to a different polystyrene cup. Place thermometers in each solution and leave until both temperatures are equal. Record the temperature. Transfer the alkali into the acid and stir. Record the maximum temperature reached.

The following results were obtained:

initial temperature = 20.0 °C

maximum temperature reached = 33.3 °C

(i) Which piece of apparatus should be used to add 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid to the polystyrene cup?

____ [1]

(ii) What is the advantage of using a polystyrene cup?

____ [1]

(iii) Write an equation for the neutralisation reaction.

____ [1]

(iv) Assuming that the mass of the solution (in grams) is equal to its volume (in cm^3) and that the heat capacity of the solution is $4.2\,J\,g^{-1}\,K^{-1}$, use the equation $q = mc\Delta T$ to calculate the heat energy released (in Joules).

____

______________________________ [2]

(v) Calculate the number of moles of water produced.

____

______________________________ [1]

(vi) Calculate the enthalpy of neutralisation in $kJ\,mol^{-1}$.

____

____

______________________________ [3]

(vii) Suggest why the value calculated may be different from the data book value.

____

______________________________ [1]

16 A hydrocarbon contains 85.7% carbon by mass.

(a) Calculate the empirical formula of this hydrocarbon using its percentage composition.

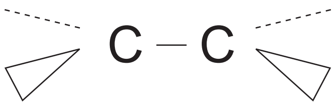
____

____

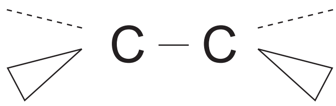
____ [2]

(b) The C=C bond and the four atoms which are attached to the carbon atoms all lie in the same plane.

(i) Complete the diagram below to show the formation of the pi bond from two p-orbitals.



before



after

[1]

(ii) Explain why the presence of the pi bond makes an alkene more reactive than an alkane.

____

____ [2]

(c) Detailed analysis proved that the hydrocarbon is 2-methylbut-1-ene, $CH_2=C(CH_3)CH_2CH_3$, which reacts with hydrogen bromide to form two organic products.

(i) Show the polarity of the hydrogen bromide molecule.

H–Br

[1]

(ii) Name the mechanism for the reaction of 2-methylbut-1-ene with hydrogen bromide.

____ [2]

(iii) Name the major organic product.

____ [1]

(iv) Using curly arrows to show the movement of electron pairs, draw the mechanism for the reaction of 2-methylbut-1-ene with hydrogen bromide to form the major organic product.

[4]

(v) Explain why the mechanism given in part **(iv)** produces the major organic product.

____

____

____

____ [2]

17 When 1-bromopropane is heated with aqueous potassium hydroxide, the hydroxide ions behave as nucleophiles.

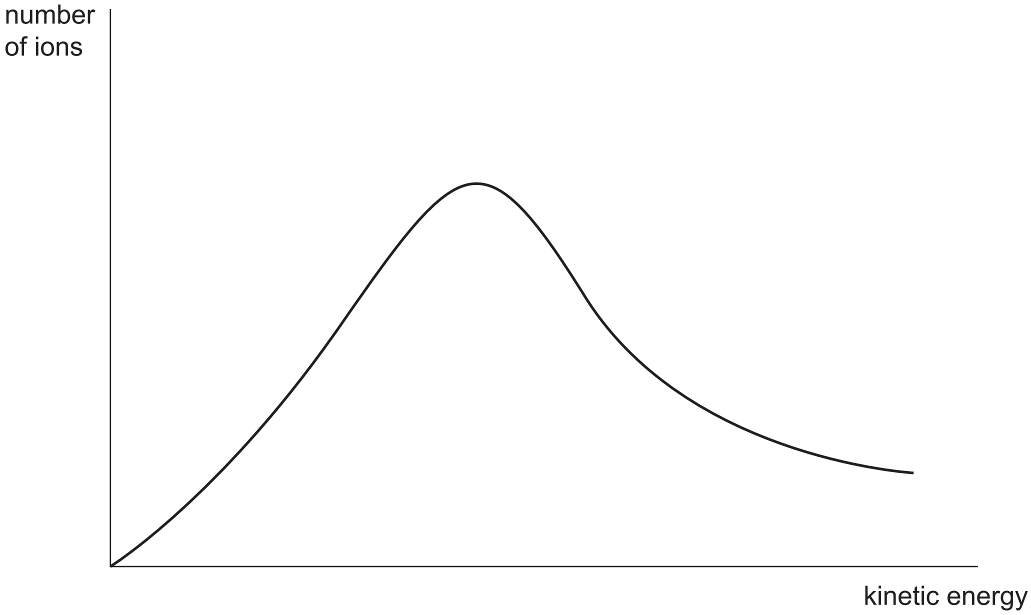
(a) What is meant by the term **nucleophile**?

____

____

____ [2]

(b) Most collisions between hydroxide ions and 1-bromopropane molecules do not result in a reaction. The following diagram shows the kinetic energy distribution of hydroxide ions in the reaction mixture:



(i) On the x-axis above, show a possible position for the activation energy. [1]

(ii) On the same axes, show the kinetic energy distribution of hydroxide ions at a lower temperature. [2]

(iii) Use the two distribution curves to explain how the rate of reaction is affected by lowering the temperature.

____

____

____ [2]

(c) Explain how the rate of the reaction between 1-iodopropane with aqueous potassium hydroxide compares with that of 1-bromopropane.

____

____

____

____ [2]

THIS IS THE END OF THE QUESTION PAPER

DO NOT WRITE ON THIS PAGE

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
17	
Total Marks	

General Information

1 tonne = 10^6 g
1 metre = 10^9 nm
One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3
Avogadro Constant = 6.02×10^{23} mol^{-1}
Planck Constant = 6.63×10^{-34} J s
Specific Heat Capacity of water = 4.2 J g^{-1} K^{-1}
Speed of Light = 3×10^8 m s^{-1}

Characteristic absorptions in IR spectroscopy

Wavenumber/cm^{-1}	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–C**H**	Saturated alkanes
0.5–5.5	–O**H**	Alcohols
1.0–3.0	–N**H**	Amines
2.0–3.0	–CO–C**H**	Ketones
	–N–C**H**	Amines
	C_6H_5–C**H**	Arene (aliphatic on ring)
2.0–4.0	X–C**H**	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=C**H**	Alkenes
5.5–8.5	RCON**H**	Amides
6.0–8.0	–$C_6\mathbf{H}_5$	Arenes (on ring)
9.0–10.0	–C**H**O	Aldehydes
10.0–12.0	–COO**H**	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

New Specification

cea
Rewarding Learning

GCE

CHEMISTRY DATA SHEET

GCE A/AS EXAMINATIONS

CHEMISTRY

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and Advanced Level
Chemistry Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations.

For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

THE PERIODIC TABLE OF ELEMENTS

Group

I	II											III	IV	V	VI	VII	0
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** Hydrogen 1																	4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	98 **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La*** Lanthanum 57	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	210 **Po** Polonium 84	210 **At** Astatine 85	222 **Rn** Radon 86
223 **Fr** Francium 87	226 **Ra** Radium 88	227 **Ac**† Actinium 89	261 **Rf** Rutherfordium 104	262 **Db** Dubnium 105	266 **Sg** Seaborgium 106	264 **Bh** Bohrium 107	277 **Hs** Hassium 108	268 **Mt** Meitnerium 109	271 **Ds** Darmstadtium 110	272 **Rg** Roentgenium 111	285 **Cn** Copernicium 112						

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	145 **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	237 **Np** Neptunium 93	242 **Pu** Plutonium 94	243 **Am** Americium 95	247 **Cm** Curium 96	245 **Bk** Berkelium 97	251 **Cf** Californium 98	254 **Es** Einsteinium 99	253 **Fm** Fermium 100	256 **Md** Mendelevium 101	254 **No** Nobelium 102	257 **Lr** Lawrencium 103

* 58–71 Lanthanum series
† 90–103 Actinium series

a x b	
	a = relative atomic mass (approx) x = atomic symbol b = atomic number

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2017

Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry and an Introduction to Organic Chemistry

[SCH22]

MONDAY 5 JUNE, AFTERNOON

MARK SCHEME

General Marking Instructions

Introduction
The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. it also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives
Below are the assessment objectives for **GCE Chemistry:**

Candidates should be able to:

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling quantitative and qualitative data
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence (in relation to particular issues) • make judgements and reach conclusions • develop and refine practical design and procedures

Quality of candidates' responses
In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 17- or 18-year-old which is the age at which the majority of candidates sit their GCE examinations.

Flexibility in marking
Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive marking
Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do rather than penalising candidates for errors or omissions. The exception to this for GCE Chemistry is when Examiners are marking complex calculations and mechanisms when the Examiners are briefed to mark by error or omission. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 17- or 18-year-old GCE candidate.

Awarding zero marks
Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

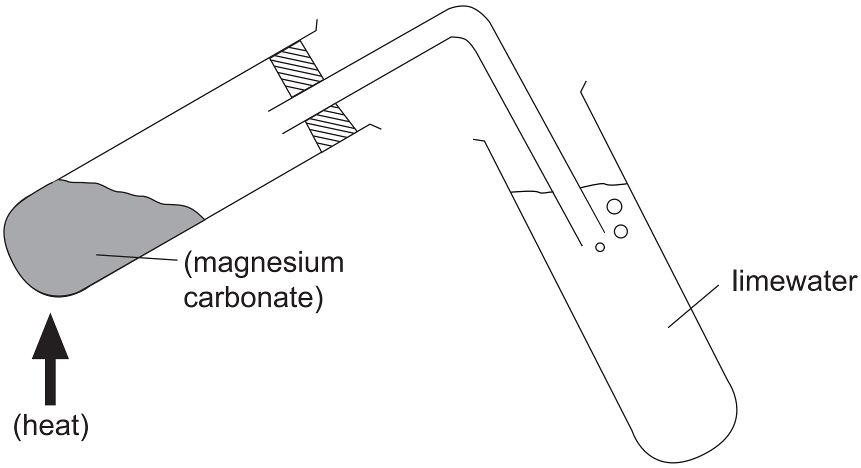
Section A

		AVAILABLE MARKS
1	B	
2	B	
3	A	
4	D	
5	A	
6	C	
7	C	
8	C	
9	D	
10	C	
[1] for each correct answer		10
	Section A	**10**

Section B

AVAILABLE MARKS

11 **(a)** **(i)**



error [–1]
size of limewater tube can be smaller/larger or any container [2]

(ii) $MgCO_3 \rightarrow MgO + CO_2$ [1]

(iii) Mg^{2+} smaller than Ca^{2+}/higher charge density [1]
Polarises carbonate ion/destabilises carbonate (more than Ca^{2+}) [1] [2]

(b) **(i)** magnesium hydroxide [1]

(ii) $Mg^{2+} + 2OH^- \rightarrow Mg(OH)_2$ [1]

(c) **(i)** barium sulfate [1]

(ii) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ [2]

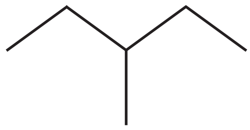
(d) **(i)** (bright) white light [1] white solid [1] [2]

(ii) $2Mg + O_2 \rightarrow 2MgO$ [1] 13

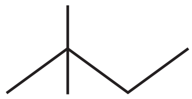
AVAILABLE MARKS

12 **(a)** same molecular formula [1]
different structural formula [1] [2]

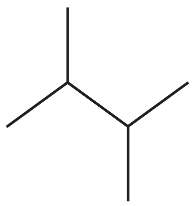
(b) 3-methylpentane



2,2-dimethylbutane



2,3-dimethylbutane



[3]

(c) More contact between molecules [1]
Greater van der Waals' forces [1] [2]

(d) **(i)** $2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$ [2]

(ii) $2C_6H_{14} + 13O_2 \rightarrow 12CO + 14H_2O$ [2] 11

13 **(a)** **(i)** $\left(K_c =\right)\dfrac{[NH_3]^2}{[N_2][H_2]^3}$ [1]
$mol^{-2}\ dm^6$ [1] [2]

(ii) equilibrium lies to left-hand side [1]

(b) **(i)** Reaction exothermic [1]
(When temperature is lowered) the equilibrium shifts to RHS
(to oppose change) [1] [2]

(ii) Reaction is too slow [1]

(iii) 4 moles of gas LHS $\rightarrow$ 2 moles gas RHS [1]
When pressure increases the equilibrium shifts to RHS
(to oppose change) [1] [2]

(iv) Too expensive since thicker pipes are required/more steel [1] 9

AVAILABLE MARKS

14 (a) Same bonds present/C–C, C–H, C–O and O–H [1]
Same absorptions/peaks in same places [1] [2]

(b) (i) $(CH_3)_3COH + PCl_5 \rightarrow (CH_3)_3CCl + HCl + POCl_3$ [2]

(ii) 2-chloro-2-methylpropane [1]

(c) Indicative content
acidified potassium dichromate(VI)
heat
butan-2-ol: orange to green
secondary alcohols can be oxidised
2-methylpropan-2-ol: remains orange
tertiary alcohols cannot be oxidised

Band	**Response**	**Mark**
A	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 3 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates use a minimum of 2 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

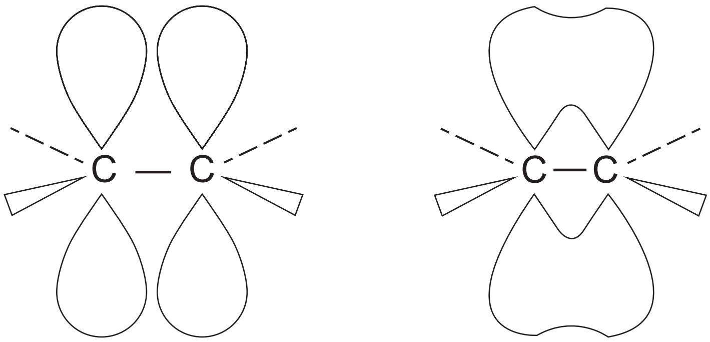
[6] 11

				AVAILABLE MARKS
15	**(a)**	Enthalpy change when one mole of water Is formed in a neutralisation reaction	[2]	
	(b)	**(i)** measuring cylinder/burette/pipette	[1]	
		(ii) Insulates/does not absorb heat	[1]	
		(iii) $NaOH + HCl \rightarrow NaCl + H_2O$ (or ionic)	[1]	
		(iv) $100 \times 4.2 \times 13.3$ 5586 J	[2]	
		(v) $2.0 \times 0.05 = 0.1$ moles NaOH **or** $2.0 \times 0.05 = 0.1$ moles HCl = 0.1 moles water formed [1]	[1]	
		(vi) $5586 \div 1000 = 5.586$ kJ $5.586 \div 0.1 = 55.86$ kJ mol^{-1} Exothermic -55.86 kJ mol^{-1}	[3]	
		(vii) Some heat lost to the surroundings	[1]	12

		C	H	AVAILABLE MARKS
16	**(a)**	85.7	14.3	
		7.14 moles	14.3 moles	
		1	2 (.014)	

Empirical formula = CH_2 [2]

(b) (i)



[1]

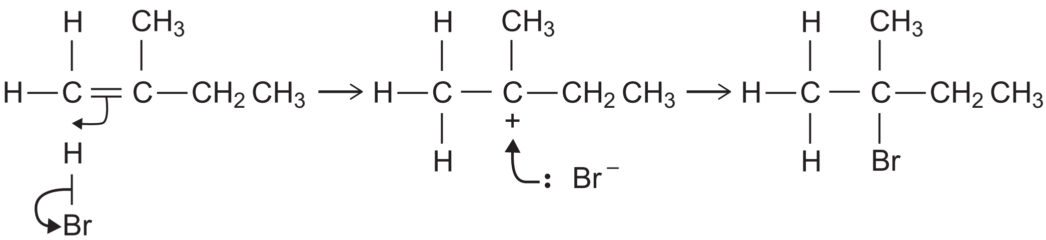
(ii) Pi bond is a weaker bond than sigma
Electron rich/high electron density
Prone to attack by electrophiles
Any 2 from 3 [2]

(c) (i) $\overset{\delta+}{H}–\overset{\delta–}{Br}$ [1]

(ii) Electrophilic [1] addition [1] [2]

(iii) 2-bromo-2-methylbutane [1]

(iv)



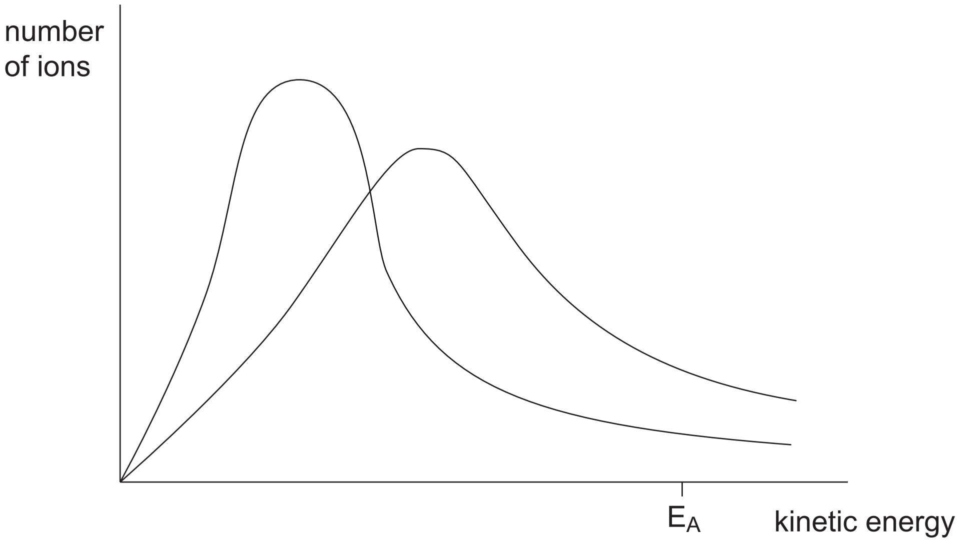
[3] is for mechanism
[1] is for correct use of curly arrows [4]

(v) Tertiary carbocation/carbonium ion [1]
More stable than primary carbocation [1] [2] 15

17 **(a)** An ion or molecule, with a lone pair of electrons, that attacks regions of low electron density. [2]

(b) **(i)** activation energy (E_A) at a high energy value on the x-axis [1]

(ii)



Starts at origin
Peak higher
to the left
Curve below original at high kinetic energy values (error [–1]) [2]

(iii) rate decreases [1]
fewer hydroxide ions with energy greater than activation [1] [2]

(c) faster [1]
C–I bond weaker than C–Br bond [1] [2]

AVAILABLE MARKS	
	9
Section B	**80**
Total	**90**

Rewarding Learning

Centre Number

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2018

Chemistry

Assessment Unit AS 2
assessing
Further Physical and Inorganic Chemistry and an Introduction to Organic Chemistry

SCH22

[SCH22]

FRIDAY 25 MAY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fourteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all four** questions in **Section B**. **You must answer the questions in the spaces provided.**
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in Question **14(a)(ii)**.
In Section A all questions carry equal marks, i.e. **one** mark for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements, containing some data, is included with this question paper.

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Section A – Multiple Choice

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

Each multiple choice question is worth 1 mark.

1 Carbon monoxide reacts with steam as follows:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \quad -40.0\,kJ\,mol^{-1}$$

Which change will shift the position of equilibrium to the right-hand side of the equation?

A Decrease in pressure

B Decrease in temperature

C Increase in pressure

D Increase in temperature

2 Which compound has the highest boiling point?

A Butan-1-ol

B Butan-2-ol

C 2-methylpropan-2-ol

D Pentane

3 Which of the following molecules can show a strong absorption peak at $1750\,cm^{-1}$ in an infrared spectrum?

A C_4H_8

B C_4H_{10}

C C_4H_8O

D $C_4H_{10}O$

4 Neutralisation of 25.0 cm^3 of 2.0 mol dm^{-3} sodium hydroxide by 50.0 cm^3 of 1.0 mol dm^{-3} hydrochloric acid resulted in an 8.0 °C increase in temperature.

The enthalpy of neutralisation for this reaction is

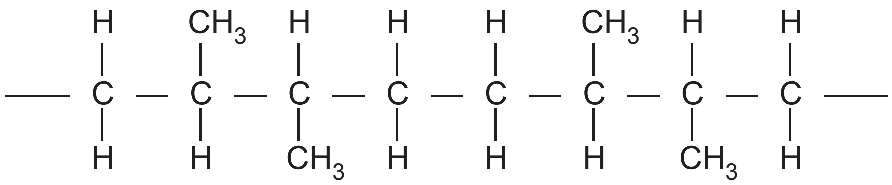
A –16.8 kJ mol^{-1}.

B –25.2 kJ mol^{-1}.

C –33.6 kJ mol^{-1}.

D –50.4 kJ mol^{-1}.

5 Part of a polymer chain is shown below.



Which monomer produces this polymer?

A But-1-ene

B But-2-ene

C Methylpropene

D Propene

6 Sulfur trioxide is produced by the reversible reaction between sulfur dioxide and oxygen.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

What are the units of the equilibrium constant, K_c, for the forward reaction?

A mol dm^{-3}

B mol^{-1} dm^3

C mol^2 dm^{-6}

D mol^{-2} dm^6

7 Ethanoic acid can be produced by the oxidation of butane.

$$2C_4H_{10} + 5O_2 \rightarrow 4CH_3COOH + 2H_2O$$

The atom economy for ethanoic acid is

A 22%.

B 52%.

C 67%.

D 87%.

8 Which statement correctly describes the boiling points of fluoroethane and iodoethane?

A Fluoroethane has a higher boiling point because it forms hydrogen bonds.

B Fluoroethane has a higher boiling point because the C-F bond is stronger than the C-I bond.

C Fluoroethane has a lower boiling point because it has weaker van der Waals' forces between the molecules.

D Fluoroethane has a lower boiling point because the C-F bond is more polar than the C-I bond.

9 The table shows standard enthalpy changes of formation.

compound	$NH_4NO_3(s)$	$H_2O(g)$	$CO_2(g)$
ΔH_f /kJ mol^{-1}	–366	–242	–394

Which is the standard enthalpy change for the following reaction?

$$2NH_4NO_3(s) + C(s) \rightarrow 2N_2(g) + 4H_2O(g) + CO_2(g)$$

A –270 kJ mol^{-1}

B +270 kJ mol^{-1}

C +630 kJ mol^{-1}

D –630 kJ mol^{-1}

10 The first reaction that occurs when a car airbag is set off is:

$$2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$$

When 3.25 g of NaN_3 decomposes

A 1.80 dm^3 of nitrogen is formed.

B 2.30 g of sodium is formed.

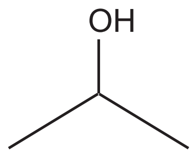
C 3.60 dm^3 of nitrogen is formed.

D 5.35 g of products are formed.

Section B

Answer all **four** questions in this section.

11 Isopropyl alcohol is used as a hand sanitiser and as a cleaning agent for electronic equipment.



isopropyl alcohol

(a) Give the IUPAC name for isopropyl alcohol.

____ [1]

(b) (i) Propan-1-ol is a **structural isomer** of isopropyl alcohol. Explain this term.

____

____

____ [2]

(ii) Ethyl methyl ether ($CH_3CH_2OCH_3$) is a structural isomer of isopropyl alcohol.

Explain, using intermolecular forces, why the boiling point of this isomer is lower than isopropyl alcohol.

____

____

____

____ [3]

(c) Isopropyl alcohol can be oxidised using acidified potassium dichromate(VI).

(i) Draw the skeletal formula of the organic product formed.

[1]

(ii) Name the type of compound formed.

____ [1]

(iii) Explain how infrared spectroscopy could be used to show that the oxidation reaction was complete.

____

____ [1]

(d) Oxidation of 1.50 g of isopropyl alcohol gives 1.0 g of the organic product. Calculate the percentage yield of this reaction.

____

____

____ [3]

(e) Isopropyl alcohol is completely soluble in water.

(i) Explain why isopropyl alcohol is soluble in water.

____

____

____ [2]

(ii) Suggest why the addition of sodium chloride to an aqueous solution of isopropyl alcohol causes the alcohol to become less soluble.

____

____

____ [1]

12 Calcium is present in teeth in the form of calcium phosphate. This salt does not react with water although the element calcium does react forming a gas.

(a) Write the formula of calcium phosphate.

____ [1]

(b) **(i)** Write an equation for the reaction of calcium with water.

____ [2]

(ii) Explain why, using the same mass of strontium in place of calcium, the volume of gas produced when strontium reacts with water is less under the same conditions.

____

____ [1]

(iii) Suggest another difference that would be observed in the reaction with water when strontium is used in place of calcium. Explain your answer.

____

____

____ [2]

(c) The Group II metal oxides can be formed from the metal hydroxides.

(i) How would you convert calcium hydroxide to calcium oxide?

____ [1]

(ii) State and explain the trend in thermal stability of the Group II hydroxides as the Group is descended.

____

____

____ [3]

(d) What chemical property of magnesium oxide makes it suitable for indigestion remedies?

______________________________ [1]

(e) Magnesium sulfate is an important compound in horticulture. Industrially, the sulfates of magnesium and calcium are produced by reacting dolomite rock with excess sulfuric acid.

$$MgCO_3.CaCO_3 + 2H_2SO_4 \rightarrow MgSO_4 + CaSO_4 + 2H_2O + 2CO_2$$

(i) Other than a temperature change, suggest **two** observations during this reaction.

____

______________________________ [2]

(ii) Compare the solubility of magnesium sulfate with calcium sulfate in water.

____

______________________________ [1]

(iii) The solubility of magnesium sulfate at two temperatures is given in the table below. In a batch process, a saturated solution of magnesium sulfate at 70 °C contained 100 tonnes of water. Use the table to calculate the mass of solid magnesium sulfate obtained when this solution is cooled to 20 °C.

temperature / °C	solubility / g per 100 g of water
20	35.1
70	59.2

____

____

______________________________ [2]

(f) 2.50 g of hydrated magnesium sulfate crystals ($MgSO_4.xH_2O$) were heated to constant mass. The anhydrous solid has a mass of 1.22 g. Calculate the value of x and hence deduce the formula for the hydrated salt.

____

____

____

____ [3]

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(Questions continue overleaf)

13 Propene is an important building block for a large number of chemicals. At low temperatures, propene will react with chlorine in an electrophilic addition reaction.

(a) **(i)** Explain the term **electrophile**.

____

____ [2]

(ii) Draw a flow scheme to show the mechanism for the reaction between propene and chlorine using curly arrows.

[4]

(b) At 500 °C in the presence of ultraviolet light, propene will react with chlorine in a similar way to the reaction of propane with chlorine radicals. The product formed is allyl chloride ($CH_2{=}CHCH_2Cl$).

Outline the mechanism of the reaction between propene and chlorine giving equations for the initiation, propagation and termination steps.

Initiation equation ____

Propagation equations ____

____

Termination equation ____ [4]

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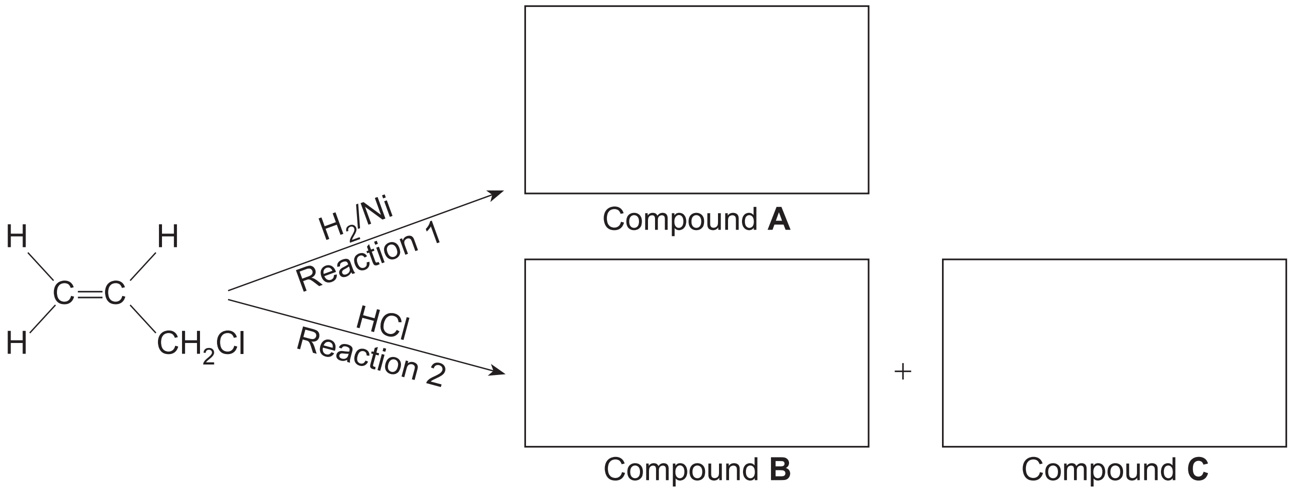
(c) (i) Two reactions of allyl chloride are shown. Fill in the structures of Compounds **A**, **B** and **C**. More of compound **B** is formed than compound **C**.



[3]

(ii) Explain why compounds **B** and **C** are not formed in equal amounts.

____

____

____ [2]

(iii) Compound **B** reacts slowly in humid conditions to form compound **D** which contains the following percentage masses: C, 40.0%; H, 7.0%; O, 53.0%. The relative formula mass of the compound is 90. Deduce the molecular formula of compound **D**.

____

____

____

____

____

____ [3]

(d) Allyl chloride will undergo an hydrolysis reaction with aqueous sodium hydroxide similar to halogenoalkanes.

(i) Draw the structural formula of the organic product formed in this reaction. Show **all** the bonds present.

[2]

(ii) Name the inorganic product formed during this hydrolysis reaction.

____ [1]

(e) Allyl chloride has a structural isomer which exists as geometrical isomers. Draw and label these geometrical isomers.

[3]

(f) Allyl chloride is highly flammable. When it burns, one of the products formed is a corrosive gas.

(i) Define the term **molar gas volume**.

____ [1]

(ii) 1.50 g of this corrosive gas occupies a volume of 0.986 dm^3 at 293 K and 1 atmosphere pressure. Use this information to calculate the relative molecular mass of the gas and suggest its identity.

____

____

____

____ [3]

14 Two million tonnes of ethanol are produced each year by the direct hydration of ethene using a phosphoric acid catalyst at 300 °C and 6000 kPa.

$$C_2H_4(g) \quad + \quad H_2O(g) \quad \rightleftharpoons \quad C_2H_5OH(g) \quad -45\,kJ\,mol^{-1}$$

(a) **(i)** Describe how a catalyst increases the rate of a reaction.

____

____ [2]

(ii) State and explain the **general** conditions of temperature and pressure required to give a high yield of ethanol. Explain how a compromise between equilibrium yield and the reaction rate may influence the conditions of temperature and pressure used.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

____

____

____

____

____

____

____

____

____

____ [6]

(b) Ethanol is a liquid at room temperature. It is increasingly used as a fuel.

(i) Give the equation, including state symbols, for the standard molar enthalpy of formation of ethanol.

____ [2]

(ii) Suggest why this standard enthalpy change cannot be measured directly.

____

____ [1]

(iii) Using the enthalpy changes below, calculate the enthalpy change of formation of gaseous ethanol.

$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$ $\quad -45.0\,\text{kJ mol}^{-1}$

$2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$ $\quad +52.3\,\text{kJ mol}^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$ $\quad -242.0\,\text{kJ mol}^{-1}$

____

____

____

____ [3]

(c) **(i)** Give the equation for the standard enthalpy of combustion of ethanol.

____ [2]

(ii) Using bond enthalpies explain why enthalpy changes of combustion are negative.

____

____ [2]

11382

New Specification

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2018

Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry
and an Introduction to Organic Chemistry

[SCH22]

FRIDAY 25 MAY, MORNING

MARK SCHEME

General Marking Instructions

Introduction
The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. It also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives
Below are the assessment objectives for **GCE Chemistry:**

Candidates should be able to:

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling quantitative and qualitative data
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence (in relation to particular issues) • make judgements and reach conclusions • develop and refine practical design and procedures

Quality of candidates' responses
In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 17- or 18-year-old which is the age at which the majority of candidates sit their GCE examinations.

Flexibility in marking
Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive marking
Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do rather than penalising candidates for errors or omissions. The exception to this for GCE Chemistry is when examiners are marking complex calculations and mechanisms when the examiners are briefed to mark by error or omission. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 17- or 18-year-old GCE candidate .

Awarding zero marks
Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

Section A

		AVAILABLE MARKS
1	B	
2	A	
3	C	
4	D	
5	D	
6	B	
7	D	
8	C	
9	D	
10	A	
[1] for each correct answer	[10]	10
	Section A	**10**

Section B

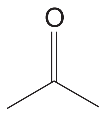
AVAILABLE MARKS

11 **(a)** propan-2-ol/2-hydroxypropane [1]

(b) **(i)** molecules which have the same molecular formula [1]
but a different structural formula [1] [2]

(ii) **Between** molecules of ethyl methyl ether there are permanent dipole and/or van der Waals' forces [1]
Between molecules of isopropyl alcohol there are H–bonds and (van der Waals' forces) [1]
H–bonds are stronger/require more energy to break [1] [3]

(c) **(i)**



structure [1] [1]

(ii) ketone [1]

(iii) disappearance of absorption peak at 3200–3600 cm^{-1} [1]

(d) $\frac{1.\square 0}{60} = 0.025$
moles of propanone = 0.025
expected mass of propanone = 0.025 × 58 = 1.45 g
% yield = $\frac{1.0}{1.45} \times 100 = 68.97\%$ ([–1] each error) [3]

(e) **(i)** Isopropyl alcohol contains an OH group [1]
and can form H-bonds with water molecules [1] [2]

(ii) increased competition for bonding with water molecules
or
water molecules form stronger bonds with Na^+/Cl^- ions [1] 15

12 **(a)** $Ca_3(PO_4)_2$ [1]

(b) **(i)** $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ [2]

(ii) fewer moles of strontium/strontium has a higher RAM. [1]

(iii) reaction faster/more vigorous [1] as strontium is more reactive [1]
or
product mixture is less cloudy [1] as strontium hydroxide is more soluble [1] [2]

(c) **(i)** thermal decomposition (breakdown using) heat [1]

(ii) thermal stability increases as Group is descended. [1]
Cation radius increases. [1] Therefore polarising ability decreases.[1] [3]

(d) It is a base [1]

(e) **(i)** Effervescence [1]
(white) solid appears/rock disappears [1] [2]

(ii) magnesium sulfate is more soluble than calcium sulfate [1]

(iii) 59.2 – 35.1 = 24.1 g in 100 g of water
24100 kg in 100 tonnes of water
24.1 tonnes [2]

(f) mass of H_2O = 2.50 – 1.22 = 1.28 g

Moles of $H_2O = \frac{1.28}{18} = 0.07(11)$

Moles of $MgSO_4 = \frac{1.22}{120} = 0.0102$

$MgSO_4$: H_2O

0.01 : 0.07

1 : 7

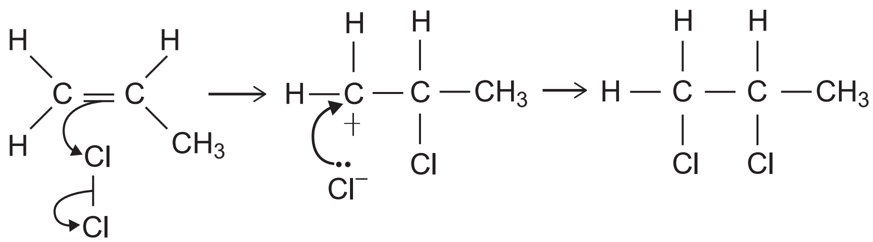
$MgSO_4.7\ H_2O$

([–1] each error) [3]

AVAILABLE MARKS: 19

13 **(a)** **(i)** An ion or molecule [1]
that attacks regions of high electron density [1] [2]

(ii)



[4]

(b) initiation: $Cl_2 \rightarrow 2Cl^\bullet$

propagation: $CH_2CHCH_3 + Cl^\bullet \rightarrow CH_2CHCH_2{}^\bullet + HCl$

$CH_2CHCH_2{}^\bullet + Cl_2 \rightarrow CH_2CHCH_2Cl + Cl^\bullet$

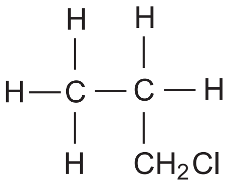
termination: $Cl^\bullet + Cl^\bullet \rightarrow Cl_2$

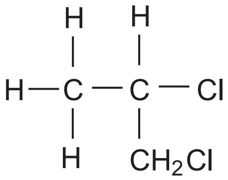
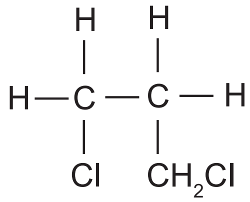
$CH_2CHCH_2{}^\bullet + CH_2CHCH_2{}^\bullet \rightarrow CH_2CHCH_2CH_2CHCH_2$

$CH_2CHCH_2{}^\bullet + Cl^\bullet \rightarrow CH_2CHCH_2Cl$ [4]

AVAILABLE MARKS

(c) **(i)**

Compound A 

Compound B  Compound C 

[3]

(ii) The intermediate/carbocation formed in the formation of compound B is a sec carbocation. This is more stable (error (−1)) [2]

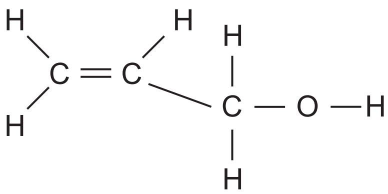
(iii)

C	:	H	:	O
40	:	7	:	53
12	:	1	:	16
3.33	:	7.0	:	3.31
1	:	2	:	1

Empirical formula = CH_2O

Molecular Formula = $C_3H_6O_3$ [3]

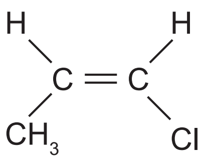
(d) **(i)**



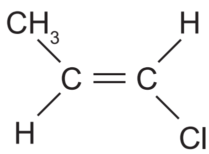
[2]

(ii) Sodium chloride [1]

(e)



Z



E

[3]

(f) **(i)** the volume of one mole of gas under specified conditions of temperature and pressure [1]

(ii) 1 mol = 24 dm^3

0.041 mol = 0. 986 dm^3

$M_r = \frac{1.50}{0.0411} = 36.5$

HCl = 1 + 35.5 = 36.5 [3]

28

AVAILABLE MARKS

14 (a) (i) (Reaction to proceed via a route with) lower activation energy [1] a greater proportion of molecules with energy equal/greater than the activation energy [1] [2]

(ii) Indicative content

- Low temperature
- As temperature decreases equilibrium moves in exothermic direction
- High pressure
- As pressure increases equilibrium moves towards the side with smaller number of gas moles
- Low temperature means rate is slow so compromise temperature of (300°C) used
- High pressure is expensive therefore compromise of (6000kPa) used

Band	Response	Mark
A	Candidates must use appropriate specialist terms giving 5–6 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms giving 3–4 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates must use 1–2 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style is of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

(b) (i) $2C(s) + 3H_2(g) + 1/2\ O_2(g) \rightarrow C_2H_5OH(l)$ [2]

(ii) (If these elements were reacted together) other products would form/carbon does not react with hydrogen/oxygen under standard conditions [1]

(iii) $-189.7 + (-45.0) = \Delta H_r$
$-234.7\ kJ\ mol^{-1} = \Delta H_r$
([–1] each error) [3]

(c) (i) $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ [2]

(ii) Energy produced during bond making in products is greater [1] than energy needed to break bonds in the reactants [1] [2] 18

Section B **80**

Total **90**

Rewarding Learning

Centre Number

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019

Chemistry

Assessment Unit AS 2
assessing
Further Physical and Inorganic Chemistry and an Introduction to Organic Chemistry

[SCH22]

SCH22

THURSDAY 23 MAY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fourteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all four** questions in **Section B**. **You must answer the questions in the spaces provided.**
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in Question **13(a)(ii)**.
In Section A all questions carry equal marks, i.e. **one** mark for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements, containing some data, is included with this question paper.

11983.05**R**

Section A – Multiple Choice

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

Each multiple choice question is worth 1 mark.

1 How many carbon to carbon bonds are there in 3,3-dichloro-2-methylbutan-2-ol?

A 3

B 4

C 5

D 6

2 Which sequence of elements is arranged in order of increasing bond strength?

A F_2 O_2 N_2

B N_2 O_2 F_2

C O_2 F_2 N_2

D O_2 N_2 F_2

3 0.005 mole of a chloride of an element Z was mixed with water and the resulting solution required 25 cm^3 of 0.6 M aqueous silver nitrate for complete precipitation of silver chloride. Element Z is in Group

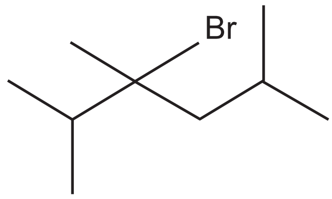
A III.

B IV.

C V.

D VI.

4 The bromoalkane below reacts with ethanolic potassium hydroxide and eliminates hydrogen bromide.



What is the number of alkenes formed and how many pairs of E/Z isomers exist?

	number of alkenes	pairs of E/Z isomers
A	2	1
B	2	2
C	3	1
D	3	2

5 The Williamson synthesis of an ether (ROR′) is summed up by the following two steps:

Step 1 $2ROH + 2Na \rightarrow 2RONa + H_2$

Step 2 $RONa + R'Cl \rightarrow ROR' + NaCl$

Using propan-2-ol and 2-chlorobutane the ether formed is

A $CH_3CH_2CH_2OCH(CH_3)CH_2CH_3$.

B $CH_3CH_2CH_2OCH_2CH_2CH_2CH_3$.

C $CH_3CH(CH_3)OCH_2CH_2CH_2CH_3$.

D $CH_3CH(CH_3)OCH(CH_3)CH_2CH_3$.

[Turn over

6 Which of the following describes a dynamic equilibrium?

	concentration of reactants and products	**forward and reverse reaction rates**
A	constant	equal
B	constant	not equal
C	not constant	equal
D	not constant	not equal

7 A mixture of potassium bromide and potassium carbonate contains 0.6 moles of bromide ion and 0.2 moles of carbonate ion. How many moles of potassium ions are present?

A 0.4

B 0.5

C 0.8

D 1.0

8 The total pressure is increased in each of the following reactions. For which reaction would the yield of product(s) **not** change?

A $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

B $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

C $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$

D $3H_2(g) + CO(g) \rightleftharpoons CH_4(g) + H_2O(g)$

9 One molecule of cuprimine contains one sulfur atom. The percentage, by mass, of sulfur in cuprimine is 21.47%. The relative molecular mass of cuprimine is

A 85.

B 101.

C 125.

D 149.

10 The general formula of an alkyl group is

A C_nH_{n+1}

B C_nH_{n-1}

C C_nH_{2n+1}

D C_nH_{2n-1}

[Turn over

Section B

Answer all **four** questions in this section

11 Group II metal nitrates are formed when either the metal, the metal oxide or the metal carbonate are reacted with nitric acid. Metal nitrates are very soluble in water and all of the reactions proceed normally, apart from magnesium with nitric acid, because nitric acid is an oxidising agent and causes other reactions to take place.

(a) Write equations for the reactions of calcium, calcium oxide and calcium carbonate with dilute nitric acid.

(i) calcium:

____ [1]

(ii) calcium oxide:

____ [1]

(iii) calcium carbonate:

____ [1]

(b) Magnesium does not react with most concentrations of nitric acid to give hydrogen. Instead, nitrogen(IV) oxide together with magnesium nitrate and water are produced. Write the equation for the reaction.

____ [1]

(c) Group II metal nitrates increase in thermal stability as the Group is descended.

(i) Explain what is meant by the term **thermal stability**.

____

____ [1]

(ii) Explain why thermal stability increases down the Group.

____

____ [1]

(d) When heated, the Group II nitrates, $M(NO_3)_2$, decompose according to the following equation:

$$2M(NO_3)_2 \rightarrow 2MO + 4NO_2 + O_2$$

(i) Explain why the residue left after the reaction gives an alkaline solution when dissolved in water.

____

____ [1]

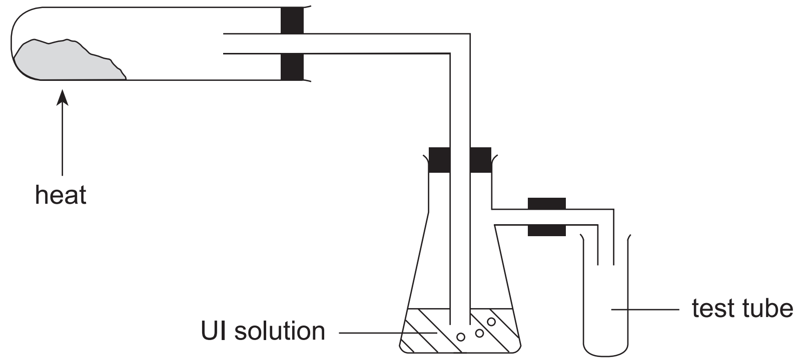
(ii) If 3.6 g of strontium nitrate is heated and completely decomposes, what is the total volume of gases collected at 20 °C and a pressure of one atmosphere?

____

____

____ [3]

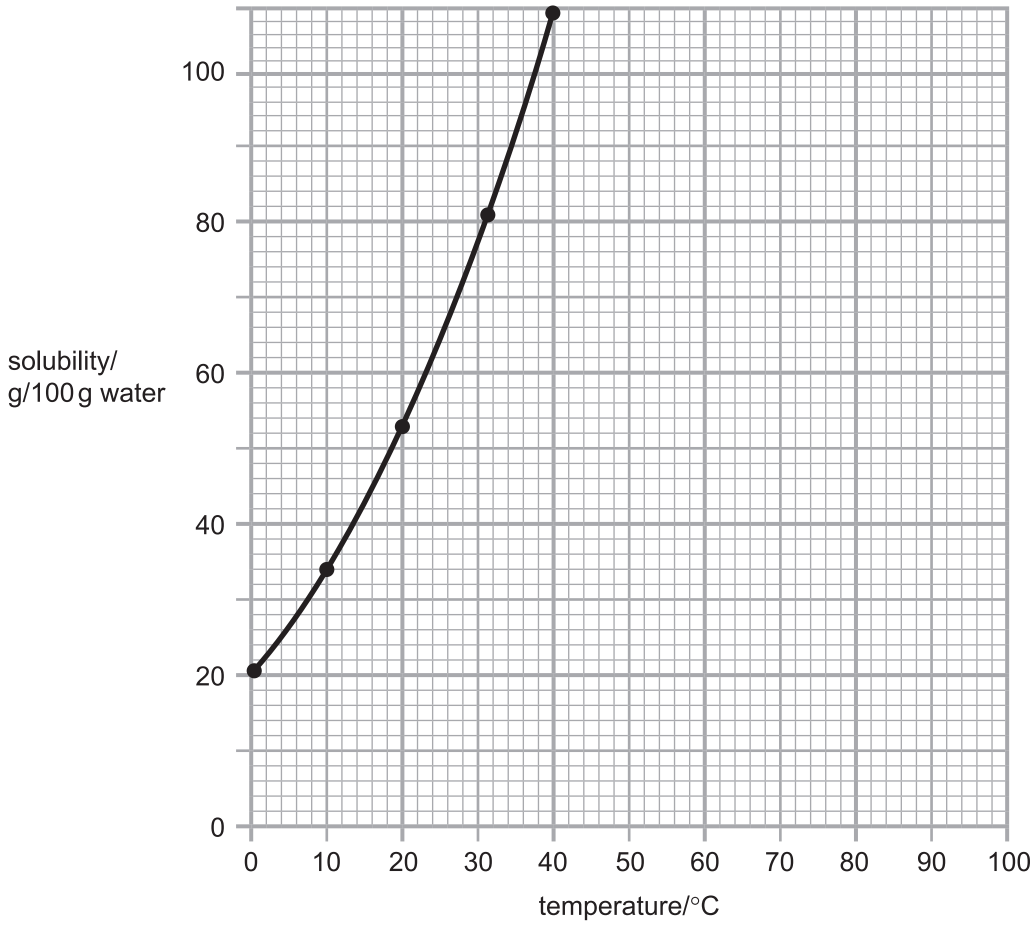
(iii) The diagram below shows the gases from the decomposition of a nitrate passing through Universal Indicator (UI) solution and one gas being collected in a test tube. Explain why the UI solution goes red and name the gas collected in the test tube.



____

____ [2]

(e) Group II metal nitrates are soluble in water. The solubility curve for the Group I nitrate, rubidium nitrate, is shown below.



The following data refers to the solubility of strontium nitrate with temperature.

Solubility/ g/100 g water	40	55	71	88	91	93	94	97	99	101
Temperature/°C	0	10	20	30	40	50	60	70	80	90

(i) Plot the solubility curve for strontium nitrate on the axes above. [1]

(ii) Determine the temperature at which rubidium nitrate and strontium nitrate have the same solubility.

____

____ [1]

12 Hypochlorous acid has the formula HOCl. It adds to alkenes to form chlorohydrins.

$$CH_2{=}CH_2 + HOCl \rightarrow CH_2ClCH_2OH$$

(a) **(i)** Calculate the enthalpy change for the reaction between ethene and hypochlorous acid using the following average bond enthalpies.

bond	**enthalpy/ kJ mol^{-1}**
C=C	612
C—C	347
Cl—O	272
C—Cl	346
C—O	358

____

____

____

____ [3]

(ii) Construct a simple labelled enthalpy level diagram for the reaction between ethene and hypochlorous acid. Insert the enthalpy value calculated in part **(i)** onto the diagram.

[2]

(b) Hypochlorous acid adds to alkenes because it has a polar bond, HO—Cl.

(i) Explain what is meant by the term **polar bond**.

____

____ [2]

(ii) Draw the polarity of a hypochlorous acid molecule.

[1]

(iii) Draw the mechanism, using curly arrows, for the reaction of hypochlorous acid with propene to form $CH_2ClCHOHCH_3$.

[4]

(iv) Name the compound $CH_2ClCHOHCH_3$.

____ [2]

[Turn over

(v) The compound $CH_2ClCHOHCH_3$ is the major product. Draw the structure of the minor product and explain why it is the minor product.

____

____

____ [2]

(vi) If the reaction in part **(iii)** is carried out in the presence of sodium nitrite, $NaNO_2$, some $CH_2ClCHNO_2CH_3$ is formed. Suggest how this compound is formed.

____

____

____ [1]

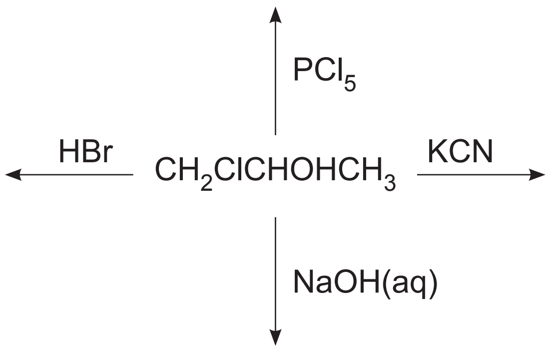
(c) Chlorohydrins are useful in synthetic chemistry because they are bifunctional.

(i) Suggest the meaning of the term **bifunctional**.

____

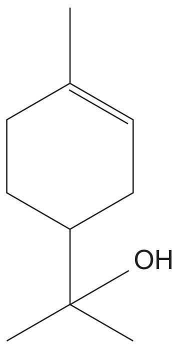
____ [1]

(ii) Complete the following reaction scheme for $CH_2ClCHOHCH_3$ by drawing the organic products.



[4]

13 α-Terpineol is a terpene which is the main ingredient in pine oil.



α-terpineol

It is a colourless liquid with a smell of violets. The boiling point of α-terpineol is 214–216 °C and its density is 0.93 g cm^{-3}. α-Terpineol is slightly soluble in water; 2.42 g dissolves in 1 dm^3 of water at room temperature.

(a) **(i)** Describe and explain, using calculated values, what you would observe if you added 1.1 g of α-terpineol to 200 cm^3 of water in a beaker at room temperature and stirred the mixture.

____

____

____

____

____

____

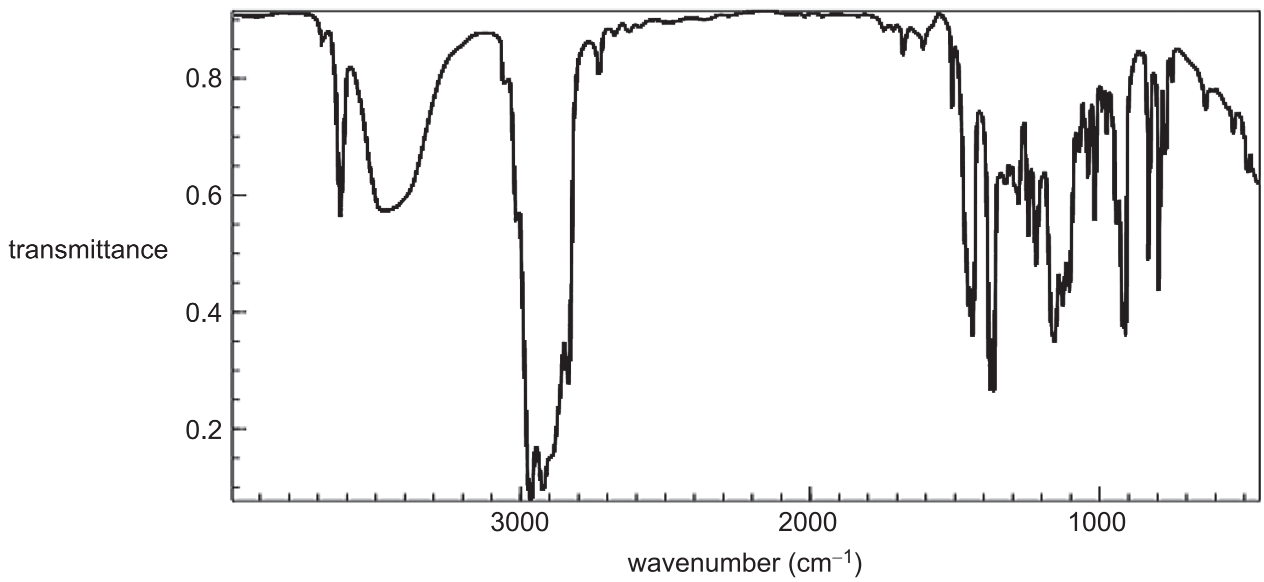
____ [4]

(ii) Explain, with full experimental detail, how you would separate α-terpineol from a mixture of 50 cm^3 of α-terpineol and 10 cm^3 of water. Your method should include separating with a funnel, distillation and drying.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

[6]

(b) The purity of the α-terpineol obtained from part **(a)** may be determined by the infrared spectrum which is shown below.



(i) Explain why molecules absorb infrared radiation producing infrared spectra.

____

____

____

____ [2]

(ii) Identify the peaks, by stating the range of wavenumbers in the spectrum, which correspond to the functional groups in the molecule.

____

____

____ [2]

(iii) Explain how you could use infrared spectrometry to determine that a sample of α-terpineol is pure and free from all impurities.

____

____ [1]

(c) (i) Explain, using the structure of α-terpineol, whether the alcohol is primary, secondary or tertiary.

____

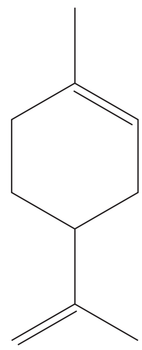
____ [2]

(ii) State what would be observed when a few drops of α-terpineol are added to acidified potassium dichromate(VI) and the mixture is heated.

____

____ [1]

(d) When α-terpineol is dehydrated it forms a mixture of limonene and δ-terpinene.



limonene

Suggest the structure of δ-terpinene.

[1]

(e) Limonene is an unsaturated hydrocarbon which reacts with bromine and hydrogen.

(i) Define the term **unsaturated**.

____

____

____ [1]

(ii) Explain, giving experimental detail, how you would use bromine water to test for unsaturation.

____

____

____

____ [3]

(iii) Explain, naming the catalyst, what is meant by catalytic hydrogenation.

____

____

____

____ [2]

(iv) Cadinene, $C_{15}H_{24}$, reacts with hydrogen and becomes completely saturated. 0.34 g of cadinene reacts with 80 cm^3 of hydrogen at 20 °C and a pressure of one atmosphere. Calculate the number of double bonds in a molecule of cadinene.

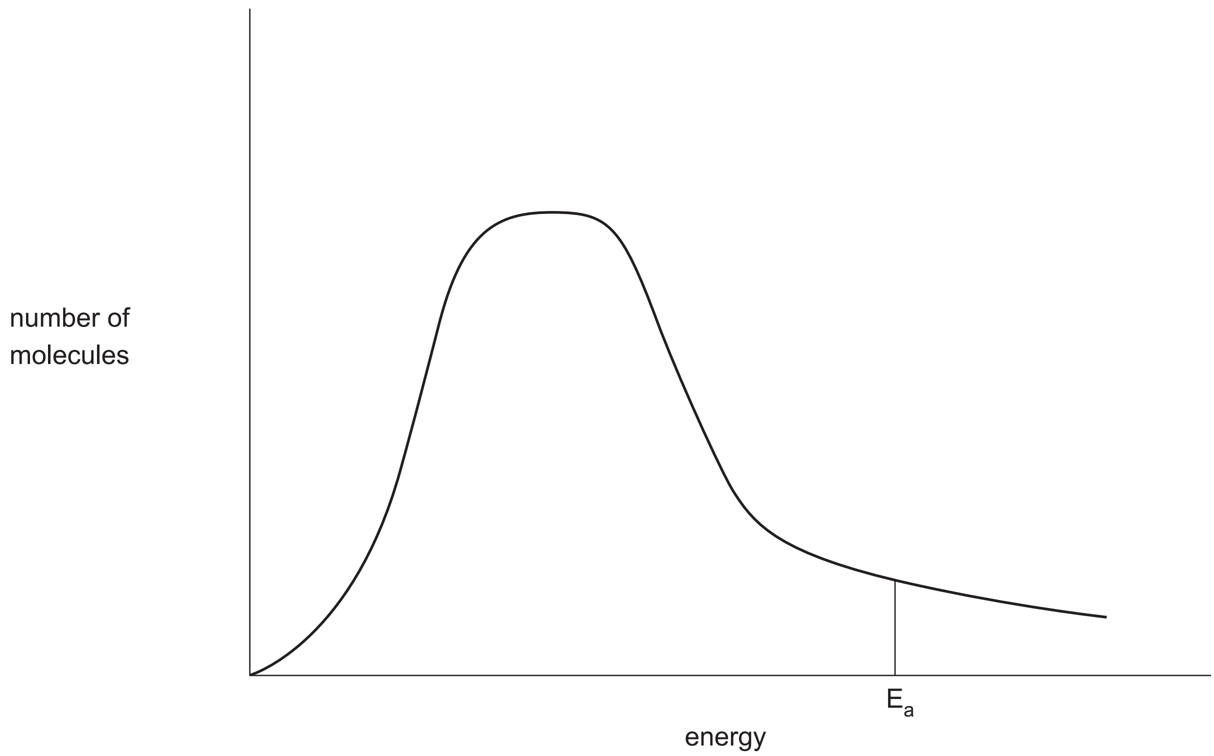
____

____

____

____ [3]

14 The Maxwell–Boltzmann distribution curve below shows the distribution of molecular energies in a mixture of the gases sulfur dioxide and oxygen at 25 °C.



The x-axis can either be labelled as energy or speed. The distribution curve starts at the point 0,0 and at the end approaches the x-axis but does not touch it. The symbol E_a is the activation energy.

(a) Draw, on the axes above, the Maxwell–Boltzmann distribution curve for a mixture of sulfur dioxide and oxygen, at a *lower* temperature.

[2]

(b) Explain why the x-axis can either be labelled as energy or speed.

____

____ [1]

(c) Explain what it means if the distribution curve starts at the point 0,0.

____

____ [1]

(d) Explain what it would mean if the Maxwell–Boltzmann curve touched the x-axis at a final energy value.

____

____ [1]

(e) Activation energy varies from reaction to reaction.

(i) Explain the term **activation energy**.

____

____ [2]

(ii) Comment on the reaction speed between silver ions and chloride ions in aqueous solution and how it relates to activation energy.

____

____ [2]

(iii) State the effect of a catalyst on the activation energy of a reaction.

____ [1]

(f) The reaction between sulfur dioxide and oxygen is part of the process to manufacture sulfuric acid.

(i) What is the name of this industrial process?

______________________________ [1]

(ii) Describe and explain the conditions used in this process for the reaction between sulfur dioxide and oxygen referring to temperature, pressure and catalyst.

temperature

____

____

____

______________________________ [2]

pressure

____

____

____

______________________________ [2]

catalyst

____

______________________________ [1]

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240427

Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019

Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry
and an Introduction to Organic Chemistry

[SCH22]

THURSDAY 23 MAY, MORNING

Standardising Meeting Version

MARK
SCHEME

Not to be circulated beyond the Examining Team

General Marking Instructions

Introduction
The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. It also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives
Below are the assessment objectives for **GCE Chemistry:**

Candidates should be able to:

AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling quantitative and qualitative data
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence (in relation to particular issues) • make judgements and reach conclusions • develop and refine practical design and procedures

Quality of candidates' responses
In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 17- or 18-year-old which is the age at which the majority of candidates sit their GCE examinations.

Flexibility in marking
Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive marking
Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do, rather than penalising candidates for errors or omissions. The exception to this for GCE Chemistry is when examiners are marking complex calculations and mechanisms when the examiners are briefed to mark by error or omission. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 17- or 18-year-old GCE candidate.

Awarding zero marks
Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

Section A

		AVAILABLE MARKS
1	B	
2	A	
3	A	
4	C	
5	D	
6	A	
7	D	
8	A	
9	D	
10	C	
[1] for each correct answer		10
	Section A	**10**

Section B

AVAILABLE MARKS

11 (a) (i) $Ca + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2$ [1]

(ii) $CaO + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O$ [1]

(iii) $CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$ [1]

(b) $Mg + 4HNO_3 \rightarrow Mg(NO_3)_2 + 2NO_2 + 2H_2O$ [1]

(c) (i) resistance to decomposition at high temperature [1]

(ii) the metal cation is larger and polarises the nitrate ion less [1]

(d) (i) the metal oxide (is basic) and forms a soluble hydroxide [1]

(ii) $Sr(NO_3)_2 = 88 + 2 \times 14 + 6 \times 16 = 88 + 28 + 96 = 212$
3.6 g = 3.6/212 = 0.01698 = 0.017 mol
2 mol of nitrate gives 5 mol of gas
1 mol of nitrate gives 2.5 mol of gas
0.017 mol gives 0.017 × 2.5 = 0.0425 mol of gas = 0.0425 × 24 dm^3
= 1.02 dm^3 = 1.0 dm^3 [3]

(iii) nitrogen(IV) oxide is a strongly acidic oxide [1] oxygen [1] [2]

(e) (i) points accurately plotted [1]

(ii) 35 °C ±2°C error [1] 14

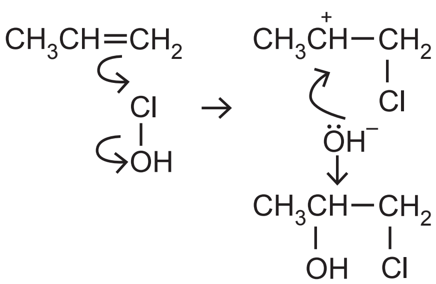
12 (a) (i) bonds broken: C═C + O–Cl = 612 + 272 = +884 kJ
bonds formed: C–Cl + C–O + C–C = 346 + 358 + 347 = –1051 kJ
enthalpy of reaction = +884 – 1051 = –167 kJ [3]

(ii) exothermic reaction with reactants and products labelled
value of –167 kJ inserted [2]

(b) (i) a covalent bond in which there is unequal sharing of the bonding electrons [2]

(ii) δ- δ+
HO—Cl [1]

(iii)



lone pair on oxygen

for mechanism [3]
for 3 curly arrows [1] [4]

(iv) 1-chloropropan-2-ol or 1-chloro-2-hydroxypropane [2]

(v) $CH_2OHCHClCH_3$ [1] the (primary) carbocation is less stable [1] [2]

AVAILABLE MARKS

(vi) the nitrite ion reacts with the carbocation [1]

(c) (i) two reactive groups are present [1]

(ii) $CH_2ClCHClCH_3$ [1]
$CH_2CNCHOHCH_3$ [1]
$CH_2OHCHOHCH_3$ [1]
$CH_2ClCHBrCH_3$ [1] [4] 22

13 (a) (i) 2.42 g dissolves in 1000 cm^3 of water; 2.42/5 = 0.484 g dissolves in 200 cm^3 of water; 0.484 g is about half of 1.1 g
density of terpineol = 0.93; hence 1.1 g = 1.1/0.93 = 1.18 = 1.2 cm^3
the density of terpineol is less than that of water
hence half of it disappears/dissolves and the rest floats on the surface [4]

(ii) Indicative content
- add to a separating funnel, allow to settle
- run off the lower layer of water
- add the terpineol to a distillation flask and distil off the water
- collect the terpineol at 214–216 °C
- add anhydrous sodium sulfate
- leave until clear
- decant/filter off

Band	Response	Mark
A	Candidates must use appropriate specialist terms using a minimum of 7 points of indicative content. They must use good spelling, punctuation and grammar and the form and style are of an excellent standard.	[5]–[6]
B	Candidates must use appropriate specialist terms using a minimum of 5 points of indicative content. They must use satisfactory spelling, punctuation and grammar and the form and style are of a good standard.	[3]–[4]
C	Candidates use a minimum of 3 points of indicative content. They use limited correct spelling, punctuation and grammar and the form and style are of a basic standard.	[1]–[2]
D	Response not worthy of credit.	[0]

[6]

(b) (i) groups of atoms within a molecule absorb infrared radiation because bonds vibrate at characteristic frequency/molecular vibrations [2]

(ii) 1600 or 1700 C═C (for alkene) [1]
3500 O—H for alcohol [1] [2]

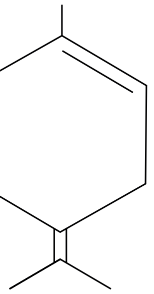
(iii) compare the IR spectrum of pure terpineol with the impure, if they are the same the sample is pure [1]

(c) (i) it is tertiary [1] the carbon, attached to the —OH is attached to three carbon atoms [1] [2]

(ii) the orange colour remains, there is no change [1]

AVAILABLE MARKS

(d)



[1]

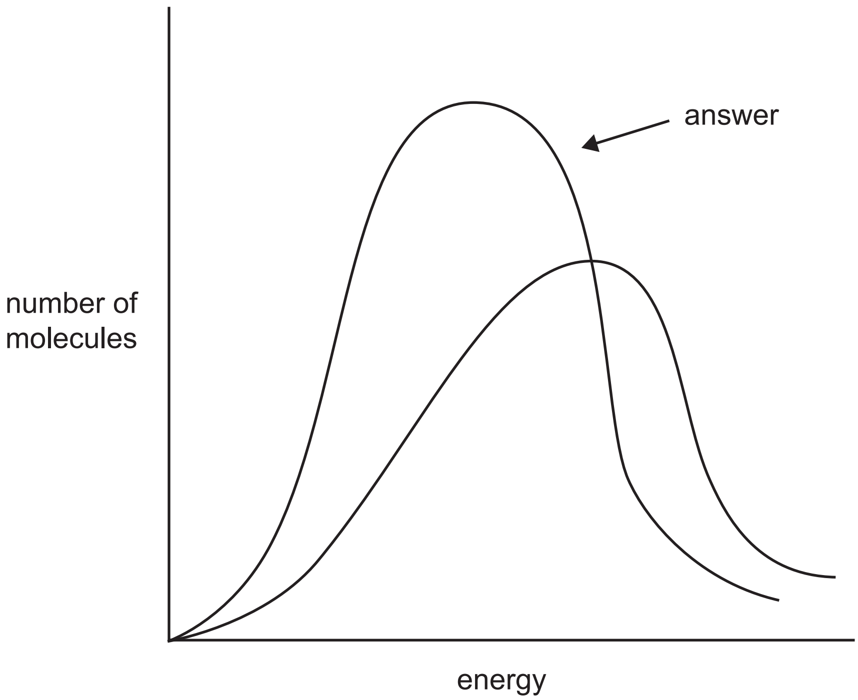
(e) **(i)** contains at least one C═C or C≡C [1]

(ii) add the unsaturated compound to bromine water [1] and shake [1]
the orange colour disappears/goes colourless [1] [3]

(iii) adding hydrogen to a C═C [1] using nickel [1] [2]

(iv) $C_{15}H_{24}$ = 15 × 12 + 24 × 1 = 180 + 24 = 204
0.34 g = 0.34/204 = 0.00166 mol
80 cm^3 = 80/24000 = 0.00333 mol
the ratio of moles = 0.00333/0.00166 = 2
hence there are 2 double bonds in one molecule of cadinene [3] 28

14 **(a)** the curve is to the left
the peak is higher
It runs roughly parallel to the original but does not cross far to the right
It does not touch the x-axis



[–1] each error [2]

		AVAILABLE MARKS
(b) a moving molecule has energy	[1]	
(c) at 0,0 there are zero molecules with zero energy	[1]	
(d) no molecules have a high energy value	[1]	
(e) **(i)** the minimum amount of energy required for a reaction to occur	[2]	
(ii) very fast [1] very low activation energy [1]	[2]	
(iii) (the activation energy) is lowered	[1]	
(f) **(i)** Contact process	[1]	
(ii) 450 °C [1] reaction is exothermic but high temperature for speed [1] 1–2 atm [1] high pressure should be used but conversion % is high [1] vanadium pentoxide [1] effective or not poisoned by arsenic	[5]	16
	Section B	**80**
	Total	**90**