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ADVANCED
General Certificate of Education

Centre Number

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Candidate Number

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Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals,
Electrochemistry and Further
Organic Chemistry

[ACH22]

ACH22

Assessment

TIME

2 hours.

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**.

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 110.

Quality of written communication will be assessed in Questions **14(c)** and **16(a)**.

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 the Elements, containing some data, is included with this question paper.

12684

Assessment Level of Control:

Tick the relevant box (✓)

Controlled Conditions	
Other	



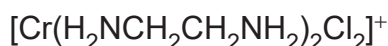
28ACH2201

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 What is the co-ordination number and the oxidation state of chromium in the following complex?



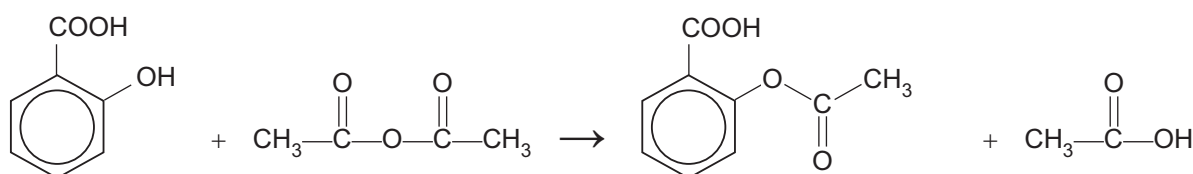
- A 4 and +1
- B 4 and +3
- C 6 and +1
- D 6 and +3
- 2 Which of the following is **not** a reason why TMS is used as a standard in nuclear magnetic resonance spectroscopy?
- A It contains twelve chemically equivalent hydrogen atoms
- B It is unreactive
- C It only produces one peak in the spectrum
- D The hydrogen atoms in TMS are not well shielded
- 3 How many molecular ions peaks would be present in the mass spectrum of CHCl_3 ?
- A 2
- B 3
- C 4
- D 5



4 The acid-catalysed hydrolysis of propanamide produces

- A a propanoate and ammonia.
- B a propanoate and an ammonium salt.
- C propanoic acid and ammonia.
- D propanoic acid and an ammonium salt.

5 The reaction of salicylic acid with ethanoic anhydride is as follows:



Assuming a 25% yield, what mass of salicylic acid (RMM 138) is required to produce 4.50 g of aspirin (RMM 180)?

- A 1.13 g
- B 3.45 g
- C 13.8 g
- D 18.0 g

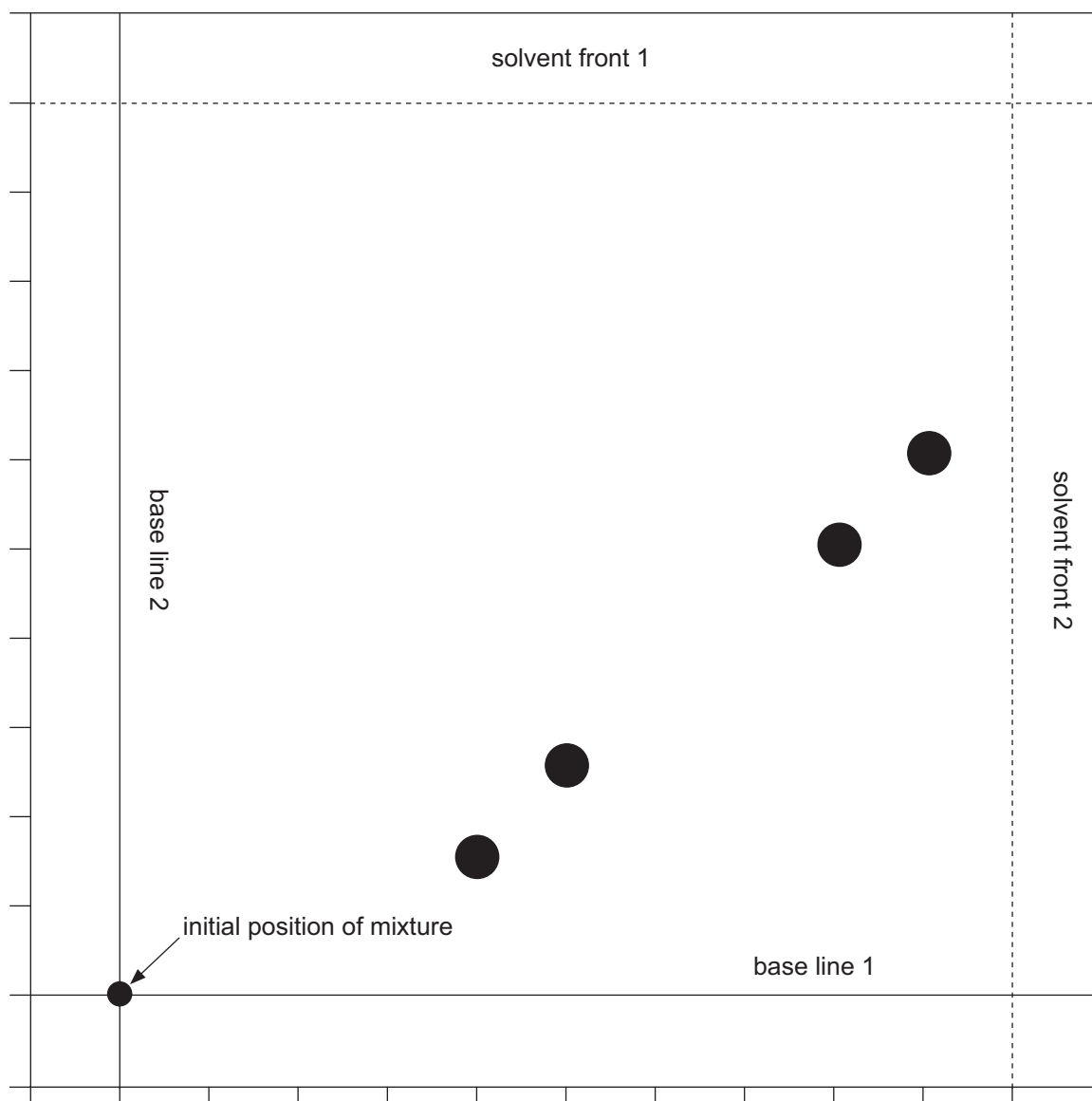
6 An aqueous solution containing the VO²⁺ ion is

- A blue
- B green
- C violet
- D yellow

[Turn over



7 A two-way chromatogram for a mixture containing four amino acids is shown below:



Which of the following gives the correct R_f values for one of the amino acids?

	Solvent 1	Solvent 2
A	0.40	0.15
B	0.50	0.25
C	0.50	0.80
D	0.90	0.60



- 8 When dissolved in a solution of sodium hydroxide, glycine exists as
- A a cation.
 - B a dipolar ion.
 - C a neutral molecule.
 - D an anion.
- 9 Which colour change is produced when an acidified solution of iodate(V) ions is reduced by iodide ions?
- A Blue-black to colourless
 - B Brown to colourless
 - C Brown to straw/yellow
 - D Colourless to brown
- 10 When aqueous sodium hydroxide is added to an aqueous solution of a transition metal compound, a green-blue precipitate is formed which is soluble in excess aqueous sodium hydroxide. The transition metal ion present in the original solution is
- A Cr^{3+} .
 - B Fe^{2+} .
 - C Fe^{3+} .
 - D Ni^{2+} .

[Turn over

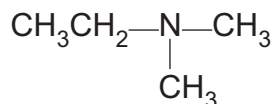


Section B

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

- 11** Butylamine, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$, is a primary amine which exists as a colourless liquid at room temperature and pressure (20°C and 1 atm). It has a boiling point of 78°C and has a “fishy” smell.

- (a)** Dimethylethylamine (a tertiary amine) is a structural isomer of butylamine with a boiling point of 37°C .



dimethylethylamine

- (i)** Name a secondary amine that is a structural isomer of butylamine.

_____ [1]

- (ii)** Explain the relative basic strength of primary and secondary amines.

_____ [2]



(iii) Explain why butylamine has a higher boiling point than dimethylethylamine.

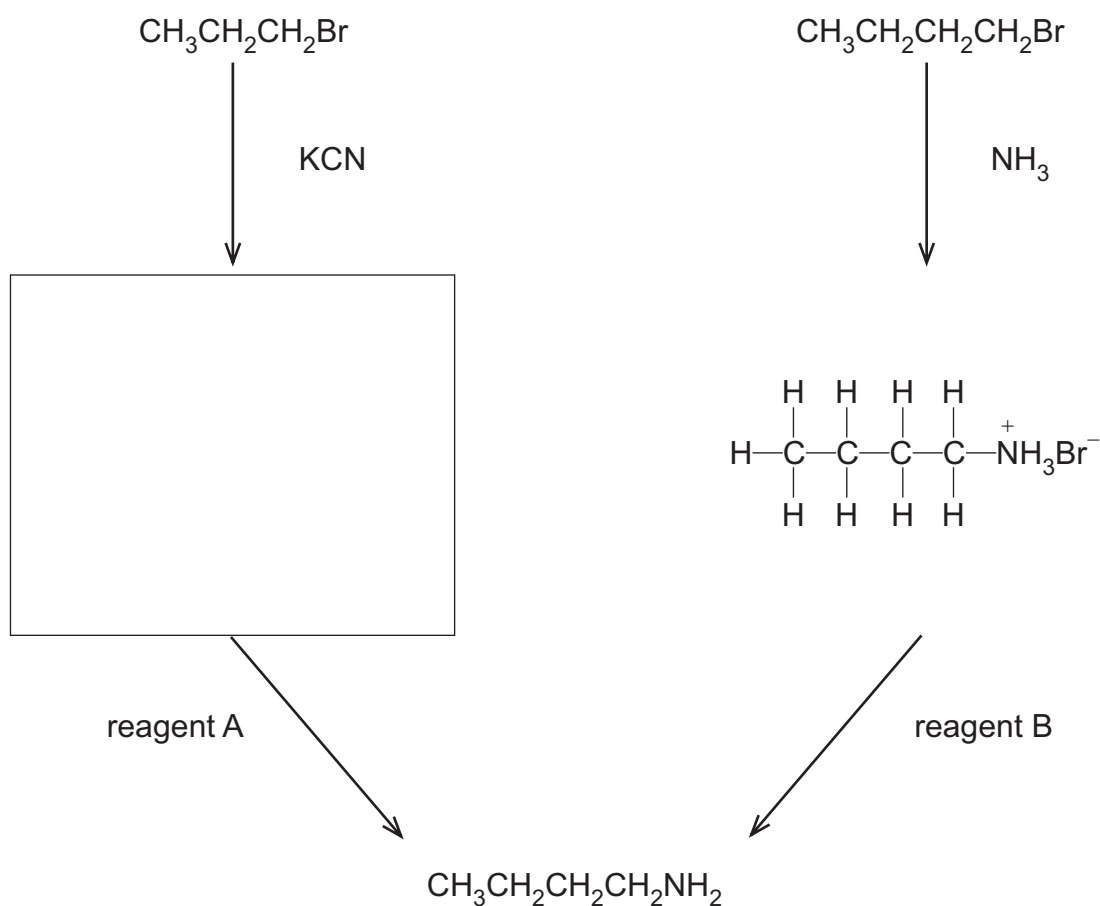
[3]

(iv) Write an equation for the reaction which occurs when an excess of dimethylethylamine reacts with sulfuric acid.

[2]



(b) Butylamine can be formed from 1-bromopropane or 1-bromobutane.



(i) Complete the diagram by including the missing structure in the box provided.

[1]

(ii) Name reagents A and B.

Reagent A _____ [1]

Reagent B _____ [1]



(iii) Name the organic product formed when 1-bromopropane reacts with potassium cyanide.

_____ [1]

(iv) Give an equation for the second step in the formation of butylamine from 1-bromobutane.

_____ [1]

(c) Unknown amines can be identified by reacting with ethanoyl chloride or benzoyl chloride, $\text{C}_6\text{H}_5\text{COCl}$.

(i) Write an equation for the reaction of butylamine with benzoyl chloride.

_____ [1]

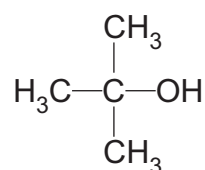
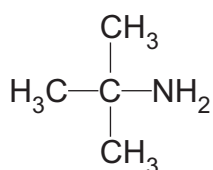
(ii) How can the purified product of the reaction in part (c)(i) be used to identify the amine as butylamine?

_____ [2]

[Turn over]



- (d) The structural isomer of butylamine shown below has a very similar structure to the tertiary alcohol 2-methylpropan-2-ol.



2-methylpropan-2-ol

- (i) Explain why the alcohol is classified as tertiary.

[1]

- (ii) Classify the amine as primary, secondary or tertiary and explain your answer.

[2]





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28ACH2211

12 Hydrated copper(II) sulfate, hydrated nickel(II) sulfate and hydrated zinc sulfate dissolve in water to form solutions containing the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$, $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$ complexes.

(a) (i) Deduce the electronic configurations of the following atom and ion:

Cu _____

Cu^{2+} _____ [2]

(ii) Name the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ complex and draw its shape using dotted lines and wedges.

_____ [2]

(iii) State the colours, if any, of the solutions containing the following complexes.

$[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ _____

$[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ _____

$[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$ _____ [2]



(iv) In terms of electronic configuration, what is a transition metal?

[2]

(v) In terms of electronic configuration, why is zinc not a transition metal?

[1]

(b) When a few drops of sodium hydroxide solution are added to a solution containing the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ complex, a precipitate forms, which can be represented as $[\text{Cu}(\text{OH})_2(\text{H}_2\text{O})_4]$. On addition of an excess of aqueous ammonia, the precipitate disappears and a deep blue solution forms.

(i) Using the formula $[\text{Cu}(\text{OH})_2(\text{H}_2\text{O})_4]$, write an ionic equation for the formation of the precipitate.

[1]

(ii) Using the formula $[\text{Cu}(\text{OH})_2(\text{H}_2\text{O})_4]$, write an ionic equation for the reaction which occurs on addition of an excess of aqueous ammonia.

[2]

[Turn over



(c) A solution was prepared by dissolving hydrated nickel(II) sulfate in water. On addition of an excess of aqueous ammonia, the $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ complex is converted to $[\text{Ni}(\text{NH}_3)_6]^{2+}$. When an excess of 1,2-diaminoethane (en) is then added, all the ammonia ligands are replaced and a purple solution is formed. When an excess of the polydentate ligand, edta, is added the purple solution turns blue.

(i) What is the colour of the $[\text{Ni}(\text{NH}_3)_6]^{2+}$ complex?

_____ [1]

(ii) Write an equation for the replacement of the ammonia ligands by 1,2-diaminoethane (en).

_____ [2]

(iii) Suggest a reason why the enthalpy change for the reaction in part (c)(ii) is approximately zero.

_____ [2]

(iv) Suggest a reason why the reversal of the replacement of the ammonia ligands is not feasible.

_____ [2]



(v) What is a **polydentate ligand**?

[2]

(vi) Write an equation for the reaction which results in the conversion of the purple solution to a blue solution.

[2]

[Turn over

12684



28ACH2215

13 Polyethylene terephthalate and nylon are classified as condensation polymers and they are biodegradable.

(a) (i) What type of condensation polymer is polyethylene terephthalate?

_____ [1]

(ii) Draw the repeating structural unit in polyethylene terephthalate.

[1]

(b) (i) What type of condensation polymer is nylon?

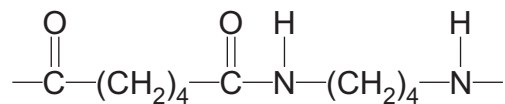
_____ [1]

(ii) Why is nylon biodegradable?

_____ [2]



(c) The repeating structural unit in a condensation polymer, **X**, is shown below:



(i) Draw the skeletal formulae for the two monomers required to produce polymer **X**.

[2]

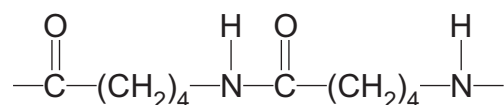
(ii) Name the monomers required to produce polymer **X**.

[2]

[Turn over]



- (d) A section of the polymer chain in a different condensation polymer, **Y**, is shown below. This section is isomeric with the repeating structural unit of polymer **X**.



- (i) Name the monomer required to produce polymer **Y**.

_____ [1]

- (ii) Suggest why the attractions between the polymer chains in **X** and **Y** are stronger than the attractions between polyester molecules of comparable length.

_____ [2]

- (iii) Why can the repeating structural units in **X** and **Y** be described as isomeric?

_____ [2]





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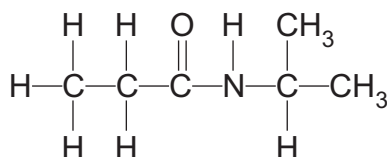
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28ACH2219

- 14 The N-substituted amide shown below can be prepared by reacting an acyl chloride with a primary amine.



- (a) Name the acyl chloride and the primary amine which would be used.

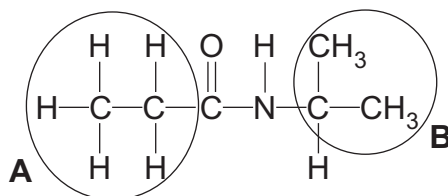
_____ [2]

- (b) Identify the ion which produces a peak at an m/z value of 57 in the mass spectrum of this N-substituted amide.

_____ [1]

- (c) Describe the high resolution ^1H nmr spectrum of this N-substituted amide. Your answer should make reference to the information that would be provided by an integration curve. References to spin-spin splitting patterns should be limited to the hydrogen atoms in the groups which have been circled and labelled as **A** and **B**. References to chemical shift should be limited to the hydrogen atom which is directly bonded to the nitrogen atom.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.







[6]

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28ACH2221

15 Cells are used in everyday life as a source of electrical energy.

- (a) A conventional representation of a cell which has an emf of +0.50 V is given below:



The standard electrode potential for the half-cell with the more positive value is +2.01 V.

- (i) Define the term **standard electrode potential**.

[2]

- (ii) Calculate the standard electrode potential of the other half-cell.

[1]

- (iii) Which species in this cell is the strongest oxidising agent?

[1]

- (iv) Which species in this cell is the strongest reducing agent?

[1]

- (v) Write the half-equation for the reaction which occurs at the positive electrode when the cell is discharging, and explain whether the process is oxidation or reduction.

[2]



- (vi) Write the half-equation for the reaction which occurs at the negative electrode when the cell is discharging, and explain whether the process is oxidation or reduction.

_____ [2]

- (vii) Write an overall equation for the cell reaction when the cell is discharging.

_____ [1]

- (b) Rechargeable lithium cells are used to power mobile phones and laptops. The cell reactions and standard electrode potentials for a lithium cell are given below:



- (i) Calculate the emf of this lithium cell.

_____ [1]

- (ii) Write an equation for the overall reaction that occurs when this lithium cell is being **recharged**.

_____ [2]

[Turn over



(c) Rechargeable cells and hydrogen fuel cells have the potential to power vehicles.

(i) Give an environmental advantage associated with the use of a hydrogen fuel cell.

_____ [1]

(ii) Give a disadvantage associated with the use of a hydrogen fuel cell.

_____ [1]

(iii) State **two** disadvantages that lithium-ion rechargeable cells have compared with fuel cells when used to power vehicles.

_____ [2]





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28ACH2225

16 Hydrochloric acid in the stomach creates the optimum pH for enzymes to work. Indigestion remedies are used to treat excess acid in the stomach. A back titration can be used to determine the percentage of calcium carbonate in an indigestion tablet.

- (a) Describe how you would carry out a back titration in order to determine the percentage of calcium carbonate in an indigestion tablet. Details of any calculations are not required.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

[6]

- (b)** Write **two** equations to represent the reactions which occur in the method described in part **(a)**.

[2]



- (c) It is stated that the indigestion remedy known as “Milk of Magnesia” contains 415 mg of magnesium hydroxide in every 5.00 cm³ of the remedy. Calculate the number of moles of hydrochloric acid which can be neutralised using 205 cm³ of the remedy.

[3]

- (d) Amino acids are the building blocks for enzymes.

- (i) Give the structure and IUPAC name of an amino acid which contains an asymmetric centre.

[2]

- (ii) Explain why amino acids have relatively high melting points.

[2]

- (e) Suggest why an increase in pH, in the stomach, would result in the enzymes in the stomach becoming less effective.

[3]



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