MS3 WELSH JOINT EDUCATION COMMITTEE
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General Certificate of Education
Advanced Subsidiary/Advanced

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MARKING SCHEMES

SUMMER 2007

CHEMISTRY

INTRODUCTION

The marking schemes which follow were those used by the WJEC for the 2007 examination in GCE Chemistry. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

The WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

CHEMISTRY CH1

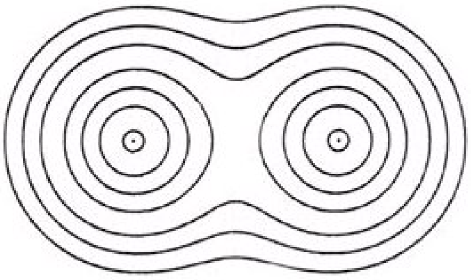
1. **B** They all contain the same number of electrons [1]

2. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$ [1]

3.

	1^{st} IE	2^{nd} IE	3^{rd} IE	4^{th} IE / kJ mol^{-1}	
C	738	1451	7733	10541	[1]

4.



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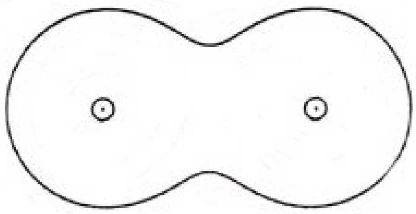


(Dot and cross diagram not acceptable) [1]

5. (a) The *mole* is the amount of material that contains the same number of particles as there are atoms in exactly 12 g of ^{12}C isotope. [1]

(b) (i) *ammonium ions*, NH_4^+ 0.4 mol [1]

(ii) *hydrogen atoms*, H 1.6 mol [1]

6. (a)

	Cl	H	S
Cl_2	0		
H_2S		+1	-2
HCl	-1	+1	
S			0

2 marks for all six correct, 1 mark for 4 correct [2]
1 mark if all six correct except 1- or 1+ instead of -1 or +1.

(b) S atom (increase from -2 to 0). [1]

Section A Total [10]

Section B

7. (a) (i) γ-radiation is high energy/ high frequency (½) electromagnetic radiation (½) [1]

(ii) (Four times correct dose → Two times correct dose → Correct dose)
Two half lives / 12 hours (1)
So sample would be ready at 8 p.m. (1) [2]

(b) (i) X is an electron / β- particle. [1]

(ii) ^{99}Mo stays usable for longer / has a longer half-life
or ^{99}Tc decays too quickly / has too short a half-life [1]

(iii) To absorb / prevent the escape of emitted electrons / radiation [1]

(c) (i) *Empirical formula*

K $\frac{19.36}{39.1} = 0.495$ Tc $\frac{48.96}{98.9} = 0.495$ O $\frac{31.68}{16.0} = 1.98$ (1)

$\frac{0.495}{0.495} = 1$ $\frac{0.495}{0.495} = 1$ $\frac{1.98}{0.495} = 4$

$\therefore$ $KTcO_4$ (1) [2]

Molecular formula
$A_r\text{K} + A_r\text{Tc} + 4A_r\text{O} = 39.1 + 98.9 + 64.0 = 202.0$
Since $M_r = 202.0$, molecular formula = $KTcO_4$ [1]

(ii) No moles $KTcO_4$ = $\frac{31.5}{202.0}$ (may be part of larger formula) (1)

Concentration = $\frac{31.5}{202.0} \times \frac{1000}{250} = 0.624\ \text{mol dm}^{-3}$ (1)

(½ mark for 0.62, 0.6. No penalty for excess figures or if units not given) [2]

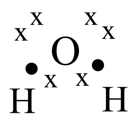
(d) Any six points 6 × (½) Max 3 marks.

- Metallic bonding has (a regular array of) cations
- Outer/ valence electrons involved in metallic bonding
- act like an "electron glue" / "sea of electrons" / hold cations together
- Delocalised electrons / free to move over whole crystal
- Metallic bonding is (very) strong
- A lot of energy needed to break the bonds (leading to high melting temperature)
- Electricity conducted by movement of the delocalised electrons under an applied potential difference.

[3]

Total [14]

8. (a) (i) Must show lone pairs to get the mark [1]



(ii) Water has a V-shaped / "bent" / angular molecule (or appropriate diagram) (1)
Lone pairs repel the shared pairs
to give tetrahedral arrangement of electron pairs
or to push the shared pairs / H atoms closer together
or to distort the shape away from linear (1) [2]

(b) (i) A ***coordinate bond*** is a covalent bond where both electrons in the shared pair originate from the same atom.
Must be mention of covalent / shared electrons (to distinguish from ionic bonding). [1]

(ii) The shape of the H_3O^+ ion is pyramidal (or equivalent unambiguous diagram). [1]

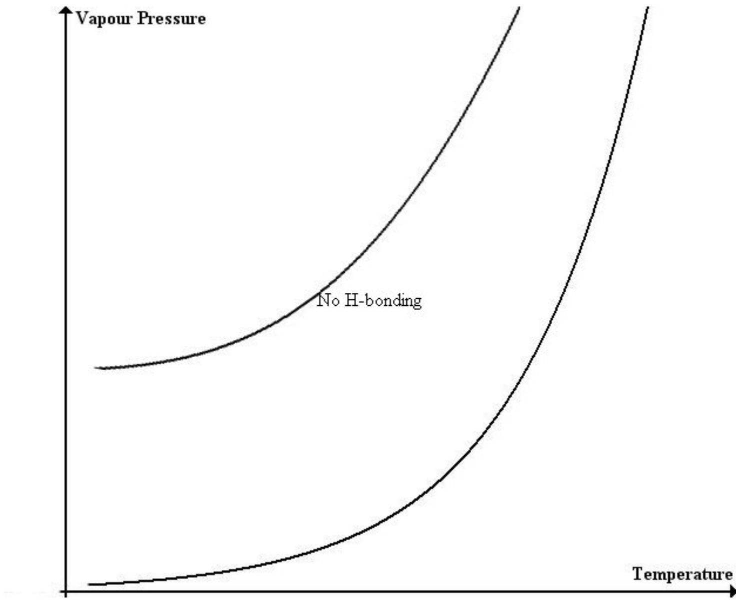
(c) (i) Any six points 6 x (½) Max 3 marks

- Oxygen is much more electronegative than hydrogen (must imply large difference)
- leading to unequal sharing of the electron pair / polar bond
- $^{\delta+}H - O^{\delta-}$ dipole
- $^{\delta+}H$ on one molecule attracted to $O^{\delta-}$ on a neighbouring molecule
- Dipole – dipole interaction / intermolecular bonding
- Particularly strong when H is involved (because of small size of H)
- Each lone pair on O can hydrogen bond to an H atom
- Maximum 4 hydrogen bonds per water molecule
- giving tetrahedral arrangement of hydrogen bonds

[3]

(d) (i) As the temperature increases, molecules possess more energy / move faster (1)
more molecules have sufficient energy to overcome hydrogen bonding (and escape from the liquid) (1) [2]

(ii) [1]



Allow any curve which shows higher vapour pressure at all temperatures.

(iii) van der Waals forces / induced dipole – induced dipole forces [1]

(e) (i) 0.20 mol decrease (½ mark for 0.2) [1]

(ii) $0.20 \times 34\ dm^3 \rightarrow 6.8\ dm^3$ decrease
(Consequential marking if (e)(i) wrong) [1]

Total [14]

9. (a) *Calcium ions* Flame test gives brick red / orange red (*not "red"*) colour [1]

Bromide ions Add (dilute nitric acid and) silver nitrate (solution to a solution of the salt) (½)
A cream / off-white (½) precipitate (½) forms which is soluble in concentrated ammonia solution / partially soluble in dilute ammonia (½)
or
Add Cl_2 (1 mark)
Orange / brown colour produced (1 mark) [2]

(b) (i) *Observations* Brown solution forms (1)

Equation $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ (1)
or $Cl_2 + CaBr_2 \rightarrow CaCl_2 + Br_2$ [2]

(ii) *Observations* White (½) precipitate / cloudiness (½) forms

Equation $Ca^{2+} + 2OH^- \rightarrow Ca(OH)_2$ (1)
or $CaBr_2 + 2NaOH \rightarrow Ca(OH)_2 + 2NaBr$ [2]

(c) (i) Molar mass $CaBr_2$ = 199.9 g mol^{-1} [1]
Allow 200. No penalty if units not given.

(ii) Mass water in 1 mol crystals = 307.9 – 199.9 = 108.0 (1)
$x = \frac{108.0}{18.0} = 6$ $CaBr_2.6H_2O$ (1) [2]

(d) (i) *Name* carbonate (½)
Formula CO_3^{2-} (½)

Name hydrogencarbonate / bicarbonate (½)
Formula HCO_3^- (½) [2]

(ii) Carbonate forms a white (½) precipitate (½) *or* calcium carbonate is only sparingly soluble (1 mark).
Hydrogencarbonate gives a colourless solution / does not form a precipitate (since calcium hydrogencarbonate is soluble). (1) [2]

Total [14]

10. This question concerns the elements in the third period of the Periodic Table

Na Mg Al Si P S Cl Ar

(a) (i) has the highest melting point Si [1]

(ii) is the most electronegative Cl [1]

(iii) has the largest atomic radius Na [1]

(iv) has a half-full p-subshell of electrons P [1]

(v) has the highest second ionisation energy Na [1]

(b) (i) **one** basic oxide Na_2O / MgO / Al_2O_3 [1]

(i) **one** covalent chloride Al_2Cl_6 / $AlCl_3$/ $SiCl_4$ / PCl_3 / PCl_5 / SCl_2 / SCl_4 [1]

(c) (i) Chlorine with water

$Cl_2 + H_2O \rightarrow HCl + HClO$

or $2Cl_2 + 2H_2O \rightarrow 4HCl + O_2$ [1]

(ii) Magnesium with hydrochloric acid

$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$

or $Mg + 2HCl \rightarrow MgCl_2 + H_2$ [1]

Q10(d)(i) is to be assessed for Quality of Written Communication. [L]
Candidates must satisfy the following criteria

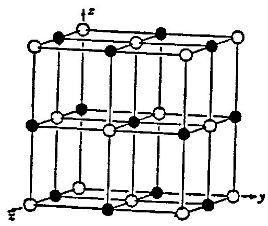
- *Selection of a form and style of writing appropriate to the question*
- *Organisation of the relevant information clearly and coherently*
- *Use of legible text with adequate spelling, punctuation and grammar.*

(d) (i) 2 marks for correct description / diagram of structure

eg face-centred cubic structure of Na^+ and Cl^-

or octahedral arrangement of Cl^- around Na^+ (1) and of Na^+ around Cl^- (1)

or



1 mark only if Na^+ and Cl^- are not mentioned in text / correctly labelled on diagram

Na^+: Cl^- 6 : 6 co-ordination (1)
Like ions repel, unlike ions attract 2 x (½) [4]

(ii) Caesium cation is larger than sodium cation (½)
and can accommodate more (eight) chloride anions (½) [1]

Total [14]

CHEMISTRY CH2

1. 2,2-dimethylbutane [1]

2. (a) An electron rich species / an electron pair donor / species attracted to regions of low electron density or nucleus [1]

(b) e.g. OH^- / NH_3 / Br^- / H_2O [1]

3. $C_8H_{18} + 12\frac{1}{2}O_2 \longrightarrow 8CO_2 + 9H_2O$ [1]

4. (i) $K_p = \dfrac{pCH_4 \times pH_2O}{pCO \times (pH_2)^3}$ [1]

(ii) Measure (changes in) pressure (at constant temperature) / volume (at constant pressure) [1]

(iii) The reverse is larger since $\Delta H = E_f - E_r$ / (forward) reaction is exothermic / it requires 207 kJ more than the forward reaction [1]
(Accept correct diagram)

5. Enthalpy change when 1 mole of compound is formed from its elements in their standard states / under standard conditions. [1]

6. C [1]

7. e.g. conc H_2SO_4 in esterification / Cl radicals in ozone depletion / enzymes in digestion / washing powder / making bread / brewing. [1]

Section A Total [10]

Section B

8. (a) Air / atmosphere [1]

(b) (i) Yield decreases (½) since equilibrium moves to the left / back reaction is favoured (½)

because back reaction is endothermic / absorbs heat. (1) [2]

(ii) Yield increases (½) since equilibrium moves to the right / forward reaction is favoured (½)

because r.h.s. has fewer (gas) moles / molecules (1) [2]

(c) (i) Rate increases because more molecules have required activation energy / molecules have more energy therefore more successful collisions [1]

(ii) Rate increases because there are more effective collisions per unit time / increased chance of more successful collisions [1]

(d) (i) Temperature (is moderate) since reaction proceeds too slowly at low temperatures. (1)

Temperature not higher since yield would be too small / decreased (1)

Pressure (is high) since both yield (½) and rate increased (½)

Pressure not higher due to increased costs / safety concerns / too dangerous (1)

Catalyst used to speed reaction (at moderate temperature) / to keep temperature as low as possible (1) [3]

(3 marks maximum)
(Do not accept to give maximum profit / these are the optimum conditions – insufficient)

(ii) Iron [1]

(iii) Recycled to be used in the process / again [1]

(e) (i) Moles NH_3 = $\dfrac{500\times10^3}{17.03} = 2.94\times10^4$ [1]

(ii) Mass NH_4NO_3 = $2.94\times10^4\times80.04 = 2353\text{ kg}$ [1]

(Consequential marking if (e)(i) incorrect)

Total [14]

9. (a) $K_a = \dfrac{[CH_3COO^-][H^+]}{[CH_3COO]}$ [1]

Unit = mol dm^{-3} [1]

(b) Acid that fully dissociates / ionises [1]

(c) $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$ [1]

(d) (i) $nHNO_3 = \dfrac{0.500 \times 50.0}{1000} = 0.025$ [1]

(ii) Heat of reaction = $mc\Delta T$ [1]

$= (100 \times 4.18 \times 3.4) = 1421$ J [1]

(Accept –1421)

(iii) ΔH neutralisation $= \dfrac{\text{Heat of reaction}}{\text{No. of moles}}$ [1]

$= \dfrac{-1.421}{0.025} = -56.8 \text{ kJ mol}^{-1}$ [1]

(Must have – sign for 2nd mark.
Consequential marking if (d)(ii) incorrect)

(e) Hydrochloric acid is also a strong acid while ethanoic acid is a weak acid / ethanoic acid is weaker [1]

(f) (i) The enthalpy change (of a reaction) is independent of the route taken (or equivalent statement). [1]

(ii) If Hess's Law were not true, energy could be created from nothing (½) by performing a reaction by one route and going back again by a route needing less energy (½) / principle of conservation of energy states that energy cannot be created or destroyed (½) so enthalpy change must be independent of route (½) [1]

(g) $\Delta H = \Delta H = 4(-176) - 2(-242)$ [1]

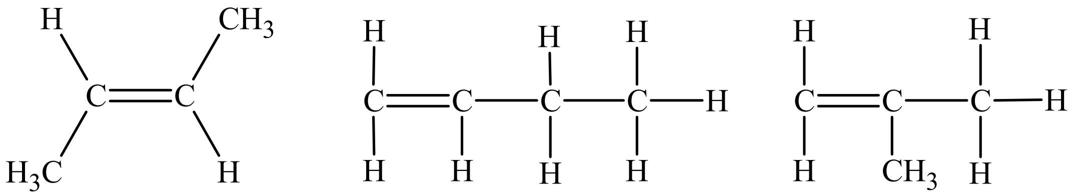
$\Delta H = -220 \text{ kJ mol}^{-1}$ [1]

(If answer = 220 kJ mol^{-1} award 1 mark)

Total [14]

10. (a) (i) Breaking down of (large) molecules into smaller (more useful) molecules. [1]

(ii)



[2]

(Accept any 2 out of 3 and cyclobutane)

(iii) 2,3-dibromobutane [1]

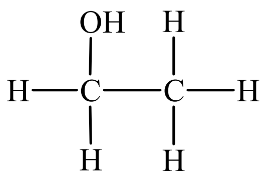
Electrophilic addition [1]

(b) More / stronger van der Waals forces (between C_4H_8 molecules) [1]

(forces in C_4H_8 loses mark)

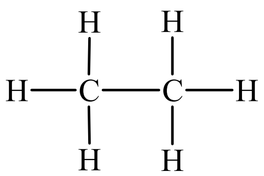
greater energy / more heat needed to break forces. [1]

(c) (i) A is



[1]

B is



[1]

(ii) Sodium / potassium dichromate(VI) solution [1]

acidified (½) and reflux/heat (½) [1]
(need correct reagent for conditions mark)

(iii) Elimination / dehydrobromination [1]

(d) e.g. Polystyrene / PVC / PTFE(Teflon) / PTCE / Perspex / PVA [2]

(Accept any two, 1 mark each)

Total [14]

11. (a) (i) Compounds with same functional group / same general formula (1)

Each successive member differs by CH_2 / gradation in physical properties along series (1)

Compounds show similar chemical properties (1)

(Accept any two points) [2]

e.g. methane, CH_4, ethane, C_2H_6, [1]

(ii) Compounds with same molecular formula [1]

but different structural formula / structures / arrangement of the atoms [1]

e.g. C_4H_{10}, butane and 2-methyl propane [1]

(iii) Reaction in which there is a replacement or swapping of one species in a molecule by another [1]

(Accept atom or functional group instead of species)

e.g. chlorination of methane [1]

Q. 11(b) is to be assessed for the quality of Written Communication. Candidates must satisfy the following criteria to be awarded the marks designated as [L].

- *Selection of a form and style of writing which is appropriate to this question.*
- *Organisation of the relevant information clearly and coherently.*
- *Use of legible text with accurate spelling, grammar and punctuation.*

(b) Build up due to **increase** in burning of fossil fuels / deforestation / traffic [1]

CO_2 lets Sun's UV rays / shorter wavelengths through [1]

but traps IR rays / longer wavelengths from Earth's surface. [1]

(Only need UV **or** IR for both marks)
(CO_2 prevents heat energy from escaping – 1 mark only)

Problems could be melting of ice caps / raised levels of oceans / create deserts / decrease food production / extreme weather conditions / destruction of habitats [1]

Build up reduced by burning less fossil fuels / using renewable energy / nuclear energy / reducing traffic on roads [1]

planting more trees / stop chopping down rain forests. [1]

Total [14]

Section B Total [56]

CHEMISTRY CH3a

1. (a) (i) Points correctly plotted (2); minus ½ for each error; curve quality (1)

(ii) 1.60, within 0.16 (2); within 0.24 (1)

(b) (i) and (ii), rate proportional to concentration of each (1 each)
consider consequential on error in (a) (ii)

(c) (i) Rate depends on temperature (1)

(ii) Cool or dilute with water (1)

(iii) Need to know how much has reacted at the time of sampling (1)

(iv) 1:1 stoichiometry (1); ester left equals KOH left (1)

[12]

2. (a) (i) Equation and state symbols (1)
(ii) To ensure complete pptn of chloride (1)
(iii) To prevent other silver salts precipitating (1)
(iv) To check that all chloride was precipitated (1)
(v) To remove soluble impurities / excess silver nitrate (1)
(vi) To remove all water / volatiles (1)

(b) (i) $\text{mass Cl}^- = \dfrac{0.500 \times 35.5}{143.5}$ (1)

$\text{mass Cl}^- \text{ in } 25\text{cm}^3 = \dfrac{0.123}{4}\text{g}$ (1)

$\text{conc} = \dfrac{0.123 \times 1000}{25} = 4.94\,\text{g dm}^{-3}$ (1)

(ii) $\dfrac{4.94}{35.5} = 0.138\,\text{mol dm}^{-3}$ (1)

[10]

3.	A	(1)	buff ppt	(1)
	D	(1)	gas evolved turns limewater milky	(1)
	B	(1)	bromine water decolourized	(1)
	C	(1)	colour change orange to green	(1)

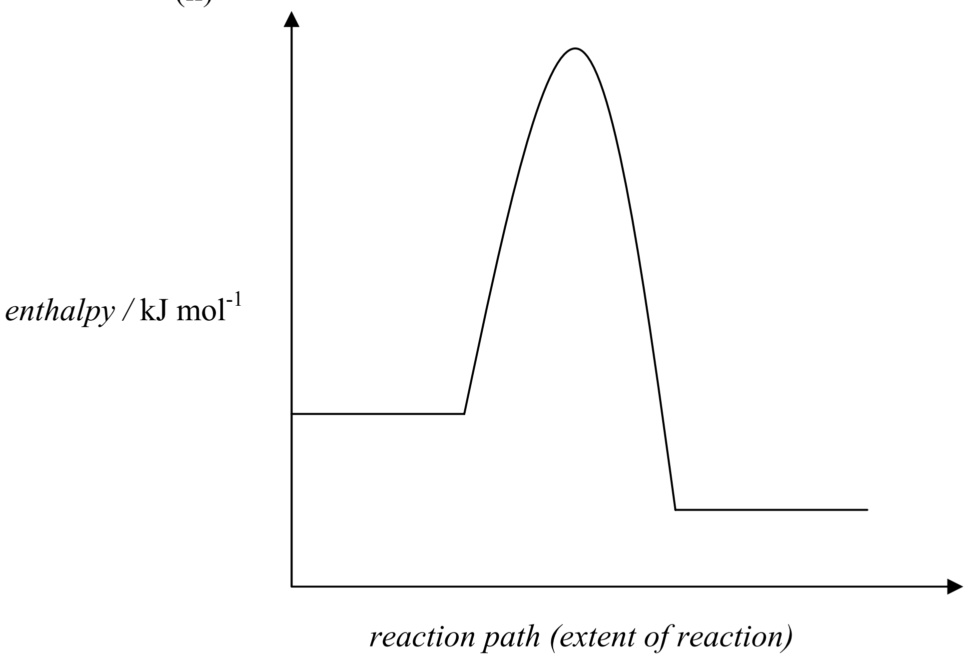
[8]

Total Section [30]

CHEMISTRY CH4

1. (a) (i) CH / C_1H_1 [1]

(ii)



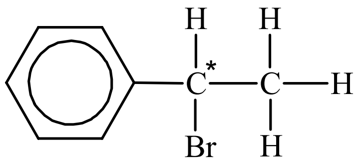
[1]

(iii) I A molecule / atom / ion / species containing an unpaired electron [1]

II *Infrared spectroscopy* Benzenecarboxylic acid would show the presence of an O-H bond (½) at 2500 – 3550 cm^{-1} (½). Phenyl benzenecarboxylate would not show this peak (½).

Chemical test Add a carbonate / hydrogencarbonate (½). The acid would produce bubbles of gas / CO_2 (½), the ester would not give a gas (½). [3]

(b) (i)

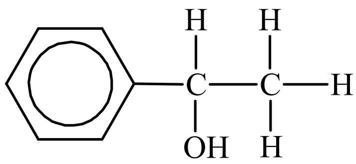


[1]

The optical isomer will rotate the plane of polarised light (½),
the other isomer will not affect the plane of polarised light (½). [1]

(ii) *Stage 1 reagent(s)* (aqueous) sodium hydroxide [1]

Stage 1 product [1]



Stage 2 reagent(s) acidified potassium dichromate [1]

Total [11]

Q. 2(a)(iii) is to be assessed for Quality of Written Communication.
Candidates must satisfy the following criteria to be awarded the marks designated as [L].

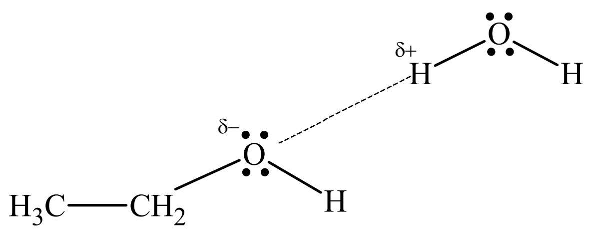
- *Selection of a form and style of writing which is appropriate to this question*
- *Organisation of the relevant information clearly and coherently*
- *Use of legible text with adequate spelling, punctuation and grammar*

2. (a) (i) (Ethene and) steam (½) are reacted together at a temperature of 250-350 ºC (½) and a pressure of 60 / 70 atmospheres (½) in the presence of a phosphoric acid catalyst (½). [2]

(ii) Benefit:
e.g. as a fuel / solvent [1]

Disadvantage:
excessive alcohol consumption causes social problems [1]

(iii) Hydrogen bonding is an intermolecular force (½) occurring between hydrogen and oxygen (½) due to the high electronegativity of oxygen (½)



polarisation (½)

lone pair (½)

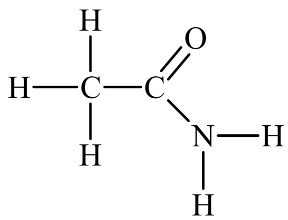
(or two ethanol molecules)

Ethanol is freely soluble in water (½) and has a relatively high boiling temperature / relatively low volatility (½) because of strong forces between molecules needing more energy to break them. (½) [4]

(b) (i) Purple (solution) [1]

(ii) Electrophilic addition [1]

(iii) Electrophilic substitution [1]

(c) (i)  [1]

(ii) Neutralise the acid with ammonia (1) and heat (1) (strongly)
OR heat (1) with ammonium carbonate (1) [2]

Total [14]

3. (a) (i) I Number of moles of hydrochloric acid used $= \dfrac{1.60 \times 25.0}{1000} = 0.0400$ (½)

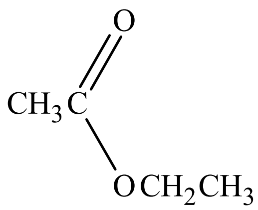
II (Mole ratio NaOH : ester is 1 : 1)
$\therefore$ number of moles of the ester = 0.0400 (½)

III Number of moles of sodium hydroxide that have reacted with the ester = 0.0800 – 0.0400 = 0.0400 (½)

IV (Mole ratio NaOH : ester is 1 : 1)
$\therefore$ number of moles of the ester = 0.0400 (½) [2]

(ii) M_r of the ester $= \dfrac{\text{mass}}{\text{moles}} = \dfrac{3.52}{0.0400} = 88$ [1]

(iii) Ester could be any of these [1]



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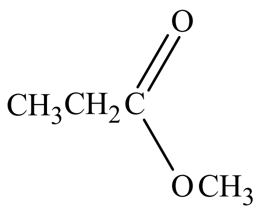

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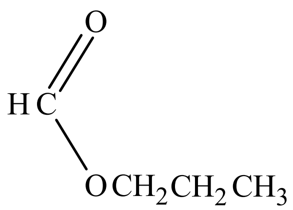

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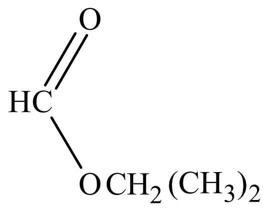


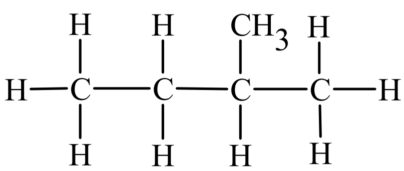
(b)

Reagent(s)	*Organic product (if any)*
$NaBH_4$	butan-2-ol (1)
acidified $K_2Cr_2O_7$	no reaction (1)
I_2/NaOH or NaOCl/KI (1)	yellow antiseptic smelling solid

[3]

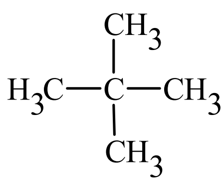
(c) (i) C_5H_{12} [1]

(ii)



2-methylbutane

or



(1)

(2,2)-dimethylpropane
(1)

[2]

Total [10]
Total Section A [35]

Section B

4. (a) The mass spectrum gives the M_r as 86 (½)
55.8% of 86 is 48 (½)
$\therefore \frac{48}{12} = 4$ carbon atoms per molecule (½)
A_r 4 carbon atoms + 2 oxygen atoms = 80; 86 – 80 = 6
$\therefore$ 6 hydrogen atoms
Molecular formula is $C_4H_6O_2$ (½)

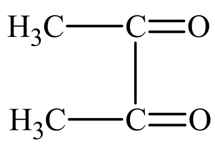
NMR at 2.2 ppm indicates $CH_3C{=}O$ (½)

Infrared spectrum suggests C=O (½)

(Structure fits with single NMR peak) all hydrogen protons equivalent (½)

Not an aldehyde, negative with Tollens' reagent, (could be a ketone) (½)

Structure confirmed as



(1) [5]

(b) (i) Method shows a safe way of heating an alcoholic solution [1]

(ii) Remove traces of impurities [1]

(iii) Add crystals to minimum (½) quantity of hot (½) (or heat) ethanol. Filter hot if necessary (½).Leave to cool (½), filter (½). Dry in air / oven less than 112 ^{o}C (½) [3]

(c) (i) Yellow reflected / transmitted, (½)
other colours absorbed (½) [1]

(ii) M_r C_6H_5CHO = 106.06 (½)

moles of C_6H_5CHO = $\frac{3.18}{106.06}$ = 0.0300 (½)

mole ratio 2 : 1 (½)
∴ moles of compound **G** = 0.0150 (½)

M_r of compound **G** is 234.14 (½)
∴ theoretical yield = 234.14 × 0.0150 = 3.51 g (½)

% Yield = $\frac{2.82 \times 100}{3.51}$ (½) = 80 (½) [4]

(d) E = hf or higher frequency ≡ higher energy (½)

$f \propto \frac{1}{\lambda}$ or higher frequency ≡ shorter wavelength (½)

OR $E = \frac{hc}{\lambda}$ (1)

Absorption in the UV is of a higher energy than absorption in the visible (½)

∴ Higher frequency in the UV ∴ shorter wavelength (½)

∴ Diphenylmethanone absorbs at a shorter wavelength (1) [3]

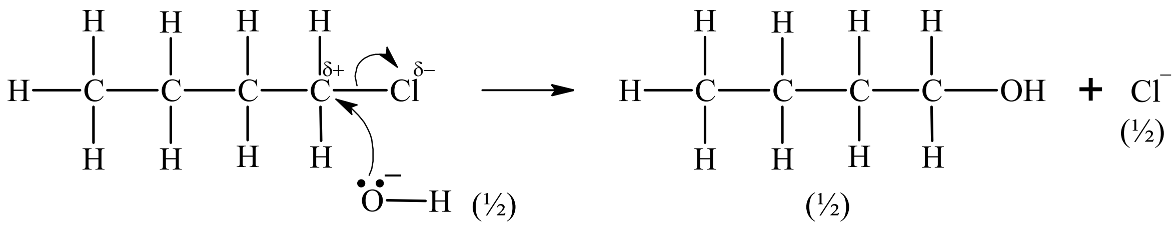
(e) e.g. measurement of intensity of IR absorption (1)
in blood / urine alcohol testing (1) [2]

Total [20]

5. (a) $CH_3CH_2CH_2CH_3 \; + \; Cl_2 \; \rightarrow \; CH_3CH_2CH_2CH_2Cl \; + \; HCl$ (1)

UV light / elevated temperatures (1) [2]

(b)



polarisation (½) arrows (½)(½)

or accept mechanism with transition state ((½) for correct transition state)

nucleophilic substitution (1) [4]

(c) (i) Stage 1 $C_4H_9Cl \; + \; CN^-$ / KCN / name (1)

$\longrightarrow CH_3CH_2CH_2CH_2C{\equiv}N$ / name (1)

Stage 2 C_4H_9CN heat / reflux (1) with dilute acid (1)

$\longrightarrow CH_3CH_2CH_2CH_2COOH$ / name

(ii) $CH_3CH_2CH_2CH_2COOH$ / name + CH_3OH / name (1)

sulphuric acid catalyst (1) allow heat / reflux (1) if not gained in part (i)
$\longrightarrow$ methyl pentanoate [6]

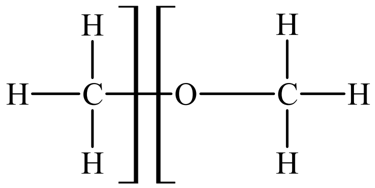
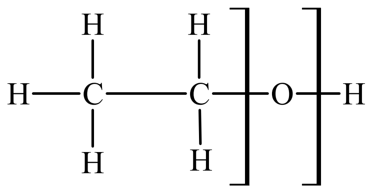
(d) butylamine $\rightarrow$ indicator paper (½) basic (½) (accept correct colour change)

butan-1-ol $\rightarrow$ acidified dichromate (½) heat (½) orange to green (½)

pentan-3-one $\rightarrow$ 2,4-DNP (½) orange precipitate (½)

butanoyl chloride $\rightarrow$ add to water (½) add Ag^+ (½) white precipitate (½)
OR moist (½) indicator paper (½) acidic (½) (accept correct colour change)

[5]

(e)  

15	31	29	45
(½)	(½)	(½)	(½)

(ignore charges)

∴ likely to be methoxymethane (1) [3]

Total [20]

Total Section B [40]

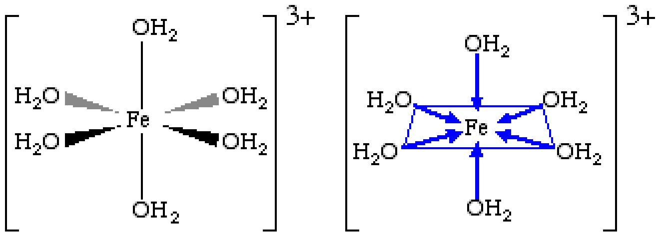
CHEMISTRY CH5

1. (i)

	3d						4s
Ar	1	1	1	1	1		1

[1]

(ii)



(accept either type) [1]

(iii) The ligand (½) splits (½) the d orbitals into 2 higher levels and 3 lower levels (½). As an electron is promoted from a lower to a higher level (½), energy is absorbed (½)from the visible spectrum. The colour seen is the unabsorbed colours (½). [3]

(iv) Brown/yellow/red (½) precipitate (½) that is insoluble in excess of the sodium hydroxide solution (1).

$Fe^{3+} + 3OH^{-} \rightarrow Fe\,(OH)_3$ (1) [3]

(v) Reagent silver nitrate/$AgNO_3$ (1) [1]

Observation White precipitate (1) [1]

Total [10]

2. (a) (i) $2Li + 2H_2O \rightarrow 2LiOH + H_2$ [1]

(ii) $[H^+] = \text{antilog} -11.5 = 3.16 \times 10^{-12}\ \text{mol dm}^{-3}$ (1)

$K_w = [H^+][OH^-]$ (1)

$\therefore\ [OH^-] = \dfrac{K_w}{[H^+]} = \dfrac{1.00 \times 10^{-14}}{3.16 \times 10^{-12}} = 3.16 \times 10^{-3}\ (\text{mol dm}^{-3})$ (1) [3]

(b) (i) $K_p = \dfrac{pCO_2 \times pH_2}{pCO \times pH_2O}$ (1) [1]

(ii) pCO_2 = 1150 kPa as the ratio is 1:1 (1)

pCO and pH_2O are both $\dfrac{2500 - 2300}{2} = 100\text{kPa}$ (1)

$K_p = \dfrac{pCO_2 \times pH_2}{pCO \times pH_2O} = \dfrac{1150 \times 1150}{100 \times 100} = 132$ (1) no units (1)

[4]

(iii) higher pressure $\therefore$ increased collision rate $\therefore$ faster reaction [1]

(c) (i) rate = k [ICl] [H_2] (1)

$\therefore k = \dfrac{\text{rate}}{[ICl][H_2]} = \dfrac{6.40 \times 10^{-7}}{0.0016 \times 0.0016} = 0.250$ (1) $\text{mol}^{-1}\ \text{dm}^3\ \text{s}^{-1}$ (1)

[3]

(ii) $ICl + H_2 \rightarrow HCl + HI$
(accept other suitable intermediates)

[1]

(iii) $HI + ICl \rightarrow I_2 + HCl$ [1]

Total [15]

3. (a) Observations misty fumes (½) black solid/ purple vapour (½)
pungent smell (½) rotten egg smell (½)

Explanation HI / I^- reduces (½) the sulphuric acid (½) to sulphur dioxide (½) sulphur (½) and hydrogen sulphide (½) and is itself oxidised (½) to iodine (½)

maximum [4]

(b) (i) Number of moles of iodine $= \frac{20.0 \times 0.050}{1000} = 0.00100$ (1)

Mole ratio $As_4O_6 : I_2$ is 1:4 (½)

Number of moles of As_4O_6 in 25.0 cm^3 is $\frac{0.00100}{4} = 0.00025$ (½)

[2]

(ii) Number of moles of As_4O_6 in 250 cm^3 is

$\frac{250 \times 0.00025}{25} = 2.50 \times 10^{-3}$ (½)

M_r of As_4O_6 = $(4 \times 74.9) + (6 \times 16.0)$ = 395.6 (½)

Mass of arsenic oxide present = $395.6 \times 2.50 \times 10^{-3}$ = 0.989 g (½)

% of arsenic oxide in the sugar $= \frac{0.989 \times 100}{40.0} = 2.47$ (½) [2]

(c) Arsenic is in group 5 ∴ 5 outer electrons 3 bonding pairs and 1 lone pair (½)
Electron pairs repel to bonds become angled as far apart as possible (½)

lone pair/bonding pair repulsion > bonding pair/bonding pair repulsion (½)

∴ tetrahedral angle reduced from $109.5\ ^{o}$ (½) [2]

Total [10]

Total Section A [35]

Section B

4. (a) (i) A compound that reacts with both acid and base / acts both as a base and an acid. (1) [1]

(ii) Add an alkali (½), aluminium oxide dissolves (½), iron(III) oxide does not (½), filter off the iron(III) oxide (½) [2]

(b) (i) $4Al + 3O_2 \rightarrow 2Al_2O_3$ [1]

(ii) Oxygen is more electronegative than aluminium (1), an oxidising agent removes electrons (from the other reactant) (1) [2]

(c) (i) Potassium iodide [1]

(ii) Lead(II) chloride [1]

(iii) $Pb^{2+} + 2OH^{-} \rightarrow Pb(OH)_2$ [1]

precipitate dissolves (½) giving a colourless solution (½) [1]

(iv) Pb $\frac{86.6}{207}$ O $\frac{13.4}{16.0}$ (½)

= 0.418 = 0.838

ratio 1 : 2 (½) $\therefore PbO_2$ (1) [2]

(v) $PbO_2 + 4HCl \rightarrow PbCl_2 + Cl_2 + 2H_2O$ [2]

(d) (i) Mole ratio $CO : I_2$ 5 : 1 (½)

Number of moles of iodine $= \frac{5.0\times10^{-3}}{2} = 2.5\times10^{-3}$ (½)

Number of moles of CO $= 5\times2.5\times10^{-3} = 0.0125$ (½)

Volume of CO $= 0.0125\times24 = 0.300\ dm^3$ (½)

% CO by volume $= \frac{0.300\times100}{20} = 1.5$ (1) [3]

(ii) Oxidation state of carbon in CO is +2 and in CO_2 is +4 (½)
Oxidation state of iodine in I_2O_5 is +5 and in I_2 is 0 (½)

Reducing agent is CO (1) [2]

(e) eg $PbO + CO \rightarrow Pb + CO_2$ [1]

Total [20]

5. (a) (i) Thymolphthalein (1)
Changes colour in the more vertical section of the pH curve (1) [2]

(ii) 9.0 (1) (accept 8-10 inclusive)
At the end point there is no excess of ethanoic acid or sodium hydroxide (1) [2]

(iii) I Lattice breaking enthalpies + hydration enthalpies = enthalpy of solution [1]

II 1000 cm^3 contain 0.1 mole of NaOH (½)
150 cm^3 contain 0.015 mole of NaOH (½)
Heat change is 45×0.015 (½)
= 0.675 KJ or 675J (½) [2]

(iv) The hydroxide ion is smaller than the ethanoate ion (½) and $\therefore$ there is more attraction between the ions in sodium hydroxide than between the ions in sodium ethanoate / more energy is needed to separate the ions (½) [1]

Q. 5(b) is to be assessed for Quality of Written Communication.
Candidates must satisfy the following criteria to be awarded the marks designated as [L].

- *Selection of a form and style of writing which is appropriate to this question*
- *Organisation of the relevant information clearly and coherently*
- *Use of legible text with adequate spelling, punctuation and grammar*

(b) Sodium nitrate melts (½) and then decomposes giving the nitrite / $NaNO_2$ (½) and oxygen gas (½) which relights a glowing splint (½).
Calcium nitrate decomposes to give a brown gas (½), nitrogen dioxide NO_2, (½) and oxygen (½) which relights a glowing splint (½) and calcium oxide (½) steam (½).
Sodium nitrate is the more thermally stable (½).
$2NaNO_3 \rightarrow 2NaNO_2 + O_2$ (1)
$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$(1) OR
$2Ca(NO_3)_2.6H_2O \rightarrow 2CaO + 4NO_2 + O_2 + 6H_2O$(1)
Maximum [5]

(c) (i) The value should be 0.00 V (1); this is used as a comparative value against which to measure other standard electrode potentials. (1) [2]

(ii) $Zn(s) + Cd^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cd(s)$ [1]

(iii) EMF $= -0.40 - (-0.76) = (+)0.36V$ [1]

(iv) The Cu^{2+} / Cu system is the more positive
$\therefore$ $V^{2+}(aq)$ is a more powerful reducing agent than copper (1)
and $\therefore$ $V^{2+}(aq)$ will reduce $Cu^{2+}(aq)$ to copper (1) [2]

(d) $PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$ [1]

Total [20]

Total Section B [40]

CHEMISTRY CH6a

1. (a) Lead (II) Iodide (½), Triiodomethane (iodoform) (½) [1]

(b) Ethanamide (½), Triiodomethane (iodoform) (½) [1]

(c) CH_3CO- / CH_3CHOH- (1) [1]

(d) (i) Mix solutions (½)
(of sodium iodide and) lead nitrate/ ethanoate / soluble lead(II) salt / Pb^{2+} (aq) (½)
Filter off the precipitate (½)
(Wash and) dry (½) [2]

(ii) Heat (to remove water) / dehydration (1) [1]
(Allow (½) for "remove water")

(e) Any two from four (formulae acceptable instead of names for all products):

Solid	Aminoethanoic Acid (glycine)
Observations	Dissolves to give (colourless) solution (1)
Product(s	Sodium 1-aminoethanoate (½) and water (½)
Solid	Ethanamide
Observations	Effervescence (as ammonia evolved) / gas turns litmus blue / smell of ammonia (1)
Product(s)	Ammonia (½), sodium ethanoate (½)
Solid	Lead (II) Iodide
Observations	Turns white / yellow colour lost (½), then redissolves (½)
Product(s)	Lead hydroxide, sodium plumbate(II), sodium iodide Any 2 for (½) each
Solid	Ammonium Ethanoate
Observations	Effervescence (as ammonia evolved on warming) / gas turns litmus blue / smell of ammonia (1)
Product(s)	Ammonia, sodium ethanoate / ethanoate ion, water Any 2 for (½) each

[4]

Total [10]

Section B

2. (a)

$$\begin{array}{ccccccc} & & \mathrm{xx} & & \mathrm{xx} & & \\ \mathrm{H} & {}^{\mathrm{x}}_{\mathrm{o}} & \mathrm{O} & {}^{\mathrm{x}}_{\mathrm{x}} & \mathrm{O} & {}^{\mathrm{x}}_{\mathrm{o}} & \mathrm{H} \\ & & \mathrm{xx} & & \mathrm{xx} & & \end{array}$$ [1]

(b) (i) $\Delta H^{\ominus} = 2\,\Delta H_f^{\ominus}\ H_2O(l) - 2\,\Delta H_f^{\ominus}\ H_2O_2(l)$ (1)
or
$2\,(-285.8) - 2\,(-187.8)$ (1)
$= -571.6 + 375.6$
$= -196.0\ \text{kJ mol}^{-1}$ (1) [2]
(consequential marking, but for one mistake only)

(ii) Catalases / blood enzymes catalyse reaction A (½)
(speeding up the) production of O_2 gas. (½) [1]

(c) (i) $\Delta H^{\ominus}$ = 4BE O-H + 2BE O-O – 4BE O-H – BE O=O
–210 = 4(464) + 2BE O-O – 4(464) – 498
–210 = 2BE O-O – 498 *or* 1856 + 2BE O-O – 2354 (1)
BE O-O = 288 / 2 kJ mol^{-1} = 144 kJ mol^{-1} (1)
(2 marks for correct answer with no working. Consequential marking, but only for one mistake) [2]

(ii) Less energy needed to break it than other bonds. (1) [1]

(d) (i) Has the most positive electrode potential (1)
so accepts electrons most readily. (1) [2]

(ii) *EMF* + 1.23V (no penalty if units not given) (1)
Equation $H_2O_2 + 2H^+ + 2\,I^- \rightarrow 2H_2O + I_2$ (1) [2]
(Allow (1) for -1.23 V followed by reversed equation)

(e) (i) Chromophore. [1]

(ii) H_2O_2 reacts with / oxidises / destroys double bonds in large organic molecules (½)
destroying the chromophore group (consequential on (e)(i)). (½) [1]

(f) 3 g H_2O_2 made up to 100 cm^3 solution. (from text)
30 g dm^{-3} H_2O_2 (½)
M_r H_2O_2 = 34.02 (½)
Molar Conc = $\dfrac{30}{34.02} = 0.882\ \text{mol dm}^{-3}$ (1) (½ mark if not 3sf) [2]
(2 marks for correct answer with no working)

Total [15]

Section C

Q3(a)(i) is to be assessed for Quality of Written Communication. [L]
Candidates must satisfy the following criteria

- *Selection of a form and style of writing appropriate to the question*
- *Organisation of the relevant information clearly and coherently*
- *Use of legible text with adequate spelling, punctuation and grammar.*

3. (a) (i) Convert to moles

C $\frac{7.603}{7.603} = 7.603$ H $\frac{8.77}{1.01} = 8.683$

Simplest ratio

C $\frac{7.603}{7.603} = 1$ H $\frac{8.683}{7.603} = 1.142$ (½)

× 7 to give M_r 92.08

∴ Molecular formula C_7H_8 (½)

NMR spectrum
Peak at 2.2ppm –CH_3 attached to benzene ring (½)
Peak at 7.3ppm –H attached to benzene ring (½)
Structure $C_6H_5CH_3$ (½)

Oxidation
Alkaline (do not allow if H^+ quoted as well) (½)
Manganate (VII) (½)
Reflux / warm (½) [4]

(ii) Dissolve benzenecarboxylic acid in minimum volume (½)
of hot water. (½)
Filter hot (to remove insoluble impurities). (½)
Allow to (cool to) crystallise. (½)
Filter to separate crystals. (½)
Wash (with a small quantity of cold water). (½)
Dry (by gentle warming in an oven). (½)
Any 6 for (½) each [3]

(b) (i) heated with sodalime.

Organic product Benzene (1)
Type of reaction Decarboxylation (1) [2]

(ii) treated with lithium tetrahydridoaluminate(III), $LiAlH_4$, in dry ether.

Organic product Phenylmethanol/phenylmethanal/benzaldehyde (1)
Type of reaction Reduction/redox (1) [2]

(c) $[H^+] = \sqrt{(2.79 \times 10^{-2} \times 6.3 \times 10^{-5})}$
$= 1.326 \times 10^{-3}$ mol dm^{-3} (1)

pH $= -\log [1.326 \times 10^{-3}] = 2.9$ (1) [2]
(consequential on $[H^+]$ value) (½ mark if less than 2 sig fig)

Total [13]

4. (a) There are only three pairs of outer electrons around the Al in $AlCl_3$ (1)

Less than the usual "stable" outer octet / noble gas structure of electrons. (1) [2]

(Allow (½) for "full outer shell").

(b) $AlCl_3$, under appropriate conditions, will react with a chloride ion to form $AlCl_4^-$.

(i) (Lone pair on) Cl^- forms dative covalent bond to Al. (1) [1]
(Allow (½) mark if incorrect form of chlorine used or it is not mentioned)

(ii) State the shapes of the $AlCl_3$ molecule and the $AlCl_4^-$ ion.

$AlCl_3$ shape Trigonal / Planar triangular (1)

$AlCl_4^-$ shape Tetrahedral (1) [2]

(c) (i) Any two from:

Save on fuel costs / cheaper
Less thermal degradation
Safer / more convenient operating conditions
No need for separate solvents
Easier to control the temperature
or other appropriate reason [2]

(ii) Addition (polymerisation). [1]

(iii) Chlorination / halogenation of benzene. [1]

(d) (i) Exothermic since bond formation is exothermic / since the dimer (with Al outer octet) is more stable than the monomer. [1]

(ii) Low temperature since, by Le Chatelier's Principle, the forward exothermic reaction is favoured by low temperature. (Consequential on (d)(i)). [1]

(iii) High pressure, since, by Le Chatelier's Principle, the forward reaction with a decrease in the number of moles of gas is favoured by high pressure [1]

Total [12]

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