Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2025

Chemistry

Standard level

Paper 2

12 pages

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Subject Details: Chemistry Standard Level Paper 2 Markscheme

Candidates are required to answer **ALL** questions. Maximum total = **[50 marks]**.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative word is indicated in the "Answers" column by a slash (*/*). Either word can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***". Either answer can be accepted.

7. An alternative markscheme is indicated in the "Answers" column under heading **ALTERNATIVE 1** *etc*. Either alternative can be accepted.

8. Words inside chevrons **« »** in the "Answers" column are not necessary to gain the mark.

9. Words that are <u>underlined</u> are essential for the mark.

10. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

11. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect) in the "Notes" column.

12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

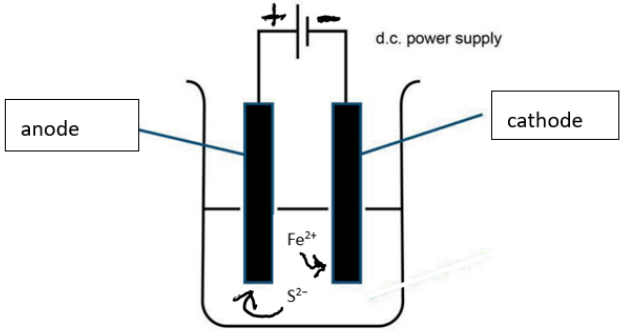
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.

14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

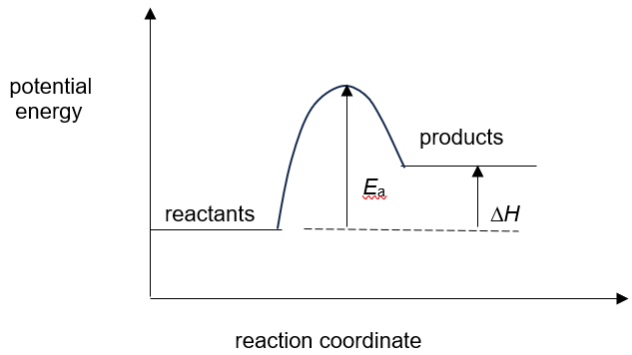
15. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the "Notes" column. Similarly, if the formula is specifically asked for, do not award a mark for a correct name unless directed otherwise in the "Notes" column.

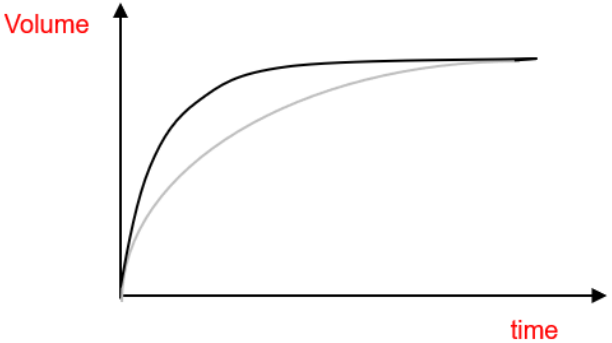
16. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the "Notes" column.

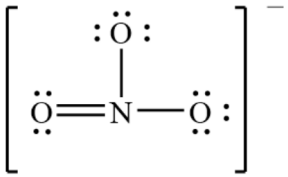
17. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the "Notes" column.

Question			Answers	Notes	Total
1.	**(a)**		elements contain only one type of atom / atoms with same atomic number/same number of protons ***OR*** cannot be chemically broken down «into simpler substances» ✓ compounds contain different types of atoms «chemically» bonded together ***OR*** consist of different elements «chemically» bonded together «in fixed ratios» ✓	*Accept **combined/joined** for bonded in M2.*	**2**
1.	**(b)**		<<electronegativity difference>> ΔX = 0.8 ***AND*** average <<electronegativity >> X = 2.2 ✓		**1**
1.	**(c)**	**(i)**	 left electrode: anode ***AND*** right electrode: cathode ✓ S^{2-} to left electrode ***AND*** Fe^{2+} to right electrode ✓	*Do not apply ECF.* *Award 1 mark for any 2 correct of the 4*	**2**

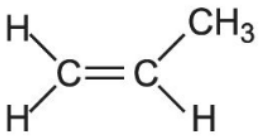
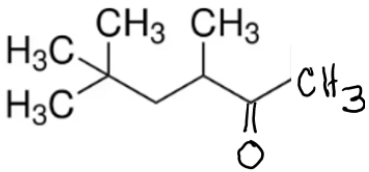
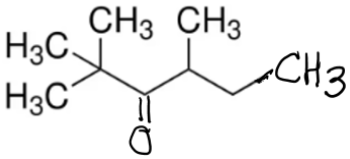
Question			Answers	Notes	Total
1.	**(c)**	**(ii)**	*Negative electrode:* $Fe^{2+} + 2e^- \rightarrow Fe$ ✓· *Positive electrode:* $S^{2-} \rightarrow S + 2e^-$ ✓·	*Award [1 max] for correct equations at wrong electrodes.* *Do not accept reverse equations.* *Penalize equilibrium arrows once only*	**2**
1.	**(c)**	**(iii)**	*Any one of:* Fe is electrical/thermal conductor ***AND*** FeS is not ✓ Fe is malleable/ductile ***AND*** FeS is brittle/not malleable/ductile ✓ Fe is magnetic ***AND*** FeS is not ✓ Fe has higher melting point «than FeS» ✓ Fe is denser «than FeS» ✓	*Do not accept atomic or molar mass.* *Do not accept any chemical properties.* *Accept colour or shininess* *Accept iron is sonorous*	**1**
2.	**(a)**		$1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^7$ / [Ar] $3d^7$ ✓		**1**
2.	**(b)**	**(i)**	«*K* = » $[CoCl_4^{2-}]/[Co^{2+}][Cl^-]^4$ ✓		**1**
2.	**(b)**	**(ii)**	no effect on *K* ***AND*** mixture has more $[CoCl_4]^{2-}$ /product ***OR*** no effect on *K* ***AND*** equilibrium shifts to the right ✓		**1**
2.	**(b)**	**(iii)**	endothermic ***AND*** equilibrium shifts to right ***OR*** endothermic reaction is favoured by increase in temperature ✓	*Accept endothermic as forward reaction removes heat* *Accept endothermic and more products formed*	**1**

Question			Answers	Notes	Total
2.	**(b)**	**(iv)**	 products and reactants labelled ✓ E_a from reactants level to peak ✓ ΔH from reactant to product ✓	*Accept double-headed arrows for E_a and ΔH.* *ΔH should correspond to answer in 2a* *Accept names of reactants and products*	**3**
3.	**(a)**		$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$ correct products ***AND*** state symbols ✓ correct balancing ✓	*Do not accept $H_2CO_3(aq)$ for M1.* *Accept ionic equation.*	**2**
3.	**(b)**		$n(CaCO_3)$ «$= \frac{3.162\ g}{100.09\ g\ mol^{-1}}$» = 0.0316 «mol» ***AND*** $n(HCl)$ «$= 4.00\ mol\ dm^{-3} \times 20.0 \times 10^{-3}\ dm^3$» = 0.0800 «mol» ✓ $CaCO_3$ is limiting ✓	*Do **not** award M2 without working/answer seen for M1*	**2**
3.	**(c)**		«$V = 0.0316\ mol \times 22.7\ dm^3 mol^{-1} =$» 0.717 «$dm^3$» ✓		**1**

Question			Answers	Notes	Total
3.	**(d)**		 Greater gradient ***AND*** from origin ***AND*** same final volume ✓	*Lines must not cross.*	**1**
4.	**(a)**	**(i)**	«catalyst provides» alternative reaction pathway ✓ «catalyst» lower(s) activation energy ✓	*M1 requires a description of the reaction going from reactants to products if exact wording not given.* *Accept explanation of how a transition metal catalyst works for M1*	**2**
4.	**(a)**	**(ii)**	*Oxidation half-equation:* $S_2O_3^{2-} + H_2O \rightarrow 2SO_2 + 2H^+ + 4e^-$ ✓ *Overall redox equation:* $S_2O_3^{2-} + 4Fe^{3+} + H_2O \rightarrow 2SO_2 + 4Fe^{2+} + 2H^+$ ✓	*Allow ECF for M2*	**2**

Question			Answers	Notes	Total
4.	**(b)**	**(i)**	*Ionic bonding:* electrostatic attraction between oppositely charged ions/cations ***AND*** anions ✓ *Covalent bonding:* electrostatic attraction between shared electron pair and positively charged nuclei ✓	*Do not accept answers referring to transfer of electrons for M1.* *Penalize missing electrostatic attraction once only.*	**2**
4.	**(b)**	**(ii)**	 ✓	*Do not accept resonance structure.* *Negative charge must be shown.* *Accept single negative charges on two O atoms **AND** a single positive charge on the N atom.* Accept any combination of lines, dots or crosses	**1**
4.	**(b)**	**(iii)**	trigonal planar ✓	*Accept triangular planar.* *Apply **ECF** for any N containing species in 4b(ii)*	**1**

Question			Answers	Notes	Total
5.	**(a)**		n(C) «$= n(CO_2) = \frac{9.49\ g}{44.01\ g\ mol^{-1}}$» = 0.216 «mol» ***AND*** n(H) «$2n(H_2O) = 2 \times \frac{5.18\ g}{18.02\ g\ mol^{-1}}$» = 0.575 «mol» ✓ ***OR*** *H = 0.581* «g» ***AND*** C = 2.59 «g»✓ «m(O) = 4.32 – (m(C) + m(H)) = 4.32 – (2.59 + 0.581) = 1.15 g » n(O) = $\frac{1.15\ g}{16.00\ g\ mol^{-1}}$ / 0.0718 «mol» ✓ «n(C):n(H):n(O) = 0.216 : 0.575 : 0.0718 = 3 : 8 : 1 » C_3H_8O ✓	*M2 for finding mass of oxygen* *M3 for finding empirical formula Award [3] for correct final answer.*	**3**
5.	**(b)**	**(i)**	T = 373 K ***AND*** V = 5.57 x 10^{-5} m^3 ***OR*** T = 373 K ***AND*** 0.0557 dm^3 and 1x10^2 kPa ✓ «$n = \frac{PV}{RT} = \frac{1.00 \times 10^5\ Pa\ \times 5.57 \times 10^{-5}\ m^3}{8.31\ J\ K^{-1} mol^{-1} \times 373\ K}$» n = 0.00180 «mol» ✓	*Award [2] for correct final answer.*	**2**
5.	**(b)**	**(ii)**	«$M = \frac{0.108\ g}{0.00180\ mol}$» 60.0 / 60.1 «g mol^{-1}» ✓	*If n = 0.00220 mol is used, M = 49.1 «g mol^{-1}»* *Accept mass of 60*	**1**

Question			Answers	Notes	Total
6.	**(a)**	**(i)**	 ✓	Accept any correct structural representation including skeletal formulas	**1**
6.	**(a)**	**(ii)**	«chemically» inert/unreactive ✓	*Accept "non-biodegradable"* *Do not accept physical properties such as strength*	**1**
6.	**(b)**	**(i)**	carbonyl ✓	*Do **not** accept aldehyde.*	**1**
6.	**(b)**	**(ii)**	3,5,5-trimethylhexanal ✓	*Accept 5,5,3 instead of 3,5,5 do not penalize missing hyphen/dash*	**1**
6.	**(b)**	**(iii)**	 ***OR***  ✓	*Accept any ketone, unsaturated alcohol/ether or cyclic alcohol/ether, with molecular formula $C_9H_{18}O$.* *Accept any correct representation including skeletal structures.* *Ignore connectivity of methyl groups*	**1**

Question			Answers	Notes	Total
6.	**(b)**	**(iv)**	*Product of reaction with oxidizing agent:* RCOOH ✓ *Product of reaction with reducing agent:* RCH_2OH ✓	*Award **[1 max]** for 'carboxylic acid and primary alcohol'.* *Award **[1 max]** if correct products are reversed.* *Accept full and correct structures for both products.* *Accept any correct representation including skeletal structures.*	**2**
6.	**(c)**	**(i)**	1,2-dibromoethane ✓	*Accept name or structure.*	**1**
6.	**(c)**	**(ii)**	high electron density of the carbon-carbon double bond ***OR*** C=C double bond can undergo addition reactions	*Accept C=C double bond susceptible to electrophilic attack.* *Accept "Pi electrons available"*	**1**
6.	**(c)**	**(iii)**	C_nH_{2n} ✓	*Subscripts of numbers not essential*	**1**
6.	**(c)**	**(iv)**	London (dispersion) forces «only» ✓ stronger forces of attraction with increasing chain length / larger electron cloud /molar mass ✓	*Accept dispersion forces/ instantaneous / transient / induced dipole attractions for M1 .* *Do not accept van der Waals' forces for M1.* *Accept "more electrons" for "larger electron cloud" in M2.* *Accept increased surface area.*	**2**

Question			Answers	Notes	Total
6.	**(d)**		**ALTERNATIVE 1:** Bonds broken: 1 C=C + 4 C-H + 2 O-H / 614 + 4(414) + 2(463) / 3196 «kJ» ✓ Bonds formed: 1 C-C + 1 C-O + 5 C-H +1 O-H / 346 + 358 + 5(414) + 463 / 3237 «kJ» ✓ ΔH = «3196 – 3237 = » −41 «kJ » ✓ **ALTERNATIVE 2:** Bonds broken: 1 C=C + 1 O-H / 614 + 463 / 1077 «kJ» ✓ Bonds formed: 1 C-C + 1 C-O + 1 C-H / 346 + 358 + 414 / 1118 «kJ» ✓ ΔH = «1077 – 1118 = » −41 «kJ » ✓	*Award [3] for correct final answer.* *Award [2 max] for +41* «kJ ».	**3**