Markscheme

May 2024

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.

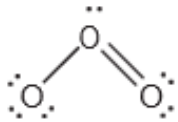
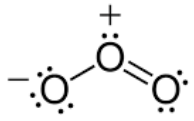
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

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)		percentages do not add up to 100% ***OR*** contains oxygen ✓		1
1.	(b)		<u>oxygen/O</u> content = «100 – 71.93 – 12.10 =» 15.97 % ***OR*** C: «$\frac{71.93}{12.01}$ =» 5.99 mol ***AND*** H: «$\frac{12.10}{1.01}$ =» 11.98 mol ✓ $C_6H_{12}O$ ✓	*Award **[2]** for correct formula.*	2
1.	(c)		«$M = \frac{d \times RT}{p}$ = » $\frac{2.544 \times 10^3\ g\ m^{-3} \times 8.31\ J\ K^{-1}\ mol^{-1} \times 473\ K}{1.00 \times 10^5\ Pa}$ ***OR*** n = «$\frac{pV}{RT} = \frac{1.00 \times 10^5\ Pa \times 1.00\ m^3}{8.31\ J\ K^{-1}\ mol^{-1} \times 473\ K}$ =» 25.4 «mol per m^3» ✓ «*M* =» 1.00 x 10^2 «g mol^{-1}» ***AND*** $C_6H_{12}O$ ✓		2
1.	(d)		O–H ✓		1
1.	(e)		carboxyl ***OR*** $COOH/CO_2H$ ✓	*Accept carboxylic acid*.	1

Question			Answers	Notes	Total
2.	**(a)**		*Electron configuration:* $1s^2 2s^2 2p^4$ ✓ *Unpaired electrons:* 2 ✓		**2**
2.	**(b)**	**(i)**	✓ 	*Accept any combination of dots, crosses and lines for electron pairs, including an arrow for the coordinate bond.* *Do **not** accept delocalized structures.* *Accept*  .	**1**
2.	**(b)**	**(ii)**	bent/angular/V-shaped ✓ any estimated value in the range *110 ° – 119 °* ✓	*Accept a bent diagram for M1.*	**2**
2.	**(c)**		**«**both equal and**»** any estimated value in the range 122–147 **«**pm**»** ✓ resonance ***OR*** delocalization ***OR*** bond order is 1.5 ✓		**2**

(continued…)

(Question 2 continued)

Question			Answers	Notes	Total
2.	**(d)**	**(i)**	negative/inverse «correlation» ***OR*** one concentration increases as the other decreases ✓	*Do **not** accept an answer that includes the term "proportional".*	**1**
2.	**(d)**	**(ii)**	*Any two of:* evidence/supports **«**the claim**»** but does not prove the claim ***OR*** correlation does not imply causation ✓ mechanism/explanation of the link is needed ✓ other factor**«**s**»** may have caused these changes ✓	*Accept $Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$ **OR** $ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$ **OR** $ClO\bullet + O_3 \rightarrow ClO_2 + O_2$ for M2 (without penalizing missing radical symbols).* *Accept CFCs/Cl radicals deplete ozone **AND** ClO is part of the depletion mechanism for M2.*	**2 max**

Question			Answers	Notes	Total
3.	**(a)**	**(i)**	acid rain/deposition ***OR*** smog ✓	*Accept any specific environmental problem caused by acid deposition or smog.*	**1**
3.	**(a)**	**(ii)**	$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ ***OR*** $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$ ***OR*** $2SO_2(g) + 2H_2O(l) + O_2(g) \rightarrow 2H_2SO_4(aq)$ ✓		**1**

(continued…)

(Question 3 continued)

Question			Answers	Notes	Total
3.	**(b)**	**(i)**	$H_2O(l) + Na_2O(s) \rightarrow 2NaOH(aq)$ ✓		**1**
3.	**(b)**	**(ii)**	**«**$[OH^-] = 2 \times 0.100 = 0.200$ mol dm^{-3}**»** ***Alternative One:*** $[H^+] = «\frac{1.00 \times 10^{-14}}{0.200} = » 5.00 \times 10^{-14}$ **«**mol dm^{-3}**»** ✓ **«***pH* = –log 5.00×10^{-14} **=»** 13.30 ✓ ***Alternative Two:*** **«***pOH* = –log 0.200 **=»** 0.699 ✓ **«***pH* = 14.00 – 0.699 **=»** 13.30 ✓		**2**
3.	**(c)**	**(i)**	**«**K_c **=»** $\frac{[H_3O^+][H_2PO_4^-]}{[H_3PO_4]}$ ✓		**1**

(continued…)

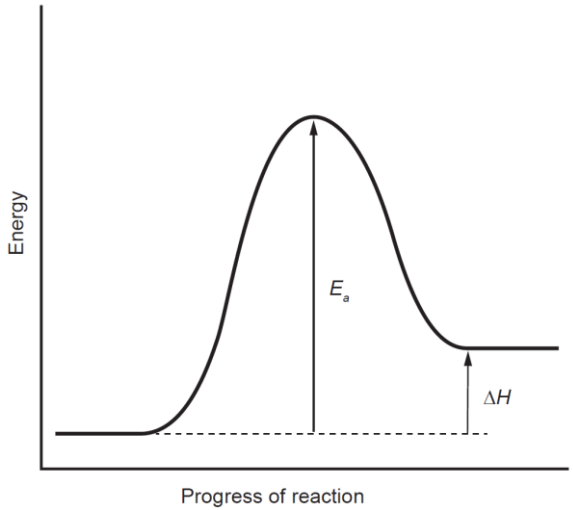
(Question 3 continued)

Question			Answers	Notes	Total
3.	**(c)**	**(ii)**	shifts to the left/toward reactants ***AND*** **«**forward**»** reaction is exothermic ***OR*** shifts to the left/toward reactants ***AND*** favours endothermic **«**reverse**»** reaction ✓		**1**
3.	**(d)**		same electron configuration ***AND*** P^{3-} has smaller nuclear charge/number of protons/atomic number ✓	*Accept "same «number of» electrons/shells" **OR** "same shielding" for "same electron configuration".* *Accept "P^{3-} has smaller effective nuclear charge" for "P^{3-} has smaller nuclear charge".*	**1**

Question			Answers	Notes	Total
4.	**(a)**		*Any two of:* e*th*: contains two carbon atoms ✓ *en*: contains a carbon-carbon double bond / C=C ✓ *one*: contains a carbonyl / C=O ✓	*Accept "alkene" for C=C and "ketone" for C=O.* *Award **[1 max]** if two structural features given without relating to the relevant part of IUPAC name.*	**2 max**
4.	**(b)**		both have **«**similar**»** London/dispersion forces **«**due to having same number of electrons/similar M_r**»** ✓ ethenone has dipole-dipole forces **«**and carbon dioxide does not**»** ✓		**2**

(continued…)

(Question 4 continued)

Question			Answers	Notes	Total
4.	**(c)**	**(i)**	**«**$\Delta H° = \sum \Delta H°_{f\ products} - \sum \Delta H°_{f\ reactants}$**»** = -74.0 - 87.2 + 248 ✓ = **«**+**»**86.8 **«**kJ**»** ✓	*Award **[2]** for correct final answer.* *Award **[1]** for –86.8 **«**kJ**»**.*	**2**
4.	**(c)**	**(ii)**	 endothermic graph ***AND*** labelled arrow/line showing Δ*H* ✓ labelled arrow/line showing E_a ✓		**2**

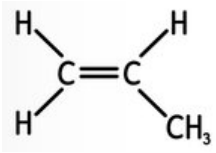
(continued…)

(Question 4 continued)

Question			Answers	Notes	Total
4.	**(d)**		CH_3COOH / ethanoic acid ✓ *Award **[2 max]*** for any two of: **«**m/z=**»** 60 due to molecular ion/CH_3COOH^+ ✓ **«**m/z=**»**15 due to CH_3^+ / due to loss of $COOH^+$ ✓ **«**m/z=**»** 43 due to CH_3CO^+ / due to loss of OH^+ ✓ **«**m/z=**»** 45 due to $COOH^+$ / due to loss of CH_3^+ ✓	*Accept molar/molecular mass is 60.*	**3 max**
4.	**(e)**		20.0 **«**cm^3**»** of O_2 (g) reacts ***OR*** 80.0 **«**cm^3**»** of O_2 (g) remains ***OR*** 20.0 **«**cm^3**»** of CO_2 (g) produced ✓ 100 **«**cm^3**»** ✓	*Award **[2]** for correct final answer*.	**2**
4.	**(f)**		intermolecular forces no longer negligible/OWTTE ***OR*** volume occupied by molecules no longer negligible **«**compared to the total volume**»** ✓		**1**

(continued…)

(Question 4 continued)

Question			Answers	Notes	Total
4.	**(g)**		*H:*  / $H_2C{=}CHCH_3$ ✓ *G:* 2-chloropropane ***OR*** 2-bromopropane ***OR*** 2-iodopropane ✓	*Accept H_2CCHCH_3 / CH_2CHCH_3 for M1.* *Award **[1 max]** for name for H and structure for G.*	**2**

Question			Answers	Notes	Total
5.	**(a)**		rate decreases as concentrations of reactants decrease ✓	*Accept calculated rate is the average rate.* *Accept rate decreases with time.*	**1**

(continued…)

(Question 5 continued)

Question			Answers	Notes	Total
5.	**(b)**	**(i)**	*[RCl]:* 6.00×10^{-6} **«**mol dm^{-3} as this is *y* intercept**»** ✓ *Initial rate:* **«**is equal to –**»** gradient of tangent at time 0 s ***OR*** tangent drawn at time 0 ***AND*** evidence of gradient calculation ✓ 6.4×10^{-8} **«**mol dm^{-3} s^{-1}**»** ✓		**3**
5.	**(b)**	**(ii)**	frequency/probability of collisions decreases ✓	*Do **not** accept "fewer collisions" without reference to time*.	**1**

Question			Answers	Notes	Total
6.	**(a)**		*Positive electrode (anode)*: $2Br^- \rightarrow Br_2(g) + 2e^-$ ✓ *Negative electrode (cathode)*: $Na^+ + e^- \rightarrow Na(l)$ ✓	*Award **[1 max]** if equations are given for wrong electrodes*.	**2**
6.	**(b)**		*Species oxidized:* $SO_3^{2-}(aq)$ ✓ *Number of electrons transferred:* 2 ✓		**2**