Markscheme

November 2024

Chemistry

Standard level

Paper 2

12 pages

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)**	**(i)**	London/dispersion forces **«**only**»** ✓ strength **«**of intermolecular forces**»** increases as size of electron cloud/number of electrons increases ✓	*Accept strength of intermolecular forces increases as mass/size of molecule increases for M2.*	**2**
1.	**(a)**	**(ii)**	boils/vaporizes ***OR*** molecules have sufficient energy to overcome intermolecular forces ✓ gaseous molecules are further apart **«**than in liquid**»** ✓	*Accept gases have a **«**much**»** lower density than liquids for M2.* *Do **not** award M2 unless a change of state is indicated.*	**2**
1.	**(a)**	**(iii)**	**«***M*r(C_3H_8) = 44.11**»** **«**n =**»** 0.146 **«**mol**»** ✓ **«**V = $\frac{0.146\times8.31\times288}{100}$ =**»** 3.49 **«**dm^3**»** ✓	*Award **[2]** for correct final answer.* *Accept answers in the range 3.49 - 3.59 **«**dm^3**»**.*	**2**
1.	**(a)**	**(iv)**	not behaving as an ideal gas **«**at very high pressure**»** ✓ ideal gas molecules have no volume ***OR*** volume of **«**propane**»** molecules is not negligible ✓	*Accept propane is a real gas for M1.*	**2**
1.	**(b)**	**(i)**	substitution ***AND*** **«**free**»** radical ✓		**1**

(continued…)

(Question 1 continued)

Question			Answers	Notes	Total
1.	**(b)**	**(ii)**	*One initiation step:* $Cl_2 \rightarrow 2\ \bullet Cl$ ✓ *Two propagation steps:* $C_2H_6 + \bullet Cl \rightarrow \bullet C_2H_5 + HCl$ ✓ $\bullet C_2H_5 + Cl_2 \rightarrow C_2H_5Cl + \bullet Cl$ ✓ *One termination step:* $\bullet C_2H_5 + \bullet C_2H_5 \rightarrow C_4H_{10}$ ***OR*** $\bullet C_2H_5 + \bullet Cl \rightarrow C_2H_5Cl$ ***OR*** $\bullet Cl + \bullet Cl \rightarrow Cl_2$ ✓		**4**
1.	**(c)**		*Reagent:* sodium hydroxide/NaOH/hydroxide ions/OH^- ✓ *Conditions:* warm/heat/reflux ***OR*** aqueous ***OR*** **«**aprotic**»** solvent ✓	*Accept any strong base for M1.* *Award **[2]** for NaOH(aq).*	**2**

Question			Answers	Notes	Total
2.	**(a)**		*K(s):* high **«**electrical conductivity**»**/conductor ***AND*** electrons free to flow/delocalized ✓ *KCl(s)*: low **«**electrical conductivity**»**/not a conductor ***AND*** ions/charged particles are fixed in position ✓	*Award **[1 max]** for K(s) is a conductor **AND** KCl(s) is not a conductor.* *Do **not** accept just "metal" or "metallic bonding" for M1.* *Do **not** accept an explanation in terms of electrons for M2.*	**2**
2.	**(b)**		*Anode (positive electrode):* $Cl^- \rightarrow ½\ Cl_2 + e^-$ ✓ *Cathode (negative electrode):* $K^+ + e^- \rightarrow K$ ✓	*Award **[1 max]** for correct equations at wrong electrode.* *Ignore reversible arrows.*	**2**

(continued…)

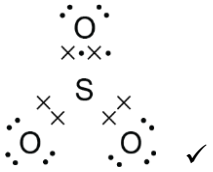
(Question 2 continued)

Question			Answers	Notes	Total
2.	**(c)**		*Protons:* 19 ***AND*** *Electrons:* 18 ***AND*** *Neutrons:* 22 ✓		**1**
2.	**(d)**	**(i)**	***Alternative 1:*** **«**$\Delta H_f(H_2O(l))$ =**»** −285.8 **«**kJ mol^{-1}**»** ✓ **«**$\Delta H_{reaction} = \Sigma\Delta H_f$(products) – $\Sigma\Delta H_f$(reactants)**»** **«**$\Delta H_{reaction}$ = (2(−481.8) +0) – (0 + 2(−285.8))**»** **«**$\Delta H_{reaction}$ =**»** −392.0 **«**kJ**»** ✓ **«**ΔH =**»** −196.0 **«**kJ mol^{-1}**»** ✓ ***Alternative 2:*** **«**$\Delta H_f(H_2O(l))$ =**»** −285.8 **«**kJ mol^{-1}**»** ✓ $K(s) + H_2O(l) \rightarrow KOH(aq) + \frac{1}{2}H_2(g)$ ***OR*** **«**$\Delta H_{reaction} = \Sigma\Delta H_f$(products) – $\Sigma\Delta H_f$(reactants)**»** **«**$\Delta H_{reaction}$ =**»** (−481.8) – (−285.8) ✓ **«**$\Delta H_{reaction}$ =**»** −196.0 **«**kJ**»** ✓	*Award **[3]** for correct final answer.* *M1 may be awarded from working.*	**3**

(continued…)

(Question 2 continued)

Question			Answers	Notes	Total
2.	**(d)**	**(ii)**	sodium reaction is slower/less vigorous/produces less heat ✓	*Accept sodium yellow **AND** potassium lilac flame.* *Accept hydrogen gas does not ignite with sodium.* *Do **not** accept answers such as "sodium is less reactive" that do not describe the difference in the reaction with water.*	**1**
2.	**(d)**	**(iii)**	$K_2O(s) + H_2O(l) \rightarrow 2K^+(aq) + 2OH^-(aq)$ ✓	*Accept $K_2O(s) + H_2O(l) \rightarrow 2\ KOH(aq)$.* *Accept an equation for a neutralization reaction of K_2O with an acid e.g. $K_2O(s) + 2H^+(aq) \rightarrow 2K^+(aq) + H_2O(l)$.*	**1**

Question			Answers	Notes	Total
3.	**(a)**	**(i)**	 ✓	*Accept any combination of dots or crosses to represent electrons, or lines to represent electron pairs.* *Do **not** accept a delocalized structure.*	**1**

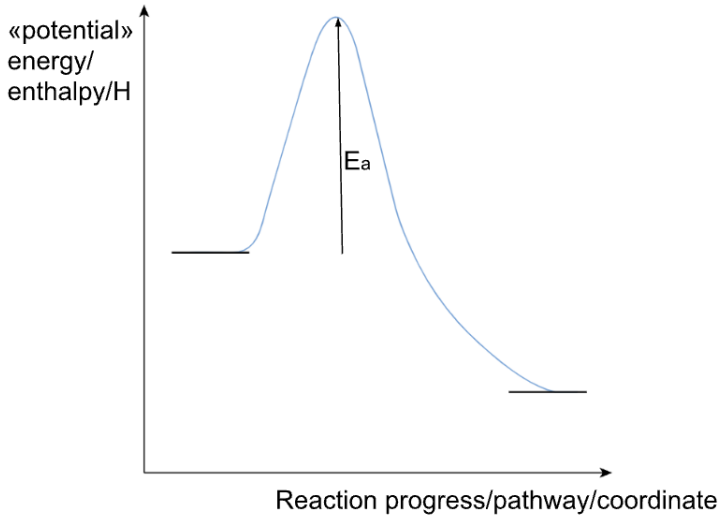
(continued…)

(Question 3 continued)

Question			Answers	Notes	Total
3.	**(a)**	**(ii)**	**«**all bonds**»** less than 161 **«**pm**»** ✓	*Accept any value less than 161 pm and above 121 pm (actual value is 142 pm).* *Do **not** award the mark if two bond length values are given.* *Do **not** apply ECF from the Lewis structure in (a)(i).*	**1**
3.	**(a)**	**(iii)**	*Molecular geometry:* trigonal planar ✓ *Bond angle:* 120^{o} ✓		**2**
3.	**(b)**		**«**reacts with water and forms sulfuric**»** acid rain/deposition ***OR*** is highly corrosive ✓	*Do **not** accept health problems caused by SO_3 such as irritant/poisonous/toxic.* *Accept "forms smog" **OR** "causes global dimming".* *Accept any specific environmental problem caused by acid deposition or smog.*	**1**

(continued…)

(Question 3 continued)

Question			Answers	Notes	Total
3.	**(c)**		flue gas desulfurization ***OR*** **«**alkaline**»** scrubbing ✓	*Accept injection of/neutralization with $CaCO_3$/basic oxide **«**into flue gas**».*** *Do **not** accept just neutralization.*	**1**
3.	**(d)**	**(i)**	 x-axis labelled reaction progress/pathway/coordinate ***AND*** y-axis labelled **«**potential**»** energy/enthalpy/H ✓ curve showing exothermic reaction ✓ labelled arrow/line showing E_a ✓	*Do **not** accept just "reaction" or "time" for x-axis label.* *Accept double-headed arrow for E_a but do **not** accept a downward arrow.* *Accept more complex diagrams showing an intermediate.*	**3**

(continued…)

(Question 3 continued)

Question			Answers	Notes	Total
3.	**(d)**	**(ii)**	more molecules/collisions have energy ≥ E_a ✓ frequency/probability of **«**successful**»** collisions increases ✓	*Do **not** accept **"**more collisions" in M2 without reference to time or probability.*	**2**
3.	**(d)**	**(iii)**	**«**provides**»** alternative reaction pathway/mechanism ✓ lowers E_a ***OR*** more molecules/collisions have sufficient energy/energy ≥ E_a ✓	*Accept description of how catalyst lowers E_a such as "reactants adsorb on surface **«**of catalyst**»**", "reactant bonds weaken **«**when adsorbed**»**" for M1.*	**2**
3.	**(d)**	**(iv)**	V_2O_5 : +5 ***AND*** V_2O_4 : +4 ✓	*Do **not** accept 5+ or 4+.*	**1**
3.	**(d)**	**(v)**	**«**K_c =**»** $\frac{[SO_3]^2}{[O_2][SO_2]^2}$ ✓		**1**
3.	**(d)**	**(vi)**	shifts to the right/products ***AND*** fewer moles/molecules **«**of gas**»** in products ✓		**1**

Question			Answers	Notes	Total
4.	**(a)**		**«**n(NaOH) = n(H^+) = 0.150 x 20.0 x 10^{-3} =**»** 3.00×10^{-3} **«**mol**»** ***OR*** **«**volume at equivalence point =**»** 18.0 **«**cm^3**»** ✓ **«**[NaOH] = $\frac{3.00\times10^{-3}}{18.0\times10^{-3}}$ **»** = 0.167 **«**mol dm^{-3}**»** ✓	*Award **[2]** for correct final answer.*	**2**

(continued…)

(Question 4 continued)

Question			Answers	Notes	Total
4.	**(b)**		*Number of signals:* 3 ✓ *Ratio of areas:* 3:2:1 ✓	*Accept ratio in any order.*	**2**
4.	**(c)**	**(i)**	isotopes **«**of C, O and H with larger mass numbers**»** ✓		**1**
4.	**(c)**	**(ii)**	*m/z 57:* $CH_3CH_2CO^+$ ✓ *m/z 45:* $COOH^+$ ✓		**2**
4.	**(d)**		***Alternative 1*:** *Method:* measure pH **«**of both acids**»** ✓ *Observation:* propanoic acid has higher pH ✓ ***Alternative 2:*** *Method:* react **«**both acids**»** with metal/metal oxide/hydroxide/hydrogen carbonate/carbonate ✓ *Observation:* propanoic acid reacts more slowly/less vigorously ✓ ***Alternative 3:*** *Method:* measure **«**electrical**»** conductivity ✓ *Observation:* propanoic acid has lower **«**electrical**»** conductivity ✓	*Accept specific examples for Alternative 2.* *Accept other suitable methods such as titration, indicator/pH paper, or enthalpy change and corresponding observations such as shape of curve/pH at equivalence point, colour or enthalpy change/amount of heat released upon neutralization.*	**2**