Markscheme

May 2026

Chemistry

Higher level

Paper 2

18 pages

Subject Details: Chemistry Higher Level Paper 2 Markscheme

Candidates are required to answer **ALL** questions. Maximum total = **[90 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 underlined 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)	«[H+] = 0.250 mol dm^{-3}» pH = 0.602 ✓		1
1.	(a)	(ii)	HBr(aq) + KOH(aq) → KBr(aq) + H_2O(l) ✓		1
1.	(a)	(iii)	«n(KOH) = n(HBr) = 0.250 mol dm^{-3} x 0.0200 dm^3 =» 0.00500 «mol» ✓		1
1.	(a)	(iv)	«V(KOH) = $\frac{0.00500\ mol}{0.220\ mol\ dm^{-3}}$ =» 0.0227 «dm^3» / 22.7 «cm^3» ✓		1

Question			Answers	Notes	Total
1.	(a)	(v)	***ALTERNATIVE 1:*** *Method:* measure pH/use pH meter/universal indicator ✓ *Expected result:* lower pH/red for HBr ***OR*** higher pH/Orange/yellow for HCOOH ✓ **ALTERNATIVE 2:** *Method:* react with carbonate/hydrogencarbonate/«reactive» metal ✓ *Expected result:* HBr bubbles more vigorously/ produces bubbles «of gas» faster ✓ **ALTERNATIVE 3:** *Method:* measure conductivity/use conductivity meter ✓ *Expected result:* HBr higher conductivity ✓ **ALTERNATIVE 4:** *Method:* measure temperature of reaction with alkali/«solid» base/metal oxide ✓ *Expected result:* HBr greater temperature «change» ✓	*Expected result must match the method.* *Accept specific bases or metals for alternatives 2 and 4.*	**2**
1.	(a)	(vi)	*Formula of conjugate base:* $HCOO^-$ ✓ *pK_b:* «14 – 3.75 =» 10.25 ✓	*Accept "$COOH^-$".*	**2**

Question			Answers	Notes	Total
1.	(a)	vii	«n($HCOO^-$) = n(HCOOH) = 0.250 mol dm^{-3} x 0.0200 dm^3 = 0.00500 mol» [$HCOO^-$]« = $\frac{0.00500\ mol}{0.0420\ dm^3}$ = »0.119 «mol dm^{-3} » ✓ «K_b = $\frac{[HCOOH][OH^-]}{[HCOO^-]}$ = 5.62 x 10^{-11}» [OH^-] «= $\sqrt{(5.62 \times 10^{-11} \times 0.119)}$ = √(6.69 x 10^{-12}) » = 2.586 x 10^{-6} «mol dm^{-3}» ✓ «pOH = 5.587 » pH = 8.41 ✓	*Award **[3]** for correct final answer.*	**3**
1.	(a)	viii	phenolphthalein ***OR*** phenol red ✓		**1**

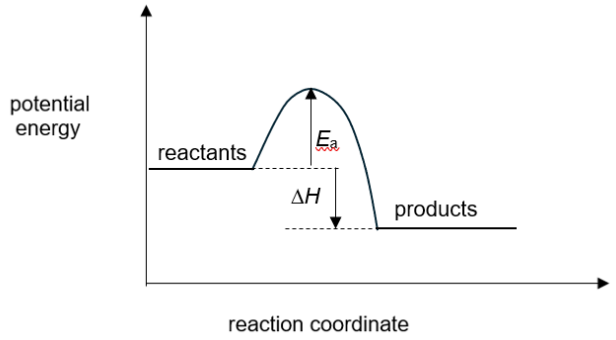
Question			Answers	Notes	Total
1.	(a)	(ix)	*Equilibrium in HInd(aq) solution:* $HInd \rightleftharpoons H^+ + Ind^-$ «colour A» «colour B» ✓ *Adding H^+:* shifts equilibrium to left / $H^+ + Ind^- \rightarrow HInd$ ***OR*** «more of» colour A is seen ✓ *Adding OH^-:* shifts equilibrium to right / $HInd \rightarrow H^+ + Ind^-$ /$HInd + OH^- \rightarrow H_2O + Ind^-$ ***OR*** «more of» colour B is seen ✓		3
1.	(b)	(i)	sp^2 ✓		1
1.	(b)	(ii)	*sigma (σ) bond:* head-on combination/overlap of atomic orbitals ✓ *pi (π) bond:* lateral/sideways combination/overlap of p-orbitals ✓	*Accept suitable diagrams.*	2
1.	(b)	(iii)	*Number of signals:* 7 ✓ *Relative areas*: 4:1:2:2:2:2:2 ✓	*Accept ratios in any order for M2.*	2
1.	(b)	(iv)	«(7 x 14.01 x 100)/337.51 =» 29.06 % ✓		1

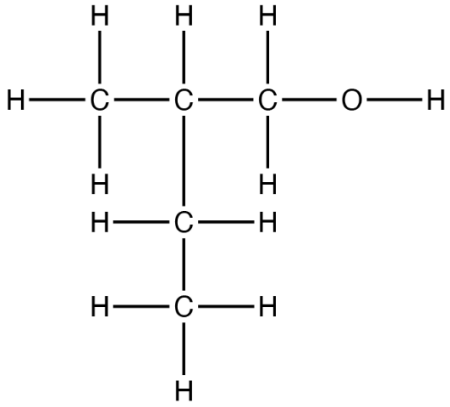
Question			Answers	Notes	Total
2.	(a)	(i)	*Change of state:* sublimation ✓ *Type of force:* London/dispersion forces ✓	*For M2, do **not** accept van der Waals' forces or intermolecular forces.*	**2**
2.	(a)	(ii)	endothermic «phase change» ✓ formation of vapour favoured ***OR*** equilibrium shifts to the right/vapour side ✓		**2**
2.	(a)	(iii)	*Any two of:* more «gas» molecules/moles ***OR*** concentration «of gas» increases ✓ molecules have more «kinetic» energy ***OR*** moving faster ✓ molecules collide «with flask wall» with greater force ✓ more frequent collisions ✓		**2 max**

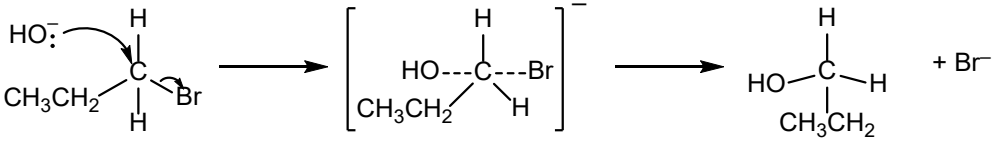
Question			Answers	Notes	Total
2.	(a)	(iv)	V = 0.500 dm^3 / 5.00 x 10^{-4} m^3 ***AND*** T = 298 K ✓ «$n = \frac{m}{M} = \frac{2.05\times10^{-3}}{2\times126.90}$ =» 8.077 x 10^{-6} «mol» ✓ «$P = \frac{nRT}{V} = \frac{8.077\times10^{-6}\times8.31\times298}{5.00\times10^{-1}}$ = » 0.0400 «kPa» ✓	*Award **[3]** for correct final answer.*	**3**
2.	(b)	(i)	−1 ✓	*Do **not** accept 1– or I.*	**1**
2.	(b)	(ii)	$2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-$ ✓		**1**
2.	(b)	(iii)	increase concentration of $H^+/I^-/H_2O_2$ ***OR*** increase temperature ✓	*Accept decrease in pH.*	**1**

Question			Answers	Notes	Total
2.	**(c)**		*Information from group number:* 7 valence electrons /s^2p^5 ✓ *Information from period number:* 5 «occupied electron» shells /energy levels ✓		**2**
3.	**(a)**	**(i)**	*Structure:* «lattice of» metal/Al /positive ions ***AND*** sea of/delocalized «valence» electrons ✓ *Forces:* electrostatic attraction «between cations and delocalized electrons» ✓	*Do **not** accept "positive nucleus" for positive ions.*	**2**
3.	**(a)**	**(ii)**	«layers of» cations slide over each other without disrupting bonding ***OR*** changing position of atoms does not disrupt bonding/forces of attraction ***OR*** changing shape does not disrupt bonding/forces of attraction ***OR*** metallic bonds are non-directional ✓		**1**

Question			Answers	Notes	Total
3.	(a)	(iii)	Al has higher charge density «than Ga» ✓ stronger bonding/electrostatic forces «in Al» ✓		2
3.	(a)	(iv)	[Ar] $3d^{10}$ $4s^2 4p^1$ ***OR*** $1s^2$ $2s^2 2p^6$ $3s^2 3p^6 3d^{10}$ $4s^2 4p^1$ ✓	*Accept $4s^2$ before $3d^{10}$.*	1
3.	(a)	(v)	Mg has outer electrons in 3s orbital / $1s^2$ $2s^2 2p^6$ $3s^2$ ***AND*** Al has electron in 3p orbital / $1s^2$ $2s^2 2p^6$ $3s^2 3p^1$ ✓ 3p orbital has higher energy «than 3s so electron easier to remove» ***OR*** 3p orbitals are more shielded ✓	*Accept orbital diagrams showing 3s and 3p sublevels for M1.*	2
3.	(b)	(i)	disrupts regular arrangement of Al atoms ***OR*** Li and Al atoms are different sizes ✓ prevents atoms/layers sliding over each other ✓		2
3.	(b)	(ii)	«Li» has low density ***OR*** «Li» reduces density of the alloy «compared to Al metal» ***OR*** «Li» is lighter ✓		1

Question			Answers	Notes	Total
3.	(c)	(i)	$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$ ✓	*Award **[1]** for balanced equation and **[1]** for correct state symbols.*	**2**
3.	(c)	(ii)	*Any one of:* solution becomes warm ✓ lithium floats/moves on surface/disappears ✓ bubbles of gas/hydrogen / effervescence / fizzing ✓		**1 max**
3.	(c)	(iii)	 exothermic reaction / products lower energy «than reactants» ✓ E_a and ΔH correctly labelled ✓		**2**

Question			Answers	Notes	Total
4.	**(a)**	**(i)**	2-methylbutanal ✓		**1**
4.	**(a)**	**(ii)**	carbonyl ✓	*Do **not** accept "aldehyde".*	**1**
4.	**(a)**	**(iii)**	120° ✓		**1**
4.	**(a)**	**(iv)**	1700–1750 «cm^{-1}»✓	*Accept any value within the range.*	**1**
4.	**(a)**	**(v)**	 ✓	*Do **not** accept condensed or skeletal formula: **all** bonds must be shown.*	**1**
4.	**(b)**	**(i)**	propan-1-ol ***OR*** 1-propanol ✓	*Accept a structural formula but not a molecular formula.*	**1**
4.	**(b)**	**(ii)**	nucleophilic substitution ***AND*** «OH^-/hydroxide ion» nucleophile/donates electron pair ***OR*** nucleophilic substitution ***AND*** Br^-/bromide «ion» is substituted by OH^-/hydroxide «ion» ✓	*Accept "S_N2 **AND** 1-bromopropane is a primary halogenoalkane".*	**1**

Question			Answers	Notes	Total
4.	**(b)**	**(iii)**	 curly arrow from lone pair/negative charge on O in HO^- to C attached to Br ✓ curly arrow from C—Br to Br ✓ transition state showing negative charge ***AND*** partial bonds ✓	*Award **[3]** for correct mechanism using any primary halogenoalkane.* *Do **not** allow curly arrow originating on H in HO^-.* *Accept curly arrow either going from bond between C and Br to Br in 1-bromopropane or in the transition state.* *Do **not** penalize if HO and Br are not at 180°, or the square bracket is missing, in M3.* *Do **not** award M3 if OH–C bond is represented.* *Award **[2 max]** for correctly drawn S_N1 mechanism.*	**3**
4.	**(c)**	**(i)**	$Cl_2(g) \rightarrow 2Cl\bullet(g)$ ✓		**1**
4.	**(c)**	**(ii)**	$CH_3CH_3 + Cl\bullet \rightarrow \bullet CH_2CH_3 + HCl$ ✓ $\bullet CH_2CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + Cl\bullet$ ✓		**2**
4.	**(d)**		provides alternative reaction pathway ✓ activation energy of reaction reduced ✓		**2**

Question			Answers	Notes	Total
4.	(e)	(i)	«$\Delta S^{\ominus}$ = (+199) – (+199 +220)» −220 «J K^{-1} mol^{-1}» ✓		1
4.	(e)	(ii)	2 mol gas changes to 1 mol liquid ***OR*** number of gas molecules/moles decreases ✓		1
4.	(e)	(iii)	$\Delta S^{\ominus}$ = −220 x 10^{-3} «kJ K^{-1} mol^{-1}» ***AND*** «T = 298 «K» ✓ «$\Delta G^{\ominus}$ = −106 – (298 x (−220 x 10^{-3}))» «$\Delta G^{\ominus}$ =» −40.4 «kJ mol^{-1}» ✓	*Award **[2]** for correct final answer.* *Award **[2]** for −46.4 «kJ mol^{-1}» if −200 J K^{-1} mol^{-1} used.*	2
4.	(e)	(iv)	«$\Delta G = \Delta H - T\Delta S$» «-ΔS » at higher temperatures $T\Delta S$ becomes more negative / *-$T\Delta S$ becomes more positive* ✓ ΔG becomes less negative/more positive ✓		2
4.	(e)	(v)	«0 = −106 – (T x (−220 x 10^{-3}))» «$T = \frac{106}{0.220} =$ » 482 «*K*» ✓	*Award **[1]** for 530«K» if −200 J K^{-1} mol^{-1} used.*	1

Question			Answers	Notes	Total
5.	**(a)**		*Overall reaction:* $O_3 + O\bullet \rightarrow 2O_2$ ✓ $\Delta H_{reaction}$*:* «$= \Sigma\Delta H_f^{\ominus}{}_{products} - \Sigma\Delta H_f^{\ominus}{}_{reactants} = 2(0) - (142.7 + 249.2) =$» −391.9 «kJ mol^{-1}» ✓		**2**
5.	**(b)**		«bonds broken =» 632 + 2(302) / 1236 «kJ mol^{-1}» ✓ «bonds formed =» 2(469) + 498 / 1436 «kJ mol^{-1}» ✓ «ΔH = bonds broken – bonds formed = 1236 – 1436 = » −200 «kJ mol^{-1}» ✓	*Award **[3]** for correct final answer.*	**3**
6.	**(a)**		*Order of reaction with respect to Br_2:* 1 ***AND*** *Order of reaction with respect to HCOOH:* 1 ✓ *Rate equation:* «rate =» $k[Br_2][HCOOH]$ ✓		**2**
6.	**(b)**		«$k = \frac{rate}{[Br_2][HCOOH]} = \frac{1.1\times10^{-5}}{2.4\times10^{-3}\times5.0\times10^{-1}} =$» 9.2 x 10^{-3} ✓ mol^{-1} dm^3 s^{-1} ✓		**2**

Question			Answers	Notes	Total
6.	(c)		perform experiment at different temperatures ✓ **ALTERNATIVE 1:** plot a graph of ln k against $1/T$ ✓ gradient is $-E_a/R$ ✓ **ALTERNATIVE 2:** «system of» two Arrhenius equations «using (k_1, T_1) in one and (k_2, T_2) in another» ***OR*** $\ln\frac{k_1}{k_2}=\frac{E_a}{R}\left(\frac{1}{T_2}-\frac{1}{T_1}\right)$ ✓ solve system for E_a ✓	*Accept a suitable diagram for M2 and M3.*	**3**
7.	(a)		coordination bond ✓ both electrons «of shared pair» originate from ligand ✓	*Accept dative/coordinate «covalent» bond for M1.*	**2**

Question			Answers	Notes	Total
7.	(b)		*Any three from:* partially filled d-orbitals ✓ «ligands cause» d-orbitals «to» split ✓ light/energy is absorbed as electrons transition to a higher energy level «in d–d transitions» ***OR*** light/energy is absorbed as electrons are promoted ✓ light absorbed/energy gap/wavelength corresponds to the visible region «in the spectrum» ✓	*Do **not** accept colour observed is complementary colour of light absorbed for final marking point.*	**3 max**