



**General Certificate of Education (A-level)  
January 2012**

**Chemistry**

**CHEM4**

**(Specification 2420)**

**Unit 4: Kinetics, Equilibria and Organic  
Chemistry**

**Final**

***Mark Scheme***

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Question	Marking Guidance	Mark	Comments
1(a)	Exp 2 $14.(4) \times 10^{-3}$ <b>OR</b> $1.4(4) \times 10^{-2}$ or 0.014 Exp 3 0.1(0) Exp 4 0.3(0)	1 1 1	Allow 2sf If three wrong answers, check their value of $k$ in 1(b). They can score all 3 if they have used their (incorrect) value of $k$ . see below. Exp 2 rate = $0.096 \times k$ Exp 3 <b>[Q]</b> = $0.015/k$ Exp 4 <b>[P]</b> = $0.116/\sqrt{k}$
1(b)	$k = \frac{1.8 \times 10^{-3}}{(0.20)^2 \times 0.30}$ $= 0.15 \text{ (min 2sfs)} \quad \text{(allow } \frac{3}{20} \text{)}$ $\text{mol}^{-2} \text{ dm}^6 \text{ s}^{-1}$	1 1 1	mark is for insertion of numbers into a correctly rearranged rate equ , $k =$ etc if upside down, score only units mark AE (-1) for copying numbers wrongly or swapping two numbers Any order If $k$ calculation wrong, allow units conseq to their $k$
1(c)	G	1	

Question	Marking Guidance			Mark	Comments	
2(a)(i)	Mol SO <sub>3</sub> = 5.2 Mol SO <sub>2</sub> = 2.8			1 1		
2(a)(ii)	$\frac{[\text{SO}_2]^2[\text{O}_2]}{[\text{SO}_3]^2}$	Penalise expression containing numbers or V Ignore subsequent <u>correct</u> working		1	Allow ( ) but must have all brackets. If brackets missing but otherwise correct, penalise here but mark on If Kc wrong (wrong powers or upside down etc) can only score M1 in 2(a)(iv)	
2(a)(iii)	mol dm <sup>-3</sup>			1	Allow conseq to their wrong Kc	
					If Kc wrong in 2(a)(iv) (wrong powers or upside down etc) can only score M1	
2(a)(iv)	Values from (a)(i) $\frac{[2.8/12]^2[1.4/12]}{[5.2/12]^2}$ or $\frac{[0.233]^2[0.117]}{[0.433]^2}$	Alternative values $\frac{[2.1/12]^2[1.4/12]}{[5.8/12]^2}$	M1	1	For dividing all three by volume - if volume missed or used wrongly, lose M1 & M2 but can score M3 conseq insertion of values (allow conseq use of their wrong values from 2a(i)) AE (-1) for copying numbers wrongly or swapping two numbers	
			M2	1		
	= 0.0338 or 0.034 (allow 0.03376 to 0.035) Min 2 sfs Ignore units in (a)(iv)	0.0153 or 0.015 (allow 0.015 to 0.017) Min 2 sfs Ignore units in (a)(iv)	M3	1	If vol missed score only M3  Values from (a)(i) 0.406 - allow values between 0.40 (if correctly rounded) and 0.41	from alternative values allow 0.18 to 0.184

2(b)(i)	Increase or more moles (of oxygen) or higher		1	
2(b)(ii)	No change or no effect or none or (remains) same		1	
2(c)	<p><math>T_1</math></p> <p>(At Temp, <math>T_2</math>, when <math>K_c</math> is lower) Equm/reaction moves to left or towards reagent or towards <math>SO_3</math> OR moles <math>SO_3</math> increases</p> <p>This reverse reaction is exothermic,</p> <p><b>OR</b></p> <p>(forward) reaction is endothermic</p> <p>if Temp is increased Equm/reaction moves to right or towards product or towards <math>SO_2</math> OR moles <math>SO_2</math> increases</p> <p><b>OR</b></p> <p>(forward) reaction is endothermic</p> <p>if Temp is decreased Equm/reaction moves to left or towards reagent or towards <math>SO_3</math> OR moles <math>SO_3</math> increases</p>	<p>M1</p> <p>M2</p> <p>M3</p> <p>M3</p> <p>M2</p> <p>M3</p> <p>M2</p>	<p>1</p> <p>1</p> <p>1</p> <p></p> <p></p> <p></p> <p></p>	<p>If <math>T_2</math> CE = 0</p>

Question	Marking Guidance	Mark	Comments
3(a)	<u>Proton acceptor</u>	1	
3(b)(i)	$\text{CH}_3\text{CH}_2\text{NH}_2 + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{NH}_3^+ + \text{OH}^-$	1	allow eq with or without $\rightleftharpoons$ allow $\text{C}_2\text{H}_5\text{NH}_2$ and $\text{C}_2\text{H}_5\text{NH}_3^+$ (plus can be on N or H or 3) allow RHS as $\text{C}_2\text{H}_5\text{NH}_3\text{OH}$
3(b)(ii)	Mark independently of 3b(i) reaction/equilibrium lies to left or low $[\text{OH}^-]$ <b>OR</b> little $\text{OH}^-$ formed <b>OR</b> little ethylamine has reacted	1	Allow Ethylamine is only partly/slightly dissociated OR Ethylamine is only partly/slightly ionized  Ignore “not fully dissociated” or “not fully ionized”  Ignore reference to ionisation or dissociation of water
3(c)	Ethylamine alkyl group is electron releasing/donating <b>OR</b> alkyl group has (positive) inductive effect increases electron density <u>on N(H<sub>2</sub>)</u> <b>OR</b> increased availability of <u>lp</u> <b>OR</b> increases ability of <u>lp</u> (to accept H(+))	M1 M2 M3	1 1 1  If wrong no marks in 3c  Mark M3 is independent of M2

3(d)	$\text{CH}_3\text{CH}_2\text{NH}_3\text{Cl}$ allow name (ethylammonium chloride or ethylamine hydrochloride) or other halide for Cl	1	Or any amine hydrochloride or a strong <b>organic</b> acid <b>NOT</b> $\text{NH}_4\text{Cl}$
3(e)	Mark independently of 3(d) Extra $\text{H}^+$ reacts with ethylamine or $\text{OH}^-$ <b>OR</b> $\text{CH}_3\text{CH}_2\text{NH}_2 + \text{H}^+ \rightarrow \text{CH}_3\text{CH}_2\text{NH}_3^+$ <b>OR</b> $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ Equilibrium shifts to RHS <b>OR</b> ratio $[\text{CH}_3\text{CH}_2\text{NH}_3^+]/[\text{CH}_3\text{CH}_2\text{NH}_2]$ remains almost constant	1          1	Or makes reference to Equilibrium (in 3(b)(i)) with amine on LHS

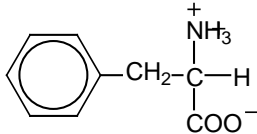
Question	Marking Guidance		Mark	Comments
4(a)	$[H^+] = 0.0170$ $pH = 1.77$	M1 M2	1 1	2 dp <b>Allow M2 for correct pH calculation from their wrong <math>[H^+]</math> for this pH calculation only</b>
4(b)(i)	$K_a = \frac{[H^+][X^-]}{[HX]}$ Ignore $K_a = \frac{[H^+]^2}{[HX]}$		1	Penalize missing [ ] here <b>and not elsewhere</b> Allow HA instead of HX
4(b)(ii)	$[H^+] = 10^{-2.79}$ OR $1.6218... \times 10^{-3}$ $K_a = \frac{[H^+]^2}{[HX]}$ OR $\frac{[1.62 \times 10^{-3}]^2}{[0.0850]}$ $K_a = 3.09 \times 10^{-5}$ 3sfs min (allow $3.10 \times 10^{-5}$ if 1.6218 rounded to 1.622) Ignore units	M1 M2 M3	1 1 1	If $[H^+]$ wrong, can only score M2 Allow HA instead of HX If $[HX]$ used as $(0.0850 - 1.62 \times 10^{-3})$ this gives $K_a = 3.15 \times 10^{-5}$ $(0.0016)^2 / 0.085 = 3.01 \times 10^{-5}$ scores 2 for AE



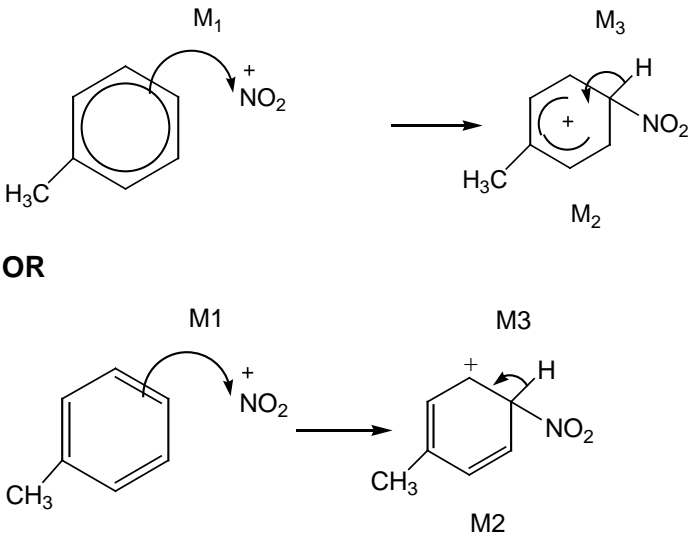
4(c)	$\text{mol OH}^- (= (38.2 \times 10^{-3}) \times 0.550 )$ $= 2.10(1) \times 10^{-2} \text{ or } 0.0210(1)$	M1	1	Mark for answer
	$\text{mol H}^+ (= (25.0 \times 10^{-3}) \times 0.620 )$ $= 1.55 \times 10^{-2} \text{ or } 0.0155$	M2	1	Mark for answer
	$\text{excess mol OH}^- = 5.5(1) \times 10^{-3}$	M3	1	Allow conseq for M1 – M2 <b>If wrong method</b> e.g. no subtraction or use of $\sqrt{\quad}$ <b>can only score max of M1, M2, M3 and M4.</b>
	$[[\text{OH}^-] = 5.51 \times 10^{-3} \times \frac{10^3}{63.2} [= 0.08718 \text{ (0.0872)} ]$  <b>OR</b> $[\text{OH}^-] = 5.5 \times 10^{-3} \times \frac{10^3}{63.2} = 0.0870(2)$	M4	1	(M1 – M2) / vol in $\text{dm}^3$ mark for dividing by volume (take use of 63.2 without $10^{-3}$ as AE so 9.94 scores 5) If no use or wrong use of vol lose M4 & M6 Can score M5 for showing ( $10^{-14}$ /their XS alkali)
	$[\text{H}^+] = \frac{10^{-14}}{0.08718} = 1.147 \times 10^{-13}$  <b>OR</b> $\frac{10^{-14}}{0.0870} = 1.149 \times 10^{-13}$	<b>OR</b> pOH = 1.06	M5	1
pH = 12.9(4) allow 3sf		M6	1	If vol missed score max 4 for 11.7(4)
				If acid- alkali reversed max 4 for pH = 1.06 Any excess acid - max 4

Question	Marking Guidance	Mark	Comments
5(a)	H <b>OR</b> hydrogen <b>OR</b> H $\cdot$	1	Ignore brackets ignore dot penalise + or – charge
5(b)	CH <sub>3</sub> <b>OR</b> methyl <b>OR</b> CH <sub>3</sub> $\cdot$ <b>OR</b> $\cdot$ CH <sub>3</sub>	1	Ignore brackets ignore dot penalise + or – charge
5(c)	Either order	1	Ignore brackets ignore dot
	C <sub>2</sub> H <sub>5</sub> <b>OR</b> ethyl <b>OR</b> CH <sub>3</sub> CH <sub>2</sub> $\cdot$ <b>OR</b> C <sub>2</sub> H <sub>5</sub> $\cdot$ CHO <b>OR</b> HCO <b>OR</b> COH <b>OR</b> H—C=O	1	penalise + or – charge
5(d)	I A	1	
	II C	1	
	III D	1	
	IV B	1	

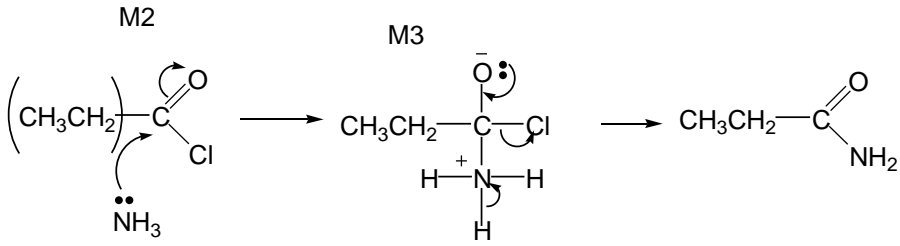
Question	Marking Guidance		Mark	Comments
6(a)	<u>OH alcohols</u>		1	
6(b)(i)	2.6	$\begin{array}{c} \text{---CH}_2\text{---C---} \\ \quad \quad \quad \parallel \\ \quad \quad \quad \text{O} \end{array}$ Ignore any group on RHS On LHS, penalise H or CH or CH <sub>2</sub> or CH <sub>3</sub>	1	Must clearly indicate relevant <b>two</b> H on a C next to C=O Ignore missing trailing bonds or attached R groups
6(b)(ii)	2.2	$\begin{array}{c} \text{CH}_3\text{---C---} \\ \quad \quad \quad \parallel \\ \quad \quad \quad \text{O} \end{array}$ Ignore all groups on RHS	1	Must clearly indicate relevant <b>three</b> H on C next to C=O Ignore missing trailing bonds or attached R group
6(b)(iii)	1.2	$\begin{array}{c}   \\ \text{CH}_3\text{---C---CH}_3 \\   \end{array}$ Or in words: two <u>equivalent</u> CH <sub>3</sub> groups  Penalise attached H	1	Must clearly indicate two <u>equivalent</u> methyl groups. Ignore missing trailing bonds or attached R groups
6(b)(iv)	$\begin{array}{c} \text{CH}_3\text{---C---CH}_2\text{---C---CH}_3 \\ \quad \quad \quad \parallel \quad \quad \quad   \\ \quad \quad \quad \text{O} \quad \quad \quad \text{OH} \end{array}$		1	

Question	Marking Guidance	Mark	Comments
7(a)	Heating <u>speeds up</u> (hydrolysis / breaking of peptide bonds) <b>OR</b> forms non-sweet (amino acids)	1	
7(b)	(2-)aminobutan <u>e</u> dioic acid OR (2-)aminobutan <u>e</u> (-1,4-)dioic acid	1	2 not necessary but penalise other numbers at start 1,4 not necessary but penalise other numbers and 1,4 must be in correct place (QoL)
7(c)	$\begin{array}{c} \text{H} \\   \\ \text{H}_2\text{N}-\text{C}-\text{COO}^- \\   \\ \text{CH}_2 \\   \\ \text{COO}^- \end{array}$	1	allow $-\text{CO}_2^-$ allow $\text{NH}_2-$
7(d)		1	allow $-\text{CO}_2^-$ allow $^+\text{NH}_3-$ don't penalize position of + on $\text{NH}_3$
7(e)(i)	Compounds/molecules with same <u>structural formula</u> But with <u>bonds/atoms/groups</u> arranged differently <u>in space</u> or <u>in 3D</u>	M1 Independent marks M2	1 1 Not just structure Allow -with different <u>spatial</u> arrangement of <u>atom/bond/group</u>
7(e)(ii)	(Plane) polarised light <u>Rotated</u> in opposite directions	1 1	Not bent or turned or twisted; not different directions (QoL)

Question	Marking Guidance	Mark	Comments
8(a)(i)	(As a) soap	1	Allow washing, cleaning, degreasing, detergents
8(a)(ii)	(Bio)diesel or biofuel or fuel for cars/lorries	1	Allow <u>to make</u> soap
8(a)(iii)	(Cationic) surfactant /detergent /fabric softener /germicide / shampoos /(hair) conditioners /spermicidal jelly	1	Allow cleaning
8(b)(i)	(Poly)ester Terylene <b>OR</b> PET	1 1	Allow polyester
8(b)(ii)	(Poly)amide Kevlar <b>OR</b> nylons	1 1	Ignore numbers with nylons Allow polyamide(e)
8(b)(iii)	(Independent marks) Hydrogen bonding in b(ii) Imfs in (b)(ii) are stronger <b>OR</b> H bonding stronger than dipole-dipole/van der Waals/ dispersion/London forces in b(i)	1 1	CE = 0

Question	Marking Guidance	Mark	Comments
9(a)(i)	Conc HNO <sub>3</sub> Conc H <sub>2</sub> SO <sub>4</sub> $2 \text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow 2 \text{HSO}_4^- + \text{NO}_2^+ + \text{H}_3\text{O}^+$ <b>OR</b> $\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{HSO}_4^- + \text{NO}_2^+ + \text{H}_2\text{O}$ <b>OR</b> via two equations $\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{HSO}_4^- + \text{H}_2\text{NO}_3^+$ $\text{H}_2\text{NO}_3^+ \rightarrow \text{NO}_2^+ + \text{H}_2\text{O}$	1 1 1	If either or both conc missing, allow one; this one mark can be gained in equation`  Allow + anywhere on NO <sub>2</sub> <sup>+</sup>
9(a)(ii)		3	<ul style="list-style-type: none"> <li>ignore position or absence of methyl group in M1 but must be in correct position for M2</li> <li>M1 arrow from within hexagon to N or <u>+</u> on N</li> <li>Allow NO<sub>2</sub><sup>+</sup> in mechanism</li> <li>Bond to NO<sub>2</sub> must be to N</li> <li>horseshoe must not extend beyond C2 to C6 but can be smaller</li> <li>+ not too close to C1</li> <li>M3 arrow into hexagon unless Kekule</li> <li>allow M3 arrow independent of M2 structure</li> <li>ignore base removing H in M3</li> <li>+ on H in intermediate loses M2 not M3</li> </ul>
9(b)	5	1	

9(c)	2	1	
9(d)	$2\text{C}_7\text{H}_5\text{N}_3\text{O}_6 \rightarrow 5\text{H}_2\text{O} + 3\text{N}_2 + 7\text{C} + 7\text{CO}$	1	Or halved

Question	Marking Guidance	Mark	Comments
10(a)	<p>(Nucleophilic) addition-elimination</p> <p>M2</p>  <p>M1</p> <p>M3</p> <p>M4 for 3 arrows and lp</p> <p>propanamide (Ignore -1- )</p>	<p>1</p> <p>4</p> <p>1</p>	<ul style="list-style-type: none"> <li>• Minus sign on <math>\text{NH}_3</math> loses M1 (but not M4 also)</li> <li>• M2 not allowed independent of M1, but</li> <li>• allow M1 for correct attack on <math>\text{C}^+</math></li> <li>• + rather than <math>\delta^+</math> on <math>\text{C}=\text{O}</math> loses M2</li> <li>• <b>If Cl lost with <math>\text{C}=\text{O}</math> breaking, max1 for M1</b></li> <li>• <b>M3</b> for correct structure <u>with charges</u> but lp on O is part of <b>M4</b></li> <li>• only allow <b>M4</b> after correct/very close <b>M3</b></li> <li>• For M4, ignore <math>\text{NH}_3</math> removing <math>\text{H}^+</math> but lose M4 for <math>\text{Cl}^-</math> removing <math>\text{H}^+</math> in mechanism,</li> <li>• but ignore <math>\text{HCl}</math> shown as a product</li> </ul> <p>penalise other numbers</p> <p>penalise propaneamide and N-propanamide</p>



10(b)	<p>Nucleophilic substitution</p> <p>Propylamine (ignore number 1) or propan-<u>1</u>-amine or <u>1</u>-aminopropane (<u>number 1 needed</u>)</p>	1  4  1	<ul style="list-style-type: none"> <li>• Minus sign on <math>\text{NH}_3</math> loses M1 (not M4 also)</li> <li>• + rather than <math>\delta+</math> on <math>\text{C}=\text{O}</math> loses M2</li> <li>• ALLOW SN1 so allow M2 for loss of <math>\text{Cl}^-</math> before attack of <math>\text{NH}_3</math> on <math>\text{C}^+</math> for M1</li> <li>• only allow M4 after correct/very close M3</li> <li>• For M4, ignore <math>\text{NH}_3</math> removing <math>\text{H}^+</math> but lose M4 for <math>\text{Cl}^-</math> removing <math>\text{H}^+</math> in mechanism,</li> <li>• but ignore <math>\text{HCl}</math> shown as a product</li> </ul> penalise other numbers allow <u>1</u> -propanamine
10(c)	electron rich ring or benzene or pi cloud <u>repels</u> nucleophile/ammonia	1 max	Allow <ul style="list-style-type: none"> <li>• <math>\text{C}-\text{Cl}</math> bond is short/stronger than in haloalkane</li> <li>• <math>\text{C}-\text{Cl}</math> is less polar than in haloalkane</li> <li>• resonance stabilisation between ring and <math>\text{Cl}</math></li> </ul>

Question	Marking Guidance		Mark	Comments	
11	<b>L</b>	$\begin{array}{c} \text{H} \\   \\ \text{H}_3\text{C}-\text{C}-\text{CH}_3 \\   \\ \text{OH} \end{array}$	Allow $(\text{CH}_3)_2\text{CHOH}$ or $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$	1	Allow name propan-2-ol Penalise contradiction of name and structure
	<b>M</b>	$\begin{array}{c} \text{H}_3\text{C}-\text{C}=\text{CH}_2 \\   \\ \text{H} \end{array}$	Allow $\text{CH}_3\text{CH}=\text{CH}_2$	1	Allow name propene ignore -1- but penalise other numbers Penalise contradiction of name and structure
	M1	Step 1 $\text{NaBH}_4$ or $\text{LiAlH}_4$	$\text{Zn}/\text{HCl}$ or $\text{Sn}/\text{HCl}$ or $\text{H}_2/\text{Ni}$ or $\text{H}_2/\text{Pt}$	1	Ignore name if formula is correct ignore solvent ignore acid (for 2nd step) but penalise acidified $\text{NaBH}_4$ Apply list principle for extra reagents and catalysts.
	M2	(nucleophilic) addition	Addition (not nucleophilic)	1	Penalise electrophilic Ignore reduction
	M3	Step 2 <u>conc</u> $\text{H}_2\text{SO}_4$ or <u>conc</u> $\text{H}_3\text{PO}_4$ or $\text{Al}_2\text{O}_3$		1	Apply list principle for extra reagents and catalysts.
	M4	elimination		1	Independent from M3 penalise nucleophilic or electrophilic ignore dehydration
	M5	Step 3 $\text{HBr}$		1	Apply list principle for extra reagents and catalysts.
	M6	electrophilic addition		1	Independent from M5

### **General principles applied to marking CHEM4 papers by CMI+ (January 2012)**

It is important to note that the guidance given here is generic and specific variations may be made at individual standardising meetings in the context of particular questions and papers.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are required information to gain credit.**
- **Occasionally an answer involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**
- 

#### **A. The “List principle” and the use of “ignore” in the mark scheme**

If a question requires **one** answer and a candidate gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

N.B. Certain answers are designated in the mark scheme as those which the examiner should “Ignore”. These answers are not counted as part of the list and should be ignored and will not be penalised.

#### **B. Incorrect case for element symbol**

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip. For example, penalise the use of “h” for hydrogen, “CL” for chlorine or “br” for bromine.

#### **C. Spelling**

In general

- The names of chemical compounds and functional groups **must be spelled correctly** to gain credit.
- Phonetic spelling may be acceptable for some chemical terminology.

N.B. Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the “Quality of Language” (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

#### D. Equations

In general

- Equations **must** be balanced.
- When an equation is worth two marks, one of the marks in the mark scheme will be allocated to one or more of the reactants or products. This is independent of the equation balancing.
- State symbols are generally ignored, unless specifically required in the mark scheme.

#### E. Reagents

The command word “Identify”, allows the candidate to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when both the name and the formula are used. Specific details will be given in mark schemes.

The guiding principle is that a reagent is a chemical which can be taken out of a bottle or container. Failure to identify complete reagents **will be penalised**, but follow-on marks (e.g. for a subsequent equation or observation) can be scored from an incorrect attempt (possibly an incomplete reagent) at the correct reagent. Specific details will be given in mark schemes.

For example, **no credit** would be given for

- the cyanide ion or  $\text{CN}^-$  when the reagent should be potassium cyanide or KCN;
- the hydroxide ion or  $\text{OH}^-$  when the reagent should be sodium hydroxide or NaOH;
- the  $\text{Ag}(\text{NH}_3)_2^+$  ion when the reagent should be Tollens’ reagent (or ammoniacal silver nitrate). In this example, no credit is given for the ion, but credit could be given for a correct observation following on from the use of the ion. Specific details will be given in mark schemes.

In the event that a candidate provides, for example, **both** KCN and cyanide ion, it would be usual to ignore the reference to the cyanide ion (because this is not contradictory) and credit the KCN. Specific details will be given in mark schemes.

#### F. Oxidation states

In general, the sign for an oxidation state will be assumed to be positive unless specifically shown to be negative.

### G. Marking calculations

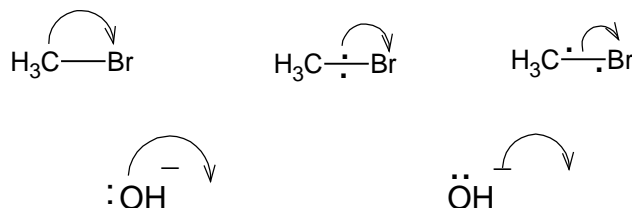
In general

- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- An arithmetic error may result in a one mark penalty if further working is correct.
- A chemical error will usually result in a two mark penalty.

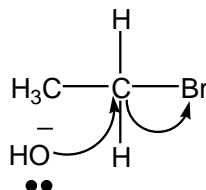
### H. Organic reaction mechanisms

Curly arrows should originate either from a lone pair of electrons or from a bond.

**The following representations should not gain credit and will be penalised each time** within a clip.



For example, the following would score zero marks



When the curly arrow is showing the formation of a bond to an atom, the arrow can go directly to the relevant atom, alongside the relevant atom or **more than half-way** towards the relevant atom.

In free-radical substitution

- The absence of a radical dot should be penalised **once only** within a clip.
- The use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip

In mass spectrometry fragmentation equations, the absence of a radical dot on the molecular ion and on the free-radical fragment would be considered to be two independent errors and both would be penalised if they occurred within the same clip.

## I. Organic structures

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms. This principle applies in all cases where the attached functional group contains a carbon atom, e.g. nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if candidates show the alcohol functional group as C – HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C – C bonds in alkyl groups, given that CH<sub>3</sub>– is considered to be interchangeable with H<sub>3</sub>C– even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH<sub>2</sub>– C will be allowed, although H<sub>2</sub>N– C would be preferred.
- Poor presentation of vertical C – CH<sub>3</sub> bonds or vertical C – NH<sub>2</sub> bonds should **not** be penalised. For other functional groups, such as – OH and – CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group. By way of illustration, the following would apply.

allowed	allowed	not allowed				
allowed	allowed	allowed	allowed	not allowed	not allowed	

$\begin{array}{c}   \\ \text{CN}-\text{C}- \\   \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{CN} \end{array}$	$\begin{array}{c}   \\ \text{COOH}-\text{C}- \\   \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{COOH} \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{COOH} \end{array}$	
not allowed	not allowed	not allowed	not allowed	not allowed	
$\begin{array}{c}   \\ \text{CHO}-\text{C}- \\   \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{CHO} \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{CHO} \end{array}$	$\begin{array}{c}   \\ \text{COCl}-\text{C}- \\   \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{COCl} \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{COCl} \end{array}$
not allowed	not allowed	not allowed	not allowed	not allowed	not allowed

- In most cases, the use of “sticks” to represent C – H bonds in a structure should **not** be penalised. The exceptions will include structures in mechanisms when the C – H bond is essential (e.g. elimination reactions in haloalkanes) and when a displayed formula is required.
- Some examples are given here of **structures** for specific compounds that should **not** gain credit

$\text{CH}_3\text{COH}$  for ethanal

$\text{CH}_3\text{CH}_2\text{HO}$  for ethanol

$\text{OHCH}_2\text{CH}_3$  for ethanol

$\text{C}_2\text{H}_6\text{O}$  for ethanol

$\text{CH}_2\text{CH}_2$  for ethene

$\text{CH}_2\cdot\text{CH}_2$  for ethene

$\text{CH}_2:\text{CH}_2$  for ethane

N.B. Exceptions may be made in the context of balancing equations

- Each of the following **should gain credit** as alternatives to correct representations of the structures.

$\text{CH}_2 = \text{CH}_2$  for ethene,  $\text{H}_2\text{C} = \text{CH}_2$

$\text{CH}_3\text{CHOHCH}_3$  for propan-2-ol,  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

### J. Organic names

As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

but-2-ol	should be <b>butan-2-ol</b>
2-hydroxybutane	should be <b>butan-2-ol</b>
butane-2-ol	should be <b>butan-2-ol</b>
2-butanol	should be <b>butan-2-ol</b>
2-methopropan-2-ol	should be <b>2-methylpropan-2-ol</b>
2-methylbutan-3-ol	should be <b>3-methylbutan-2-ol</b>
3-methylpentan	should be <b>3-methylpentane</b>
3-mythylpentane	should be <b>3-methylpentane</b>
3-methypentane	should be <b>3-methylpentane</b>
propanitrile	should be <b>propanenitrile</b>
aminethane	should be <b>ethylamine</b> (although aminoethane can gain credit)
2-methyl-3-bromobutane	should be <b>2-bromo-3-methylbutane</b>
3-bromo-2-methylbutane	should be <b>2-bromo-3-methylbutane</b>
3-methyl-2-bromobutane	should be <b>2-bromo-3-methylbutane</b>
2-methylbut-3-ene	should be <b>3-methylbut-1-ene</b>
difluorodichloromethane	should be <b>dichlorodifluoromethane</b>