CAMBRIDGE
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CHEMISTRY **0620/42**

Paper 4 Theory (Extended) **May/June 2026**

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.

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General marking principles

All examiners must apply these marking principles when marking candidate responses.

1	Examiners must award marks for each response in line with: • the specific **content** defined in the mark scheme • the specific **skills** defined in the mark scheme or in the level descriptions • the **standard of response** required as exemplified by the standardisation scripts.
2	Examiners must award **whole marks** (not half marks, or other fractions).
3	Examiners must award marks **positively**. This means that: • marks are not deducted for errors or omissions • marks are awarded for correct/valid answers as defined in the mark scheme and also for **other valid answers** which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate • the quality of spelling, punctuation and grammar are judged **only** when the mark scheme indicates that these features are **specifically assessed** in the question. However, the meaning of all responses must be unambiguous.
4	Examiners must **consistently** apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly.
5	Examiners must use the **full range of marks** defined in the mark scheme, unless limited by the quality of the candidate responses seen.
6	Examiners must award marks according to the mark scheme and **must not** award marks with grade thresholds or grade descriptions in mind.

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Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

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6	<u>Calculation specific guidance</u> Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'. For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values. For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme. Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.
7	<u>Guidance for chemical equations</u> Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme. State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
^	information missing or insufficient for credit
BOD	benefit of doubt given
CON	contradiction in response, mark not awarded
✗	incorrect point or mark not awarded
●	key point attempted / working towards marking point / incomplete answer / response seen but not credited / blank page seen
ECF	error carried forward applied
I	incorrect or insufficient response, mark not awarded
NAQ	response has not answered question
NBOD	benefit of doubt was considered, but the response was decided to not be sufficiently close for benefit of doubt to be applied
R	incorrect point or mark not awarded
SEEN	blank page seen

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Annotation	**Meaning**
✔	correct point of mark awarded

Mark Scheme Abbreviations:	
;	separates marking points
/	alternative responses for the same marking point
R	reject the response
A	allow/accept the response
I	ignore the response
CON	contradiction in response, no mark
ecf	error carried forward
ora	or reverse argument
AW	alternative wording
underline or **bold**	actual word given must be used by candidate (grammatical variants excepted)
( )	the word / phrase in brackets is not required but sets the context
max	indicates the maximum number of marks that can be given
MP / M	marking point

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Question	Answer	Marks	Guidance
			For equations throughout: Unless stated – Allow multiples Ignore state symbols For spelling throughout: Unless stated – Allow unambiguous phonetic near misses If the name is asked for in an answer the name takes precedence over a formula
			Q1 Symbol takes precedence over incorrect name
1(a)(i)	Na	**1**	**A** 'sodium' **I** NA **I** Na^+
1(a)(ii)	Br	**1**	**A** 'brom**ine**' **I** BR **I** br **R** Br_2 **R** Br^-
1(a)(iii)	I	**1**	**A** 'iod**ine**' **A** I_2 **R** I^-
1(b)(i)	Br	**1**	**A** 'brom**ine**' **I** 'water' / 'aq' **A** Br_2 **I** BR **I** br **R** Br^- but **A** 'BR' **or** 'br' if **exact** ECF from **1(a)(ii)**
1(b)(ii)	K	**1**	**A** K^+ **A** Cs / Cs^+
1(b)(iii)	C*l*	**1**	**A** 'chlor**ine**' **A** C*l*$_2$ **A** F 'fluorine' / F_2 **R** C*l*$^-$ / F^- **A** carelessly drawn lower case letter '*l*' but **I** 'CL' where 'L' is definitely capital.

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>2(a)(i)</td><td>
<table>
<tr><th>Br_2</th><th>Mg</th><th>SiO_2</th></tr>
<tr><td>M1
covalent</td><td>M4
metallic</td><td></td></tr>
<tr><td>M2
Br</td><td>M5
Mg^{2+}</td><td>M6
Si and O</td></tr>
<tr><td>M3
atom(s)</td><td></td><td>M7
atom(s)</td></tr>
</table>
</td><td>7</td><td>
I names of symbol for M2 / M5 / M6
M1 I intramolecular
M2 A ‘Br and Br’ (i.e. symbol for two atoms)
M2 I e^- / e
A BR / br symbol if exact ecf from 1(a)(ii) and 1(b)(i)

M3 and M7
A nucleus / nuclei and electrons
A atoms and shared (pair of) electrons

M5 A Mg^{+2} or Mg^{++}
</td></tr>
<tr><td>2(a)(ii)</td><td>intermolecular forces</td><td>1</td><td>
A ‘intermolecular (bonds)’ / ‘intermolecular (attractions)’
A ‘attraction (forces) between molecules’
A ‘forces (of attraction) holding molecules together’
A ‘intermolecular forces between particles’
A ‘London (forces)’ / ‘van der Waals (forces)’ / ‘dispersion (forces)’ / ‘dipole-dipole (forces)’ / ‘induced dipole-induced (forces)’
I IMF / VDW / LDF / ‘dipole (forces)’ / ‘id-id (forces)
R Hydrogen bonding
R strong (as question tells them it is weak)
I ‘intermolecular forces between bonds’ (does not score)
R ‘intermolecular forces between atoms’
A ‘intermolecular forces between bromine (particles)’

R ‘intramolecular forces / covalent bonds between molecules but I if between atoms
R ‘ionic bonds’ / ‘metallic bonds’

A ‘covalent molecules have intermolecular forces’ but I ‘covalent bonds have intermolecular forces’
I simple molecular
I electrostatic
</td></tr>
</table>

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Question	Answer	Marks	Guidance
2(b)(i)	a regular (arrangement of) alternating positive and negative ions M1 a regular (arrangement of) alternating ions M2 positive and negative ions	**2**	regular **and** alternating needed for M1 – no need for ions **I** 'lattice' this is given in the question **A** regular (arrangement of) alternating particles for M1 (as 'ions' appears in question) For 'particles' A 'atoms' / 'molecules' / etc. for M1 but this loses M2 For 'regular': **A** repeating' / 'pattern' / 'uniform' **A** / 'ordered' / 'organised' / 'rows and columns' **I** 'fixed' **I** layers of ions / touching ions / close ions **I** 'arrangement' alone (without regular) **I** 'straight rows' / 'straight lines' For 'alternating': **A** oppositely charged ions / particles next to each other **A** 'alternative' for 'alternating' I interchanging For 'arrangement' (if used): **A** 'structure' / '3D shape' **I** close packed **A** 'oppositely-charged ions' / 'anions **and** cations' / 'Na^+ **and** Cl^-' (**A** incorrect charges but must be opposite e.g. **A** Na^- **and** Cl^{2+}) **A** 'sodium ions and chlor**ide** ions' (without charges given) **I** 'oppositely charged atoms' for M2 **R** 'molecules' / 'electrons' for M2 **I** references to forces of attraction / bonding between ions / forces holding ions together, whether correct or incorrect **A** diagram showing regular alternating arrangement of + and – symbols (any charges as long as opposite) but must be at least 2 × 2 + and – symbols **I** statements about e loss / gain **I** numbers of alternating ions for M2 e.g. 1 Na+ alternates with 2 C*l*– ions is OK for M2 (not M1) Descriptions of covalent bonding / shared electrons / metallic bonding / delocalised electrons = 0

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Question	Answer	Marks	Guidance
2(b)(ii)	diamond	1	**I** carbon **R** graphite / graphene **A** silicon **A** germanium(IV) oxide **A** silicon carbide / boron carbide etc.

Question	Answer	Marks	Guidance
3(a)	H_2O **and** CO_2	1	**R** incorrect balancing **R** other species
3(b)	zinc oxide / zinc hydroxide	1	**A** zinc sulfide / zinc sulfite **A** ZnO / $Zn(OH)_2$ / ZnS / $ZnSO_3$ but name takes precedence **I** wrong formulas **A** zinc(II) oxide / hydroxide / sulfide / sulfite but **R** other oxidation numbers **I** oxide / hydroxide / sulfide / sulfite (alone) **A** equation attempts, (word or symbol) with correct zinc compound on LHS **R** zinc
3(c)	no (more) effervescence	1	for no effervescence **A** no fizzing / no bubbles **I** 'no more gas produced' I names of gases e.g. no more bubbles of hydrogen gets the mark **I** any gas tests **R** colour of gas except 'colourless' / 'invisible' **I** comments repeating the question e.g. solid stops dissolving / deposit appears in the solution I colour of solution **R** precipitate appears **R** effervescence (alone) (it is the **lack** of fizzing we need)
3(d)(i)	saturated (solution)	1	**I** saturation **R** super-saturated **I** concentrated
3(d)(ii)	50 cm^3	1	**I** trailing zeroes
3(d)(iii)	12 g	1	**A** 18 g Confusion here: Question should be 'Calculate mass of $ZnSO_4$ dissolved in solution B' = 12 g Current question could be interpreted as 'Calculate mass of $ZnSO_4$ formed when solution B forms (from solution A)' = 18 g

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Question	Answer	Marks	Guidance
3(e)(i)	M1 e.g. lead(II) nitrate M2 e.g. sodium sulfate	2	**I** oxidation numbers / states in this question **A** 'nitrate' only on answer line (as lead(II) is part of the answer line) **A** Other suitable examples most likely to be 'lead ethanoate' **A** 'sodium' only on answer line (as sulfate is part of the answer line) **A** Other suitable examples most likely to be group 1 metal / ammonium but allow others e.g. $MgSO_4$ / $CuSO_4$ **R** sulfuric acid / H_2SO_4 / 'hydrogen sulfate' **R** Insoluble sulfates e.g. $BaSO_4$ / $PbSO_4$ / $CaSO_4$ / Ag_2SO_4 For M1 and M2 Name takes precedence. **A** correct formulas **I** incorrect formulas.
3(e)(ii)	precipitation	1	**A** phonetic near misses e.g. percipitation (reaction) **I** 'double decomposition' **A** precipitate / 'ppt' **R** solidification **R** Filtration

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Question	Answer	Marks	Guidance
3(e)(iii)	M1 **filter** M2 **wash** (the residue) using water M3 **dry** the residue between filter papers / in a warm place	**3**	**I** description of mixing initial reagents **I** heating (alone) before filtration **R** crystallisation / heating to dryness / evaporation / boiling before filtration **A** 'filtrate it' for 'filtration' 'filter' **A** description of filtration e.g. 'use a filter funnel to …' **R** 'filtration' if it not separating any solid from liquid No penalty for referring to ppt / residue etc. as 'crystals' if part of initial filtration of residue **R** filtration after crystallisation (i.e. filtering crystals from solution as residue) **R** Crystallisation after filtration – this means no M2 or M3 they may be washing / drying the crystals and not the residue. **A** 'wash' / 'rinse' alone or a description of washing (such as pour water over the residue) **R** M2 if it is implied the crystals from the solution are being washed after evaporation / crystallisation **A** 'dry' on its own **I** 'leave it' but **A** leave to dry 'Dry' need not be stated, but must be implied (such as "remove water") **A** description of drying without seeing 'dry' **A** heat / warm (to remove water) **I** evaporating the residue but **A** evaporate water from residue **I** any processes conducted on the filtrate. It must be implied it is residue being dried We need to have 'dry' as a verb, not an adjective **R** heating residue **to form** crystals **I** extra unnecessary steps that do not compromise the procedure (e.g. heating mixture / cooling filtrate etc.) but **R** steps that would compromise the process 'Electrolysis' e.g. 'filter and electrolyse = 1 mark (M1) 'electrolyse and filter = 0 marks

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Question	Answer	Marks	Guidance
3(e)(iii)			Essentially: If crystallise before filtration no M1 or M2 or M3 If crystallise after filtration M1 can be awarded but not M2 and M3 If no filter no M1 or M2 or M3 Rinse; filter; rinse; dry; = 3 marks Rinse; filter; dry; = 2 marks Filter; dry = 2 marks (rinsing omitted)
3(e)(iv)	$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$ **M1** correct ionic equation **M2** state symbols	**2**	 **R** ionic charges on $PbSO_4$ ie $Pb^{2+}SO_4^{2-}$ **R** spectator ions / electrons as reactants or products **R** full non-ionic or semi-ionic equation for M1 **A** state symbols even if ionic equation is unbalanced **A** M2 for correct state symbols on any +ve lead ion and any – ve sulfate ion and any lead 'sulfate' formula e.g. **A** M2 for $Pb^{+}(aq) + SO_4^{3-}(aq) \rightarrow Pb(SO_4)_2(s)$ **R** AQ / Aq / aQ for aq **R** semi-ionic equations for M2 **A** 1 mark ECF for correct state symbols in any balanced **full** equation which would correctly produce $PbSO_4$ by precipitation from 2 aqueous solutions (including H_2SO_4) The solutions do not need to be those named in **3(e)(i)**
3(e)(v)	any insoluble sulfate e.g. barium sulfate	**1**	**I** oxidation numbers / states in this question Name takes precedence. **A** correct formulas **I** incorrect formulas **A** $CaSO_4$ **A** Ag_2SO_4 **I** $PbSO_4$

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Question	Answer	Marks	Guidance
4(a)	melting point density	2	Assume response refers to transition elements **A** reverse argument if applied to group 1 **I** high(er) for melting point / density for transition elements **R** low(er) melting point / density for transition elements but **A** if referring to Group 1 **A** dense(r) **A** strong(er) / strength or **A** Hard(er) / hardness as separate marking points **A** weak(er) / soft(er) / softness if applied to group 1 **I** conductivity / sonorous / malleability / ductility / shiny / less easily cut / boiling point **R** chemical properties e.g. catalysts, variable oxidation states **I** form coloured compounds
4(b)	Cu_2O $Ni(NO_3)_2$	2	**A** either if seen as only Cu / Ni product of an attempted equation. **R** ionic charges on both i.e. $Cu_2^+O^{2-}$ or $Ni^{2+}(NO_3)_2^-$ etc. Be lenient upon the size of 'u' and 'o' **R** oxidation states appearing within formulas e.g. $Cu_2(I)O$ $Ni(II)(NO_3)_2$
4(c)(i)	no change in oxidation number	1	For oxidation number **A** oxidation state **I** charge **I** valency **A** no change in oxidation number (and **I** what the 'no change in oxidation number' is being applied to) E.g. A no change in oxidation number of chromate / of ions / of atoms etc. **I** incorrect oxidation number if seen e.g. **A** oxidation no of Cr stays at +4 I no increase (only) in oxidation number or no decrease (only) in oxidation number **I** no e loss **and** no e gain I no electron transfer **I** no oxygen transfer **I** no *simultaneous* reduction **and** oxidation **I** no reduction and oxidation

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Question	Answer	Marks	Guidance
4(c)(ii)	M1 (rates are) equal M2 (concentrations are) no longer changing	**2**	**A** (rates are) the same **I** (rates) **stay** the same / (rates) **remain** the same / **I** (rates are) **constant** **A** (concentrations are or concentrations stay) constant / (concentrations) **stay** the same / (concentrations) **remain** the same / no change (in concentration) **R** (concentrations **are** the) same **R** (concentrations **are**) equal
4(c)(iii)	no gases (present in the equilibrium)	**1**	**A** Any response which implies lack of **gases** in both reactants **and** products **I** (Number of) moles of **gas** same on each side (there are not any) **R** 'equal no of moles on each side' **I** equal no of atoms on each side **I** reactants and products are aqueous or liquid (only) **A** the system is non-gaseous **A** pressure changes only affect the position of equilibrium in reactions involving gases

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Question	Answer	Marks	Guidance
4(c)(iv)	M1 OH– ions react with H^+(aq) M2 Concentration of H^+(aq) is reduced	2	For 'OH^- ions' **A** 'OH^-' / 'alkali' / 'proton acceptor' / 'base' For 'react' in M1 **A** 'neutralise' / 'alkali(s) accept(s) (the) protons' / 'are / is proton acceptors' **A** $H^+ + OH^- \rightarrow H_2O$ for M1 only For 'H^+(aq)' **A** 'H^+' / 'protons' / 'acid' **I** 'hydrogen' (alone) M2 For 'concentration' **A** 'amount' / '(number of) moles' / 'mass' For H^+ **A** 'acid' **I** 'reactant' For concentration reduced **A** 'gets less' / 'H^+ removed' / 'H^+ used up' etc. **A** Concentration of water is increased **I** concentration of products increase For increases concentration **A** 'water is formed' as a statement **A** equilibrium shifts to replace / make H^+ (implies H^+ have been removed) **A** equilibrium shifts to remove H_2O (implies H_2O is formed) **A** Equilibrium shifts to minimise / oppose change (as long as M1 is correct) I comments on reaction rates I comments on pH Some responses state things backward e.g. 'equilibrium shifts so H^+ can react with OH^-' M1 only
4(d)(i)	brass	1	
4(d)(ii)	stainless carbon	2	**A** C I 'graphite'

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Question	Answer	Marks	Guidance
5(a)(i)	hydrogen: methane nitrogen: (liquid) air	2	**A** natural gas **A** Steam (reforming) **A** Water / **A** Electrolysis of water **A** Hydrocarbons **I** Petroleum **A** 'Alkanes' **A** other named alkanes **R** Alkenes **I** cracking / fractional distillation / other processes but **R combustion** of methane / hydrocarbons etc. / **boiling** of water etc. **I** equations **A** Atmosphere
5(a)(ii)	$N_2 + 3H_2 \rightleftharpoons 2NH_3$ M1 species M2 correct equation	2	**A** other versions of reversible arrow e.g. ⇋ or ⇄ or ⇆ **A** '→' or '='
5(a)(iii)	20 000	1	**A** range 15 000 to 25 000 (look out for 200 000)
5(b)(i)	green chromium(III) hydroxide	2	**I** shades **I** 'grey' i.e. grey-green is allowed. **R** other colours **I** solubility statements, right or wrong **A** $Cr(OH)_3$ Name takes precedence over formulas. **I** incorrect formulas. **A** 'chromium hydroxide' (no oxidation state / number) **R** other oxidation numbers

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Question	Answer	Marks	Guidance
5(b)(ii)	M1 Observation 1 zinc hydroxide (ppt) forms M2 Observation 2 (Zn^{2+} ions are soluble because) NH_3(aq) is in excess	2	**A** Zn^{2+} / zinc ions react with NH_3 / ammonia **or** Zn^{2+} / zinc ions react with OH^- / hydroxide ions **A** Zn^{2+} / zinc ions form a (new) compound with NH_3 / ammonia / OH^- / hydroxide ions **I** Zn^{2+} / zinc ions form a ppt with NH_3 / ammonia (given in question) **A** '$Zn(OH)_2$' forms Must be Zn^{2+} / zinc ions not just 'Zn' / 'zinc' for the reaction in M1 **I** white ppt forms (given in question) **I** Ammonia is not in excess **I** Zn^{2+} are in excess **A** any response which links solubility to NH_3 is in excess e.g. NH_3 is in excess (so ppt / $Zn(OH)_2$ cannot form or ppt is soluble) **R** ppt insoluble in excess ammonia **A** 'Zinc' soluble in **excess ammonia** for M2 **I** Zn^{2+} / zinc ions reacts with ammonia in observation 2 **I** 'ppt (re)dissolves' so **A** 'ppt dissolves / ppt is soluble in **excess ammonia**' for M2 **I** Zn^{2+} is the limiting reagent **I** name of ppt in M2, right or wrong. **I** concentration / moles / volume ammonia higher than Zn^{2+} / too much NH_3
5(c)(i)	M1 ΔH is negative / ΔH is –870 (kJ / mol) M2 use of reversible arrow / use of ⇌	2	**A** '**Change** in … enthalpy / energy / heat … is negative' / $\Delta H < 0$ **I** comments about products having less / more E than reactants **I** –870 without reference to enthalpy change e.g. 'cos its –870' **I** '–' / 'cos its negative' alone **I** Comments about bond breaking / making **A** any answer that refers to or describes the arrow (in the equation) e.g. **A** 'the arrow' (as a minimum) **I** 'The reversible sign' (alone) but **A** The (reversible) sign / symbol in middle of equation (as this tells us where to look) **I** comments describing reversible reactions e.g. reaction goes both ways

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Question	Answer	Marks	Guidance
5(c)(ii)	*M1 Labels mark* $NH_3(g) + 3F_2(g)$ on reactant line **and** $NF_3(g) + 3HF(g)$ on product line *M2 Activation E mark* upward arrow labelled E_a from energy level of reactants to top of 'hump' *M3 Energy change mark* one downward arrow labelled ΔH **and** energy change starting from E level of reactants and finishing at E level of products	**3**	**I** 'reactants' and 'products' as labels (formulas asked for) **A** unbalanced stoichiometry **A** formulas closely above / below lines **I** state symbols For M2 and M3, line must be (near) vertical but **A** 'near misses' M2 **A** label as 'activation energy' / 'EA' / 'E' etc. **A** double headed arrow for E_a or no arrow heads (i.e. labelled line is OK) **A** arrows which are outside of the hump and finish (about) equal in E to the top of the hump (i.e. arrow must be (around) correct length) M3 Arrow must have (only) **one** arrowhead **A** For ΔH labels as 'H' or '–870' or '–ΔH' or 'enthalpy change' '**I** heat change' **R** 'diagonal' from reactant to products **A** 'near misses' for start and finish of the arrow line **A** arrowheads mid-line **A** ECF for arrow not quite being the right length (i.e. penalise poorly drawn arrow once if the correct intention is there) If one single line showing both E_a and ΔH is shown with downward arrow at the bottom but correctly split by dotted horizontal energy line, **A** M2 and M3 If one single line showing both E_a and ΔH is shown with downward arrow at the bottom but without dotted horizontal energy line, **A** M3 as ECF as it is impossible to tell where each line starts.

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Question	Answer	Marks	Guidance
5(c)(iii)	M1 *BE needed in breaking bonds* = 3 × 390 + 3 × 150 = **1620** on answer line 1 M2 *BE released forming bonds* = 1620 + 870 = **2490** on answer line 2 M3 *BE energy of 3H–F bonds* = 2490 – (3 × 270) = **1680** M4 *BE of each H–F bond* = 1680 ÷ 3 = **560** on answer line 3	**4**	Mark each marking point but see M4 / M3 comment below **I** signs on M1 and M2 M2 **A** ECF for = M1 + 870 M3 = **A** ECF for M2 – 810 (even if M3 is a negative value) M4 = **A** ECF for M3 / 3 **A** M4 subsumes M3 if **2490 / –2490** seen on **line 2** **A** M4 subsumes M3 as an ECF if M4 = (incorrect M2 – 810) ÷ 3 For M3 / M4 **A** M3 for a calculation where –1680 divided by –3 is seen (probably due to algebraic work) and M4 for 560 Do not allow M3 for a calculation in which – 1680 is divided by 3 but **A** M4 ECF if 560 is subsequently seen (i.e. sign has been changed to match the positive nature of bond energy) or – 560 for a correct division But – 560 without calculations does not get M4 If applying ECF to M4 from incorrect M3 **A** M4 for M3 ÷3 whether M4 is positive or negative **A** M4 for negative processed number ÷ –3 to give +ve M4 value as ECF M4 must be to minimum of 2 SF **A** ECF for any processed number (need not be evaluated) correctly ÷ 3 **A** truncation for ECF and **I** RE after 3rd SF **A** M4 for M2 ÷ 3 (if no attempt at M3)

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Question	Answer	Marks	Guidance
5(c)(iii)			Special case **If** –2490 (if seen in M2) and is used to calculate M3 = **–3300** do **not** award M3 but A M4 for –1100 or +1100
5(d)	M1 single dot cross bonds for each N–F bond M2 2 non-bonding **dot** e on N to complete an octet M3 6 non-bonding **cross** e on each F to complete an octet	**3**	All dots scores M2 only No M1 and incorrect M3 All crosses scores M3 only No M1 and incorrect M2 **A** 'o' as carelessly drawn dots If consistent extra symbol, e.g. 'Δ' instead of all dots, is used No M1

Question	Answer	Marks	Guidance
6(a)	same functional group	**1**	For 'functional group' **A** 'the reactive part of the molecule / compound / substance' **A** 'function' / 'functioning' for 'functional' **A** 'functional group has same structure / bonds' A (all have) -OH group / hydroxy(l) group R hydroxide / OH^- group / R '–OH–' group **R** additional incorrect answers (such as 'same general formula and same functional group') **R 'similar** functional group' **A** 'share / belongs to (the same) functional group
6(b)(i)	18	**1**	
6(b)(ii)	C_2H_6O	**1**	**A** any order **R** other formulas unless part of obvious working out for answer e.g. $C_2H_5OH \rightarrow C_2H_6O$
6(b)(iii)	propan-1-ol	**1**	Correct spelling needed **A** 1-propanol **R** 'propanol' **I** lack of hyphens

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Question	Answer	Marks	Guidance
6(b)(iv)	propan-2-ol	**1**	Correct spelling needed **A** 2-propanol **R** 'propanol' **I** lack of hyphens **A** ECF for the same **exact** error on the following near misses which indicate: chain length, ('prop'), alkane ('an') and functional group ('ol') 'propane-2-ol' if 'propane-1-ol' seen in **6(b)(iii)** 'prop-2-anol' if 'prop-1-anol' seen in **6(b)(iii)** 'propa-2-nol' if 'propa-1-nol' seen in **6(b)(iii)** We would not allow 'prop-2-ol' if 'prop-1-ol' seen in **6(b)(iii)**
6(c)	**A** C_3H_7– can be $CH_3CH_2CH_2$– or $CH_3(CH_3)CH$–	**1**	**A** C_3H_7– can be written as more than one structure / has more than one structural formula **A** 'D has the same formula (as C)' / is also C_3H_7OH / is a (structural) isomer (of C) **A** There are (structural) isomers / **A** 'C_3H_7OH has (2) different (structural) isomers' / 'C is an (structural) isomer **A** 'C_3H_7OH can be propan-1-ol or propan-2-ol' / 'C_3H_7OH can be $CH_3CH_2CH_2OH$ or $CH_3CH(OH)CH_3$ **A** 'C_3H_7OH does not show position of the OH / hydroxy(l) / functional group' A hydroxide / '-OH-' group here **R** -OH bond **A** 'C_3H_7OH does not show which carbon the OH / hydroxy(l) / functional group is on' **A** displayed formulas of both structural isomers if clear both represent C_3H_7OH **A** 'C has same structural formula as D' (as C_3H_7OH is called a structural formula in the question) **A** 'molecular formula has isomers'
6(d)	$CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ M1 CO_2 **and** H_2O as **only** products M2 Correct equation	**2**	**A** ethanol written as C_2H_5OH or C_2H_6O or as unambiguous displayed / semi-displayed formula But **R** CH_3CH_2HO

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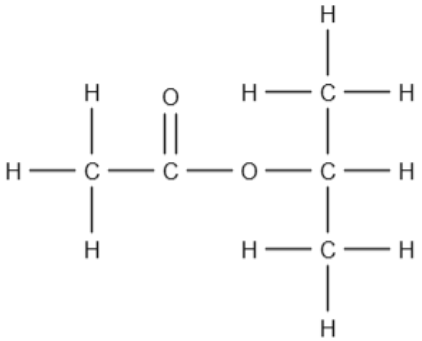
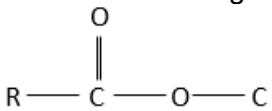
Question	Answer	Marks	Guidance
6(e)(i)	potassium manganate(VII)	**1**	**A** $KMnO_4$ but name takes precedence over formulas. **I** incorrect formula **I** lack of brackets **R** missing or incorrect oxidation state / oxidation state in wrong place, e.g. potassium(VII) manganate **A** (vii) **A** potassium permanganate **A** potassium permanganate(VII) **A** near miss phonetic spellings of 'manganate' e.g. 'magnate' / 'mangenate' / 'maganate' etc. but must end in 'ate' **R** 'ite' or 'ide' ending **I** 'oxidising agent' **I** acidified **I** named acids **I** aqueous **A** potassium / sodium dichromate(VI) / $K_2Cr_2O_7$ / $Na_2Cr_2O_7$ etc.
6(e)(ii)	ethanoic acid	**1**	Correct spelling needed **A** Acetic acid **A** ethan**al** **R** ethan-1-oic acid **I** 'carboxylic acid' **R** water
6(e)(iii)	vinegar	**1**	**A** phonetic near-misses e.g. 'venager' **I** name or types of vinegar e.g. cider vinegar / malt vinegar gets the mark **I** water
6(f)(i)	 M1 displayed formula of any ester link M2 correct displayed formula		Ester link must have all atoms and all bonds shown. C of C=O must have correct valency **I** incorrect valency of alkyl C for M1 but do not allow linking O atom to bond to a block **I** other functional groups on alkyl chains  **A** Alkyl groups to be non-displayed but must indicate structure ie not C_3H_7
6(f)(ii)	water	**1**	**A** H_2O

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