



Cambridge International AS & A Level

CHEMISTRY

9701/21

Paper 2 AS Level Structured Questions

May/June 2020

MARK SCHEME

Maximum Mark: 60

Published

Students did not sit exam papers in the June 2020 series due to the Covid-19 global pandemic.

This mark scheme is published to support teachers and students and should be read together with the question paper. It shows the requirements of the exam. The answer column of the mark scheme shows the proposed basis on which Examiners would award marks for this exam. Where appropriate, this column also provides the most likely acceptable alternative responses expected from students. Examiners usually review the mark scheme after they have seen student responses and update the mark scheme if appropriate. In the June series, Examiners were unable to consider the acceptability of alternative responses, as there were no student responses to consider.

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This document consists of **10** printed pages.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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> (see examples below) For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i> • Incorrect responses should not be awarded credit but will still count towards <i>n</i> • 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 <i>n</i> responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

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 Guidance for chemical equations

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.

Question	Answer	Marks
1(a)(i)	(different) number of neutrons.	1
1(a)(ii)	the relative abundance / % abundance of (each) the isotopes.	1
1(b)(i)	M1 attractions between atoms within a gallium trichloride molecule covalent (bonds) M2 attractions between gallium trichloride molecules temporary induced dipoles	2
1(b)(ii)	coordinate / dative (covalent)	1
1(c)(i)	$4\text{Ga} + 3\text{O}_2 \rightarrow 2\text{Ga}_2\text{O}_3$ M1 correct formula of Ga_2O_3 M2 correctly balanced equation based on $\text{Ga} + \text{O}_2$ and formula of gallium oxide in M1	2
1(c)(ii)	amphoteric	1

Question	Answer	Marks
2(a)(i)	$2\text{CuSO}_4(\text{aq}) + 4\text{KI}(\text{aq}) \rightarrow 2\text{CuI}(\text{s}) + (1)\text{I}_2(\text{aq}) + 2\text{K}_2\text{SO}_4(\text{aq})$ M1 correct balancing M2 correct state symbols	2
2(a)(ii)	Oxidation state of copper in CuSO_4 (+)2 AND Oxidation state of copper in CuI (+)1	1
2(a)(iii)	M1 redox	1
	M2 iodide ions – lost electron(s) AND copper ions – gained electron(s)	1

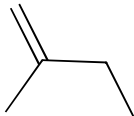
Question	Answer		Marks
2(b)	Mass of 0.0982 mol CuSO ₄ in 17.43g CuSO ₄ .yH ₂ O	M1 calculate M_r CuSO ₄ using A_r from data booklet $63.5 + 32.1 + 64.0 = 159.6$ M2 use M_r to calculate mass of CuSO ₄ $(0.0982 \times M1) = 15.67272\text{g}$	4
	number of water in 17.43g of CuSO ₄ yH ₂ O	M3 calculate the mass amount of water in sample AND use this value to calculate the amount of water present $(17.43 - 15.67) / 18 = 0.097778 \text{ mol}$	
	value of y	M4 use the ratio of M2: 0.0982 to find y $(\text{mol H}_2\text{O} \div \text{mol CuSO}_4) = 1$	

Question	Answer	Marks
3(a)	M1 (enthalpy / energy change) when one mole of a compound/substance is formed M2 from its elements in their standard states	2
3(b)	M1 <u>use</u> of correct stoichiometry in calculation $3 \times \Delta H_f \text{NO}_2 \quad 1 \times -\Delta H_f \text{H}_2\text{O} \quad 2 \times \Delta H_f \text{HNO}_3 \quad 1 \times \Delta H_f \text{NO}$ M2 correct signs associated with the appropriate ΔH_f values/terms used for the calculation of $\Delta H_{\text{reaction}}$ M3 $\Delta H_{\text{reaction}} = -(102 - 286) + (-346 + 91.1) = -70.9 \text{ kJ mol}^{-1}$	3
3(c)	M1 nitrogen has a triple bond M2 EITHER high energy is needed to break the bond OR at normal temperatures there is not enough energy to break the bond / to overcome the activation energy	2
3(d)	lightning	1

Question	Answer	Marks
3(e)(i)	M1 <i>define homogeneous</i> (homogeneous catalyst is) in the same phase / state as the reactants M2 and M3 <i>Define catalyst</i> <i>All 3 points scores 2 marks. Any 2 points scores 1 mark</i> increase the rate AND lowers the activation energy AND without being chemically altered at the end of the reaction / are regenerated at the end of the reaction	
3(e)(ii)	M1 $\text{NO}_2 + \text{SO}_2 \rightarrow \text{NO} + \text{SO}_3$ M2 $\text{NO} + \frac{1}{2} \text{O}_2 \rightarrow \text{NO}_2$	2

Question	Answer	Marks												
4(a)	Accepts a proton / H^+ (ion)	1												
4(b)	<i>Two reasons why product mixture is added to soil – allow in any order</i> M1 Acts as a fertiliser / adds nutrients (for plants) M2 Neutralise acid soils / increases the pH of acid soil	2												
4(c)	<table border="1"> <thead> <tr> <th></th><th>name of shape</th><th>bond angle / °</th></tr> </thead> <tbody> <tr> <td>CO_2</td><td>Linear</td><td>180</td></tr> <tr> <td>NH_3</td><td>Pyramid(al)</td><td>107</td></tr> <tr> <td>H_2O</td><td>non-linear / V / bent</td><td>104.5</td></tr> </tbody> </table> All 6 correct – 3 marks 4 or 5 correct – 2 marks 2 or 3 correct – 1 mark		name of shape	bond angle / °	CO_2	Linear	180	NH_3	Pyramid(al)	107	H_2O	non-linear / V / bent	104.5	3
	name of shape	bond angle / °												
CO_2	Linear	180												
NH_3	Pyramid(al)	107												
H_2O	non-linear / V / bent	104.5												

Question	Answer	Marks
5(a)(i)	Cl	1
5(a)(ii)	HCl AND H_2O	1
5(a)(iii)	M1 CO_3^{2-} M2 propanoic acid – effervesce. (Propan-1-ol – no reaction)	2
5(b)(i)	ultraviolet light / uv	1
5(b)(ii)	homolytic fission (of chlorine (gas) / Cl_2)	1
5(c)(i)	carbonyl / aldehyde / ketone	1
5(c)(ii)	tertiary halogenoalkane	1
5(d)(i)	<i>Two structures representing the intermediate</i> M1 $C_2H_5C^+HCH_3$ M2 $CH_3CH_2CH_2C^+H_2$	2
5(d)(ii)	<i>Identify the most stable intermediate</i> M1 $C_2H_5C^+HCH_3$ <i>explanation</i> M2 (more / 2 alkyl groups attached so) it has the greater inductive / electron donating effect	2

Question	Answer	Marks
6(a)		1
6(b)(i)	hot AND concentrated	1
6(b)(ii)	oxidation	1

Question	Answer	Marks
6(c)	<i>Structural formula of X:</i> HCO ₂ H OR HCOOH	1
6(d)	M1 reagent (2,4–) DNPH / (2,4)-dinitrophenylhydrazine M2 observation yellow / orange / red precipitate	2
6(e)	<i>Predict two differences, with reasons, between spectra of Y, CH₃CH₂COCH₃ and 2-methylbut-1-ene (shown)</i> <i>first difference</i> M1 absence of peak/ absorption at 3100 (cm ⁻¹) as no longer any =C–H present (in Y) <i>second difference</i> M2 peak at 1650 (cm ⁻¹) moves to the left to any value / range of values between 1670 and 1740) due to disappearance of C=C (in Y) and appearance of C=O (in Y) OR absence of peak at 1650 (cm ⁻¹) as no longer any C=C present (in Y) AND appearance of peak (in Y) at (any value / range of values) between 1670-1740(cm ⁻¹) due to C=O	2
6(f)(i)	CH ₃ CH ₂ CO ₂ H + 4[H] → CH ₃ CH ₂ CH ₂ OH + H ₂ O	1
6(f)(ii)	propan-1-ol ALLOW propan-2-ol as error carried forward from 6f(i)	1
6(g)(i)	<i>Molecular formula of W</i> C ₃ H ₆ O ₂	1
6(g)(ii)	<i>Possible structure of W</i> CH ₃ COOCH ₃ OR HCOOCH ₂ CH ₃	1



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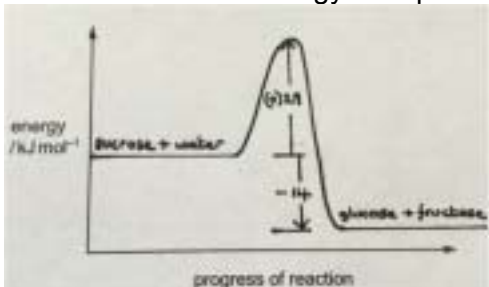
Question	Answer				Marks								
1(a)	EITHER M1 (weighted) average/mean mass of the isotope(s)/an atom(s) M2 relative to 1/12 of the mass (of an atom) of ¹² C (where an atom of ¹² C is exactly 12). OR M1 mass of one mol of atoms M2 relative / compared to 1/12 (the mass) of 1 mol of C-12 OR in which one mol C-12 (atom) has a mass of (exactly) 12 g				2								
1(b)	M1 60.11/100 x 69 + 39.89/100x71 M2 69.80				2								
1(c)	<table><tr><td>isotope</td><td>nucleon number</td><td>total number of electrons in lowest energy level</td><td>type of orbital contains the electron in the highest energy level</td></tr><tr><td>⁷¹Ga</td><td>M1 71</td><td>M2 2</td><td>M3 p (-orbital)</td></tr></table>	isotope	nucleon number	total number of electrons in lowest energy level	type of orbital contains the electron in the highest energy level	⁷¹ Ga	M1 71	M2 2	M3 p (-orbital)				3
isotope	nucleon number	total number of electrons in lowest energy level	type of orbital contains the electron in the highest energy level										
⁷¹ Ga	M1 71	M2 2	M3 p (-orbital)										
1(d)	M1 shape Cl. [•] Ga [•] Cl Cl M2 bond angle 120(°)				2								
1(e)(i)	Ga ₂ O ₃ + 6HCl → 2GaCl ₃ + 3H ₂ O				1								

Question	Answer	Marks
1(e)(ii)	M1 Identity of correct gallium containing product $\text{NaGa}(\text{OH})_4$ OR NaGaO_2 M2 correctly balanced equation for reaction of Ga_2O_3 with $\text{NaOH}(\text{aq})$ EITHER $\text{Ga}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaGa}(\text{OH})_4$ OR $\text{Ga}_2\text{O}_3 + 2\text{NaOH} \rightarrow 2\text{NaGaO}_2 + \text{H}_2\text{O}$	2

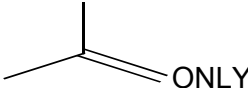
Question	Answer	Marks
2(a)	$4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$	1
2(b)	$ \begin{array}{c} \text{xx} \\ \text{H} \overset{\circ}{\text{X}} \text{N} \overset{\circ}{\text{X}} \text{H} \\ \text{xO} \\ \text{H} \end{array} $	1
2(c)(i)	$3\text{NO}_2 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_3 + \text{NO}$ (+4) (+5) (+2) 3 correct oxidation numbers – 2 marks 2 correct oxidation numbers – 1 mark	2
2(c)(ii)	<i>relates the term disproportionation to the reaction described</i> M1 <u>nitrogen /N</u> (in nitrogen dioxide) is both gaining electrons and losing electrons during the reaction M2 <i>refer to relevant transfer of electrons when NO_2 reacts to form HNO_3 and NO</i> NO_2 to HNO_3 involves loss of electron(s) AND NO_2 to NO involves gain of electron(s)	

Question	Answer	Marks
2(d)	M1 state the effect of NO gas on contact with moist air NO reacts with water OR NO reacts with oxygen and water. M2 consequence of M1 in terms of atmospheric pollution causing acid rain OR photochemical smog / ground level ozone OR destroy ozone layer	2
2(e)	M1 number of mol in sample of NH_4NO_3 40t NH_4NO_3 = 500 000 mol ammonium nitrate M2 ratio of mol NO_2 : NH_4NO_3 3/2 mol NO_2 :1 mol NH_4NO_3 M3 volume of no mol NO_2 at rtp using 1 mol = 24dm^3 18 000 000 dm^3 of NO_2	3
2(f)	fertiliser	1

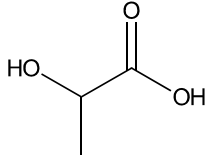
Question	Answer	Marks
3(a)	hydrolysis	1
3(b)	M1 both have molecular formula - $\text{C}_6\text{H}_{12}\text{O}_6$ M2 idea that in glucose and fructose there are the same number and type of atoms present but the atoms are arranged in a different order ie one has a carbonyl group at the end of the chain/molecule and the other has a carbonyl group in the middle of the chain/molecule	2
3(c)(i)	value for the activation energy for the reaction A (no enzyme) compared to reaction B (with enzyme) value / range of values that are more (+) 29 kJ mol^{-1}	1
3(c)(ii)	value for the enthalpy change for reaction A (no enzyme) compared to reaction B (with enzyme) -14 kJ mol^{-1}	1

Question	Answer	Marks
3(c)(iii)	M1 show the energy of the reactants > products AND label ΔH using the predicted value given in (ii) M2 show activation energy 'hump' AND label using the value given in (i) 	2
3(d)(i)	M1 (enthalpy change) when 1 mole of sucrose M2 burns/combusts/reacts in excess air/oxygen OR completely burns/combusts/reacts in air/oxygen	2
3(d)(ii)	M1 for finding amount of energy released per gram of sucrose using $\Delta H / Q = mc\Delta T$ OR $\Delta H = - mc\Delta T$ $= (-)250 \times 4.18 \times (40.7 - 25) = (-)16406.5$ J per gram OR $(-)16.4065$ kJ / g M2 for finding amount (mol) sucrose in 1g = $1/342$ mol M3 = $M1 / (M2 \times 1000)$ $\Delta H = -5610$ kJ mol⁻¹ (3 sig figs) OR -5611 kJ mol⁻¹ (4 sig figs)	3

Question	Answer	Marks
4(a)(i)	Bromine / Br	1
4(a)(ii)	$\text{Ag}^+(\text{aq}) + \text{X}^-(\text{aq}) \rightarrow \text{AgX}(\text{s})$ OR $\text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq}) \rightarrow \text{AgBr}(\text{s})$	1
4(a)(iii)	M1 reagent Add (aqueous) ammonia M2 expected result EITHER (Dilute ammonia) – partial amount precipitate dissolves OR not much precipitate dissolves OR add concentrated ammonia – precipitate dissolves	2

Question	Answer	Marks
4(b)(i)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$	1
4(b)(i)	M1 primary/ 1° (carbo)cation formed is not very stable M2 EITHER (as) only one alkyl group exerting an inductive effect OR only one alkyl group so the charge is (more) localised on the C^+	2
4(c)(i)	elimination	1
4(c)(ii)	$\text{C}_4\text{H}_9\text{Cl} + \text{NaOH} \rightarrow \text{C}_4\text{H}_8 + \text{NaCl} + \text{H}_2\text{O}$	1
4(c)(iii)	 ONLY	1
4(c)(iv)	M1 2-chloro(-2-)methylpropane M2 1-chloro(-2-)methylpropane ALLOW in any order	2

Question	Answer			Marks
5(a)	Rxn.	name of mechanism	Name of reagents and conditions	6
	1	M1 electrophilic addition	M2 steam AND concentrated phosphoric acid (catalyst)	
	2		M3 & M4 Two marks for name of reagent and both conditions. One mark for name of reagent and one conditions acidified potassium dichromate ((VI)) condition 1 warm condition 2 distil NOT reflux	
	6	M5 nucleophilic substitution	M6 ammonia (alcoholic) AND heat in a sealed tube / heat under pressure	
5(b)(i)	<i>mechanism for ethanal and HCN using CN⁻ (from KCN) as the catalyst</i> M1 arrow from lone pair of electrons on :CN⁻ to C of C=O M2 correct dipole on C^{δ+}=O^{δ-} AND arrow from the double bond to or beyond the O of C=O M3 arrow from lone pair of electrons on O of intermediate to H of HCN AND arrow from H-C bond to C of H-C≡N			3

Question	Answer	Marks
5(b)(ii)	ALLOW in any order M1 nitrile M2 (secondary) alcohol	2
5(b)(iii)	 ALLOW any unambiguous structure	1



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GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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> (see examples below) For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i> • Incorrect responses should not be awarded credit but will still count towards <i>n</i> • 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 <i>n</i> responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

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.

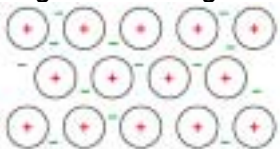
Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

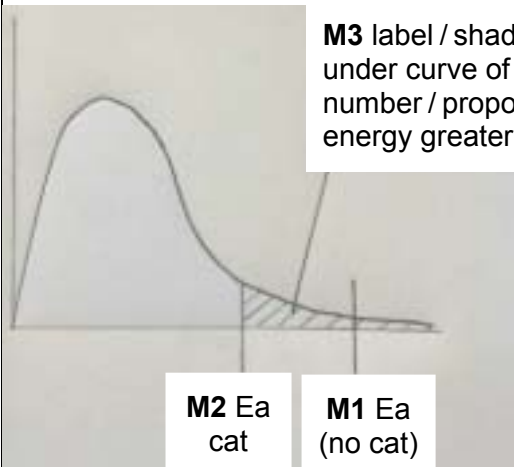
Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

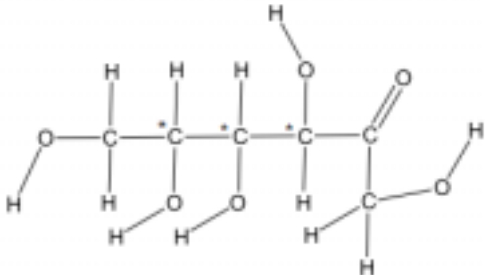
State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Question	Answer	Marks						
1(a)(i)	M1 green flame / white flame (with green tinge) M2 white solid formed	2						
1(a)(ii)	$2\text{Ba(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{BaO(s)}$	1						
1(b)(i)	M1 heat (followed by) add water M2 $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ M3 $\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2$	3						
1(b)(ii)	thermal decomposition.	1						
1(b)(iii)	neutralise acid soil / reduce the acidity in soil / increase the pH in soil	1						
1(c)(i)	$4\text{Ga} + 3\text{O}_2 \rightarrow 2\text{Ga}_2\text{O}_3$	1						
1(c)(ii)	(+) 3	1						
1(c)(ii)	<table><tr><td>reagent and conditions</td><td>Formula of gallium containing product</td></tr><tr><td>M1 gallium oxide+ hot HCl(aq)</td><td>M1 GaCl_3</td></tr><tr><td>M2 gallium oxide+hot concentrated NaOH(aq)</td><td>M2 NaGa(OH)_4 OR NaGaO_2</td></tr></table>	reagent and conditions	Formula of gallium containing product	M1 gallium oxide+ hot HCl(aq)	M1 GaCl_3	M2 gallium oxide+hot concentrated NaOH(aq)	M2 NaGa(OH)_4 OR NaGaO_2	2
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Question	Answer	Marks
2(a)	EITHER M1 mass of an atom / isotope M2 relative / compared to 1/12 (the mass) of (an atom of) C-12 OR on a scale in which a C-12 (atom / isotope) has (a mass of exactly) 12 (units) OR M1 mass of one mol (of atoms) of an isotope M2 relative / compared to 1/12 (the mass) of 1 mol of C-12 OR in which one mol C-12 (atom / isotope) has a mass of (exactly) 12 g	2
2(b)	% abundance of ^{63}Cu = 72.5% % abundance of ^{65}Cu = 27.5% M1 <i>correct algebraic expression AND correct calculation of x for one isotope</i> % ab of ^{63}Cu = x $(x/100 \times 63) + ((1-x)/100 \times 65) = 63.55$ so $x = 72.5$ OR % ab of ^{65}Cu = x $(1-x)/100 \times 63 + x/100 \times 65 = 63.55$ so $x = 27.5$ M2 <i>calculation of abundance of other isotope by $100 - x$</i>	2
2(c)(i)	metallic	1
2(c)(ii)	<i>diagram showing the bonding in a sample of copper</i>  M1 diagram shows regular arrangement of spheres labelled as positively charged ions / +2 or +1 / cations M2 diagram shows surrounded by electrons and clearly labelled as 'delocalised electrons'	3
2(c)(iii)	$(1s^2) 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$ OR $(1s^2) 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$	1

Question	Answer		Marks						
2(d)(i)	M1 calculate the number mol $\text{S}_2\text{O}_3^{2-}$ added $20/1000 \times 0.10 = 2 \times 10^{-3} = 0.002$ (mol $\text{S}_2\text{O}_3^{2-}$) M2 calculate number mol CuSO_4 in 250cm^3 (1mol $\text{S}_2\text{O}_3^{2-}$: 1 mol CuSO_4) = 0.002 mol CuSO_4 in 25cm^3 so 0.02 mol CuSO_4 in 250cm^3		2						
2(d)(ii)	<table><tr><td>M1 amount of CuSO_4 in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$</td><td>$7.98 / (159.6) = \underline{0.05}$ (mol)</td></tr><tr><td>M2 amount of H_2O in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$</td><td>$(10.68 - 7.98) / 18 = 2.7 / 18 = \underline{0.15}$ (mol)</td></tr><tr><td>M3 value of x</td><td>$(\text{mol } \text{H}_2\text{O} \div \text{mol } \text{CuSO}_4 =) 3$</td></tr></table>		M1 amount of CuSO_4 in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$	$7.98 / (159.6) = \underline{0.05}$ (mol)	M2 amount of H_2O in 10.68 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$	$(10.68 - 7.98) / 18 = 2.7 / 18 = \underline{0.15}$ (mol)	M3 value of x	$(\text{mol } \text{H}_2\text{O} \div \text{mol } \text{CuSO}_4 =) 3$	3
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M3 value of x	$(\text{mol } \text{H}_2\text{O} \div \text{mol } \text{CuSO}_4 =) 3$								

Question	Answer	Marks
3(a)(i)	hydrolysis	1
3(a)(ii)	 M3 label / shading indicating greater area under curve of $E_a(\text{cat})$ AND state greater number / proportion of sucrose molecules have energy greater than $E_a(\text{cat})$ (so faster rate) M2 E_a cat M1 E_a (no cat)	3

Question	Answer	Marks
3(b)(i)	an atom which is bonded to four different substituents / groups / atoms	1
3(b)(ii)	ALL three chiral carbons need to be shown by * 	1
3(b)(iii)	<i>empirical formula of fructose</i> CH ₂ O	1
3(c)(i)	M1 (enthalpy change) when 1 mole of a substance M2 burns/combusts/reacts in excess air/oxygen OR completely burns/combusts/reacts in air/oxygen	2
3(c)(ii)	$\text{C}_{12}\text{H}_{22}\text{O}_{11} + 12 \text{O}_2 \rightarrow 12\text{CO}_2 + 11\text{H}_2\text{O}$	1
3(c)(iii)	M1 $\Delta H = -5643 - (-2805 + -2810)$ M2 = -28 kJ mol^{-1}	2

Question	Answer	Marks
4(a)	M1 (no reaction) not enough energy M2 bromine (free) radicals are not produced OR homolytic fission of bromine does not occur.	2
4(b)(i)	free-radical substitution	1

Question	Answer	Marks
4(b)(ii)	$\text{C}_6\text{H}_{14} + (\cdot)\text{Br} \rightarrow (\cdot)\text{C}_6\text{H}_{13} + \text{HBr}$	1
4(b)(iii)	$(\cdot)\text{C}_6\text{H}_{13} + \text{Br}_2 \rightarrow \text{C}_6\text{H}_{13}\text{Br} + (\cdot)\text{Br}$	1
4(b)(iv)	$(\cdot)\text{C}_6\text{H}_{13} + (\cdot)\text{Br} \rightarrow \text{C}_6\text{H}_{13}\text{Br}$	1
4(c)(i)	$\text{CH}_3(\text{CH}_2)_3\text{CH}=\text{CH}_2$	1
4(c)(ii)	cold AND acidified AND dilute 2 marks for 3 correct conditions 1 mark for 2 correct conditions	2
4(d)(i)	addition OR reduction	1
4(d)(ii)	M1 only sigma / σ (bonds) in hexane / alkanes M2 B has sigma σ (bonds) and a / one pi / π (bond)	2

Question	Answer	Marks
5(a)(i)	dehydration	1
5(a)(ii)	M1 correct identification of butan-2-ol M2 correct displayed formula including correct connectivity of C–O–H $ \begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{O} & \text{H} \\ & & & \\ & & \text{H} & \end{array} $	2

Question	Answer		Marks
5(a)(iii)	isomer	name	2
	C	cis but-2-ene	
	D	trans but-2-ene	
	E	but -1-ene	
	2 marks for 3 correct names 1 mark for 2 correct names		
5(b)(i)		Functional group	3
	F	M1 Ester / RCOOR ⁽¹⁾ / RCO ₂ R ⁽¹⁾	
	G	M2 Carboxyl / carboxylic acid / RCOOH	
	H	M3 Alcohol / hydroxy / R-OH	
5(b)(ii)	triiodomethane		1
5(b)(iii)	M1 G = HCOOH / HCO ₂ H M2 H = C ₂ H ₅ OH		2