National
Qualifications
2023

2023 Chemistry

Higher Paper 2

Finalised Marking Instructions

These marking instructions have been prepared by examination teams for use by SQA appointed markers when marking external course assessments.

General marking principles for Higher Chemistry

Always apply these general principles. Use them in conjunction with the detailed marking instructions, which identify the key features required in candidates' responses.

(a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

(b) If a candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.

(c) Do not award half marks.

(d) Where a candidate makes an error at an early stage in a multi-stage calculation, award marks for correct follow-on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. Apply the same principle for questions that require several stages of non-mathematical reasoning. The exception to this rule is where the marking instructions for a numerical question assign separate 'concept marks' and an 'arithmetic mark'. In such situations, the marking instructions will give clear guidance on the assignment or partial marks.

(e) Unless a numerical question specifically requires evidence of working to be shown, award full marks for a correct final response (including units) on its own.

(f) Candidates may fully access larger mark allocations whether their responses are in continuous prose, linked statements, or a series of developed bullet points.

(g) Do not deduct marks for inaccurate or unconventional spelling or vocabulary as long as the meaning of the word(s) is conveyed. **For example**, responses that include 'distilling' for 'distillation', or 'it gets hotter' for 'the temperature rises', are acceptable.

(h) In many questions, the unit in which the answer is to be expressed is given. In these questions, the candidate does not need to state a unit in their answer; but if they do, the unit must be correct. The full mark allocation cannot be awarded if an incorrect unit is shown. In these questions, incorrect units would only be penalised once in any paper.

(i) If a correct response is followed by a wrong response, award no marks. **For example** in response to the question, 'State the colour seen when blue Fehling's solution is warmed with an aldehyde', do not award marks for the response 'red green'. However, if a correct response is followed by additional information which does not conflict with that, ignore the additional information, whether correct or not. **For example** in response to a question concerned with melting point, 'State why the tube should not be made of copper', the response 'Copper has a low melting point and is coloured grey' **would** gain marks.

(j) Award full marks for the correct response to a calculation without working. Award partial marks, as shown in the detailed marking instructions, when working is given but the final response is incorrect. An exception is when candidates are asked to 'Find, by calculation' - do not award full marks for the correct response without working.

(k) Ignore the omission of one H atom from a full structural formula provided the bond is shown.

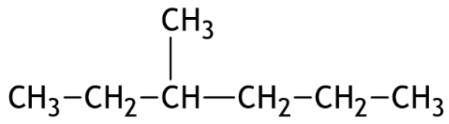
(l) Award marks for a symbol or correct formula in place of a name **unless stated otherwise in the detailed marking instructions.**

(m) When formulae of ionic compounds are given as responses, candidates only need to show ion charges if these have been specifically asked for. However, if ion charges are shown, they must be correct. If incorrect charges are shown, do not award marks.

(n) If an answer comes directly from the text of the question, do not award marks. **For example**, in response to the question, 'A student found that 0·05 mol of propane, C_3H_8 burned to give 82·4 kJ of energy. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$. Name the kind of enthalpy change that the student measured', do not award marks for 'burning' since the word 'burned' appears in the text.

(o) A guiding principle in marking is to give credit for correct elements of a response rather than to look for reasons not to give marks.

Example 1: The structure of a hydrocarbon found in petrol is shown below.



Name the hydrocarbon

- Award the full mark for '3, methyl-hexane', although the punctuation is not correct.

Example 2: A student measured the pH of four carboxylic acids to find out how their strength is related to the number of chlorine atoms in the molecule. The results are shown.

CH_3COOH	1.65
$CH_2ClCOOH$	1.27
$CHCl_2COOH$	0.90
CCl_3COOH	0.51

Describe the relationship between the number of chlorine atoms in the molecule and the strengths of the acids.

- Award the full mark for a response such as 'the more Cl_2, the stronger the acid', although not completely correct.

(p) Unless the question is clearly about a non-chemistry issue, for example costs in an industrial chemical process, do not award marks for a non-chemical response.
For example, in response to the question, 'Why does the (catalytic) converter have a honeycomb structure?', do not award a mark for 'To make it work'. This response may be correct but it is not a chemical response.

(q) Only award marks for a valid response to the question asked. Where candidates are asked to:

- **identify, name, give** or **state**, they must only name or present in brief form.
- **describe**, they must provide a statement or structure of characteristics and/or features.
- **explain**, they must relate cause and effect and/or make relationships between things clear.
- **compare**, they must demonstrate knowledge and understanding of the similarities and/or differences between things.
- **complete**, they must finish a chemical equation or fill in a table with information.
- **determine** or **calculate**, they must determine a number from given facts, figures or information.
- **draw**, they must draw a diagram or structural formula, for example 'Draw a diagram to show the part of a poly(propene) molecule formed from two propene molecules.'
- **estimate**, they must determine an approximate value for something.
- **predict**, they must suggest what may happen based on available information.
- **evaluate**, they must make a judgement based on criteria.
- **suggest**, they must apply their knowledge and understanding of chemistry to a new situation. A number of responses are acceptable: award marks for any suggestions that are supported by knowledge and understanding of chemistry.
- **use their knowledge of chemistry or aspect of chemistry to comment on**, they must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented (for example by making a statement of principle(s) involved and/or a relationship or equation, and applying these to respond to the problem/situation). Candidates gain marks for the breadth and/or depth of their conceptual understanding.
- **write**, they must complete a chemical or word equation, for example 'Write the word equation for the complete combustion of ethanol.'

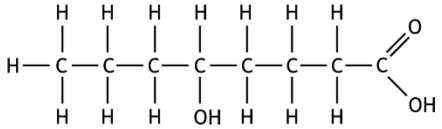
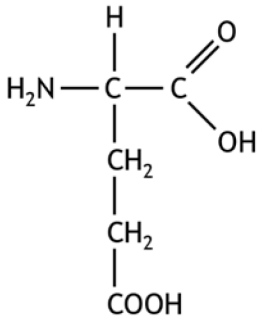
Marking instructions for each question

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	Increasing greater/stronger/larger nuclear charge (holds electrons more tightly). **OR** Increasing number of/more protons.	**1**	Increased nuclear pull is not accepted on its own. Mention must be made of nuclear charge or number of protons. Increased attraction of electron for the nucleus would be considered cancelling.
		(ii)	b or j	**1**	A correct letter must be shown.
		(iii) (A)	Second ionisation energy involves removal of an electron **from an electron shell** that is inner/ full(whole)/(more) stable/closer to the nucleus. **OR** Second electron is removed **from an electron shell** that is inner/ full(whole)/(more) stable/closer to the nucleus. **(1 mark)** The second electron is less screened/the second electron shell is less screened. **OR** The second electron is more strongly attracted to/pulled towards the nucleus. **(1 mark)**	**2**	Correct statements made about the 1st ionisation energy/electron can also be credited. Stating that the 2nd electron requires more energy than the 1st electron is not sufficient on its own. Shielding is acceptable in place of screening. Increased attraction of the electron for the nucleus would be considered cancelling.
		(iii) (B)	11472 (kJ mol^{-1})	**1**	No units required. No mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper). kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted).

Question			Expected response	Max mark	Additional guidance
1.	(b)	(i)	Elec**tronegativity is the (measure of) attraction an atom/nucleus has for the electrons in a bond/shared** electrons. **(1 mark)**	**1**	
		(ii)	(More shells so) increased screening/more screening. **(1 mark)** (Covalent radius increases/atom size increases/more shells so) attraction of the nucleus/protons for the (outer/shared) electron(s) decreases. **(1 mark)**	**2**	Shielding is acceptable in place of screening. Increased attraction of the electron for the nucleus would be considered cancelling.
		(iii)	Barium **OR** Radium **OR** Strontium	**1**	Correct symbols accepted.

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	(Intermolecular/van der Waals) forces increase (going down the group). **(1 mark)** LDFs are the forces (broken between the molecules). **(1 mark)** The more electrons the stronger the LDFs. **(1 mark)**	**3**	
		(ii)	Hydrogen bonding	**1**	
	(b)	(i)	(+) 34 (kJ mol^{-1}) [(+1517) + (-911) + (-572)] = (+) 34 (kJ mol^{-1}) Partial marks Treat as two concepts. Either would be acceptable for 1 mark. Evidence of understanding of reversal of first enthalpy value ie +1517 or 1517 must be seen. The other two enthalpy values (regardless of value) must be negative, or this partial mark cannot be awarded. **OR** Evidence of understanding of multiplying the third enthalpy value by 2. Ignore the enthalpy sign associated with these numbers.	**2**	If answer given is −34, maximum of 1 mark can be awarded. No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper). kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted).
		(ii)	39.9/ 40 (%) **(2 marks)** Partial marks Calculates theoretical mass = 6.4 (g) **(1 mark)** **OR** Correctly calculates no of moles reactant (0.2) and product (0.08) **(1 mark)**	**2**	

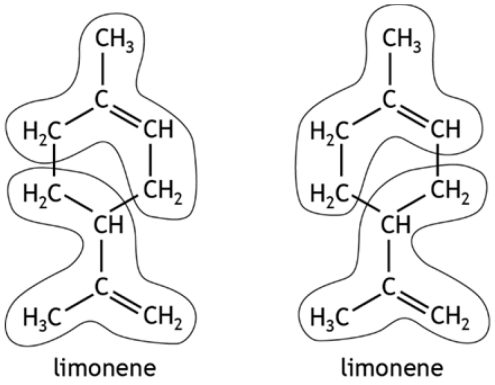
Question			Expected response	Max mark	Additional guidance
2.	(b)	(iii)	In SiO_2 covalent bonds are broken. **(1 mark)** In SiH_4 Van der Waals/LDFs/intermolecular forces are broken. **(1 mark)** Covalent bonds need more energy to break than van der Waals/LDFs/ intermolecular forces. **OR** Covalent bonds are stronger than van der Waals/LDFs/intermolecular forces. **(1 mark)**	**3**	A correct description of the relative strength of covalent bonds and van der Waals/LDFs/intermolecular forces is accepted for this mark.

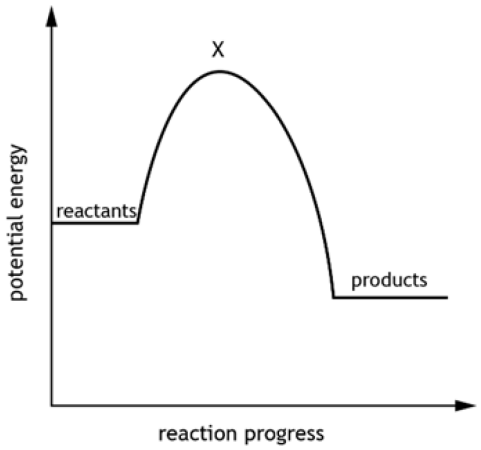
Question			Expected response	Max mark	Additional guidance
3.	(a)	(i) (A)	propane-1,2,3-triol	**1**	propan-1,2,3-triol is accepted Apply general marking principle (o)
		(i) (B)	Condensation/ esterification	**1**	
		(ii) (A)	Carbonyl	**1**	
		(ii) (B)	heptan-2-one	**1**	
		(ii) (C)	Reduction	**1**	Accept hydrogenation
		(ii) (D)	(reaction) 1	**1**	
		(iii)		**1**	
		(iv) (A)	12 – 13 (minutes)	**1**	No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper).
		(iv) (B)	dilute sample/use less of sample	**1**	
	(b)	(i)	Essential (Amino acids)	**1**	
		(ii)		**1**	
		(iii)	(The protein) denatures/denatured	**1**	
	(c)		To prevent non-polar and polar liquids separating (into layers)	**1**	
	(d)		Calcium propanoate	**1**	

Question			Expected response	Max mark	Additional guidance
4.			**Award 1 mark** where the candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) which are relevant to the situation, showing that they have understood at least a little of the chemistry within the problem. **Award 2 marks** where the candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) which are relevant to the situation, showing that they have understood the problem. **Award 3 marks** where the candidate has demonstrated, at an appropriate level, a good understanding of the chemistry involved. They show a good comprehension of the chemistry of the situation and provide a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks. **Award 0 marks** where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award this mark also if the candidate merely restates the chemistry given in the question.	**3**	

Question			Expected response	Max mark	Additional guidance
5.	(a)	(i) (A)	494.08, 494.1, 494 (litres) 494080, 494100 cm^3 Partial marking Calculating the mass of glucose in 16L ie 1852.8 (g). **(1 mark)** **OR** Number of moles of glucose in 16L 10.29 (moles) (or correctly calculated number of moles from incorrectly calculated mass of glucose). **(1 mark)** An incorrectly calculated number of moles of glucose × (2 × 24). **(1 mark)** **OR** by proportion 180g ↔ 48L **(1 mark)** Calculated mass of glucose ↔ Calculated mass of glucose × $\frac{48}{180}$ **(1 mark)** Failure to scale up to 16 litres of glucose solution but correct use of 50cm^3 and 5.79 g and 1:2 mole ratio will give an answer of 1.544 litres of carbon dioxide. This would be awarded **2 marks**. (working must be shown)	**3**	No units required. Only 2 marks can be awarded for the correct answer if wrong unit is given. (Wrong units would only be penalised once in any paper).

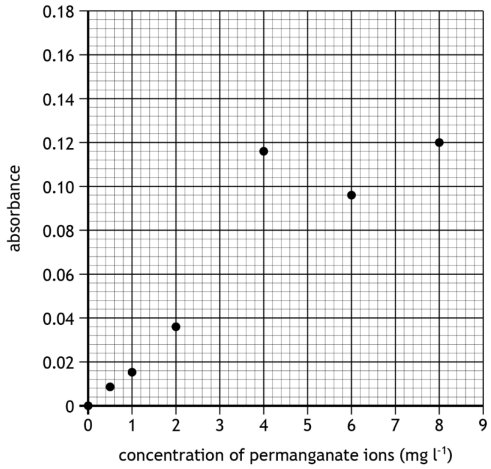
Question			Expected response	Max mark	Additional guidance
5.	(a)	(i) (B)	51, 51.1 (%) Partial mark for correct use of atom economy relationship without correct use of stoichiometry (working must be shown). $\frac{46}{180} \times 100 = 25.6$ **(1 mark)** **OR** Partial mark for correct working with no correct answer given. $\frac{(2 \times 46)}{180} \times 100$ 0.51 **(1 mark)** **OR** Partial mark for correct use of atom economy relationship with correct use of stoichiometry (working must be shown) for carbon dioxide $2 \times \frac{44}{180} \times 100$ = 48.9 % **(1 mark)**	**2**	No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (Wrong units would only be penalised once in any paper).

Question			Expected response	Max mark	Additional guidance
5.	(a)	(ii)	12, 12.2, 12.22 (% / abv) Partial mark for correctly calculated change in specific gravity. 1.075-0.985 or 0.09. **(1 mark)** Partial mark for correctly calculated value using an incorrect value for change in specific gravity. **(1 mark)**	**2**	Ignore any units.
	(b)	(i)	**Acidified** dichromate changes from orange to green (blue-green/ blue) with methanol AND no colour change would be observed with propan-2-one. **(2 marks)** **OR** Using **hot** copper oxide a brown solid forms/copper forms/colour change from black to brown would be observed with methanol AND no colour change would be observed with propan-2-one. **(2 marks)**	**2**	Acidified dichromate **(1 mark)** Hot copper oxide **(1 mark)**
		(ii) (A)	Terpene(s)	**1**	
		(ii) (B)	 limonene limonene Only one correct unit needed.	**1**	
		(ii) (C)	Ethanoic acid/acetic acid	**1**	
	(c)		2100 **(1 mark)** mg **(1 mark)** **OR** 2·1 **(1 mark)** g (**1 mark)** **OR** 0-0021 **(1 mark)** kg (**1 mark)**	**2**	If an incorrect mass is calculated but the units are appropriate to the calculation then 1 mark would be awarded. If the candidate's working is unclear in terms of what is being worked out then the mark for units cannot be awarded.

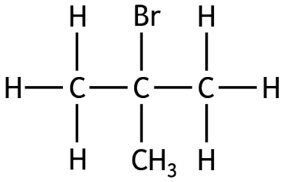
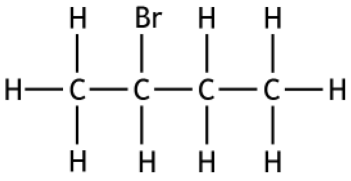
Question			Expected response	Max mark	Additional guidance
6.	(a)	(i) (A)		**1**	
		(i) (B)	Activated complex	**1**	Accept activation complex or transition state.
		(ii)	n HNO_3 = 1316 x 9.5 = 12502 moles **AND** n NH_3 = $220x10^3$ / 17 = 12941 **(1 mark)** 1:1 ratio therefore NH_3 is in excess **(1 mark)** **OR** 12502 HNO_3 moles requires 12502 moles NH_3 but have 12941 moles therefore NH_3 in excess. **(2 marks)** --- 1316 l of HNO_3 needs 212.5 kg NH_3 **(1 mark)** **OR** 220 kg NH_3 needs 1362.2 l HNO_3 **(1 mark)** **OR** 12502 HNO_3 moles requires 12502 moles NH_3 but have 12941 moles **(1 mark)** **OR** 12941 moles NH_3 requires 12941 moles HNO_3 but only have 12502 moles HNO_3 **(1 mark)** Therefore, NH_3 is in excess **(1 mark)**	**2**	Accept correct statement for incorrectly calculated values using 1:1 ratio.

Question			Expected response	Max mark	Additional guidance
6.	(a)	(iii)	It has 100% atom economy **OR** Only has 1 product	**1**	
	(b)	(i) (A)	The total number of molecules/ particles.	**1**	
		(i) (B)	Second line displaced to right of original. Peak of curve should be further to the right and no higher than the original peak.	**1**	
		(ii)	A vertical line drawn at a lower kinetic energy than the original E_a shown on graph.	**1**	
	(c)	(i)	The rate of the forward reaction equals the rate of the reverse reaction.	**1**	
		(ii) (A)	(Removal of ammonia/product will) shift equilibrium to right hand side. **(1 mark)** **OR** Increases the yield of ammonia. **(1 mark)** Decreases the rate of the reverse reaction. **(1 mark)** **OR** The rate of the forward reaction is then greater than the rate of the reverse reaction. **(1 mark)**	**2**	
		(ii) (B)	Recycles unreacted gases/ reactants. **OR** Uses a catalyst (to reduce energy costs). **OR** Air is a low cost/free resource.	**1**	
	(d)	(i)	$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$	**1**	Any correct multiple is accepted. Ignore any state symbols if given.
		(ii)	Ammonia/NH_3	**1**	

Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	Hard (water)	**1**	
		(ii)	Hydrophilic	**1**	Polar is not accepted.
		(iii)	0.000837 (mol l^{-1}) (3 marks) Partial marks can be awarded using a scheme of two "concept" marks, and one "arithmetic" mark. **1 mark** for knowledge of the relationship between moles, concentration and volume. This could be shown by one of the following steps: • Calculation of moles EDTA solution eg 0·0045 × 0·0093 = 0·00004185 • Calculation of concentration of calcium ions eg 0·00004185 ÷ 0.05 • Insertion of correct pairings of values for concentration and volume in a valid titration formula. If the relationship between moles, concentration and volume is used more than once, it must be used correctly every time. **1 mark** for the relationship between a calculated number of moles of EDTA and calcium ions. **OR** Insertion of correct stoichiometric values in a valid titration formula. **1 mark** is awarded for correct arithmetic through the calculation. This mark can only be awarded if both concept marks have been awarded.	**3**	No units required. Only 2 marks can be awarded for the correct answer if wrong unit is given. (Wrong units would only be penalised once in any paper).

Question			Expected response	Max mark	Additional guidance
7.	(b)		 4.4 to 5.4 **OR** Accurate reading from candidate's drawn line of best fit if value given is out with the range 4.4 to 5.4.	**1**	No units required. No mark can be awarded for the correct answer if wrong unit is given. (Wrong units would only be penalised once in any paper).
	(c)	(i)	Trichloromethane is polar and tetrachloromethane is non-polar. **(1 mark)** Trichloromethane has a permanent dipole and tetrachloromethane does not. **(1 mark)**	**2**	Correct description of a permanent dipole is accepted.
		(ii)	-14 (kJ mol^{-1}) Partial marks: Evidence of the use of all the correct bond enthalpies (or correct multiples thereof) (338, 412, 431, 484, 570 (ignore signs). **(1 mark)** **OR** If only four values are retrieved, the candidate recognises that bond breaking is endothermic and bond formation is exothermic and correctly manipulates the bond enthalpy values they have used to give their answer. **(1 mark)**	**2**	(+)14 (kJ mol^{-1}) would be awarded 1 mark. No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted). (Wrong units would only be penalised once in any paper).

Question			Expected response	Max mark	Additional guidance
8.			**Award 1 mark** where the candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) which are relevant to the situation, showing that they have understood at least a little of the chemistry within the problem. **Award 2 marks** where the candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) which are relevant to the situation, showing that they have understood the problem. **Award 3 marks** where the candidate has demonstrated, at an appropriate level, a good understanding of the chemistry involved. They show a good comprehension of the chemistry of the situation and provide a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks. **Award 0 marks** where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award this mark also if the candidate merely restates the chemistry given in the question.	**3**	

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	The more carbons/longer carbon chain the higher the boiling point. **(1 mark)** The further down group 7/the halogen is the higher the boiling point. **(1 mark)**	**2**	Reference to group 7 molecule is cancelling.
		(ii)	Permanent dipole- Permanent dipole interactions.	**1**	Allow permanent dipole-dipole interaction. Accept pd-pd i's.
	(b)	(i)	The halogen/bromine (atom) is attached to a carbon that is attached to two other carbons. **OR** The halogen/bromine (atom) is attached to a carbon that has only one hydrogen attached.	**1**	
		(ii)		**1**	Accept shortened structural formula
	(c)	(i)	Ultraviolet/UV (radiation/light)	**1**	
		(ii)	1 mark for one of the following $\bullet CH_3 + Br\bullet \rightarrow CH_3Br$ $\bullet CH_3 + \bullet CH_3 \rightarrow CH_3CH_3$ $Br\bullet + Br\bullet \rightarrow Br_2$	**1**	
	(d)			**1**	Accept shortened structural formula
	(e)		2-bromo-3-chloro-1,1,1-trifluoropentane	**1**	Apply general marking principle (o)

Question			Expected response	Max mark	Additional guidance
10.	(a)		Tare the balance with the crucible. **(1 mark)** Transfer 1·5 g (into the crucible). **(1 mark)** **OR** Tare a weighing boat, transfer the 1.5 g onto the weighing boat. Record mass. Transfer into the crucible. **(1 mark)** Reweigh the weighing boat and record the mass/calculate the difference. **(1 mark)** **OR** Weigh mixture and weighing boat, record the mass. Transfer mixture into the crucible. **(1 mark)** Reweigh the weighing boat and record the mass/calculate the difference. **(1 mark)** Weigh the crucible (empty) and then with (1.5 g of) mixture. **(1 mark)** Subtract the mass of crucible from mass of crucible and mixture. **(1 mark)**	**2**	Accept use of a filter paper/paper towel/watch glass or other appropriate container instead of a weighing boat.
	(b)	(i)	Allow CO_2/gas to escape.	**1**	
		(ii)	Reactants/products/mixture are not flammable.	**1**	

Question			Expected response	Max mark	Additional guidance
10.	(c)		0.582, 0.58 (g) **(2 marks)** Partial marking Calculating number of moles of CO_2 (0.0069). (**1 mark)** Calculating mass of $MgCO_3$ from incorrectly calculated number of moles of CO_2. **(1 mark)**	**2**	
	(d)	(i)	Diagram shows a workable method of generating gas with mixture in contact with acid. Labels required for mixture/powder/magnesium oxide + magnesium carbonate and (excess) acid.	**1**	
		(ii)	Carbon dioxide is (relatively) insoluble/has very low solubility (in water).	**1**	

[END OF MARKING INSTRUCTIONS]