Pearson Edexcel

Mark Scheme (Results)

November 2021

Pearson Edexcel GCE
In Chemistry (8CH0)
Paper 1: Core Inorganic and Physical Chemistry

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the world's leading learning company. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk for our BTEC qualifications. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

If you have any subject specific questions about this specification that require the help of a subject specialist, you can speak directly to the subject team at Pearson.
Their contact details can be found on this link: www.edexcel.com/teachingservices.

You can also use our online Ask the Expert service at www.edexcel.com/ask. You will need an Edexcel username and password to access this service.

Pearson: helping people progress, everywhere
Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

November 2021
Question Paper Log Number 67083
Publications Code 8CH0_01_2111_MS

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
• an idea of the types of response expected
• how individual marks are to be awarded
• the total mark for each question
• examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
• write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
• select and use a form and style of writing appropriate to purpose and to complex subject matter
• organise information clearly and coherently, using specialist vocabulary when appropriate.
Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Answer	Additional Guidance	Mark
1(a)	An answer that makes reference to the following points: • both atoms have 35 protons (1) • one atom has 44 neutrons and the other has 46 neutrons (1)	Ignore the isotopes have the same number of electrons Allow the second isotope has two more neutrons If no other mark is scored allow (1) for they both have the same number of protons but different numbers of neutrons	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(b)(i)	An answer that makes reference to the following point: • they have the same electronic configuration / structure or they both have $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^5$	Allow they have the same number of electrons / they have 35 electrons Ignore an incorrect electronic configuration Do not award just ‘they have the same number of electrons in their outermost shell’	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)(ii)	An answer that makes reference to the following points: • compare the intensity of signal / number of particles of each isotope detected **(1)** • in a mass spectrometer **(1)**	 Allow measure for compare	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(c)(i)	An answer that makes reference to the following point: • correct electronic configuration	 ($1s^2$ $2s^2$) $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^5$ Allow $3d^{10}$ before $4s^2$ Ignore repeat of $1s^2$ $2s^2$ Allow upper case letters, numbers not superscript, numbers subscript and p and / or d orbitals shown (e.g. $2p_x^2$, $2p_y^2$, $2p_z^2$ instead of $2p^6$)	**(1)**

Question Number	Answer	Mark
1(c)(ii)	The only correct answer is **B** (7) ***A*** *is not correct because this is the number of electrons in the fourth occupied subshell* ***C*** *is not correct because this assumes the electrons in the 3d orbitals are in the fourth quantum shell* ***D*** *is not correct because this is the number of electrons in the third quantum shell of bromine*	**(1)**

(Total for Question 1 = 7 marks)

Question Number	Answer		Additional Guidance	Mark
2(a)	An answer that makes reference to the following points:		Marks 1 to 3 can be scored on one of two routes Marks 4 and 5 are scored by either route	(5)
	Route 1 – Dissolve the solid in a beaker			
	• dissolve the solid in distilled / deionised water (using a glass rod)	(1)	Do not award if the solid is dissolved in 250 cm^3 Award with distilled / deionised water anywhere in the answer	
	• pour the solution into a volumetric flask (using a funnel)	(1)		
	• rinse the beaker and transfer the washings to the conical flask (and rinse the funnel and glass rod)	(1)		
	Route 2 – Transfer the solid to the volumetric flask			
	• transfer the solid to a volumetric flask (through a solids funnel)	(1)		
	• rinse the container (and funnel) with distilled / deionised water and transfer washings	(1)	Award with distilled / deionised water anywhere in the answer	
	• dissolve the solid (in less than 250 cm^3)	(1)	Do not award if the solid is dissolved in 250 cm^3	
	Both routes			
	• make up to the mark / line / 250 cm^3	(1)		
	• shake / mix / swirl the flask	(1)	For an answer making no reference to deionised / distilled water max (4)	

Question Number	Answer	Mark
2(b)(i)	The only correct answer is **C** (yellow orange) ***A*** *is not correct because this colour change would be for the acid in the flask and the carbonate in the burette* ***B*** *is not correct because this colour change would be for the acid in the flask and the carbonate in the burette and going beyond the end point* ***D*** *is not correct because this colour change would go beyond the end-point*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	• it is not concordant with the other two results / it is not within 0.2 cm^3 of the other results	Allow it is not within ± 0.2 cm^3 of the results of Titrations **2** and **3** Allow values less than 0.2 cm^3 apart Allow 'the volume is a **lot** larger than the other results' but not 'the volume is a **bit** larger than the other results' Do not award just 'it is not close to the other results'	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(iii)	• calculation of mean titre	<u>Example of calculation</u> (28.85 + 28.65) ÷ 2 = 28.75 (cm^3)	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(iv)	• calculation of moles of hydrochloric acid **(1)** • calculation of moles of Na_2CO_3 in 25 cm^3 **(1)** • calculation of moles of Na_2CO_3 in 250 cm^3 **(1)** • calculation of M_r of $Na_2CO_3.xH_2O$ **(1)**	<u>Example of calculation</u> $= \frac{28.75}{1000} \times 0.300 = 0.008625$ / 8.625×10^{-3} (mol) $= \frac{0.008625}{2} = 0.0043125$ / 4.3125×10^{-3} (mol) $= 0.0043125 \times 10 = 0.043125$ / 4.3125×10^{-2} (mol) $= \frac{10.0}{0.043125} = 232$ (g mol^{-1}) Correct answer with no working scores (4) Allow TE throughout Ignore SF except 1SF	**(4)**

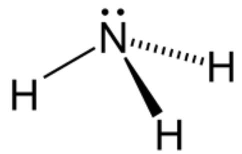
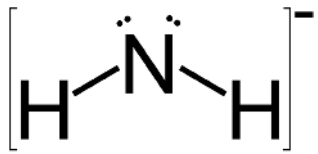
Question Number	Answer	Additional Guidance	Mark
2(c)(i)	• calculation of M_r of Na_2CO_3	<u>Example of calculation</u> $= (2 \times 23) + 12 + (3 \times 16) = 106$ Correct answer with no working scores (1)	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(c)(ii)	• calculation of mass of water in 1 mole of $Na_2CO_3 \cdot xH_2O$ and calculation of x.	Example of calculation $= \frac{286 - 106}{18} = 10$ Correct answer with no working scores (1) Ignore SF Allow TE on incorrect M_r from 2(c)(i)	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(d)	• calculation of the number of moles of sodium chloride **(1)** • calculation of number of possible moles of sodium carbonate **(1)** • calculation of the mass of sodium carbonate **(1)**	Example of calculation $= \frac{500\,000}{58.5} = 8547 / 8.547 \times 10^3$ (mol) $= \frac{8547}{2} = 4273.5 / 4.2735 \times 10^3$ (mol) $= 4273.5 \times 106 = 452991$ (g) / 453000 (g) / 452.99 (kg) / 453 (kg) Correct answer with no working scores 3 Ignore SF except 1 SF throughout Allow TE throughout Allow TE on incorrect M_r of sodium carbonate from 2(c)(i)	**(3)**

(Total for Question 2 = 17 marks)

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	An answer that makes reference to the following point: • balanced equation	$2Na + 2NH_3 \rightarrow 2NaNH_2 + H_2$ Allow multiples Ignore state symbols, even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	• dot and wedge diagram of ammonia molecule with one or two wedges or one or two series of dots / dashes **(1)** • diagram of amide ion with two bonds which are clearly not at 180° to each other **(1)** • one lone pair of electrons on the nitrogen of ammonia and two on the amide ion **(1)**	<u>Examples of diagrams</u>   Allow any combination of dots and wedges for the amide ion Ignore lack of charge and brackets	**(3)**

Question Number	Answer	Mark
3(a)(iii)	The only correct answer is **B** (107º) ***A*** *is not correct because this is the expected angle for 2 bonding pairs and 2 lone pairs of electrons* ***C*** *is not correct because this is the expected angle for 4 bonding pairs and no lone pairs of electrons* ***D*** *is not correct because this is the expected angle for 3 bonding pairs and no lone pairs of electrons*	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(a)(iv)	An explanation that makes reference to the following points: • H–N–H bond angle is smaller in the amide ion / 104.5º / 105º **(1)** • (because the amide ion has two / more) lone pairs of electrons which repel the bonding pairs more than the one lone pair of electrons in ammonia **(1)**	Allow lone pair-lone pair repulsion is greater than lone-pair bonding pair repulsion	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(b)	An answer that makes reference to the following point: • sodium amide reacts (vigorously / violently) with water / oxygen	Allow reacts with air Allow will oxidise if not stored in oil / if stored in air Do not award sodium reacts with water / oxygen / air	**(1)**

(Total for Question 3 = 8 marks)

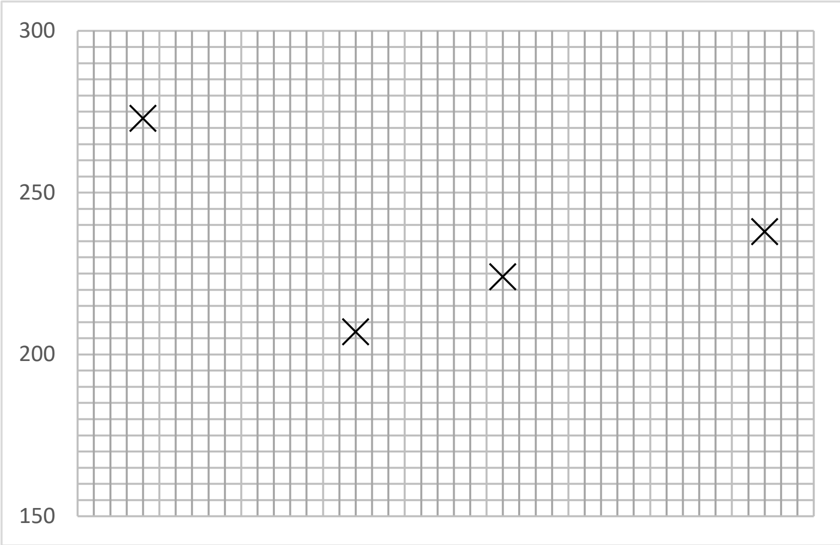
Question Number	Answer	Mark
4(a)(i)	The only correct answer is **C** ($S(g) \rightarrow S^{+}(g) + e^{-}$) ***A*** *is not correct because the sulfur must be in the gas phase* ***B*** *is not correct because the sulfur must be individual atoms and in the gas phase* ***D*** *is not correct because the sulfur must be individual atoms*	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	An explanation that makes reference to the following points: • first ionisation energy decreases down the group because although the number of protons is increasing **(1)** • the electron being removed is (one shell of electrons) further from the nucleus **(1)** • (with one shell of electrons) giving more shielding from the nucleus **(1)**	Allow greater repulsion between inner electron shells	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(a)(iii)	An explanation that makes reference to the following points: • because in sulfur the nuclear charge / atomic number / proton number / number of protons has is less (by 1) **(1)** • and the electron being removed is from the same sub-shell / a (3)p electron / has similar shielding / is further from the nucleus / **(1)**	Do not award just 'the charge has decreased (by 1) in sulfur' Allow effective nuclear charge has decreased by 1 in sulfur Allow has the same shielding Allow atomic radius is larger Do not award ionic radius is larger Ignore same shell Allow reverse arguments for chlorine	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(a)(iv)	An explanation that makes reference to the following points: • because in sulfur (spin) pairing has occurred (for the first time in the 3p sub-shell) **or** electron being removed from an orbital containing two electrons **(1)** • (resulting in an increase in) repulsion between electrons (so the electron is lost more easily) **(1)**	Ignore half-filled (sub-) shell is more stable in phosphorus Ignore reference to shielding and distance to the nucleus	**(2)**

Question Number	Answer		Additional Guidance	Mark
4(b)			Example of calculation	(5)
	• rearrangement of the ideal gas equation	(1)	$n = \dfrac{pV}{RT}$	
	• conversion of volume into m^3 and conversion of pressure into pascals	(1)	$V = 0.000132\ (m^3)$ and $p = 105\,000$ (Pa)	
	• calculation of number of moles	(1)	$n = \dfrac{105\,000 \times 0.000132}{8.31 \times 420} = 0.0039711$ (mol)	
	• calculation of molar mass	(1)	$M_r = \dfrac{m}{n} = \dfrac{0.318}{0.0039711} = 80.078/\ 80.1\ (g\,mol^{-1})$ Ignore SF	
	• deduction of formula of **X**	(1)	SO_3 Allow S_2O Allow TE at each stage Correct answer with at least MP2, MP3 or MP4 correct scores (5)	

Question Number	Answer	Additional Guidance	Mark
4(c)(i)	• plot four correct points to within 1 square **(1)** • use of suitable scales so the points cover at least half the graph paper in both directions **(1)**	<u>Example of graph</u>  Ignore straight or curved lines joining the points	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(c)(ii)	• Estimates the melting temperature of H_2S to be less than 200 (K) but greater than 170 (K)	Allow as a point on the graph or as a number in the table. Note: the actual melting temperature is 188 (K)	**(1)**

(Total for Question 4 = 16 marks)

Question Number	Answer		Additional Guidance	Mark
5(a)	An explansation that makes reference to the following points: • iodine is (simple) molecular • diamond is a giant (covalent / lattice) structure (with 4 covalent bonds per carbon atom) • iodine molecules are held together by weak London forces / dispersion forces / van der Waal's forces / instantaneous induced dipole-dipole attractions • carbon atoms in diamond are held together by (strong) covalent bonds • strong covalent bonds require more energy to break than intermolecular forces	 **(1)** **(1)** **(1)** **(1)** **(1)**	Allow iodine is made up of (I_2) molecules Do not award diamond molecules Allow weak intermolecular forces Do not award strong intermolecular forces Award converse argument for less energy need to break intermolecular forces Single sentences may contain more than one marking point. For example 'iodine molecules are held together by weak intermolecular forces' scores (2)	**(5)**

Question Number	Answer	Additional Guidance	Mark
5(b)	An answer that makes reference to the following points: • one electron free to move / delocalised (within the layer to carry the current) **(1)** • each carbon is (covalently) bonded to three other carbons or the carbon atoms are arranged in layers which allow the flow of electricity through them **(1)**	Mark independently Marks could be scored in a diagram Ignore just ‘free electrons’ Allow uses three (outer shell) electrons in bonding	**(2)**

(Total for Question 5 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
6(a)(i)	An answer that makes reference to the following point: • the oxidation number / state does not change for any element	Accept there is no transfer of electrons	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	An explanation that makes reference to the following points: • (because) sulfur in sulfuric acid is reduced further by hydrogen iodide than hydrogen bromide (and hydrogen chloride) **(1)** • SO_2 / S(IV) produced in the reaction with HBr **(1)** • more negative oxidation states of sulfur / S / H_2S / S^{2-} are produced in the reaction with HI **(1)**	Mark independently Allow potassium salt / halide ion for hydrogen halide May be shown in an equation, but ignore incorrect state symbols and/or balancing May be shown in an equation, but ignore incorrect state symbols and/or balancing	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An answer that makes reference to the following points: • chlorine / Cl_2 is simultaneously oxidised and reduced **(1)** • the oxidation number of chlorine changes from 0 to –I and (+)I / 0 to –1 and (+)1 / increases by 1 and decreases by 1 **(1)**	Allow oxidation numbers underneath or above the equation	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	• substances correct in equation **(1)** • equation is balanced **(1)**	<u>Example of equation</u> $3Cl_2 + 6NaOH \rightarrow NaClO_3 + 5NaCl + 3H_2O$ Ignore state symbols even if incorrect	**(2)**

Question Number	Answer		Additional Guidance	Mark
6(c)(i)	• calculation of the number of moles of chlorine gas reacting	**(1)**	Example of calculation $= \frac{768}{24000} = 0.032 / 3.2 \times 10^{-2}$ (mol) (answer 1)	**(2)**
	• calculation of number of moles of electron gained by chlorine	**(1)**	= (answer 1) × 2 = $0.064 / 6.4 \times 10^{-2}$ (mol) Allow TE on incorrect number of moles of chlorine (M2 is for multiplying by 2) Ignore SF except 1SF	

Question Number	Answer		Additional Guidance	Mark
6(c)(ii)	• calculation of number of moles of thiosulfate ions	**(1)**	Example of calculation $= \frac{40}{1000} \times 0.20 = 0.008 / 8 \times 10^{-3}$ (mol) (answer 1)	**(3)**
	• calculation of electrons lost per sulfur atom	**(1)**	$= \frac{6(c)(i)}{(\text{answer 1}) \times 2} = \frac{0.064}{0.008 \times 2} = 4$ (electrons)	
	• deduction of the oxidation number of the sulfur and hence the product	**(1)**	(In thiosulfate ion oxidation state of sulfur is (II)) and each loses four electrons so oxidation state is (+)(VI) / (VI)(+) / 6 (+) / (+)6 Allow TE throughout including on 6(c)(i) Ignore SF	

(Total for Question 6 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)	An answer that makes reference to the following points: • (strong) electrostatic attraction • between oppositely charged ions		**(2)**

Question Number	Answer	Mark
7(b)	The only correct answer is **B** (41.4 %) ***A*** *is not correct because this uses the atomic number in the calculation instead of the relative atomic mass* ***C*** *is not correct because this assumes the formula of strontium nitrate is* $SrNO_3$ ***D*** *is not correct because this assumes the formula of strontium nitrate is SrNO*	**(1)**

Question Number	Answer	Mark
7(c)(i)	The only correct answer is **D** (it reacts with the compounds to form volatile chlorides) ***A*** *is not correct because hydrochloric acid doesn't dissolve the metal* ***B*** *is not correct because there are no hydroxide ions present and they don't colour the flame* ***C*** *is not correct because hydrochloric acid doesn't reduce the metal ions*	**(1)**

Question Number	Answer	Mark
7(c)(ii)	The only correct answer is **C** (red) ***A*** *is not correct because ions giving green shades include barium ions* ***B*** *is not correct because ions giving lilac shades include potassium ions* ***D*** *is not correct because ions giving yellow shades include sodium ions*	**(1)**

Question Number	Answer	Mark
7(c)(iii)	The only correct answer is ***C*** (released due to different gaps between energy levels) ***A*** *is not correct because promoting electrons in a flame test uses heat energy* ***B*** *is not correct because promoting electrons does not release light* ***D*** *is not correct because electrons are promoted within the metal atoms energy levels not transferred to non-metal ions*	**(1)**

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*7(d)</td><td>This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table></td><td>Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning.

For example, an answer with five indicative marking points, which is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>(6)</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*7(c)(ii) contd</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured.</td><td>0</td></tr>
</table></td><td>In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.

Reasoning marks may be reduced for extra incorrect chemistry

The identification should be a logical deduction of unknowns.
If the candidate assumes they know which is which of the solids and prove it deduct one reasoning mark</td><td></td></tr>
</table>

	Indicative content: • IP1 no brown gas on heating with $RbNO_3$ • IP2 brown gas on heating for $LiNO_3$ and/or $Sr(NO_3)_2$ • IP3 dissolve / make a solution in deionised / distilled water • IP4 Add a solution of $NaOH$ / Na_2SO_4 / H_2SO_4 / Na_2CO_3 • IP5 White precipitate for $Sr(NO_3)_2$ • IP6 No precipitate for $LiNO_3$ and/or $RbNO_3$	Candidates may start with either heating or solutions (IP1/2 or IP3) Allow $RbNO_3$ only gives off oxygen which relights a glowing splint Allow equations giving NO_2 Allow even if added to solids Allow even if test is done on solids Allow even if test is done on solids Logical deductions may not require description of the results for both substances in IP2 or IP6 but they should mention one at least	

(Total for Question 7 = 12 marks)

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom