Questions

Q1.

A white solid was thought to be barium carbonate. A student suggested that the presence of the carbonate ion could be tested for by adding a small amount of sulfuric acid.

Explain whether or not this suggestion is valid.

(2)

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(Total for question = 2 marks)

Q2.

This question is about the elements in Group 2 of the Periodic Table.

Explain how the trend in the reactivity of the Group 2 elements is determined by their electronic configurations.

(3)

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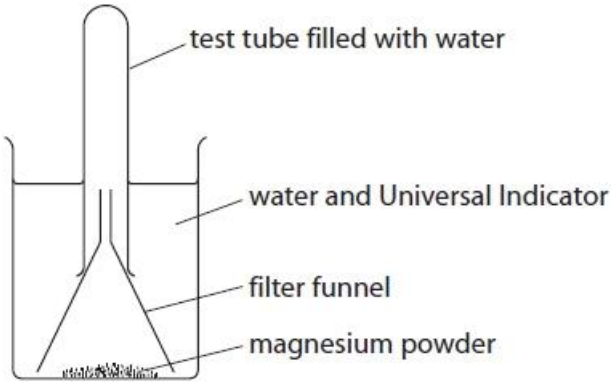
(Total for question = 3 marks)

Q3.

This question is about the elements in Group 2 of the Periodic Table.

Magnesium powder is added to a beaker of water containing a few drops of Universal Indicator.

The apparatus is set up as shown and allowed to stand for a few days.



State **two** changes that will be **seen** after a few days.

(2)

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(Total for question = 2 marks)

Q4.

A group of students design and carry out experiments to deduce the formulae of two salts, **X** and **Y**.

X contains one cation and one anion.
Y contains water of crystallisation.

(a)(i) A flame test is carried out on **X**.

Describe how to carry out a flame test.

(3)

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(ii) The colour of the flame is yellow.

Give the **formula** of the metal ion present in salt **X**.

(1)

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(b) A sample of **X** is placed in a test tube and dissolved in deionised water. The solution is acidified with hydrochloric acid and barium chloride solution is added.

A white precipitate forms.

(i) Give the **formula** of the anion present in **X**.

(1)

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(ii) Deduce the **formula** of **X**, using your answers to (ii) and (iii).

(1)

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(Total for question = 6 marks)

Q5.

This question is about tests for ions.

A student wrote the following answer to a question about the processes that can give rise to a flame colour during a flame test of an inorganic compound.

"When an inorganic compound is heated, energy is emitted as ions move up energy levels. Electrons return to lower energy levels and release energy as light which is always in the visible region of the electromagnetic spectrum."

Identify **three** errors in this account. Include in your answers a correct word or phrase that should be used instead.

(3)

First error

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Correct word or phrase

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Second error

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Correct word or phrase

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Third error

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Correct word or phrase

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(Total for question = 3 marks)

Q6.

Explain whether magnesium carbonate is more or less thermally stable than barium carbonate.

(3)

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(Total for question = 3 marks)

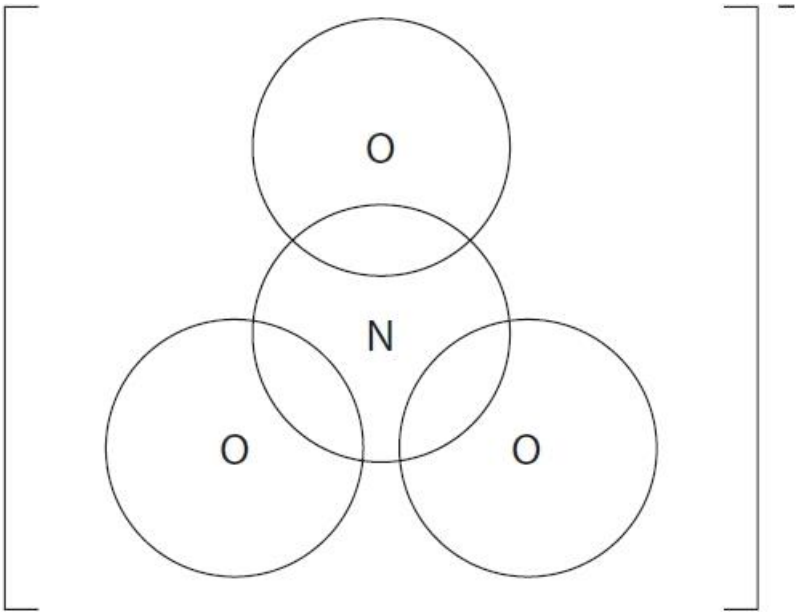
Q7.

This question is about s-block elements and some of their compounds.

The s-block nitrates undergo thermal decomposition.

(i) Draw a dot-and-cross diagram for the nitrate(V) ion, NO_3^-, showing outer electrons only.

(1)



(ii) Write an equation for the thermal decomposition of lithium nitrate.
State symbols are **not** required.

(1)

(iii) The equation for the thermal decomposition of sodium nitrate is different from that for lithium nitrate.

$$NaNO_3(s) \rightarrow NaNO_2(s) + \tfrac{1}{2}O_2(g)$$

The gas produced is collected in a gas syringe.
Calculate the theoretical volume of gas, in **cm^3**, that could be collected at 298 K and 101 kPa by the decomposition of 0.500 g of pure sodium nitrate. Give your answer to 2 significant figures.
[$pV = nRT$, $R = 8.31$ J mol^{-1} K^{-1}]

(4)

(iv) State one reason why the experimental gas volume may differ from the calculated theoretical volume.

Assume that no gas escapes and measurements have been made accurately.

(1)

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(Total for question = 7 marks)

Q8.

This question is about s-block elements and some of their compounds.

A textbook states, 'The thermal stability of Group 1 carbonates is generally higher than the thermal stability of Group 2 carbonates in the same period'.

Explain why Group 1 carbonates are more thermally stable than Group 2 carbonates.

(3)

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(Total for question = 3 marks)

Q9.

The labels on four colourless solutions had fallen off in storage. It was known that the solutions were:

hydrochloric acid	magnesium sulfate
potassium chloride	sodium carbonate

In order to identify each solution, a number of tests were carried out.

(a) Solutions can be sprayed into a flame to produce a flame colour identical to that seen in the more conventional method with a solid on a nichrome wire.

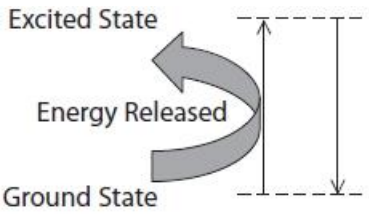
Which solution would produce a lilac flame?

(1)

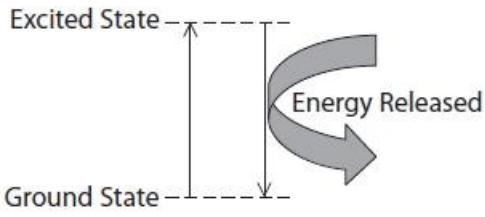
- ☒ **A** hydrochloric acid
- ☒ **B** magnesium sulfate
- ☒ **C** potassium chloride
- ☒ **D** sodium carbonate

(b) Which of the following diagrams best illustrates the electronic transitions that take place during a flame test?

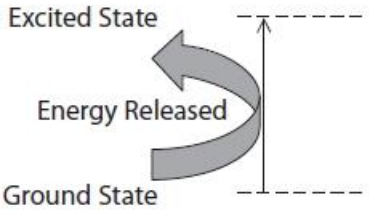
(1)



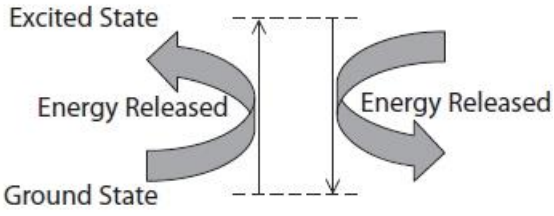
☒ **A**



☒ **B**



☒ **C**



☒ **D**

(c) Which solution produces a white precipitate with acidified barium chloride solution?

(1)

- ☒ **A** hydrochloric acid
- ☒ **B** magnesium sulfate
- ☒ **C** potassium chloride
- ☒ **D** sodium carbonate

(d) Two of the solutions produce the same result on the addition of dilute nitric acid followed by silver nitrate solution.

State the observation with this test and the **two** solutions that give this result.

(2)

Observation

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Solutions

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(e) The hydrochloric acid and the sodium carbonate solution react together. State an observation you would make and write the **ionic** equation for the reaction. State symbols are not required.

(2)

Observation

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Ionic equation

(Total for question = 7 marks)

Q10.

This question is about trends within Group 2 of the Periodic Table.

Describe, with the aid of a labelled diagram, how you would compare the thermal stability of two different Group 2 nitrates using simple laboratory equipment.

Your answer **must** include **one** safety precaution (excluding the use of gloves, laboratory coat
and eye protection).

(4)

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(Total for question = 4 marks)

Q11.

A solid, white, water-soluble compound was thought to be magnesium bromide.
A student carried out tests to confirm the identity of both ions present.

A flame test was carried out to test for the cation.

(i) Describe how a flame test is carried out.

(3)

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(ii) Explain the origin of flame test colours.

(4)

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(iii) Give a reason why the magnesium ion does not produce a flame colour.

(1)

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(iv) Give a reason why the lack of a flame colour is not a positive test for the magnesium ion.

(1)

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(Total for question = 9 marks)

Q12.

Some metal carbonates also undergo thermal decomposition.

(i) Draw a diagram of the apparatus that could be used to compare the ease of thermal decomposition of lithium carbonate, Li_2CO_3, and magnesium carbonate, $MgCO_3$.

(2)

(ii) State **one** way in which you would ensure a fair test.

(1)

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(iii) State how data obtained in this experiment could be used to make a comparison.

(1)

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(Total for question = 4 marks)

Q13.

Explain why magnesium nitrate, $Mg(NO_3)_2$ decomposes more readily on heating than potassium nitrate, KNO_3.

(4)

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(Total for question = 4 marks)

Q14.

The presence of some ions in compounds can be identified using a Bunsen burner flame.

A flame test on a white powder gave a lilac flame colour. Dilute hydrochloric acid was added to a second sample of the same powder in a boiling tube and the gas produced bubbled into limewater. The limewater turned cloudy.

Give a possible **formula** for the white powder.

(2)

(Total for question = 2 marks)

Q15.

Malachite is a green mineral with the formula $Cu_2CO_3(OH)_2$. It has a molar mass of 221 g mol^{-1}.

(i) Describe how you would carry out a flame test on a sample of powdered malachite.

(3)

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(ii) When the atoms of some elements are heated, they produce a characteristic flame colour. For example, the copper in malachite gives a blue-green colour. Explain how atoms of different elements can produce different characteristic flame colours when heated.

(4)

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(Total for question = 7 marks)

Q16.

This question is about flame tests for Group 1 and 2 metal ions.

(i) State the colour of the flame produced by separate samples of potassium and strontium ions.

(1)

Potassium ions
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Strontium ions
.....

(ii) Give a reason why carrying out a flame test on a mixture of potassium chloride and strontium chloride does not
clearly show that two different metal ions are present.

(1)

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(Total for question = 2 marks)

Q17.

This question is about flame tests for Group 1 and 2 metal ions.

In the first stage of the flame test, the nichrome wire is dipped into concentrated hydrochloric acid and then heated in a Bunsen flame.

In the second stage, this nichrome wire is dipped into fresh hydrochloric acid and then into the metal salt to be tested before being reheated in the Bunsen flame.

(i) Give **two** reasons why the wire is made of nichrome and not iron.

(2)

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(ii) Give a reason why the wire is dipped into acid and then heated in the first stage.

(1)

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(iii) State why **fresh** concentrated hydrochloric acid is used in the second stage of the flame test.

(1)

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(iv) State why **hydrochloric acid** is used in the second stage of the flame test.

(1)

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(Total for question = 5 marks)

Q18.

This question is about the chemistry of hydrated magnesium nitrate, $Mg(NO_3)_2.xH_2O$.

Group 2 nitrates decompose when heated.

(i) State **two** observations you would see when hydrated magnesium nitrate is heated.

(2)

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(ii) Explain the trend in thermal stability of Group 2 nitrates.

(3)

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(Total for question = 5 marks)

Q19.

The presence of some ions in compounds can be identified using a Bunsen burner flame.

(i) Some metal ions give characteristic colours in a flame test.

Describe how to carry out a flame test on an unknown solid.

(2)

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(ii) Which of the following ions does **not** give a red flame?

(1)

☒ **A** barium

☒ **B** calcium

☒ **C** lithium

☒ **D** strontium

(iii) Some anions can also be identified by heating in a Bunsen burner flame. A compound heated in a test tube in a Bunsen burner flame gave off a brown gas and caused a glowing splint to relight. The formula of the ion responsible is

(1)

☐ **A** Br^-

☐ **B** NO_2^-

☐ **C** NO_3^-

☐ **D** O^{2-}

(Total for question = 4 marks)

Q20.

An inorganic salt **A** contains one cation and one anion.
The results of two tests on salt **A** are shown in the table.

Test	Observation
Add aqueous sodium hydroxide to solid **A**. Warm the mixture. Test any gas evolved with damp red litmus paper.	A gas was evolved. The gas turned red litmus paper blue.
Add dilute nitric acid followed by aqueous silver nitrate to an aqueous solution of **A**.	A cream precipitate formed.

Deduce the **name** of salt **A**.

(2)

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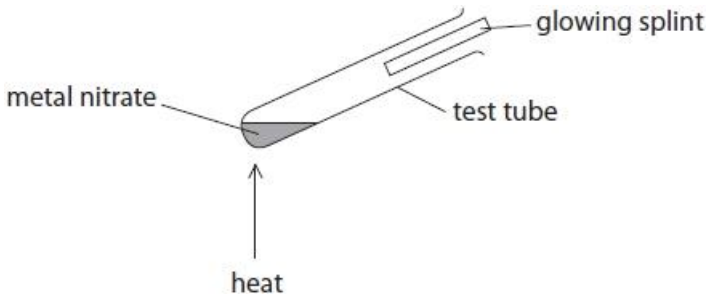
(Total for question = 2 marks)

Q21.

Thermal decomposition is the breaking down of a substance by heat.

An experiment was carried out to investigate the thermal decomposition of a metal nitrate using the apparatus shown.



(i) The glowing splint is used as a test for one of the gases given off in this experiment.
Identify this gas and the positive result of the test.

(1)

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(ii) Give the name and appearance of the other gas given off in this experiment when a Group 2 nitrate is heated.

(1)

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(iii) Write the equation for the decomposition if the Group 1 compound, sodium nitrate, was used in this experiment.
State symbols are not required.

(1)

(iv) Describe the apparatus that would be used to compare the decomposition of metal carbonates. Include how the rate of decomposition would be compared

(2)

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(Total for question = 5 marks)

Q22.

This question is about the thermal stability of Group 1 and Group 2 nitrates and carbonates.

Calcium carbonate is thermally decomposed during the manufacture of cement.

(i) Write an equation, including state symbols, for the thermal decomposition of calcium carbonate.

(1)

(ii) Name all the types of bond present in calcium carbonate.

(1)

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(iii) Give a reason, in terms of the bonding, why a high decomposition temperature is required.

(1)

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(Total for question = 3 marks)

Q23.

Colour is often used in chemistry to identify substances.

Compare and contrast the origin of the colour of a copper(II) complex with the origin of the colour of the copper(II) ion in a flame test.

You do not need to state any specific colours.

(6)

(Total for question = 6 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • (usually carbonates react with acids and) produce a (colourless) gas / CO_2 (which is an expected observation for the test) **(1)** • (but) the barium sulfate produced is insoluble (so the carbonate may appear to not react / not dissolve in acid) **(1)**	Allow effervescence / fizzing / bubbles for observation Allow little / no gas / CO_2 formed when sulfuric acid is used Ignore references to limewater / lighted splint to test for CO_2 Allow a (white) precipitate (of barium sulfate) forms Allow they should have used hydrochloric / nitric acid as the salts formed are soluble Accept bubbles of gas would not be expected because barium sulfate is insoluble for 2 marks	**(2)**

Q2.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • the **outer/ valence** electron is / the **outer electrons** are/ further from the nucleus **(1)** • there is more shielding (from shells of inner electrons) **or** there is an increase in repulsion between the filled inner shells and the electron removed **(1)** • so the (first) ionisation energy decreases (down the group) **and** so the reactivity increases **(1)**	Allow the outer (s) electron is in a higher (quantum) shell / higher energy level Ignore the atomic / ionic radius increases Allow there is reduced attraction between the nucleus and the outer electrons Do not award any reference to charge or charge density for M2 Allow the outer (s) electron(s) are removed more easily / it takes less energy to remove the (outer) electrons **and** so the reactivity increase	**(3)**

Q3.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • (the Universal Indicator changes from green) to blue / purple **(1)** • water level in the test tube drops **or** gas collects at the top of the test tube **(1)**	Allow to dark blue/ blue-green or green-blue Do not award from blue Do not award if the solution is described as 'acidic' or $[H^+]$ increases Do not award any other starting colour Allow water level in the beaker rises Allow hydrogen / H_2 for gas Do not award named incorrect gases (e.g. oxygen/air) Do not award magnesium oxide Do not award magnesium is a white powder Ignore magnesium disappears/dissolves	**(2)**

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to the following points: • any mention of platinum / nichrome wire / loop **(1)** • dip the wire into (clean / fresh concentrated) hydrochloric acid / HCl **(1)** • dip the (wet) wire into the solid and place **in** a (non-luminous / roaring / blue Bunsen) **flame** **(1)**	Allow NiCr for nichrome Allow silica rod Ignore 'inoculating' / 'sterilising' Do not award just nickel or chromium Allow mention of HCl before or after dipping wire into solid e.g. cleaning or mixing solid and HCl to make a paste Ignore concentration of HCl Ignore just 'acid' / other acids specified Do not award HCl reacting with flame test wire Allow salt / compound / paste / sample / solution for solid Allow through the flame / on the edge of the flame for in the flame Do not award element / metal for solid Do not award over / above / under the flame Do not award just 'into a Bunsen' Do not award 'burn in flame' Do not award flame if Bunsen has air-hole closed / safety flame	**(3)**

Question Number	Answer	Additional guidance	Mark
(ii)	• Na^+	Ignore state symbols Ignore sodium / sodium ion Do not award incorrect charge	**(1)**

Question Number	Answer	Additional Guidance	Mark
	SO_{42-} •	Ignore state symbols Ignore sulfate(VI) / sulfate/ sulphate Do not award sulfate(IV) / sulfite / hydrogensulfate Do not award incorrect charge	**(1)**

Question Number	Answer	Additional Guidance	Mark
	Na_2SO_4	Ignore state symbols Ignore names Allow TE from other **ions,** with correct charges, given in (a)(ii) and (b)(i) Allow large numbers e.g. Na2SO4 but not superscripts e.g. Na^2SO^4	**(1)**

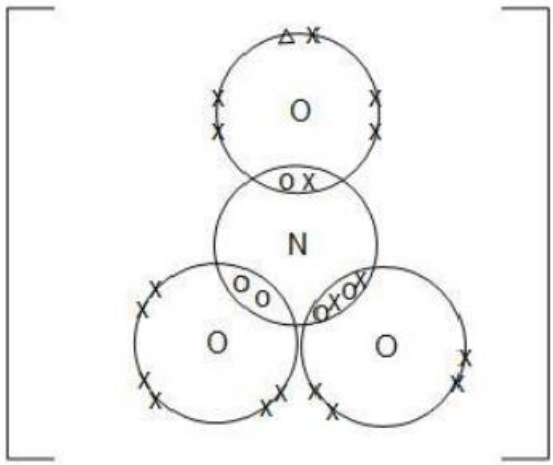
Q5.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • first error: 'emitted' **and** correction: replace with 'absorbed' **(1)** • second error: 'ions (move up)' **and** correction: remove 'ions' replace with 'electron(s)' **(1)** • third error: 'is always' **and** correction: remove 'always' replace with 'may be / sometimes' **(1)**	Allow the three errors in any order The mark is for replacement by 'electron(s)' Allow 'electron(s) **in** ions' Allow expression that implies that the radiation can be emitted as visible light, e.g. 'usually' visible light Do not award 'the error is lower energy levels' replace with return to ground state	**(3)**

Q6.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: (Magnesium carbonate is less thermally stable because) **Size** • the magnesium ion / Mg^{2+} is smaller / has a greater charge density **(1)** **Polarising power** • so more likely to polarise / distort (the carbonate (ion) / anion) **(1)** **Bonds** • and so weaken the C-O bond or the bond(s) within the carbonate ion **(1)**	Allow reverse arguments Ignore reference to 'covalent character' Ignore reference to lattice energies Allow ionic radius of cation increases down the group / charge density of cation decreases down the group Allow magnesium carbonate has a smaller **cation** Allow magnesium ions have fewer shells of electrons Ignore 'magnesium (atom) is smaller' Ignore atomic radius Do not award M1 if mention of different / incorrect charges on magnesium and barium ions Allow 'magnesium ion has more polarising power' Allow polarising power decreases down the group Allow magnesium ion has more electron pulling power on (the carbonate (ion) / anion) Do not award if $MgCO_3$ stated as more stable Allow break (more easily) for weaken Allow C=O bonds for C−O Do not award reference to weakening unspecified bonds Do not award weakening bond between cation and anion	**(3)**

Q7.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• dot-and-cross diagram	 Allow diagrams with all dots/all crosses etc Allow lone pairs with electrons separated Ignore covalent bonds (if shown) 'extra' electron may be shown as different shape, colour etc. The double bond can be to any of the three oxygens	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • balanced equation	<u>Example of equation</u> $2LiNO_3 \rightarrow Li_2O + 2NO_2 + \frac{1}{2}O_2$ Allow multiples of equation Ignore state symbols even if incorrect	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following points: • calculation of moles of sodium nitrate **(1)** • calculation of moles of oxygen **(1)** • substitution in $pV = nRT$ and rearrangement **(1)** • final answer to 2SF only and in cm^3 **(1)**	Example of calculation Ignore SF for M1, M2, M3 except 1SF, penalise once only Moles of sodium nitrate = $0.5 \div 85 = 5.8824 \times 10^{-3}$ (mol) Moles of oxygen gas $O_2 = 5.8824 \times 10^{-3} \div 2$ $= 2.9412 \times 10^{-3}$ (mol) $pV = nRT$ $V = \frac{nRT}{p} =$ $\frac{2.9412 \times 10^{-3} \times 8.31 \times 298}{101000}$ (= 7.21136×10^{-5} m^3) =72 (cm^3) If M2 not divided by 2 then final answer = 140 cm^3 – scores (3) marks. 144 cm^3 – scores (2) marks. Correct final answer with no working scores (4) Allow TE throughout	(4)

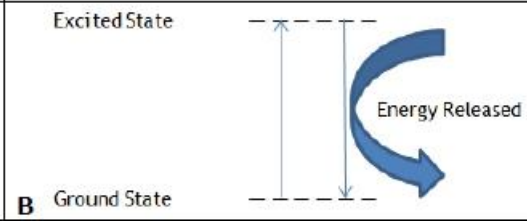
Question Number	Acceptable Answer	Additional Guidance	Mark
(iv)	• incomplete reaction / decomposition	Ignore pressure not 101 kPa or temperature not 298 K Do not award reversible reaction / impure reactant or product / oxygen soluble in water / side reactions	(1)

Q8.

Question Number	Acceptable Answer		Additional Guidance	Mark
	An answer that makes reference to the following points: • Group 2 ions have larger charge (than Group 1 ions) Or Group 2 ions have a 2+ charge and Group 1 ions have a 1+ charge	(1)	Allow the charge density of Group 2 ions is larger (than Group 1 ions) Allow reversed argument for Group 1 ions	(3)
	• Group 2 ions polarise bonds in the carbonate ion more (effectively)	(1)	Ignore reference to size Allow distort / polarise	
	• the C–O/C=O bond is weakened	(1)		

Q9.

Question Number	Answer	Mark
(a)	**C** (potassium chloride)	(1)

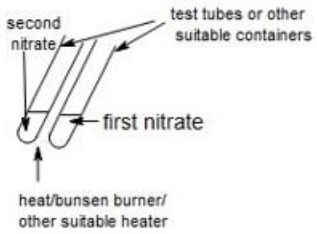
Question Number	Answer	Mark
(b)		(1)

Question Number	Answer	Mark
(c)	**B** (magnesium sulfate)	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)	• (Observation) white **and** precipitate **(1)** • hydrochloric acid **and** potassium chloride **(1)**	Do not allow 'off-white' Allow white solid Allow spelling of 'percipitate' Ignore identity of precipitate even if incorrect Both names are essential but can be in either order. Accept formulae HCl and KCl. Allow A and C. Mark independently	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)	• fizzing/bubbles/effervescence **(1)** $2H^+ + CO_3^{2-} \rightarrow CO_2 + H_2O$ **(1)**	Reject 'solid dissolves'/precipitate forms/ references to hydrogen gas Ignore CO_2/ carbon dioxide/ gas given off Ignore state symbols even if correct	**(2)**

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
	A description that makes reference to the following points: • Workable method + time / compare **(1)**	Examples of workable methods • First one to re-light a glowing splint / produce brown fumes. Accurate timing not essential. • Use of light sensor / meter to measure colour of gas • Use of gas syringe and measure rate of production of gas / time to produce specific volume • Bubble gas into indicator solution – time to change colour • Collection of gases over water and volume measured	**(4)**
	• Same heat applied **(1)**	Reward any workable alternative. e.g. use the same Bunsen Award if implied by diagram	
	• Same amount of each nitrate in separate test tubes **(1)**	Award 'equal masses'.	
		Example diagram:  	
	• safety precaution: fume cupboard/hood **(1)**	Ignore well ventilated room / face mask / goggles / gloves / lab coat This is the only acceptable safety precaution.	

Q11.

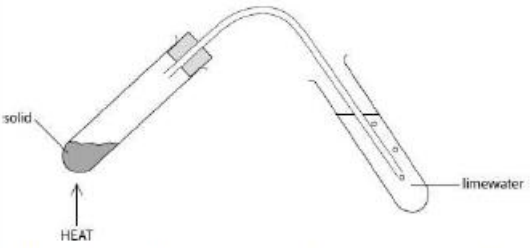
Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: • any mention of platinum/nichrome wire **(1)** • dip the wire into (clean/fresh concentrated) hydrochloric acid **(1)** • dip the (wet) wire into the solid and place in a (non-luminous/roaring/blue Bunsen) flame **(1)**	 Allow NiCr for nichrome Allow silica/magnesia for platinum or nichrome Allow loop / rod for wire Ignore inoculating / flame-test (wire) Allow any mention of HCl(aq) e.g. cleaning or mixing solid and acid or making a paste Allow HCl for HCl(aq) Ignore dilute Allow on / over / under / near / show / above for 'in'	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: • mention of energy or heat or heating (from the flame) **(1)** • electrons promoted to higher energy levels **(1)** • electrons drop down / return (to lower energy levels / ground state) **(1)** • light (in the visible region) is emitted / released / given out **(1)**	 Do not award M1 for "burning" Allow just 'electrons excited' for M2 Allow electromagnetic / e.m. radiation / photons instead of light	**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following point: • no emission of light /energy in the visible region (of the spectrum)	Do not award any mention of (bright) white light emission Allow electromagnetic / e.m. radiation / photons / colour instead of light / energy Allow the light emitted is in the UV or IR Allow any references to frequency or wavelength being too high or too low	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iv)	An answer that makes reference to the following point: • (There are) other ions that do not produce a flame colour	Allow a specific ion that does not have a flame colour e.g. 'beryllium' / Be^{2+} Allow other "elements" do not produce a flame colour Do not award if any references to "burning"	(1)

Q12.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	A diagram of suitable apparatus such that: • a sample of the carbonate can be heated **(1)** • delivery tube into limewater **or** gas collected in gas syringe **(1)**	Example diagram:  Allow the collection of gas over water with measuring cylinder/burette Do not award M1 for heating a conical flask / crucible or for an open tube Do not award M1 for heating in a water bath Do not award M2 if the limewater is in a sealed apparatus	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	Any one from: • same Bunsen setting • same distance between flame and test tube	Ignore reference to 'same apparatus' Allow same depth/volume of limewater / same amount of metal carbonate Do not award same mass / volume (of metal carbonate) Ignore Same amount of heat / same temperature	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(iii)	An answer that makes reference to: • the time taken for the limewater to go cloudy **or** the time for given volume to be produced (for use of syringe)		(1)

Q13.

Question Number	Acceptable Answers	Additional Guidance	Mark
	An explanation that makes reference to the following points: • magnesium ion is smaller (than the potassium ion) **(1)** • magnesium ion has a higher charge (than the potassium cation)/ Mg ion is 2+ but K ion is 1+ **(1)** • magnesium ion polarises nitrate (ion more) / distorts the (electron cloud of) nitrate (ion more) **(1)** • so weakening the **N−O** bonds (more) / so weakening the **nitrate** bonds (more) **(1)**	Penalise the omission of Magnesium ion once only for M1 to M3 Allow for M2: Magnesium ion has a higher charge density Allow description of polarisation Do not award references to molecule Do not award the weakening of bonds in magnesium nitrate	(4)

Q14.

Question Number	Acceptable Answer	Additional Guidance	Mark
	K_2CO_3 / $KHCO_3$ K^+ with any anion **(1)** CO_3^{2-} / HCO_3^- with any cation **(1)**	For 1 mark allow names Award 1 mark for a correct formula containing K^+, HCO_3^- or CO_3^{2-}, eg KCl, or Na_2CO_3 Award 1 mark for an incorrect formula containing both potassium and carbonate/hydrogencarbonate e.g. KCO_3 Do not award any marks for KCO_2 Ignore equations even if incorrect, but award marks for the compound as a reactant.	**(2)**

Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: • any mention of platinum / nichrome wire / loop **(1)** • dip the wire into (clean / fresh concentrated) hydrochloric acid **(1)** • dip the (wet) wire into the solid / sample **and** place in a (non-luminous / roaring Bunsen) flame **(1)**	Allow NiCr for nichrome Ignore inoculating / flame-test (wire) / spatula Do not award just nickel / chromium / Ni / Cr wire Allow any mention of HCl(aq) e.g. cleaning or mixing solid and acid or making a paste / solution Allow HCl for HCl(aq) Ignore dilute Allow on / over / under / near / show / above for 'in' flame	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • electrons move up energy levels /are excited /promoted **(1)** • electrons return to a lower energy level/ground state **(1)** • energy emitted/lost / released from the atom as visible light / flame colour **(1)** • different energy gaps / energy lost / emitted / released (in different elements) so different colours emitted. **(1)**	Penalise use of 'atom' in place of 'electron' once only Allow orbitals/subshells but not just shells Allow radiation for light Allow different amounts of energy are needed to excite the electrons, scores M1 and M4	**(4)**

Q16.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to: • (potassium ions) lilac **and** (strontium ions) crimson / red	Allow scarlet Ignore 'shades' except Do not award 'brick red' / 'orange-red'	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to: • the crimson/red colour will mask/hide/obscure the (lighter) lilac colour	Allow 'one colour will hide the other' Allow only one colour seen Allow difficult to distinguish the two colours Allow TE from colours in (i) Do not award colour from chloride ions Do not award idea of new colour resulting from both Ignore reference to impurities	(1)

Q17.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to: • nichrome produces no colour (when heated in the flame test) **or** iron can produce a colour/sparks **(1)** • nichrome is inert/ stable to heat/unreactive **or** iron reacts with oxygen/air and or hydrochloric acid **(1)**	Allow does not change the flame colour Ignore references to melting/cost Ignore reference to nichrome not being a transition element	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to: • (the wire is heated) to remove the residue of any previous sample being tested	Allow 'to clean the wire' Ignore 'to sterilise/sanitise/disinfect the wire'	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to: • the acid can become contaminated with residue from previous tests (which can give incorrect results)		**(1)**

Question Number	Answer	Additional Guidance	Mark
(iv)	An answer that makes reference to: • (concentrated hydrochloric acid) forms volatile chlorides	Allow (the wire is moistened) to enable some of the solid metal salt to become attached/stick to the wire (and then tested in the Bunsen flame) Do not award reference to bonding or reacting or adsorb or absorb with the wire	**(1)**

Q18.

Question Number	Answer	Additional Guidance	Mark
(i)	Any two observations from • solid dissolves / melts **(1)** • condensation on sides of test tube **(1)** • brown gas/ brown fumes/ brown $NO_2(g)$ produced **(1)** • white solid / powder forms **(1)**	 Do not award magnesium dissolved / just 'solid disappears' Allow 'steam given off' Ignore NO_2 / O_2 / gas given off/ bubbles/ effervescence / gas relights a glowing splint Allow red-brown Ignore 'precipitate' Ignore 'magnesium oxide forms' Do not award 'Mg^{2+} forms'	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • Nitrates increase in stability down Group 2 as ionic radius increases (as you go down group) **(1)** • so polarising ability of metal (ion) decreases / distorts (the electron cloud of) the anion less **(1)** • weakening of N-O bonds (in nitrate ion) is less **(1)**	 Allow charge density decreases as you go down Group 2 Do not award **just** 'atomic radius increases' There has to be a mention of ions somewhere in M1 or M2 Allow reverse argument	**(3)**

Q19.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	A description that makes reference to the following points: • use of a nichrome / platinum wire / ceramic / silica rod **(1)** • use of (conc.) HCl/HCl(aq)/dilute HCl AND dip into the sample and place in / over a (blue) Bunsen burner flame **(1)**	Allow splint, spray method for both marks Reject just 'nichrome', nickel/chromium, inoculation loop, spatula, capillary tubing Reject other acids, just 'acid' Assume blue/roaring flame if not stated but reject use of yellow/safety flame	**(2)**

Question Number	Answer	Mark
(ii)	**The only correct answer is A** ***B*** *is not correct because this would give a red flame (brick red)* ***C*** *is not correct because this would give a red flame (carmine red)* ***D*** *is not correct because this would give a red flame (crimson red)*	**(1)**

Question Number	Answer	Mark
(iii)	**The only correct answer is C** ***A*** *is not correct because bromine is a brown gas, but bromide does not decompose to give it.* ***B*** *is not correct because nitrate(III) not nitrate(V) and does not give* NO_2 *by decomposing* ***D*** *is not correct because* O^{2-} *does not decompose in this way*	**(1)**

Q20.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • ammonium **(1)** • bromide **(1)**	Mark independently Allow names in either order Ignore symbols as well as names Do not award ammonia Do not award bromine Allow (1) for just NH_4Br	**(2)**

Q21.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following point: • (Identity of gas is) oxygen/O_2 **and** (test result is that the splint) relights	Do not award just 'O' Allow 'rekindle'/'reignites'	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following point: • (Identity of gas is) nitrogen dioxide **and** (appearance is) brown (gas/fumes)	If name and formula given then both must be correct Allow NO_2 Do not award NO or N_2O_4 Do not award if liquid referred to Do not award if two gases are given unless one of the gases stated is colourless oxygen Ignore shades of colour	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	• equation	Example of equation $2NaNO_3 \rightarrow 2NaNO_2 + O_2$ Accept multiples Ignore state symbols even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
(iv)	A description that makes reference to following points: • use of a delivery tube to bubble gas into limewater **(1)** • compare the time taken for the limewater to go cloudy **(1)**	Allow annotated diagrams to illustrate the marking points Example of a diagram that could be given credit  Do not award if the apparatus setting would not be feasible such as • missing cork/bung or gaps around delivery tube • horizontal tube with limewater in • bung in the test tube with limewater Allow TE from an incorrect/unsuitable method Allow Any length of time, e.g. 10 minutes	(2)

Q22.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• correct formulae and state symbols of each species	$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	• ionic **and** covalent (bonding)	Ignore reference to single/double/dative	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	• strong bonds within the carbonate ion / CO_3^{2-} /C-O bond / C=O bond	Ignore bonds between the ions / (Ca^{2+} and CO_3^{2-}) are strong	(1)

Q23.

Question Number	Answer	Additional Guidance	Mark
*	This question assesses the 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. Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points 6 / 4 5-4 / 3 3-2 / 2 1 / 1 0 / 0 The following table shows how the marks should be awarded for structure and lines of reasoning Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout / 2 Answer is partially structured with some linkages and lines of reasoning / 1 Answer has no linkages between points and is unstructured / 0	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, a response with four indicative marking points that 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 were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages). If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s). More than one indicative marking point may be made within the same comment or explanation Deduct a reasoning mark if no comparison made Penalise the use of 'atom' instead of ion once only against any indicative point	(6)

	Indicative content Similarities • **(IP1)** the differences in energy levels determines the colour of the flame test and complex ion Differences Flame test • **(IP2) heat** (energy) results in electron promotion • **(IP3)** return of an (excited) electron to a lower (energy) state Complex ion • **(IP4)** d orbitals are split (in energy by the ligands) • **(IP5) light** (energy) is needed for electron promotion • **(IP6)** the colour not absorbed is the colour seen	Ignore incorrect colours This can be mentioned separately or as a comparison Allow electrons excited by **heat** Allow electron is 'de-excited' to a lower (energy) state Do not award if d-d transitions stated Allow d subshell splitting Do not award singular "d orbital" splitting Accept "The colour seen is complimentary to that absorbed" Allow 'colour reflected is the colour seen' Do not award if colour attributed to 'fall' of electron to lower energy d orbital Do not award 'emission of light'	