Group 2

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Group 2
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: **77 minutes**

Score: **/64**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 The elements in Group II, and their compounds, show a variety of trends in their properties.

(a) Magnesium, calcium and barium all react with cold water to form hydroxides.

(i) Describe and explain the trend in reactivity of these three elements with cold water.

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..... [3]

(ii) Give the equation for the reaction of magnesium with cold water.

..... [1]

(iii) Suggest why the water eventually turns cloudy during the reaction of magnesium with cold water.

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..... [1]

(iv) Suggest the equation for the reaction of hot magnesium with steam.

..... [1]

(b) The oxides of magnesium, calcium and barium all react with dilute nitric acid to form nitrates.

(i) Give the equation for the reaction of magnesium oxide with nitric acid.

..... [1]

(ii) State the trend in thermal stability of the nitrates of Group II.

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..... [1]

(iii) Give the equation for the thermal decomposition of magnesium nitrate.

..... [1]

(iv) Apart from lithium nitrate, the nitrates of the Group I elements decompose in a different way to those of the Group II elements.

The equation for the thermal decomposition of potassium nitrate is

$$2KNO_3 \rightarrow 2KNO_2 + O_2$$

By identifying any changes in oxidation number, explain which element is reduced and which is oxidised in this decomposition.

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..... [3]

(c) A refractory material is one that does not decompose or melt at very high temperatures. Over 50% of magnesium oxide production is for use as a refractory material.

Explain why magnesium oxide has a very high melting point.

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..... [2]

(d) The word 'lime' is usually used to refer to a range of calcium-containing compounds that have a range of uses.

(i) Write equations to show how calcium carbonate can be converted into calcium hydroxide by a two-step process.

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..... [2]

A garden pond, with a total volume of 8000 dm^3, has been contaminated in such a way that its pH has fallen to 4. This means that the concentration of hydrogen ions, H^+, in the water is 1×10^{-4} mol dm^{-3}.

(ii) Write an ionic equation for the neutralisation reaction that occurs between hydrogen ions and carbonate ions, CO_3^{2-}.

..... [1]

(iii) Use your equation to calculate the mass of powdered calcium carbonate that would need to be added to the pond to neutralise the acidity.

mass = ... g [2]

[Total: 19]

2 **(a)** Complete the table with the symbol of the ion that contains the number of protons, electrons and neutrons stated in the following table. The first line has been completed as an example.

protons	electrons	neutrons	*symbol*
3	2	4	$^{7}Li^{+}$
15	16	18	

[2]

(b) Describe and explain the trend in the solubilities of the sulfates of the Group II elements down the group.

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..... [4]

(c) Calcium sulfate is sparingly soluble in water.

Describe and explain what you would see when a few cm^3 of concentrated $Na_2SO_4(aq)$ were added to a saturated solution of $CaSO_4(aq)$.

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..... [2]

(d) When a solution of a chromium salt **X** is electrolysed, chromium metal is deposited on the cathode, according to the following equation.

$$Cr^{n+}(aq) + ne^- \rightarrow Cr(s)$$

When a current of 1.8A was passed for 40 minutes through a solution of salt **X**, it was found that 0.776g of chromium had been deposited.

Calculate the value of *n* in the above equation. Show your working.

n = ... [4]

[Total: 12]

3 **(a)** Chlorine exists naturally as a mixture of two isotopes, ^{35}Cl and ^{37}Cl, in the abundance ratio of 3 : 1.

The mass spectrum of chlorine consists of five peaks.

(i) Suggest the mass numbers for these five peaks and the identities of the species responsible.

mass number	formula of species

(ii) Predict the ratios of the abundances of the three species with the highest mass numbers.

ratio of abundances = ...
[4]

(b) Strontium chloride, $SrCl_2$, can be used to produce a red colour in fireworks.

(i) Draw the 'dot-and-cross' diagram for strontium chloride. Show outer shell electrons only.

(ii) Use the following data, together with relevant data from the *Data Booklet*, to calculate a value for the lattice energy of strontium chloride. You may find it helpful to construct a Born-Haber cycle.

electron affinity per mole of chlorine atoms	–349 kJ mol^{-1}
standard enthalpy of atomisation of Sr(s)	+164 kJ mol^{-1}
standard enthalpy of formation of $SrCl_2$(s)	–830 kJ mol^{-1}

lattice energy = ... kJ mol^{-1}
[5]

(c) Strontium nitrate, $Sr(NO_3)_2$, can also be used to produce a red colour in fireworks.

(i) Strontium nitrate can easily be prepared from strontium carbonate, $SrCO_3$.

Suggest an equation for this preparation of strontium nitrate.

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(ii) Write an equation for the reaction that occurs when strontium nitrate is heated.

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[2]

(d) Describe and explain the trend in the thermal stabilities of the nitrates of the Group II elements.

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..... [3]

[Total: 14]

4 **(a)** Gaseous ammonia reacts with gaseous hydrogen chloride to form solid ammonium chloride.

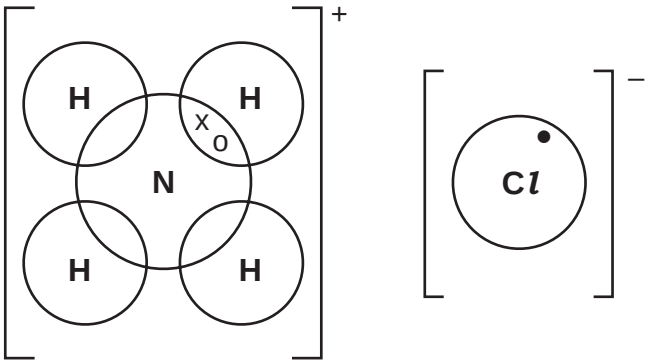
$$NH_3 + HCl \rightarrow NH_4Cl$$

The bonding in ammonium chloride includes ionic, covalent and co-ordinate (dative covalent) bonds.

Complete the following 'dot-and-cross' diagram of the bonding in ammonium chloride. For **each** of the six atoms show **all** the electrons in its outer shell. Three electrons have already been included.

Use the following code for your electrons.

- ● electrons from chlorine
- x electrons from hydrogen
- o electrons from nitrogen



[3]

(b) When a sample of dry ammonia is needed in the laboratory, the gas is passed through a tower containing lumps of solid calcium oxide, CaO.

(i) Suggest why the usual drying agent for gases, concentrated H_2SO_4, is **not** used for ammonia.

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(ii) Write an equation for the reaction between CaO and H_2O.

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(iii) Suggest why CaO rather than MgO is used to dry ammonia.

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[3]

(c) **(i)** Write an equation showing the thermal decomposition of calcium nitrate, $Ca(NO_3)_2$.

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(ii) State and explain how the thermal stabilities of the nitrates vary down Group II.

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[4]

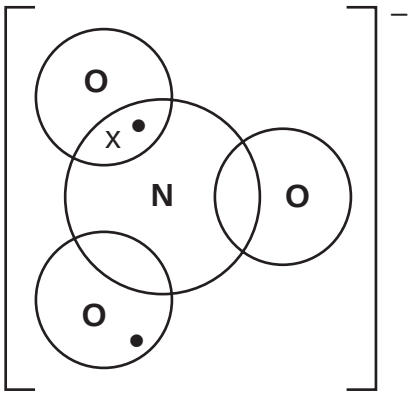
[Total: 10]

5 **(a)** The nitrate ion, NO_3^-, contains a dative covalent bond.

Complete the following 'dot-and-cross' diagram of the bonding in the nitrate ion. For **each** of the four atoms show **all** the electrons in its outer shell. Three electrons have already been included.

Use the following code for your electrons.

- ● electrons from oxygen
- x electrons from nitrogen
- □ added electron(s) responsible for the overall negative charge



[3]

(b) Write an equation showing the action of heat on magnesium nitrate, $Mg(NO_3)_2$.

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(ii) Describe and explain the trend that is observed in the thermal stabilities of the Group II nitrates.

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[4]

(c) When concentrated nitric acid, HNO_3, is added to copper turnings, a brown gas is evolved. Use data from the *Data Booklet* to construct an ionic equation for this reaction.

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[2]

[Total: 9]