Group 2
Question Paper 3

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Group 2
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 3

Time Allowed: **66 minutes**

Score: **/55**

Percentage: **/100**

Grade Boundaries:

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

1 Magnesium, Mg, and radium, Ra, are elements in Group II of the Periodic Table.

Magnesium has three isotopes.

(a) Explain the meaning of the term *isotope.*

....

....

.... [2]

A sample of magnesium has the following isotopic composition by mass.

isotope mass	24	25	26
% by mass	78.60	10.11	11.29

(b) Calculate the relative atomic mass, A_r, of magnesium to **four** significant figures.

A_r = ………………
[2]

Radium, proton number 88, and uranium, proton number 92, are radioactive elements.

The isotope ^{226}Ra is produced by the radioactive decay of the uranium isotope ^{238}U.

(c) Complete the table below to show the atomic structures of the isotopes ^{226}Ra and ^{238}U.

	number of		
isotopes	protons	neutrons	electrons
^{226}Ra			
^{238}U			

[3]

(d) Radium, like other Group II elements, forms a number of ionic compounds.

   (i) What is the formula of the radium cation?

   ………………

   (ii) Use the *Data Booklet* to suggest a value for the energy required to form one mole of the gaseous radium cation you have given in **(i)** from one mole of gaseous radium atoms. Explain your answer.

   ....

   ....

   .... [3]

[Total: 10]

2 Radium was discovered in the ore pitchblende by Marie and Pierre Curie in 1898, and the metal was first isolated by them in 1910.

The metal was obtained by first reacting the radium present in the pitchblende to form insoluble radium sulfate which was converted into aqueous radium bromide. This solution was then electrolysed using a mercury cathode and a carbon anode.

(a) Radium has chemical reactions that are typical of Group II metals and forms ionic compounds.

(i) What is the characteristic feature of the electronic configurations of all Group II metals?

....

(ii) Radium sulfate is extremely insoluble. From your knowledge of the simple salts of Group II metals, suggest another very insoluble radium salt.

....

[2]

(b) During their electrolysis of aqueous radium bromide, the Curies obtained radium at the cathode and bromine at the anode.

Write half-equations for the two electrode reactions that take place during this electrolysis.

anode ....

cathode .... [2]

(c) **(i)** Describe what you would see when magnesium reacts with

cold water, ...

....

steam. ....

....

(ii) Write an equation for the reaction with steam.

....

[5]

(d) Radium reacts vigorously when added to water.

    (i) Write an equation, with state symbols, for this reaction.

       ....

    (ii) State **two** observations that could be made during this reaction.

       ....

       ....

    (iii) Suggest the approximate pH of the resulting solution.

       ………………

    (iv) Will the reaction be more or less vigorous than the reaction of barium with water?
Explain your answer.

       ....

       ....

[6]

[Total: 15]

3 **(a)** Describe and explain qualitatively the trend in the solubilities of the sulfates of the Group II elements.

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....[3]

(b) The major ore of barium is barytes, $BaSO_4$. This is very unreactive, and so other barium compounds are usually made from the sulfide, BaS. This is obtained by heating the crushed ore with carbon, and extracting the BaS with water.

$$BaSO_4(s) + 4C(s) \longrightarrow BaS(s) + 4CO(g)$$
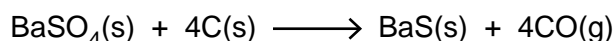
When 250 g of ore was heated in the absence of air with an excess of carbon, it was found that the CO produced took up a volume of 140 dm^3 at 450 K and 1 atm.

(i) Calculate the number of moles of CO produced.

....

(ii) Calculate the number of moles of $BaSO_4$ in the 250 g sample of the ore.

....

(iii) Calculate the percentage by mass of $BaSO_4$ in the ore.

....

[4]

(c) (i) Use the following data and data from the *Data Booklet* to construct a Born-Haber cycle and calculate the lattice energy of BaS.

standard enthalpy change of formation of BaS(s)	−460 kJ mol^{-1}
standard enthalpy change of atomisation of Ba(s)	+180 kJ mol^{-1}
standard enthalpy change of atomisation of S(s)	+279 kJ mol^{-1}
electron affinity of the sulfur atom	−200 kJ mol^{-1}
electron affinity of the S$^-$ ion	+640 kJ mol^{-1}

lattice energy = ... kJ mol^{-1}

(ii) Explain whether the magnitude of the lattice energy of BaS is likely to be greater or less than that of BaO.

....

....

[4]

[Total: 11]

4 **(a)** **(i)** Describe and explain the trend observed in the thermal stability of the carbonates of the Group II elements.

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(ii) By quoting suitable data from the *Data Booklet* suggest how the thermal stabilities of

- zinc carbonate and
- lead carbonate

might compare to that of calcium carbonate.

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[6]

(b) Malachite is an ore of copper. It contains the following percentages by mass.

copper	57.7%
oxygen	36.2%
carbon	5.4%
hydrogen	0.9%

Malachite reacts with dilute H_2SO_4 producing a gas **B** that turns limewater milky and leaving a blue solution **C**.

When heated in the absence of air, malachite produces gas **B** and steam, and leaves a black solid **D**. **D** reacts with dilute H_2SO_4 to produce the same blue solution **C**.

Adding iron filings to **C** produces a pink solid **E** and a pale green solution **F**.

(i) Calculate the empirical formula of malachite.

....

(ii) Suggest the formula of the ion responsible for the blue colour of solution **C**.

....

(iii) Identify the black solid **D** and calculate the mass of **D** that could be obtained by heating 10 g of malachite.

....

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....

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(iv) Use data from the *Data Booklet* to identify the pink solid **E** and the solution **F**, and suggest an equation for the reaction producing them.

....

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(v) What type of reaction is the reaction that produces **E** and **F**?

....

(vi) Describe and explain what you would see happen when dilute NH_3(aq) is added slowly to the solution **C** until it is in an excess.

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[13]

[Total: 19]