Atomic Structure

Question Paper 2

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

Time Allowed: **70 minutes**

Score: **/58**

Percentage: **/100**

Grade Boundaries:

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

1 **(a)** Explain what is meant by the term *nucleon number*.

.....

..... [1]

(b) Bromine exists naturally as a mixture of two stable isotopes, ^{79}Br and ^{81}Br, with relative isotopic masses of 78.92 and 80.92 respectively.

(i) Define the term *relative isotopic mass*.

.....

.....

..... [2]

(ii) Using the relative atomic mass of bromine, 79.90, calculate the relative isotopic abundances of ^{79}Br and ^{81}Br.

[3]

(c) Bromine reacts with the element **A** to form a compound with empirical formula **A**Br_3. The percentage composition by mass of **A**Br_3 is **A**, 4.31; Br, 95.69.

Calculate the relative atomic mass, A_r, of **A**.
Give your answer to **three** significant figures.

A_r of **A** = ... [3]

(d) The elements in Period 3 of the Periodic Table show different behaviours in their reactions with oxygen.

(i) Describe what you would **see** when separate samples of magnesium and sulfur are reacted with oxygen.

Write an equation for each reaction.

magnesium

.....

.....

sulfur

.....

.....
[4]

(ii) Write equations for the reactions of aluminium oxide, Al_2O_3, with

sodium hydroxide,

.....

hydrochloric acid.

.....
[2]

(e) Phosphorus reacts with chlorine to form PCl_5.

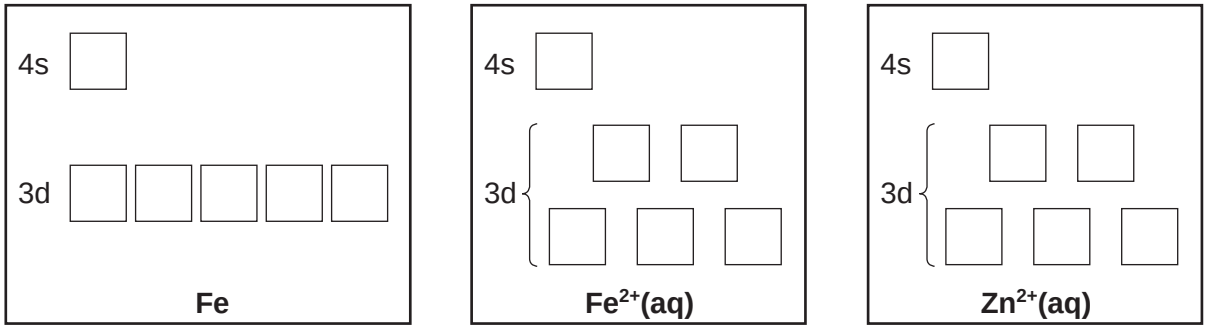
State the shape of and two different bond angles in a molecule of PCl_5.

shape of PCl_5 .....

bond angles in PCl_5 .....
[2]

[Total: 17]

2 (a) (i) On the diagrams below, show the outer electron arrangements of the atoms and ions indicated. (Use the symbol ↓↑ to represent a pair of electrons in an orbital.)



(ii) Use the above diagrams to explain why $Fe^{2+}(aq)$ ions are coloured, whereas $Zn^{2+}(aq)$ ions are colourless.

.....

.....

.....

.....

[4]

(b) When concentrated HC*l* is added to a solution of $Cu^{2+}(aq)$ ions, the solution turns yellow.

(i) State the formula of the species responsible for the yellow colour and name the *type of reaction* that has occurred.

.....

.....

(ii) Ammonia can react as a base or as a ligand.
Describe the colour changes that occur when $NH_3(aq)$ is **gradually** added, with stirring, to the yellow solution, until the $NH_3(aq)$ is in excess.
Identify the **three** ions or compounds responsible for the new colours.

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.....

.....

[7]

(c) When aqueous solutions of KI and $K_2S_2O_8$ are mixed almost no reaction occurs, but when a few drops of $Fe^{2+}(aq)$ or $Fe^{3+}(aq)$ are added, iodine, $I_2(aq)$, is produced at a steady rate.

(i) Write an equation for the overall reaction.

.....

(ii) State the precise role of the iron ions during this reaction.

.....

(iii) By means of equations or otherwise, explain why the presence of *either* Fe^{2+} *or* Fe^{3+} is able to speed up the reaction.

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.....

[3]

[Total: 14]

3 **(a)** Successive ionisation energies for the elements magnesium to barium are given in the table.

element	1st ionisation energy / kJ mol^{-1}	2nd ionisation energy / kJ mol^{-1}	3rd ionisation energy / kJ mol^{-1}
Mg	736	1450	7740
Ca	590	1150	4940
Sr	548	1060	4120
Ba	502	966	3390

(i) Explain why the first ionisation energies decrease down the group.

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.....

.....

..... [3]

(ii) Explain why, for each element, there is a large increase between the 2nd and 3rd ionisation energies.

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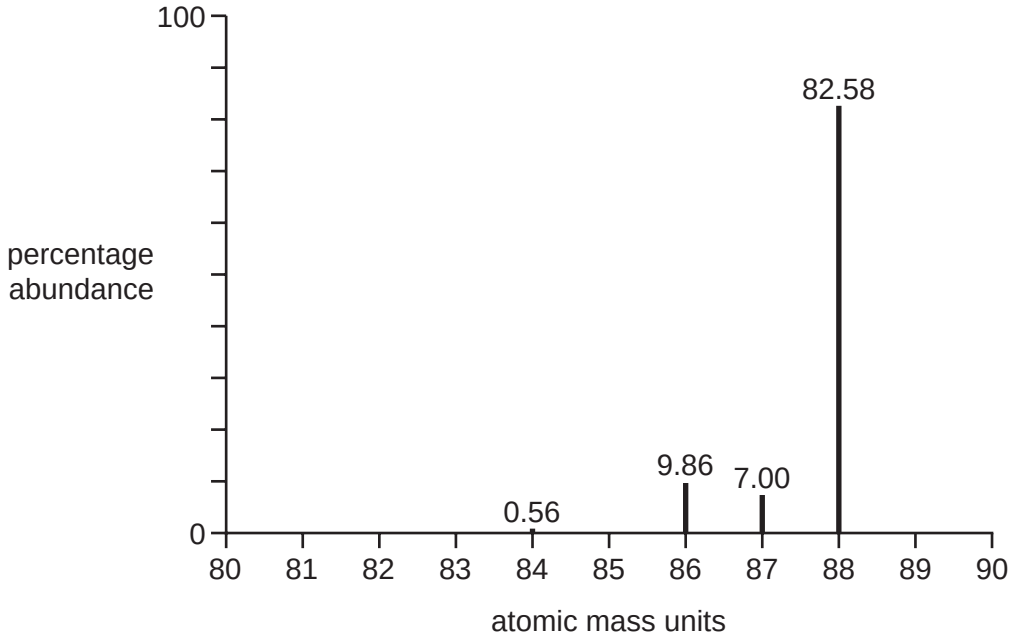
.....

..... [2]

(b) A sample of strontium, atomic number 38, gave the mass spectrum shown. The percentage abundances are given above each peak.



(i) Complete the full electronic configuration of strontium.

$1s^2\ 2s^2\ 2p^6$ ..... [1]

(ii) Explain why there are four different peaks in the mass spectrum of strontium.

.....

..... [1]

(iii) Calculate the atomic mass, A_r, of this sample of strontium.
Give your answer to **three** significant figures.

A_r = ... [2]

(c) A compound of barium, **A**, is used in fireworks as an oxidising agent and to produce a green colour.

(i) Explain, in terms of electron transfer, what is meant by the term *oxidising agent*.

.....

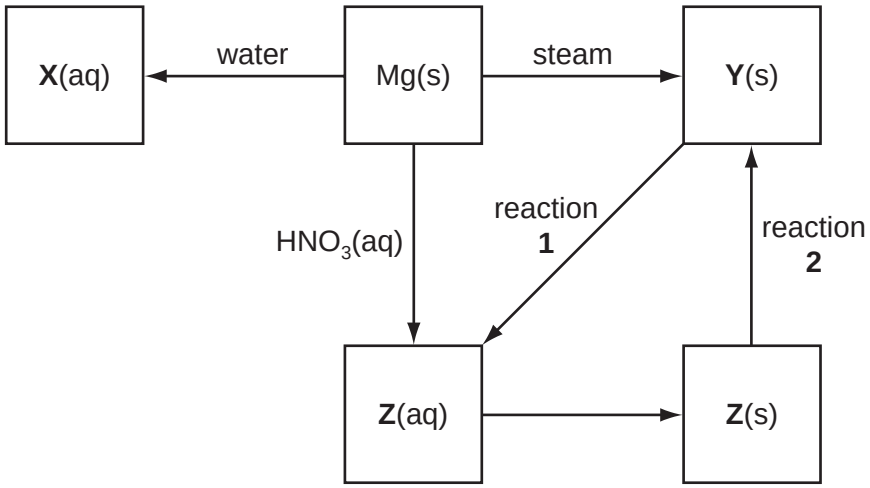
..... [1]

(ii) **A** has the following percentage composition by mass: Ba, 45.1; C*l*, 23.4; O, 31.5.

Calculate the empirical formula of **A**.

empirical formula of **A** ..... [3]

(d) Some reactions involving magnesium and its compounds are shown in the reaction scheme below.



(i) Give the **formulae** of the compounds **X**, **Y** and **Z**.

X .....

Y .....

Z .....

[3]

(ii) Name the reagent needed to convert **Y**(s) into **Z**(aq) in reaction **1** and write an equation for the reaction.

reagent .....

equation .....

[2]

(iii) How would you convert a sample of **Z**(s) into **Y**(s) in reaction **2**?

..... [1]

(iv) Give equations for the conversions of Mg into **X**, and **Z**(s) into **Y**.

Mg to **X** .....

Z to **Y** .....

[2]

[Total: 21]

4 Valence Shell Electron Pair Repulsion theory (VSEPR) is a model of electron-pair repulsion (including lone pairs) that can be used to deduce the shapes of, and bond angles in, simple molecules.

(a) Complete the table below by using simple hydrogen-containing compounds. One example has been included.

number of bond pairs	number of lone pairs	shape of molecule	formula of a molecule with this shape
3	0	trigonal planar	BH_3
4	0		
3	1		
2	2		

[3]

(b) Tellurium, Te, proton number 52, is used in photovoltaic cells.

When fluorine gas is passed over tellurium at 150 °C, the colourless gas TeF_6 is formed.

(i) Draw a 'dot-and-cross' diagram of the TeF_6 molecule, showing outer electrons only.

(ii) What will be the shape of the TeF_6 molecule?

.....

(iii) What is the F–Te–F bond angle in TeF_6?

.....

[3]

[Total: 6]