Oxford Cambridge and RSA

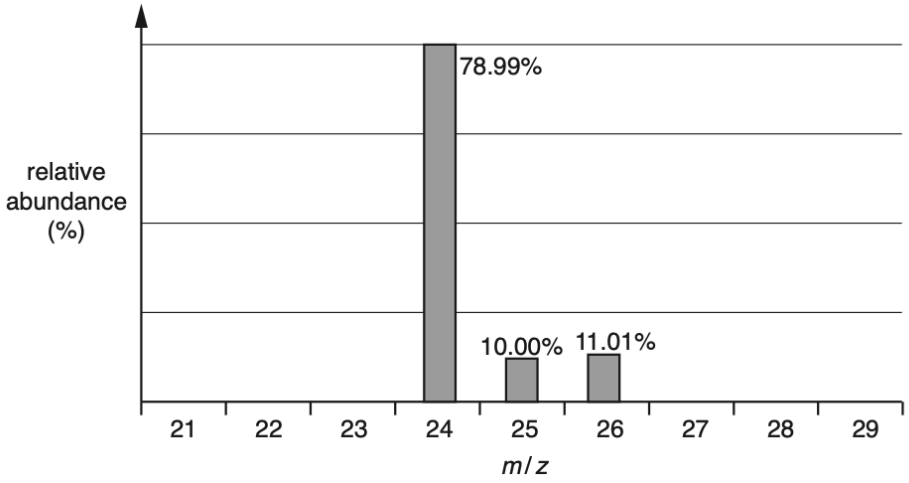
AS Level Chemistry A

H032/01 Breadth in chemistry

Question Set 9

1. This question is about elements from the s-block and p-block of the periodic table.

(a) A sample of magnesium is analysed by mass spectrometry. The mass spectrum is shown below.



(i) The species causing the peaks in the mass spectrum are 1+ ions of magnesium.

Complete the table to show the number of protons, neutrons and electrons in each **1+ ion** of magnesium.

m/z	protons	neutrons	electrons
24	12	12	11
25	12	13	11
26	12	14	11

[2]

(ii) Calculate the relative atomic mass of the magnesium in the sample.

Give your answer to **two** decimal places.

[2]

$$Ar = \frac{(78.99 \times 24) + (10 \times 25) + (11.01 \times 26)}{100}$$

$$Ar = 24.32$$

(b) **B** and **C** are ionic compounds of two different Group 1 elements. The molar masses of **B** and **C** are both approximately 140 g mol^{-1}.

A student dissolves **B** and **C** in water in separate test tubes and analyses the solutions.

The observations are shown below.

Test	Observation	
	B(aq)	C(aq)
Addition of HNO_3(aq)	bubbles CO_3^{2-}	no change
followed by $BaCl_2$(aq)	no change	white precipitate SO_4^{2-}

Use this information and the observations to identify the formulae of **B** and **C.**

Explain your reasoning.

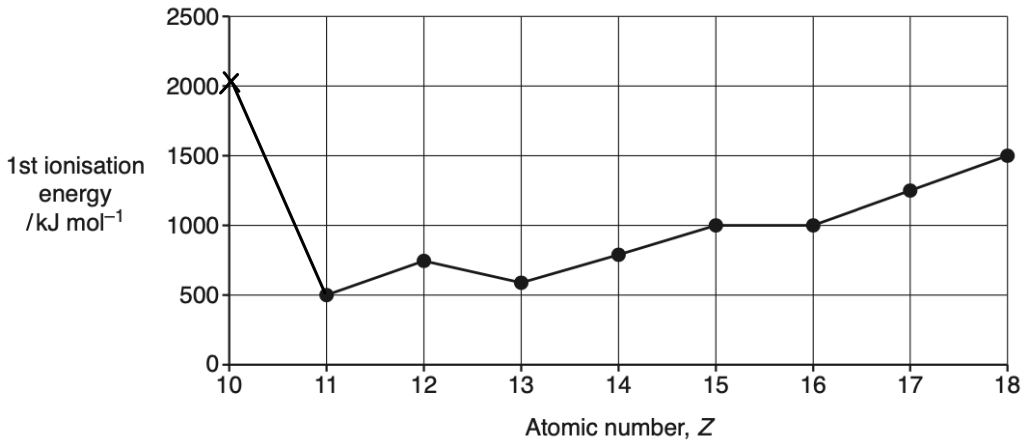
[5]

b) addition of HNO_3 causes bubbling because CO_2 gas is produced
→ group 1 metal carbonate contains CO_3^{2-} ions
Mr of 140 gmol^{-1} : CO_3 = 60
140 − 60 = 80
80 ÷ 2 (because there must be two atoms of the group 1 element).
= 40
= potassium (K)
⇒ B = K_2CO_3

A white precipitate with $BaCl_2$ means $BaSO_4$ is formed ⇒ SO_4^{2-} ions present.

Mr(SO_4^{2-}) = 96
140 − 96 = 44
44 ÷ 2 = 22 = sodium
∴ C = Na_2SO_4

(c) **Fig. 22.1** shows first ionisation energies for elements across Period 3.



(i) Add a point to **Fig. 22.1** for the first ionisation energy of the element with $Z = 10$. **[1]**

(ii) Estimate the energy required to form **one** $Na^+(g)$ ion from one Na(g) atom. Give your answer in kJ, in standard form, and to **two** significant figures. **[1]**

c) ii) $\frac{500}{6.022 \times 10^{23}} = 8.3 \times 10^{-22}$ kJ

↳ I.E is the energy required to remove an electron from each atom in ONE MOLE of atoms .. need to divide by one mole i.e. 6.022×10^{23} **[3]**

(iii) Explain why the first ionisation energies in **Fig. 22.1** show a general increase across Period 3 (Na–Ar). **[2]**

iii) as the atomic number increases the nuclear charge also increases as there are more protons in the nucleus, so the electrostatic attraction between the nucleus and outer electron increases and so more energy is required to remove the outer electron. The shielding remains similar as the number of shells remains the same.

(iv) Explain why the general increase in first ionisation energies across Period 3 is **not** followed for Mg ($Z = 12$) to Al ($Z = 13$).

iv) the outer electron in aluminium is being removed from the 3p orbital whereas the outer electron in magnesium is being removed from the 3s orbital; the 3p orbital is higher in energy than the 3s and so is further away from the nucleus, so less energy is required to remove the outer electron in aluminium so the I.E decreases.

Total Marks for Question Set 9: 11