Empirical formula – Magnesium Oxide

Below is data collected in an experiment investigating the empirical formula of Magnesium oxide.

Table 1. Reaction of $Mg_{(s)} + O_{2(g)} \rightarrow Mg_xO_{y(s)}$

Mass of Crucible with lid	676.54 grams
Mass of Mg reacted	0.18 grams
Mass of crucible, lid, and magnesium oxide	676.84 grams
Mass of Magnesium Oxide	0.30 grams
Mass of Oxide	0.12 grams

1. Determine the mass of Oxide missing from the table. (1 mark)

2. Determine the empirical formula of Magnesium oxide using this data. Show all your working (2 marks)

$\%Mg = \frac{0.18}{0.3} = 60\%$ | $\frac{60}{24.3} = 2.45$ | $\frac{2.45}{2.45} = 1$

$\%O = \frac{0.12}{0.3} = 40\%$ | $\frac{40}{16} = 2.5$ | $\frac{2.5}{2.45} = 1.01$

Mg_1O_1 or MgO

3. Determine the mass of Magnesium that would need to be reacted in order to produce 1.0 grams of oxide.

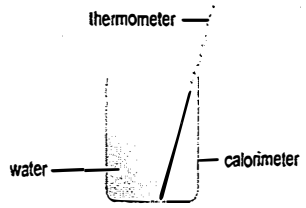
0.12 g of oxide is produced from 0.18g Mg

1 g " " " " " ?

Mass of Mg = $\frac{1}{0.12} \times 0.18 = 1.5$ g of Mg

Calorimetry

A simple calorimeter was set up as shown in the diagram below. The calorimeter was filled with 250 mL of a 1.0 M solution of Iron Chloride ($FeCl_2$), and the temperature was recorded. A small piece (1.5 grams) of calcium metal was added to the calorimeter, and the temperature was recorded every 30 seconds for 15 minutes.



The reaction which occurred was

$$Ca_{(s)} + FeCl_{2(aq)} \rightarrow CaCl_{2(aq)} + Fe_{(s)}$$

The following tablke shows the data collected over the 15 minutes of the experiment

Time (min)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10		11		12		13		14		15
Temp (°C)	25	28	31	34	36	38	39	40	40	39	39	38	39	38	37	37	36	36	36	35	35	34	34	33	32	32	31	30	30	29

1. Determine the temperature change caused by the reaction. Identify if this was an increase or decrease in temperature. (2 marks)

15°C, increase (40°C – 25°C)

2. Identify the reaction as exothermic or endothermic. Justify your answer using data from the question. (2 marks)

Exothermic, The water (surroundings) got hotter because heat was released by the reaction

3. Calculate the change in Enthalpy for the reaction in kJ/mole, assuming that the calcium metal is the limiting reactant. (3 marks)

$Q = mcx\Delta t$ | $n = m/MM$ | $\Delta H = Q/n \times 1/1000$

$= 250 \times 4.18 \times 15$ | $= 1.5/40$ | $= -15675/0.0375 \times 1/1000$

$= -15,675$ J | $= 375$ | $= -418$ kJ/mole

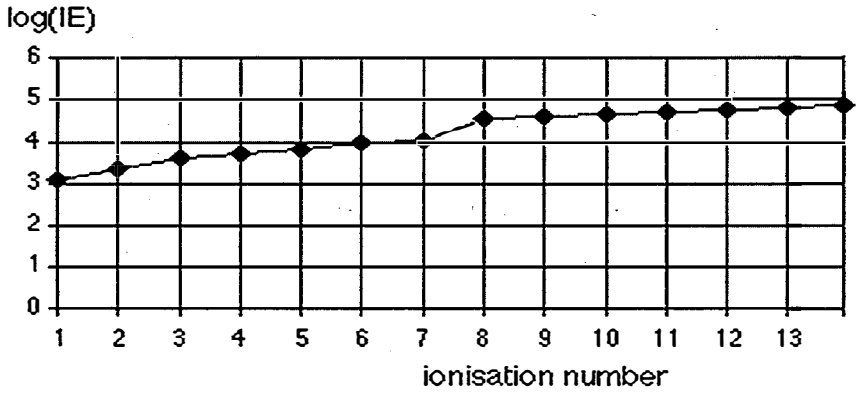
4. Do you consider it likely that the answer to question 3 (the change in enthalpy value) is accurate? Justify your answer using evidence from the question.

No

- Calorimeter does not appear to be insulated so heat would be "lost" to surroundings
- No lid, so ... "as above"
- Not stirred, so temp recording may not represent true temperature.

Successive Ionisation energies

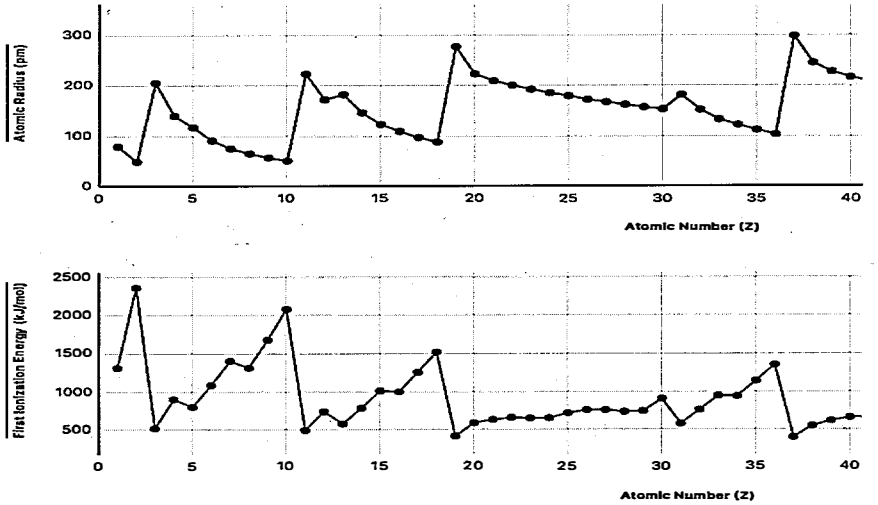
Below is a graph of the first 14 successive ionisation energies of Chlorine.



1. Identify the log value of the 5th ionisation energy. (1 mark)
   3.8
2. Describe the trend between ionisation number and log value for successive ionisation energy (1 mark)
   As ionisation number increases, the log value for successive ionisation energy increases.
3. a. How many electrons are in the valence shell of this atom? Explain your answer using data from the graph. (2 marks)
   7, there is a large jump in I.E after 7e⁻s were removed, indicating there were 7e⁻ in the outermost, valence shell.
   b. Identify the shell number and subshell from which it is easiest to remove an electron from chlorine.
   3rd Shell, p subshell
4. Compare the ionisation energies of the outermost shell of chlorine to the ionisation energy of the next shell.
   I.E of outermost shell are lower than the I.E of the second shell.
5. Predict the log value of the ionisation energy of the 15th electron lost by Chlorine 4.9
6. Identify the evidence in the graph that conclusively identifies this element as Chlorine. Explain using evidence from the graph to support your answer. Large jump in I.E after 7e⁻s indicates 7e⁻ are in the valence shell. This identifies it as a halogen. It cannot be F as there are more than 9e⁻. Could be any other halogen though.

Periodic trends

Below are graphs of two key periodic trends – atomic radii and first ionisation energy.



1. Identify a trend between
   (a) atomic number and Atomic radii (1 mark)
   As atomic No. increases, Atomic radii generally increases.
   (b) Atomic number and first ionisation energy (1 mark)
   As Atomic No. increases, 1st I.E generally decreases
   (c) Atomic radii and first ionisation energy (1 marks)
   As Atomic radii increases, 1st I.E decreases
2. Identify the group of the periodic table which has the highest atomic radii? (1 mark) Alkali Metals. (group 1)
3. Identify the group of the periodic table which has the highest first ionisation energy? (1 mark) Noble gases (group 8.)
4. Compare the first ionisation energy of the element with an atomic number of 15 to the first ionisation energy of the element with an atomic number of 7. (3 marks) The 1st I.E of element 15 is lower than that of element 7. These elements are in the same group, but element 15 is lower in ~~the~~ Group 15. Thus element 15 is larger and valence e⁻s are further from nucleus, with lower 1st I.E