Chapter 1: Moles and equations

Homework questions

1 Calcium is one of the Group 2 metals. It is biochemically important and its most common compounds are important in many industries. When exposed to air calcium readily oxidises to calcium oxide.

Calcium reacts readily with water to form calcium hydroxide and hydrogen.

The equation for the reaction is as follows:

$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$

In two linked experiments to find the relative atomic mass of calcium, 0.51 g of the metal was first added to water and 300 cm^3 of hydrogen was collected. Assume that 1 mol of gas occupies 24 dm^3 at room temperature.

a **i** Calculate the number of moles of hydrogen produced. Show your working. [1]

ii Calculate the number of moles of calcium present in the reaction. Show your working. [1]

iii Hence calculate the relative atomic mass of calcium. [2]

The calcium hydroxide produced was then titrated against standard 1.00 mol dm^{-3} hydrochloric acid. The equation for this reaction is:

$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$

In this particular experiment the volume of hydrochloric acid required to neutralise the calcium hydroxide was 25.80 cm^3.

b **i** Showing all your working, calculate the number of moles of hydrochloric acid used. [1]

ii Calculate the number of moles of calcium hydroxide present and hence the number of moles of calcium. [2]

iii Calculate the relative atomic mass of calcium using these results. [2]

c There are six naturally occurring isotopes of calcium. Their relative isotopic masses and percentage abundances are shown in the table below. Use these values to calculate the relative atomic mass of calcium. Give your results to 2 decimal places. [3]

Relative isotopic mass	40	42	43	44	46	48
Percentage abundance	96.97	0.64	0.15	2.06	0.003	0.19

d **i** Which of the two **laboratory** methods (either that in part **a** or in part **b** above) was the more accurate? Explain your answer. [1]

ii Apart from human error and that due to apparatus, give a possible reason for any inaccuracy in the results. [1]

Total = 14

2 **a** Define the term ‘relative atomic mass’. [3]

b The metal lithium (symbol Li) is one of the alkali metals. Like many elements lithium exists in two isotopic forms, with relative isotopic masses of 6 and 7, respectively. When lithium is analysed using a mass spectrometer the relative atomic mass of lithium is found to be 6.9. Using your definition of relative atomic mass suggest which of the two isotopes is the more abundant. Explain your answer. [2]

c Because of its reactivity lithium is kept under oil. When freshly cut it tarnishes very quickly in air and when added to water it reacts vigorously forming hydrogen gas and an aqueous solution of lithium hydroxide.

In a set of laboratory experiments to find the relative atomic mass of lithium, 0.15 g of the metal were first added to 100 cm^3 of distilled water and the hydrogen collected by downward displacement of water. 245 cm^3 of hydrogen were collected in this way.

i Give the balanced symbol equation for the reaction of lithium with water. [2]

ii Use these results to find the relative atomic mass of lithium. [4]

d In a second experiment the solution of lithium hydroxide remaining was made up to 250 cm^3 with distilled water. 25.0 cm^3 samples of the lithium hydroxide were then titrated against standard 0.100 mol dm^{-3} hydrochloric acid. The reaction that took place was:

$LiOH(aq) + HCl(aq) \rightarrow LiCl(aq) + H_2O(l)$

Several readings were taken and the results are given below:

	Rough	1	2	3
2nd burette reading / cm^3	22.00	43.55	27.90	43.35
1st burette reading / cm^3	0	22.00	5.10	21.80
Titre / cm^3				

i Complete the table of results and give the reading that should be used. [2]

ii Use the results to calculate the relative atomic mass of lithium in g mol^{-1}, giving your reasoning and showing your working. [5]

iii Apart from a burette, name **two** pieces of apparatus that would be used to measure volumes of the solutions in this second experiment. [2]

Total = 20

3 Sodium hydrogencarbonate ($NaHCO_3$), commonly used as baking powder, is a white solid that decomposes when heated to form sodium carbonate solid (Na_2CO_3), water and carbon dioxide.

In an experiment to find the purity of a sample of baking powder, 0.42 g of sodium hydrogencarbonate mixed with some salt (NaCl) was heated strongly. The volume of carbon dioxide formed was 48.0 cm^3.

a Write the symbol equation for the thermal decomposition of sodium hydrogencarbonate. [1]

b **i** How many moles of sodium hydrogencarbonate are there in 0.42 g of **pure** sodium hydrogencarbonate solid? [2]

ii How many moles of carbon dioxide were formed in the decomposition?
(1 mol of gas occupies 24 dm^3 at r.t.p.) [1]

iii Calculate the actual number of moles of sodium hydrogen carbonate present. Show your working. [2]

iv Use your results to calculate the percentage purity of the sodium hydrogencarbonate. [2]

c Calculate the number of moles of sodium carbonate formed in the reaction. Show all your working. [2]

d The sodium carbonate formed dissolved in water and the solution was then titrated against 0.200 mol dm^{-3} hydrochloric acid.

The equation for the reaction is:

$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

Calculate the volume of hydrochloric acid required to react with the sodium carbonate. [2]

Total = 12