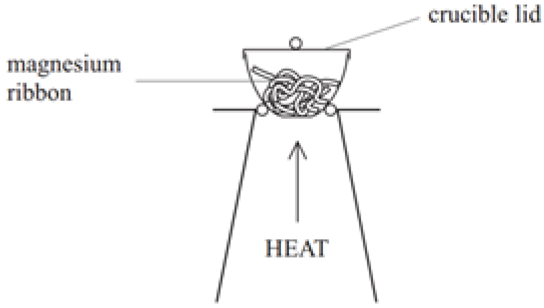
A. Chemical measurements part 1 – Chemical changes and conservation of mass

1. A piece of magnesium was heated in a crucible.



a) Write a balance equation to show how the magnesium reacts with oxygen. (2)
$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ (1 mark for formulae and 1 mark for balancing)

b) The mass of the crucible at the start of the reaction was 0.34g, but 0.56g at the end. Explain why the mass increased. (2)
Oxygen from the air / atmosphere (1) has bonded / reacted with the magnesium (1)

c) The student heated the crucible at the end of the reaction. What could the student do to make sure the reaction is complete? (2)
Reweigh the crucible (1) if the two masses are the same, the reaction is complete (1)

d) Another student heated magnesium carbonate in a similar crucible, with the lid off.
The reaction is shown below:

$$MgCO_3\ (s) \rightarrow MgO\ (s) + CO_2\ (g)$$

Use the reaction to explain whether the mass would increase or decrease. Explain your answer. (3)
The mass will decrease (1) carbon dioxide / as gas (is produced or given off (1) which can escape (1)

B. Chemical measurements part 2 – Relative formula mass

1. Calculate the relative formula mass of Na_2CO_3. (1)
106 (1)

2. Calculate the relative atomic mass of Iron (with 5.8% ^{54}Fe, 91.8% ^{56}Fe, 2.1% ^{57}Fe and 0.3% ^{59}Fe). (2)
Ar of Fe = (5.8 × 54) + (91.8 × 56) + (2.1 × 57) + (0.3 × 58)/100 = 5591.1/100 = 55.9

C. Calculations part 1 – Moles/Quantities/Balancing and Limiting factors (HT)

1. How many moles of sulfur atoms are there in:
   a) 9.8 grams of sulfur? (1)
   0.3 moles (1)
   b) 16 tonnes of sulfur? (where 1 tonne = 1000kg) (1)
   500000 moles (1)

2. What is the mass of:
   a) 0.04 moles of hydrogen H_2? (1)
   0.04 x 2 (1x2) = 0.08g (1)

b) 0.6 moles of sodium nitrate ($NaNO_3$)? (2)

23 + 14 + (16x3) = 85 (1)

0.6x 85 = 51g (1)

3. When calcium reacts with water it forms a solution of calcium hydroxide $Ca(OH)_2$ and hydrogen gas.

   a) Write a balanced symbol equation, including the state symbols to show this equation. (3)

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

   1 mark for symbols, 1 mark for balancing and 1 mark for state symbols

   b) Calculate how much calcium must be added to an excess of water to produce 3.7g of calcium hydroxide (2)

   2.0g (2)

4. What mass of sodium chloride is produced when 5.3g of sodium carbonate reacts with excess dilute hydrochloric acid? (3)

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_20 + CO_2$$

Mr of sodium carbonate = (23x2) +12+(16x3) = 106 [1]

Mr of sodium chloride = 23+35.5 = 58.5 x 2 = 117 [1]

Ratio of sodium chloride to sodium carbonate 117/106

Mass of sodium chloride 5.3 x 117/106 = 5.85g [1]

5. 0.010 moles of C_4H_{10} reacts with oxygen as in the following equation:

$$C_4H_{10} + O_2 \rightarrow \_\_\_CO_2 + \_\_\_H_20$$

1.76g of carbon dioxide and 0.90 of water are produced.

Use this information to work out the balancing numbers for carbon dioxide and water. (4)

4 CO_2 and 5 H_2O

Correct answer with or without working scores 4 marks

If the answer is incorrect award up to 3 marks for the working

Mr CO_2 = 44 and Mr H_2O = 18 (1)

moles CO_2 = 0.040 (1)

moles H_2O = 0.050 (1)

6. 84 tonnes of nitrogen were mixed with 30 tonnes of hydrogen in the following equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

   a) Calculate the number of moles of nitrogen and hydrogen and calculate which reactant is the limiting factor. (3)

   3,000,000 moles of nitrogen (1)

   15,000,000 moles of hydrogen (1)

   (using the 1:3 ratio of $N_2(g)$ + 3 $H_2(g)$) we need 5,000,000 moles of N_2 therefore it is the limiting reactant (1)

b) Calculate the maximum mass of ammonia that can be produced from 42 tonnes of nitrogen. (3)
51 tonnes
correct answer with or without working scores 3 marks
if the answer is incorrect award up to 2 marks for the working
3,000,000 moles of N_2 will give 6,000,000 moles of NH3
M_r NH3 = 17

D. Calculations part 2 – Concentrations of solutions

1. A technician made up a solution of sodium hydroxide by placing 5.00g of solid sodium hydroxide in a flask and adding 100cm^3 of water. She placed in the stopper and shook until the reaction had stopped. What was the concentration of the solution in g/dm^3? (1)
50 g/dm^3 [1]

2. A solution of copper chloride has a concentration of 300g/dm^3. What is the mass of copper chloride in 500cm^3 of the solution? (2)
500/1000 = 0.5 g/dm^3 (1)
300g/dm^3 x 0.5 = 150g (1)

3. **Higher:**
Explain how the mass of a solute and the volume of water effect the concentration of a solution. (2)
A greater mass of solute in a certain volume of water → more concentrated solution, [1]
greater volume of water for a certain mass of solute → less concentrated solution [1]

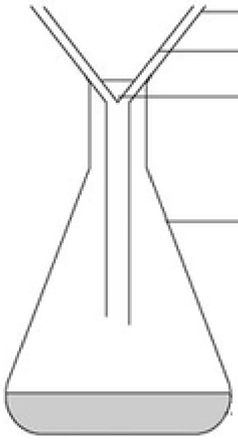
CHEMISTRY ONLY

E. Quantities part 1 – Percentage yield and atom economy

1. Give two possible reasons for the actual yield in a reaction being less that the maximum theoretical yield. (2)
ANY TWO OF:
Some of the product may have been lost when it was separated from the reaction mixture,
The reactants may have reacted in a different way to the expected reaction,
The reaction may be reversible,
Not all the reactants reacted.

2. Magnesium is burnt in air. The theoretical yield of magnesium oxide is 5g, but only 4.5g is produced. What is the percentage yield? (1)
90%

3. Lead nitrate and potassium iodide solutions are mixed to make solid lead iodide. The solid is then separated using the following equipment:



Suggest why the actual yield is less than the theoretical yield. (1)
Some of the product might have stuck to the filter paper/may have been lost (1)

4. **Higher:**
100g of magnesium carbonate is heated. It decomposes to make magnesium oxide and carbon dioxide. Calculate the theoretical yield of magnesium oxide made. (2)

$$MgCO_3 \rightarrow MgO + CO_2$$

M_r of $MgCO_3$ = 24 + 12 + (16x3) = 84
M_r of MgO = 24 + 16 = 40
84g of $MgCO_3$ would make 40 g of MgO (1)
So 200g would make 47.6g (1)

5. Calculate the atom economy for making hydrogen from the following reaction: (1)

$$C(s) + 2H_2O(g) \rightarrow CO_2(g) + 2H_2(g)$$

4/48 x 100 = 8.3%

6. Suggest why industrial processes need as high an atom economy as possible? (2)
ANY TWO OF:
Reduces the production of unwanted products,
Makes the process more sustainable,
So that they can sell it to make money.

F. Quantities part 2 – Moles of solutions and gases (HT)

1. What is the concentration of a solution that has 0.25 mol of solute in $135cm^3$ of solution? (1)

   Concentration = number of moles ÷ volume = 0.25 mol ÷ 0.135 dm^3 = 1.85 mol/dm^3 (1)

2. How many moles of copper sulfate are there in $40cm^3$ of a 0.1 mol/dm^3 solution? (1)

   Number of moles = 0.1 mol/dm^3 × 0.040 dm^3 = 0.0040 mol/dm^3 (1)

3. Calculate the concentration in mol/dm^3 of a solution that has 2 mol of an alkali in 250 cm^3 of solution.(2)

   Concentration = number of moles ÷ volume = 2 mol ÷ 0.250 dm^3 (1) = 8 mol/dm^3 (1)

4. What mass of sodium fluoride (NaF) is in $250cm^3$ of a 2 mol/dm^3 solution? (2)

   Mass of 1 mole of NaF = 23 + 19 = 42 g
   In 1 dm^3 of a 2 mol/dm^3 solution, there are (42 × 2) = 84 g of NaF (1)
   In 250 cm^3, there are 84 g × (250 cm^3 ÷ 1000 cm^3) = 21 g (1)

5. It takes $27.00cm^3$ of hydrochloric acid to neutralise $25.00am^3$ of sodium hydroxide at a concentration on 1.0 mol/dm^3. Calculate the concentration of hydrochloric acid in g/cm^3. (4)

   Number of moles of sodium hydroxide = concentration × volume
   = 1 mol/dm^3 × (25 ÷ 1000) dm^3 = 0.025 mol (1)
   The equation for the reaction shows that 1 mole of sodium hydroxide reacts with 1 mole of hydrochloric acid. So there is 0.025 mol of HCl in 27 cm^3 of solution.
   So the concentration of HCl in mol/dm^3 = number of moles ÷ volume
   = 0.025 mol ÷ (27 ÷ 1000) dm^3 = 0.925 mol/dm^3 (1)
   The mass of 1 mole of HCl is (1 + 35.5) = 36.5 g (1)
   So the concentration in g/dm^3 = 36.5 g/mol × 0.925 mol/dm^3 = 33.8 g/dm^3 (1)

6. Calculate the volume of 0.7 mol of carbon dioxide gas at RTP. (1)

   0.7 x 24 = 16.8 dm^3 (1)

7. What is the volume 12.3g of butane gas (C_4H_{10}) at RTP? (3)

   Mr = 58 (1)
   Moles = 12.3/58 = 0.21 mol (1)
   Volume = 0.21x24= 5.09 dm^3 (1)