CHEMICAL CALCULATIONS

Check List

Make sure you ….

- can define concepts such as concentration, standard solution, moles etc
- can use equations such as $n = \frac{m}{M}$
- can balance chemical equations.

Exam Questions

Question 1

What mass of ammonia will be formed if 112g of nitrogen gas reacts with excess hydrogen to form ammonia? Assume the reaction goes to completion.

The reaction is: $N_2 + 3H_2 \longrightarrow 2NH_3$ (6)

Question 2

Consider the following balanced equation:

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$$

Calculate the mass of SO_2 released if 12,7g copper reacts completely with an excess of sulphuric acid. (8)

Question 3

(Adapted from Grade 11 DoE Exemplar 2013)

Aluminium sulphate is used as a coagulant in water purification. It reacts with sodium hydroxide to form aluminium hydroxide which drags the impurities as it settles.

The balanced equation for the reaction is:

$$Al_2(SO_4)_3(aq) + 6NaOH(aq) \rightarrow 2Al(OH)_3(s) + 3Na_2SO_4(aq)$$

A chemist at a water purification plant adds 700 g of $Al_2(SO_4)_3$ to a sample of water.

3.1. Calculate the maximum mass of $Al(OH)_3$ that can be produced from this mass of $Al_2(SO_4)_3$. (5)

The chemist now dissolves 0,85 mol of Na_2SO_4 in 250 cm^3 of distilled water. He then tops it up with enough distilled water to make a 1 litre solution.

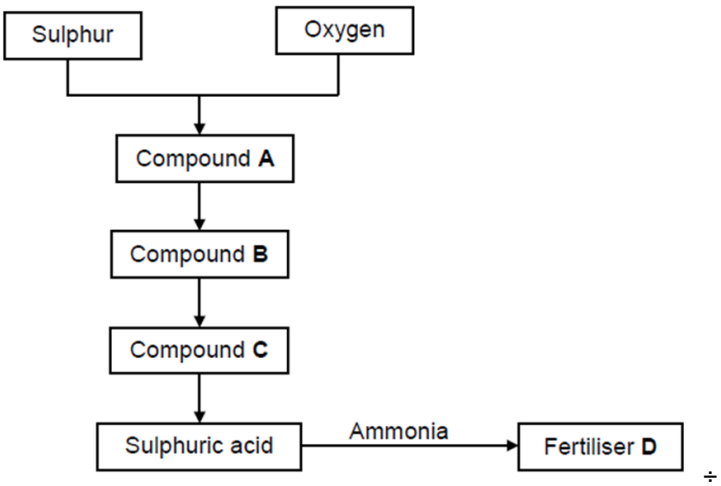
3.2. Define, in word, the term concentration of a solution. (2)

3.3. Calculate the concentration of this Na_2SO_4 solution. (3)

Question 4

(Adapted from Grade 12 DoE Exemplar 2014)

Sulphuric acid is used, amongst others, in the manufacturing of fertilisers. The flow diagram below shows how fertiliser **D** can be prepared using sulphuric acid as one of the reagents.



4.1. Write down the name of the industrial process for the preparation of sulphuric acid. (1)

4.2 An impure sample of 150g of sulphur burns in excess pure oxygen to produce Compound A which is collected and stored in a large cylinder that has a variable volume. At STP the volume of compound A is found to be 95,2 dm^3

4.2.1 Write a balanced chemical equation for the formation of Compound A (2)

4.2.2 Determine the percentage purity of the sample of sulphur (6)

4.3. An analysis of compound C shows that this compound contains hydrogen, sulphur and oxygen. Compound C has a molecular mass of 178 $g.mol^{-1}$ and the following percentage composition:

Hydrogen: 1,12%

Sulphur: 35,96%

Oxygen: 62,92%

4.3.1 Find the empirical formula of compound C (5)

4.3.2 Verify if the molecular formula is the same as the empirical formula (3)

SOLUTIONS TO CHEMICAL CALCULATIONS

Question 1

$$N_2 + 3H_2 \rightarrow 2NH_3$$
$$1 : 3 : 2$$

$n = \frac{m}{M}$ ✓
$= \frac{112}{28}$ ✓
$= 4\ mo$ ✓

$n = 4 \times \frac{2}{1}$
$= 8\ mol$ ✓

$M(NH_3) = 14 + 3(1)$
$= 17\ g.mol^{-1}$

$n = \frac{m}{M}$
$8 = \frac{m}{17}$ ✓
$m = 136g$ ✓

(6)

Question 2

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$$
$$1 : 2 : 1 : 1 : 2$$

$n\ (Cu) = \frac{m}{M}$ ✓
$= \frac{12,7}{63,5}$ ✓
$= 0,2mol$ ✓

$n(SO_2) = 0,2 \times \frac{1}{1}$ ✓
$= 0,2\ mol$

$m = nM$ ✓
$= (0,2)$ ✓$(32 + 2(16))$ ✓
$= 12,8g$ ✓

(8)

Question 3

3.1. $Al_2(SO_4)_3(aq) + 6NaOH(aq) \rightarrow 2Al(OH)_3(s) + 3Na_2SO_4(aq)$

$n(Al_2(SO_4)_3) = \frac{M}{m}$ ✓
$= \frac{700}{342}$ ✓
$= 2,05\ mol$

$n(Al(OH)_3 = 2,05 \times \frac{2}{1}$
$= 4,10$ ✓

$m = nM$
$= (4,10)(78)$ ✓
$= 319,8\ g$ ✓

(5)

3.2. Amount of solute per cubic decimetre of solution ✓✓ (2)

3.3. $c(Na_2SO_4) = \frac{n}{V}$ ✓

$= \frac{0,85}{250\ x\ 10^{-3}}$ ✓
$= 3,40\ mol.dm^{-3}$ ✓

(3)

Question 4

4.1. Contact process ✓

4.2.1 $S + O_2$ ✓→ SO_2 ✓

4.2.2 $n(SO_2) = V \div V_o$ ✓= 95,2 ÷ 22,4 = 4,25mol ✓

n(S) =4,25mol ✓

m(S used) = n.M

= 4,25 x 32

= 136g ✓

% Purity = 136 ÷ 150 ✓

= 90,67% ✓

4.3.1 Find the number of moles of each element in a 100g sample

n(H) = 1,12÷ 1 √ = 1,12
n(S) = 35,96 ÷ 32 = 1,12
n(O) = 62,92 ÷ 16 = 3,93√

Empirical formula is the simplest whole number ratio of the elements present:
H: 1,12 ÷ 1,12√ = 1 x 2 √= 2
S: 1,12 ÷ 1,12 = 1 x 2 =2
O: 3,93 ÷ 1,12 = 3,5 x 2 = 7
Empirical formula is $H_2S_2O_7$√

4.3.2 $M(H_2S_2O_7)$ = 1 x 2 + 32 x 2 + 16 x 7 √= 178g.mol^{-1}√
Empirical formula is the same as the molecular formula for Compound C√