Nat 5: Unit 1 Chemical Changes and Structure

Key Area: Formulae and Reacting Quantities

Lesson 20: Calculations Using the Mole and Balanced Equations

Learning Outcomes

By the end of the lesson you should …

1. Recognise that mathematical skills will be helpful in Chemistry.
2. Be able to calculate mole ratio of substances in balanced equations.
3. Carry out calculations using the mole triangle and proportion.

Success Criteria

You will have been successful in this lesson if you:

1. Successfully complete all self checks evaluating and correcting any errors made.
2. Understand how to calculate the number of moles of a substance required or produced in a chemical reaction.
3. Complete Homework and return to your teacher for correction in the usual way by Fri 5 Mar.

If you have any questions about the content of this lesson, you should ask your **class teacher** either through your class MS team or via email. MS Teams will be monitored throughout the week by a chemistry teacher. If you need help or clarification with either the task or the content of the lesson, just ask.

Links to Prior Knowledge:

It is essential that you have completed **lesson 19**

You may wish to have a copy of the data booklet handy for this lesson.
Download from the SQA website - ChemistryDataBookletSQPN5.pdf (sqa.org.uk)

Calculations Using Balanced Equations

This is the second type of calculation using balanced equations. However unlike the previous examples where we were given a mass of substance and asked to calculate a mass of another, this time we will be given a number of moles of a substance.
Therefore we will work out the mole ratio using simple proportion first and then use our knowledge of the mole triangle to calculate the unknown mass.

Example 1 Methane burns in excess oxygen according to the equation:

$$CH_4 + 2O_2 \text{ ----> } CO_2 + 2H_2O$$

What **mass of water** would be produced if **0.2 mol of methane** was burned?

CH_4	$2\ H_2O$
1 mole	2 mole
1 mole	2 mole
0.2	0.2 x 2 = **0.4 moles**

No need to divide because left hand side is already at 1 mole

Multiply by 0.2

Multiply by 0.2

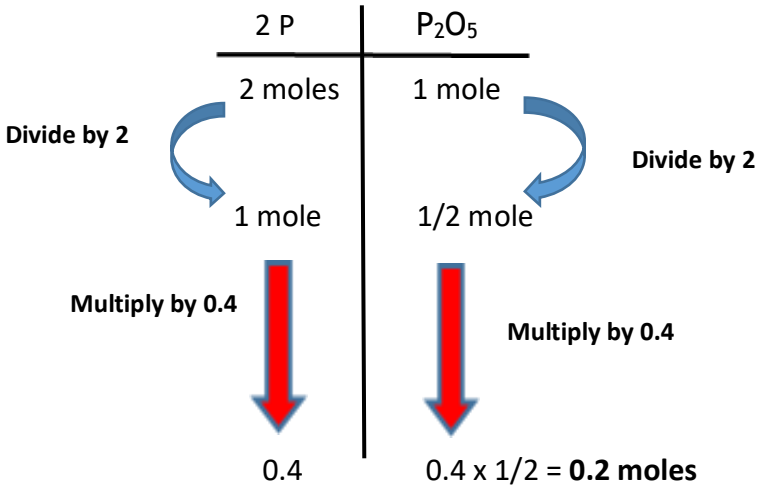
Convert moles to mass (m = n x GFM)

m = 0.4 x 18 = **7.2g**

Example 2 Phosphorous burns in air to form phosphorous (V) oxide according to the equation:

$$2P + 2\ 1/2\ O_2 \text{ ----> } P_2O_5$$

What mass of phosphorous (V) oxide will be produced from 0.4 mol of phosphorous?



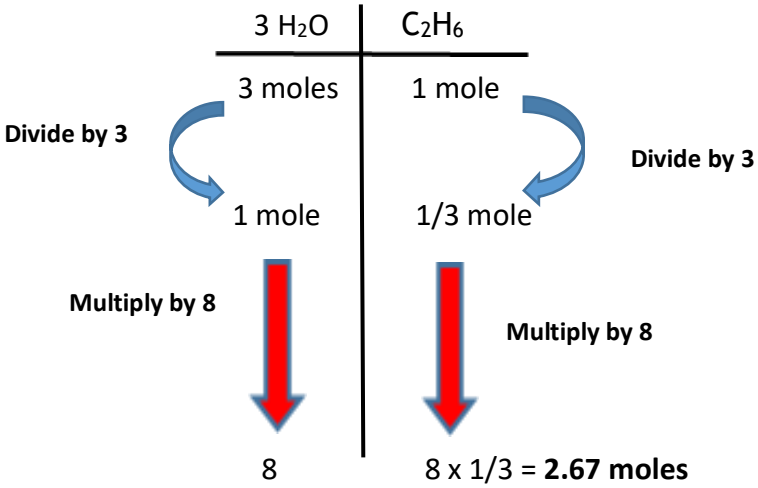
Convert moles to mass (m = n x GFM)

m = 0.2 x 142 = **28.4g**

Example 3 Ethane burns in air according to the equation

$$C_2H_6 + 3^1/_2\ O_2 \text{ ----> } 2CO_2 + 3H_2O$$

What mass of ethane is required to produce 8 moles of water



Convert moles to mass (m = n x GFM)

m = 2.67 x 30 = **80.1g**

Try the next 2 examples on into your jotter. (you don't have to show all the arrows and explanations) However make sure you follow each step very carefully. This is the hardest type of calculation you have come across so far in Nat 5, so take your time with you notes in front of you. You can check your answers and working at the end of this document.

Example 4 What mass of nitrogen hydride is produced when 0.6 moles of hydrogen reacts with excess nitrogen?

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

Example 5 What mass of water is required to produce 1.7 moles of aluminium hydroxide?

$$Al_4C_3 + 12\ H_2O \longrightarrow 4\ Al(OH)_3 + 3\ CH_4$$

Practice Makes Perfect

Once you have read and fully understand the previous information please attempt the following self checks in your jotter.

Self Check 16

1. Methane burns in excess oxygen according to the equation:

$$CH_4 + 2O_2 \text{ ----> } CO_2 + 2H_2O$$

What mass of carbon dioxide would be produced if 0.5 mol of methane was burned?

2. Phosphorous burns in air to form phosphorous (V) oxide according to the equation:

$$2P + 2^1/_2\ O_2 \text{ ----> } P_2O_5$$

What mass of phosphorous will be produced from 3.4 moles of phosphorous(V) oxide ?

3. What mass of oxygen will be produced when 0.5 mol of sodium nitrate is heated given that the equation for the decomposition of sodium nitrate is:

$$NaNO_3 \text{ ----> } NaNO_2 + {}^1/_2\ O_2$$

4. When mercury (II) oxide is heated it decomposes according to the equation:

$$2HgO \text{ ----> } 2Hg + O_2$$

What mass of mercury will be produced when 0.5 mol of mercury (II) oxide is heated.

5. Glucose ($C_6H_{12}O_6$)is converted into alcohol by a reaction called fermentation. A balanced equation for fermentation is shown below

$$C_6H_{12}O_6 \text{ ----> } 2C_2H_5OH + 2CO_2$$

What mass of glucose would produce 0.9 moles of alcohol (C_2H_5OH)?

6. Propane burns in air according to the equation

$$C_3H_8 + 5O_2 \text{ ----> } 3CO_2 + 4H_2O$$

What mass of oxygen will be needed to produce 2.5 moles of water?

7. Nitrogen hydride burns in air as shown

$$2\ NH_3(g) + 2\ ^1/_2\ O_2(g) \rightarrow 2\ NO(g) + 3\ H_2O(g)$$

What mass of water is produced when 0.25 moles of nitrogen hydride reacts?

8. Iron oxide reacts with carbon to form iron carbide and carbon monoxide

$$3\ Fe_2O_3 + 11\ C \rightarrow 2\ Fe_3C + 9\ CO$$

What mass of iron oxide will be required to produce 4 moles of carbon monoxide?

9. Aluminium sulphide reacts with hydrochloric acid to produce hydrogen sulphide as shown

$$Al_2S_3 + 6\,HCl \rightarrow 2\,AlCl_3 + 3\,H_2S$$

What mass of hydrogen sulphide will be produced if excess aluminium sulphide reacts with 1.8 moles of hydrochloric acid?

Homework 8(on next page) to be completed for Fri 5 March

Homework 8

1. A new air bag is being developed for use in cars. In the reaction, butane reacts with an oxide of nitrogen

$$C_4H_{10} + 13N_2O \rightarrow 4CO_2 + 5H_2O + 13N_2$$

Calculate the mass of water produced when 10g of butane reacts.

2. Aluminium reacts to produce aluminium oxide.

$$2Al + 3O_2 \rightarrow Al_2O_3$$

What mass of aluminium will react with 25g of oxygen?

3. When dinitrogen monoxide decomposes it forms a mixture of nitrogen and oxygen.

$$2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$$

Calculate the mass of nitrogen produced when 0.5 moles of dinitrogen monoxide reacts.

4. Nitrogen reacts with iodine as shown

$$N_2 + 3I_2 \rightarrow 2NI_3$$

Calculate the mass of iodine that would produce 0.75 moles nitrogen iodide.

5. Sodium nitrate decomposes to form sodium nitrite and oxygen gas

$$NaNO_3 \rightarrow NaNO_2 + ½O_2$$

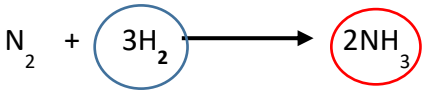
Calculate the mass of oxygen produced from 35g of sodium nitrate.

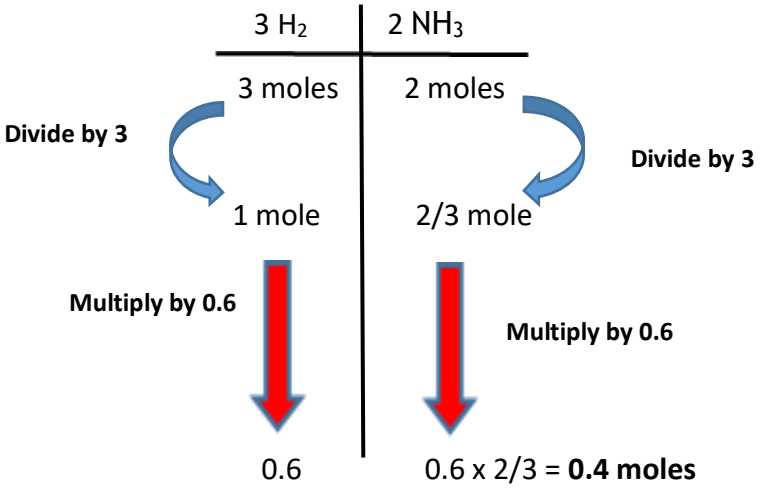
6. Pentane burns in oxygen to produce carbon dioxide and water

$$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$$

What mass of pentane will react with 100g of oxygen?

Example 4 What mass of nitrogen hydride is produced when 0.6 moles of hydrogen reacts with excess nitrogen?

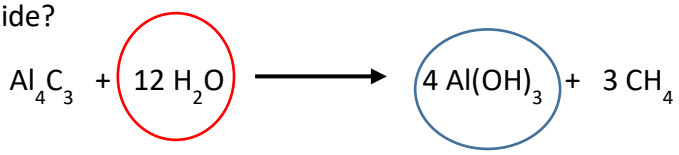


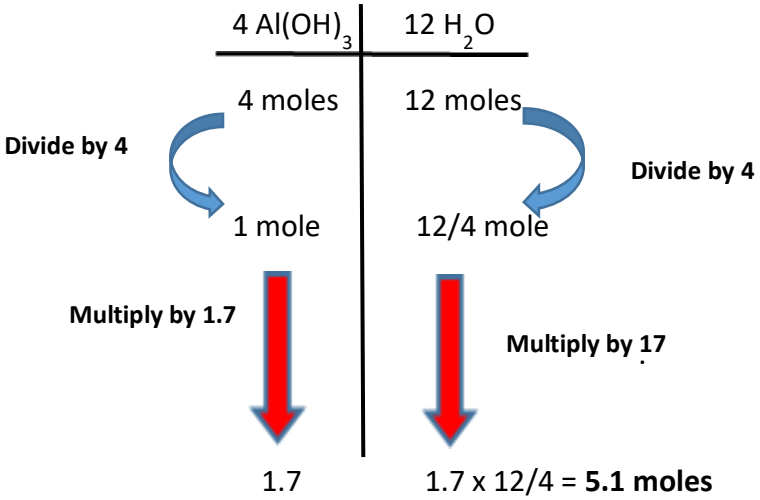


Convert moles to mass (m = n x GFM)

m = 0.4 x 17 = **6.8g**

Example 5 What mass of water is required to produce 1.7 moles of aluminium hydroxide?





Convert moles to mass (m = n x GFM)

m = 5.1 x 18 = **91.8g**