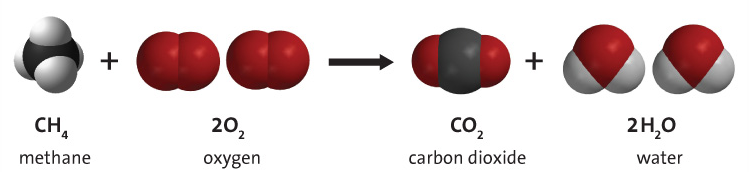
 **NATIONAL 4 AND NATIONAL 5 CHEMISTRY**

**Unit 1: Chemical Changes and Structure**

**Topic 5**

**CHEMICAL FORMULAE &  
REACTION QUANTITIES**

|  |
| --- |
| **Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Class \_\_\_\_\_** |

|  |
| --- |
| Unit 1: Chemical Changes and Structure |
| Topic 5: Chemical Formulae & Reaction Quantities |

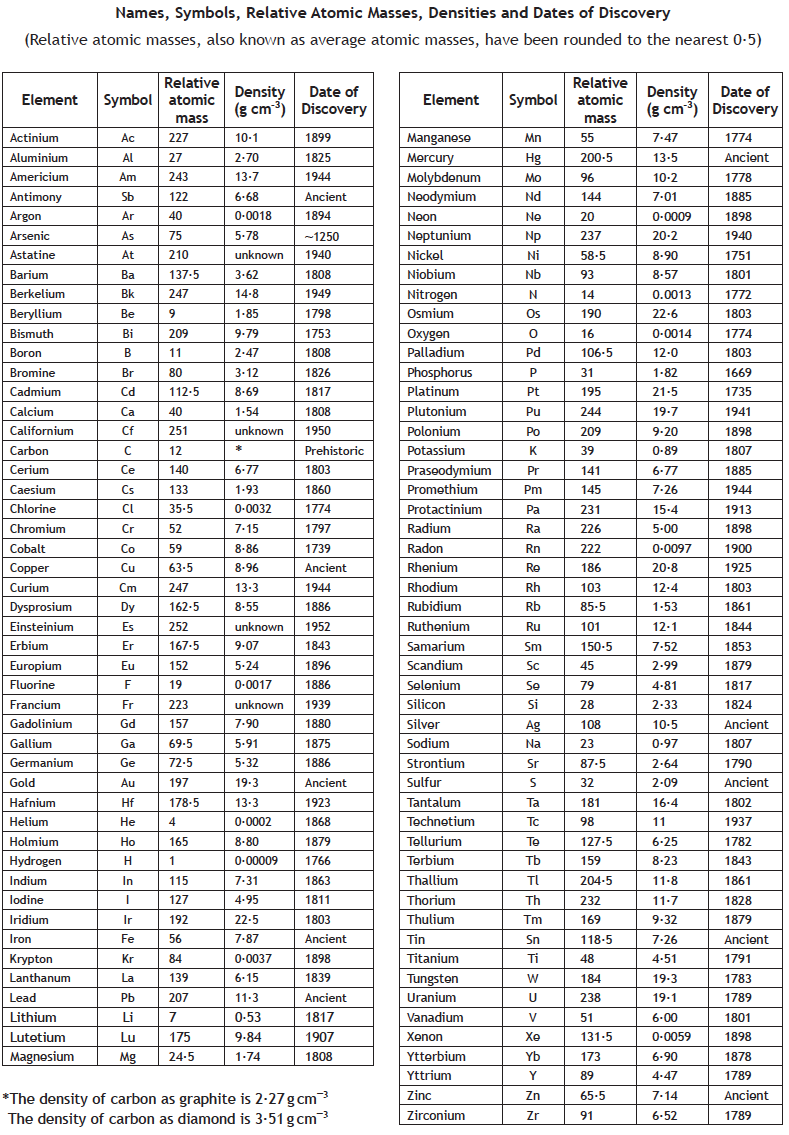
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| LEVEL N4 N5 | **AFTER COMPLETING THIS TOPIC YOU SHOULD BE ABLE TO:** | NOTES (Page) | **How well I have understood (✓)** | | |
| **☺** | **😐** | **☹** |
| N5 | Calculate the formula mass of an element or compound. | 3 - 4 |  |  |  |
| N5 | State that the gram formula mass is the formula mass expressed in grams. | 5 |  |  |  |
| N5 | State that the gram formula mass of any substance is known as one mole. | 6 |  |  |  |
| N5 | Calculate the mass of a given number of moles of a substance. **(Moles to Mass Calculation)** | 7 - 8 |  |  |  |
| N5 | Calculate the number of moles in a given mass of a substance. **(Mass to Moles Calculation)** | 8 - 11 |  |  |  |
| N5 | Calculate the number of moles of a reactant or product in a reaction, using a balanced equation. | 11 - 14 |  |  |  |
| N5 | Calculate the mass of a reactant or product in a reaction, using a balanced equation. | 15 - 20 |  |  |  |
| N5 | State that the concentration of a solution is the number of moles of solute per litre of solution and the unit is written as mol / *l* or mol *l* -1. | 20 |  |  |  |
| N5 | Calculate the concentration of a solution from the number of moles of solute and the volume of solution. **(Moles to Concentration Calculation)** | 21 - 22 |  |  |  |
| N5 | Calculate the number of moles of solute in a solution from its concentration and volume. **(Concentration to Moles Calculation)** | 22 - 23 |  |  |  |
| N5 | Calculate the concentration of a solution from the mass of solute and the volume of solution. **(Mass to Concentration Calculation)** | 25 - 27 |  |  |  |
| N5 | Calculate the mass of solute in a solution from its concentration and volume. **(Concentration to Mass Calculation)** | 27 - 28 |  |  |  |
| N5 | Calculate the concentration of a reactant using information from a titration. **(Volumetric Calculation)** | 29 - 32 |  |  |  |
| N5 | Calculate the percentage mass of an element in a compound. | 33 - 34 |  |  |  |

|  |  |  |
| --- | --- | --- |
| **N5** | **FORMULA MASS** | **N5** |

**RELATIVE ATOMIC MASS**

The average mass of an atom is called the **RELATIVE ATOMIC MASS**.

The relative atomic mass of selected elements is listed in the chemistry data booklet.



|  |  |
| --- | --- |
| **ATOM** | **RELATIVE ATOMIC MASS** |
| hydrogen  **H** | 1 |
| oxygen  **O** | 16 |
| chlorine  **Cl** | 35.5 |

**MASS OF A FORMULA**

The total mass of all the atoms in a formula is called the **FORMULA MASS.**

**12**

**35.5**

**Cl**

**Cl**

**C**

**Cl**

**Cl**

**carbon chloride (CCl4)**

**35.5**

**35.5**

**35.5**

**154**

HOW TO CALCULATE A FORMULA MASS

**32**

**O**

**O**

**16**

**16**

**R A M**

**oxygen gas**

**(O2)**

**FORMULA MASS**

**O**

**H**

**H**

**1**

**1**

**water**

**(H2O)**

**16**

**18**

**1.** Write the formula of the substance.

**2.** Make a list of the different elements in the substance. The list should include how many atoms of each element are present. In formulas, which use brackets, a number outside the brackets multiplies the number of atoms inside the brackets.

**3.** Using the table of relative atomic masses in the data booklet, calculate the mass of each element in the compound.

**4.** The total of the relative atomic masses is the formula mass.

**5.** Theformula mass is just a number, it does not have units.

**Example:** Calculate the formula mass of glucose, C6H12O6.

**C6H12O6**

6 oxygen atoms = 6 × O = 6 × 16 = 96

12 hydrogen atoms = 12 × H = 12 × 1 = 12

6 carbon atoms = 6 × C = 6 × 12 = 72

**Formula mass = 180**

**Example:** Calculate the formula mass of ammonium sulfate, (NH4)2SO4.

**(NH4)2SO4**

4 oxygen atoms = 4 × O = 4 × 16 = 64

1 sulfur atom = 1 × S = 1 × 32 = 32

8 hydrogen atoms = 8 × H = 8 × 1 = 8

2 nitrogen atoms = 2 × N = 2 × 14 = 28

**Formula mass = 132**

TRY THESE EXAMPLES

Calculate the formula mass of each of the following :  
  
**1.** chlorine [Cl2] **2.** hexane [C6H14] **3.** magnesium hydroxide [Mg(OH)2]

**4.** ammonium phosphate [(NH4)3PO4] **5.** aluminium carbonate [Al2(CO3)3]

**Answers:** **1.** [71] **2.** [86] **3.** [58.5] **4.** [149] **5.** [234]

|  |  |  |
| --- | --- | --- |
| **N5** | **GRAM FORMULA MASS** | **N5** |

The **gram formula mass** is the **mass of a formula written in grams**.

In these notes the **gram formula mass** will be written as the capital letter **“G”** for short in further calculations.

HOW TO CALCULATE GRAM FORMULA MASS

1. Follow the same steps as formula mass.

2. When you calculate the total mass write in **“g” (for grams)** after the number.

**Example:** Calculate the **gram formula mass** of glucose, C6H12O6.

**C6H12O6**

6 oxygen atoms = 6 × O = 6 × 16 = 96

12 hydrogen atoms = 12 × H = 12 × 1 = 12

6 carbon atoms = 6 × C = 6 × 12 = 72

**Gram formula mass = 180 g**

**Example:** Calculate the **gram formula mass** of ammonium sulfate, (NH4)2SO4.

**(NH4)2SO4**

4 oxygen atoms = 4 × O = 4 × 16 = 64

1 sulfur atom = 1 × S = 1 × 32 = 32

8 hydrogen atoms = 8 × H = 8 × 1 = 8

2 nitrogen atoms = 2 × N = 2 × 14 = 28

**Gram** **formula mass = 132 g**

TRY THESE EXAMPLES

Calculate the gram formula mass (**G**) of each of the following:  
  
**1.** oxygen [O2] **2.** sucrose [C12H22O11] **3.** calcium carbonate [CaCO3]

**4.** iron(III) sulfate [Fe2(SO4)3] **5.** ammonium nitrate [NH4NO3]

**Answers:** **1.** [32 g] **2.** [342 g] **3.** [100 g] **4.** [400 g] **5.** [80 g]

|  |  |  |
| --- | --- | --- |
| **N5** | **THE MOLE** | **N5** |

In chemistry the **gram formula mass** **(G)** of a substance is called **THE MOLE**.

In these notes the **MOLE** will be written as the letter **“n”** for short in further calculations.

**COPPER(II) SULFATE**

**(CuSO4)**

**CARBON**

**(C)**

**WATER**

**(H2O)**

**G = 159.5 g**

**G = 12 g**

**G = 18 g**

**1 mole**

**= 159.5 g**

**1 mole**

**= 18 g**

**1 mole**

**= 12 g**

**MOLES TO MASS CALCULATION**

**1 mole = gram formula mass (G)**

**HOW TO CALCULATE THE MASS OF A GIVEN NUMBER OF MOLES**

1. Calculate the gram formula mass **(G)** of the substance - this is 1 mole of the substance.

2. Multiply the gram formula mass **(G)** by the number of moles **(n)**.

**Example:** Calculate the mass of 3 mole of sodium carbonate, Na2CO3.

**Na2CO3**

3 oxygen atoms = 3 x O = 3 x 16 = 48

1 carbon atom = 1 x C = 1 x 12 = 12

2 sodium atoms = 2 x Na = 1 x 23 = 46

**Gram** **formula mass = 106 g**

1 mole of Na2CO3 = 106 g

Therefore, 3 mole of Na2CO3 = 3 × 106 g = **318 g**

**Example :** Calculate the mass of 0.25 mole of carbon dioxide, CO2.

**CO2**

2 oxygen atoms = 2 x O = 2 x 16 = 32

1 carbon atom = 1 x C = 1 x 12 = 12

**Gram** **formula mass = 44 g**

1 mole of CO2 = 44 g

Therefore, 0.25 mole of CO2 = 0.25 x 44g = **11 g**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SUMMARY** | | | | | |
|  | **m** | **=** | **n** | **×** | **G** |
|  | **Mass of substance.** |  | **Number of moles.** |  | **Gram formula mass.** |

TRY THESE EXAMPLES

Calculate the mass **(m)** of each of the following:

**1.** 2 moles of iron [Fe]

**2.** 0.1 mole of nitrogen [N2]

**3.** 1.5 moles of sodium oxide [Na2O]

**4.** 0.75 moles of zinc nitrate [Zn(NO3)2]

**5.** 4.7 moles of sodium hydroxide [NaOH]

Answers : **1.** [112 g] **2.**  [2.8 g] **3.** [93 g] **4.** [142.13 g] **5.** [188 g]

**MASS TO MOLES CALCULATION**

**HOW TO CALCULATE THE NUMBER OF MOLES IN A GIVEN MASS**

To calculate the mass (**m**) of a given number of moles (**n**) of a substance:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **m** | **=** | **n** | **×** | **G** |

To calculate the number of moles (**n**) of a substance in a given mass (**m**) the equation has to be rearranged.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **n** | **=** |  |  |  |

To calculate the number of moles (**n**) of a substance in a given mass (**m**), divide the mass of substance (**m**) by the gram formula mass (**G**).

**Example :** Calculate the number of moles of methane, CH4, in 4 g.

**CH4**

4 hydrogen atoms = 4 x H = 4 x 1 = 4

1 carbon atom = 1 x C = 1 x 12 = 12

**Gram** **formula mass (G) = 16g**

16 g of CH4 = 1 mole

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Therefore the number of moles in, 4 g of CH4: |  | **n** | = |  |
|  |  |  | = |  |
|  |  |  | = | **0.25 mole** |

**Example:** Calculate the number of moles of magnesium sulfate, MgSO4, in 180.75 g.

**MgSO4**

4 oxygen atoms = 4 x O = 4 x 16 = 64

1 sulfur atom = 1 x S = 1 x 32 = 32

1 magnesium atom = 1 x Mg = 1 x 24.5 = 24.5

**Gram** **formula mass (G) = 120.5 g**

120.5 g of MgSO4 = 1 mole

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Therefore the number of moles in, 180.75 g of MgSO4: |  | **n** | = |  |
|  |  |  | = |  |
|  |  |  | = | **1.5 mole** |

TRY THESE EXAMPLES

Calculate the number of moles **(n)** in :

**1.** 28 g of silicon [Si]

**2.** 40 g of bromine [Br2]

**3.** 36 g of water [H2O]

**4.** 33.3 g of calcium chloride [CaCl2]

**5.** 456.25 g of nickel(II) nitrate [Ni(NO3)2]

**Answers :** **1.**  [1 mole] **2.** [0.25 mole] **3.** [2 mole] **4.** [0.3 mole] **5.** [2.5 mole]

**SUMMARY OF MOLE CALCULATIONS**

The two calculations can be summed up using the following triangle.

**m**

**n**

**G**

**number of moles**

**gram formula mass of substance**

**mass of substance**

**MOLE and MASS TRIANGLE**

|  |  |
| --- | --- |
| To calculate the mass (m) of a given number of moles (n) cover the m. **m**  **n**  **G** m = n × G | To calculate the number of moles (n) of a given mass (m) cover the n. **m**  **n**  **G** n = |

TRY THESE EXAMPLES

Use the mole and mass triangle to calculate the answers to the following questions.

1. Calculate the mass of 4 mole of butane [C4H10].

2. Calculate the number of moles of water [H2O] in 6 g.

3. Calculate the number of moles of oxygen [O2] in 6.4g.

4. Calculate the mass of 0.125 mole silver(I) nitrate [AgNO3]

5. Calculate the number of moles of ammonium sulfate [(NH4)2SO4] in 693 g

# Answers : 1. [232 g] 2. [0.33 mole] 3. [0.2 mole] 4. [21.25 g] 5. [5.25 mole]

|  |  |  |
| --- | --- | --- |
| **N5** | **THE MOLE & REACTION QUANTITIES** | **N5** |

# BALANCED EQUATIONS

# A balanced equation shows the number of moles of each reactant and product in a reaction.

# Here is the balanced equation for the combustion of hydrogen.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **2 H2** | **+** | **O2** |  | **2H2O** |
|  |  | **+** |  |  |  |
| **MOLE QUANTITY** | **2 mole** |  | **1 mole** |  | **2 mole** |

# The balanced equation shows that 2 mole of hydrogen (H2) reacts with 1 mole of oxygen (O2) to produce 2 mole of water (H2O).

# In a reaction the ratios of the number of moles is always maintained.

# 

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **2 H2** | **+** | **O2** |  | **2H2O** |
|  | **2 mole** |  | **1 mole** |  | **2 mole** |
| **Therefore:** | 1 mole |  | 0.5 mole |  | 1 mole |
|  | 4 mole |  | 2 mole |  | 4 mole |
| **Mole Ratio:** | **2** | **:** | **1** | **:** | **2** |

# 

# 

# Example: The balanced equation below shows the reaction between magnesium and oxygen.

# Calculate the number of moles of magnesium oxide formed when 0.4 mole of magnesium reacts.

# 

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Balanced equation.** | **2 Mg** | **+** | **O2** |  | **2MgO** |
| **Insert the number of moles of the substances mentioned in the question.** | **2 mole** |  |  |  | **2 mole** |
| **Insert the number of moles given in the question.** | **0.4 mole** |  |  |  | **0.4 mole** |
|  |  | **Look at the mole ratios in the reaction, work out the answer.** | | |  |
|  |  | **Answer: 0.4 mole** of magnesium oxide. | | | |

# Example: The balanced equation below shows the combustion of ethane [C2H6]. Calculate the number of moles of oxygen required to burn 0.4 mole of ethane.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2 C2H6** | **+** | **7 O2** |  | **4 CO2** | **+** | **6H2O** |
| Insert the number of moles given in the question.  | **2 mole** |  | **7 mole** |  |  |  |  |
| **0.4 mole** |  | **? mole** |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Looking at the mole ratios in the reaction, work out the answer using a direct proportion calculation. | We know, **2** **mole** C2H6 requires | | | |  | **7** **mole** O2 | |
| Therefore, **1** **mole** C2H6 requires | | | |  | **mole** O2 | |
| Therefore, **0.4** **mole** C2H6 requires | | | |  | **× 0.4** | |
|  | | | | **Answer: =** | **1.4** **mole** O2 | |

# Example: Aluminium oxide reacts with magnesium as shown in the equation below.

# Calculate the number of moles of magnesium needed to produce 25 mole of aluminium.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Al2O3** | **+** | **3 Mg** |  | **2 Al** | **+** | **3 MgO** |
| Insert the number of moles given in the question.  |  |  | **3 mole** |  | **2 mole** |  |  |
|  |  | **? mole** |  | **25 mole** |  |  |
|  |  |  |  |  |  |  |  |
| Looking at the mole ratios in the reaction, work out the answer using a direct proportion calculation. | We know, **2** **mole** Alrequires | | | |  | **3** **mole** Mg | |
| Therefore, **1** **mole** Alrequires | | | |  | **mole** Mg | |
| Therefore, **25** **mole** Al requires | | | |  | × **25** | |
|  | | | | **Answer: =** | **37.5** **mole** Mg | |

TRY THESE EXAMPLES

**1.** The balanced equation below shows the reaction between silicon and chlorine producing silicon chloride.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Si** | **+** | **2Cl2** |  | **SiCl4** |

Calculate the number of moles of chlorine required to make 5 mole of silicon chloride.

**2.** The balanced equation for the combustion of butane, C4H10, is shown below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **2 C4H10** | **+** | **13 O2** |  | **8 CO2** | **+** | **10H2O** |

Calculate the number of moles of oxygen required to burn 0.5 mole of butane, C4H10.

**3.** The balanced equation for the reaction between zinc and silver nitrate is shown below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Zn** | **+** | **2 AgNO3** |  | **Zn(NO3)2** | **+** | **2 Ag** |

Calculate the number of moles of zinc required to produce 12 mole of silver.

**4.** The balanced equation for the reaction between magnesium oxide and phosphoric acid is shown below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **3 MgO** | **+** | **2 H3PO4** |  | **Mg3(PO4)2** | **+** | **3 H2O** |

Calculate the number of moles of magnesium oxide, MgO, required to make 2.5 mole of magnesium phosphate, Mg3(PO4)2.

**5.** The balanced equation below shows the reaction between aluminium and iodine producing aluminium iodide.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **2 Al** | **+** | **3 I2** |  | **2 AlI­3** |  |  |

Calculate the number of moles of iodine, which reacts with 0.25 mole of aluminium.

# Answers : 1. [10 mole] 2. [3.25 mole] 3. [6 mole] 4. [7.5 mole] 5. [0.375 mole]

|  |  |  |
| --- | --- | --- |
| **N5** | **THE MOLE & REACTION QUANTITIES** | **N5** |

# BALANCED EQUATIONS

# A balanced equation shows the number of moles of each reactant and product in a reaction.

# The number of moles of each reactant and product in a reaction can be converted to a mass.

**1 mole = gram formula mass (G)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **m** | **=** | **n** | **×** | **G** |

# Here is the balanced equation for the combustion of hydrogen.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **2 H2** | **+** | **O2** |  | **2H2O** |
|  |  | **+** |  |  |  |
| **MOLE QUANTITY** | **2 mole** |  | **1 mole** |  | **2 mole** |
| **CONVERT TO A MASS** | **2 × G** |  | **1 × G** |  | **2 × G** |
|  | **= 2 × 2 g** |  | **= 1 × 32 g** |  | **= 2 × 18 g** |
|  | **= 4 g** |  | **= 32 g** |  | **= 36 g** |
|  | **36 g** | | |  |  |

# The balanced equation shows the total mass of the reactants equals the total mass of the products.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **2 H2** | **+** | **O2** |  | **2H2O** |
|  | **2 mole** |  | **1 mole** |  | **2 mole** |
|  | **2 × G** |  | **1 × G** |  | **2 × G** |
|  | **= 2 × 2 g** |  | **= 1 × 32 g** |  | **= 2 × 18 g** |
|  | **= 4 g** |  | **= 32 g** |  | **= 36 g** |
| **Therefore:** | 2 g |  | 16 g |  | 18 g |
|  | 40 g |  | 320 g |  | 360 g |
|  | 0.2 g |  | 0.16 g |  | 360 g |

# Example: The balanced equation below shows the reaction between magnesium and oxygen.

# Calculate the mass of oxygen required to completely burn 12.25 g of magnesium.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **2 Mg** | **+** | **O2** |  | **2 MgO** |
|  | **2 mole** |  | **1 mole** |  |  |
| Insert the masses given in the question.  | **= 2 × 24.5 g** |  | **= 1 × 32 g** |  |  |
| **= 49 g** |  | **= 32 g** |  |  |
| **12.25 g** |  | **? g** |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| Looking at the mass ratios in the reaction, work out the answer using a direct proportion calculation. | We know, **49 g** Mg requires |  | **32 g** O2 |
| Therefore, **1** **g** Mg requires |  | **g** O2 |
| Therefore, **12.25 g** Mg requires |  | × **12.25** |
|  | **Answer: =** | **8 g** O2 |

# Example: The balanced equation below shows the combustion of pentane [C5H12]. Calculate the mass of carbon dioxide produced when 144 g of pentane is burned.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C5H12** | **+** | **8 O2** |  | **5 CO­2** | **+** | **6 H2O** |
|  | **1 mole** |  |  |  | **5 mole** |  |  |
| Insert the masses given in the question.  | **= 1 × 72 g** |  |  |  | **= 5 × 44 g** |  |  |
| **= 72 g** |  |  |  | **= 220 g** |  |  |
| **144 g** |  |  |  | **? g** |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| Looking at the mass ratios in the reaction, work out the answer using a direct proportion calculation. | We know, **72 g** C5H12 produces |  | **220 g** CO2 |
| Therefore, **1** **g** C5H12 produces |  | **g** CO2 |
| Therefore, **144g** C5H12 produces |  | × **144** |
|  | **Answer: =** | **440 g** CO2 |

# INDUSTRIAL CHEMISTRY

# In the chemical industry chemicals are manufactured in large quantities.

# Masses can be measured in grams (g), kilograms (kg) or tonnes.

# The ratios of the reactants and products from the balanced equation remain the same whether the mass units are expressed in grams, kilograms or tonnes.

# Example: In a blast furnace iron(III) oxide is reacted with carbon monoxide to produce iron and carbon monoxide. Calculate the mass of iron(III) oxide to produce 500 kg of iron.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Fe2O3** | **+** | **3 CO** |  | **2 Fe** | **+** | **3 CO** |
|  | **1 mole** |  |  |  | **2 mole** |  |  |
| Insert the masses given in the question.  | **= 1 × 160 g** |  |  |  | **= 2 × 56 g** |  |  |
| **= 160 g** |  |  |  | **= 112 g** |  |  |
| **? kg** |  |  |  | **500 kg** |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | We know, **112 g** Ferequires |  | **160 g** Fe2O3 |

# THEREFORE:

|  |  |  |  |
| --- | --- | --- | --- |
| Looking at the mass ratios in the reaction, work out the answer using a direct proportion calculation. | We know, **112 kg** Ferequires |  | **160 kg** Fe2O3 |
| Therefore, **1** k**g** Ferequires |  | **kg** Fe2O3 |
| Therefore, **500 kg** Ferequires |  | × **500** |
|  | **Answer: =** | **714.3 kg** Fe2O3 |

TRY THESE EXAMPLES

**1.** Calcium reacts with chlorine to form calcium chloride as shown by the following balanced equation.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ca** | **+** | **Cl2** | **** | **CaCl2** |

Calculate the mass of chlorine, which will react, with 10 g of calcium.

**2.** Sodium reacts with water to form sodium hydroxide and hydrogen gas. The balanced equation for the reaction is shown below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **2 Na** | **+** | **2 H2O** | **** | **2 NaOH** | **+** | **H2** |

Calculate the mass of sodium hydroxide produced when 9.2 g of sodium is reacted with water.

**3.** Zinc reacts with nitric acid to produce zinc(II) nitrate and hydrogen gas. The balanced equation for the reaction is shown below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Zn** | **+** | **2 HNO3** | **** | **Zn(NO3)2** | **+** | **H2** |

Calculate the mass of zinc required to produce 75.6 g of zinc(II) nitrate when zinc is reacted with nitric acid.

**4.** Copper(II) oxide reacts with hydrochloric acid to produce copper(II) chloride and water . The equation for the reaction is shown below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CuO** | **+** | **HCl** | **** | **CuCl2** | **+** | **H2O** |

**(a)** Copy and balance the equation.

**(b)** Calculate the mass of copper(II) chloride produced when 201.25 kg of copper(II) oxide is reacted with hydrochloric acid.

**5.** The alcohol called methanol (CH3OH) is produced in industry by reacting hydrogen with carbon monoxide. The equation for the reaction is shown below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CO** | **+** | **H2** | **** | **CH3OH** |

The manufacturer has an order for 800 tonnes of methanol (CH3OH).

**(a)** Copy and balance the equation.

**(b)** Calculate the mass of carbon monoxide required to make 800 tonnes of methanol.

**(c)** Calculate the mass of hydrogen required to make 800 tonnes of methanol.

**Answers :** **1.** [17.75 g] **2.** [16 g] **3.** [26.1g] **4. (b)** [340.5 kg] **5. (a)** [700 tonnes]

**(b)** [100 tonnes]

|  |  |  |
| --- | --- | --- |
| **N5** | **THE MOLE & SOLUTIONS (CONCENTRATION)** | **N5** |

# CONCENTRATION

The concentration of a solution tells you the **number of moles of solute** present in **1 litre of solution**.

In these notes the **concentration** of a solution will be written as the capital letter **“C”** for short in further calculations.

The units of concentration are **mole per litre**. This is written as **mol / *l*** or **mol *l*-1** for short.

**This means:**

a **1 mol *l* -1** solution of sodium chloride contains **1 mole** of sodium chloride in **1 litre** of solution.

a **4 mol *l* -1** solution of sulfuric acid contains **4 moles** of sulfuric acid in **1 litre** of solution.

a **0.35 mol *l* -1** solution of potassium nitrate contains **0.35 moles** of potassium nitrate in **1 litre** of solution.

# CONCENTRATION CALCULATIONS

# To calculate the concentration (C) of a solution you require to know:

# The number of moles of solute (n).

# The volume of solution in litres (V).

# MOLES TO CONCENTRATION CALCULATION

**Concentration** **(C) =** 

**C =** 

If the **volume (v)** of solution is given in cm3 convert to **litres (V)** by dividing by 1000.

**volume in cm3**

**Volume of solution in litres (V) = **

**Example:** A solution contains 4 moles of sulfuric acid in 2 litres. Calculate the concentration of the solution.

Volume of solution **V** = 2 litres

Concentration **C** =  = 

**Concentration of solution = 2 mol *l* -1**

**Example: A solution contains 0.1 mole of copper(II) sulfate in 100 cm3. Calculate the concentration of the solution.**

Volume of solution **v** = 100 cm 3

Volume of solution in litres =  =  = 0.1 *l*

Concentration **C** =  = 

**Concentration of solution = 1 mol *l* -1**

TRY THESE EXAMPLES

Calculate the concentration of the following solutions.

**1.** 0.5 mole of sodium chloride in 500 cm3 of solution.

**2.** 2 mole of nitric acid in 4000 cm3 of solution.

**3.** 0.25 mole of potassium carbonate in 200 cm3 of solution.

**4.** 1.5 mole of nickel(II) sulfate in 3 litres of solution.

**5.** 0.05 mole of lithium bromide in 50 cm3 of solution.

**Answers :** **1.** [1 mol *l* -1] **2.** [0.5 mol *l* -1] **3.**  [1.25 mol *l* -1] **4.**  [0.5 mol *l* -1] **5.** [1 mol *l* -1]

# CONCENTRATION TO MOLES CALCULATIONS

# To calculate the concentration (C) of a solution given the number of moles (n) of solute and the volume (V)

**C =** 

To calculate the number of moles (**n**) of solute in a given volume (**V**) of a solution the equation has to be rearranged:

**n = C × V**

# If the volume is given in cm3.

**n = C ×** ** or n =** 

**Example:** Calculate the number of moles of iron(II) sulfate in 4 litres of a 2 mol *l*-1 solution.

Volume of solution **V** = 4 litres

Number of moles **n = C x V** = 2 x 4

= **8 mole**

**Example:** Calculate the number of moles of sodium nitrate in 200 cm3 of a 0.5 mol *l*-1 solution.

Volume of solution **v** = 200 cm 3

Number of moles **n = ** = ****

= **0.1 mole**

TRY THESE EXAMPLES

Calculate the number of moles of solute in the following solutions.

**1.** 200 cm3 of a 2 mol *l* -1 solution of potassium hydroxide.

**2.** 1800 cm3 of a 0.25 mol *l* -1 solution of cobalt(II) chloride.

**3.** 75 cm3 of a 0.5 mol *l* -1 solution of phosphoric acid.

**4.** 2 litres of a 0.4 mol *l* -1 solution of zinc nitrate.

**5.** 750 cm3 of a 3 mol *l* -1 solution of copper(II) chloride.

# Answers: 1. [0.4 mole] 2. [0.45 mole] 3. [0.0375 mole] 4. [0.8 mole] 5. [2.25 mole]

**SUMMARY OF CONCENTRATION CALCULATIONS**

The two calculations can be summed up using the following triangle.

**n**

**C**

**V**

**concentration of solution**

**volume of solution in litres**

**number of moles of solute**

**MOLE and CONCENTRATION TRIANGLE**

|  |  |
| --- | --- |
| To calculate the concentration (C) cover the C. **n**  **C**  **V** C = | To calculate the number of moles (n) cover the n.n = n × Vorn =  **n**  **C**  **V** |

# CONCENTRATION AND MASS CALCULATIONS

# The concentration and mole calculations link to mole and mass calculations.

**n**

**C**

**V**

**m**

**n**

**G**

**n**

**MOLE & MASS**

**MOLE & CONCENTRATION**

# CONCENTRATION TO MASS CALCULATION

# Given C and V calculate m. Requires 2 calculations.

|  |  |  |
| --- | --- | --- |
| 1. Calculate n from C and V.  (Concentration to Moles calculation)n = C × V or n = | THEN | 2. Calculate m from n and G.  (Moles to Mass calculation)m = n × G |

**Example:** Calculate the mass of sodium hydroxide (NaOH) present in 250 cm3 of a 1 mol *l* -1 solution.

**1. CONCENTRATION TO MOLES**

Volume of solution **v** = 250 cm3

Number of moles **n = ** = ****

= **0.25 mole** of sodium hydroxide

**2. MOLES TO MASS**

**NaOH**

1 hydrogen atom = 1 × H = 1 × 1 = 1

1 oxygen atom = 1 × O = 1 × 16 = 16

1 sodium atom = 1 × Na = 1 × 23 = 23

**Gram** **formula mass G = 40 g**

1 mole of NaOH = 40 g

Therefore the mass of, 0.25 mole of NaOH **m** **= n × G** = 0.25 × 40 = **10 g**

**Example:** Calculate the mass of magnesium bromide (MgBr2) required to make 2.5 litres of a  
0.75 mol *l*-1 solution.

**1. CONCENTRATION TO MOLES**

Volume of solution = 2.5 *l*

Number of moles **n = C × V** = 0.75 × 2.5

= **1.875 mole** of magnesium bromide

**2. MOLES TO MASS**

**MgBr2**

2 bromine atoms = 2 × Br = 2 × 80 = 160

1 magnesium atom = 1 × Mg = 1 × 24.5 = 24.5

**Gram** **formula mass G = 184.5 g**

1 mole of MgBr2 = 184.5 g

Therefore the mass of, 1.875 mole of MgBr2 **m** **= n × G** = 1.875 × 184.5 = **345 .9 g**

TRY THESE EXAMPLES

Calculate the mass of compound in the following solutions.

**1.** 500 cm3 of a 2 mol *l* -1 solution of potassium carbonate (K2CO3).

**2.** 2500 cm3 of a 0.2 mol *l* -1 solution of copper(II) chloride (CuCl2).

**3.** 100 cm3 of a 0.5 mol *l* -1 solution of sulfuric acid (H2SO4).

**4.** 2 litres of a 0.4 mol *l* -1 solution of potassium nitrate (KNO3).

**5.** 250 cm3 of a 1.5 mol *l* -1 solution of tin(II) sulfate (SnSO4).

**Answers :** **1.** [138 g] **2.**  [67.25 g] **3.** [4.9 g] **4.**  [80.8 g] **5.**  [80.44 g]

# MASS TO CONCENTRATION CALCULATION

# Given m and V calculate C. Requires 2 calculations.

|  |  |  |
| --- | --- | --- |
| 1. Calculate n from m and G.  (Mass to Moles calculation)n = | THEN | 2. Calculate C from n and V.  (Moles to Concentration calculation)C = |

**Example:** A 500 cm3 solution contains 34.8 g of potassium sulfate (K2SO4). Calculate the concentration of the solution.

**1. MASS TO MOLES**

**K2SO4**

4 oxygen atoms = 4 × O = 4 × 16 = 64

1 sulfur atom = 1 × S = 1 × 32 = 32

2 potassium atoms = 2 × K = 2 × 39 = 78

**Gram** **formula mass G = 174 g**

174 g of K2SO4 = 1 mole

Number of moles in 34.8 g of K2SO4 **n**  =  = 

= **0.2 mole**

**2. MOLES TO CONCENTRATION**

Volume of solution = 500 cm3, in litres = = **0.5 *l***

Concentration **C** =  =  = **0.4 mol *l* -1**

**Example:** 2 litres of a solution of sodium chloride (NaCl) contains 29.25 g of sodium chloride. Calculate the concentration of the solution.

**1. MASS TO MOLES**

**NaCl**

1 chlorine atom = 1 × Cl = 1 × 35.5 = 35.5

1 sodium atom = 1 × Na = 1 × 23 = 23

**Gram** **formula mass G = 58.5g**

58.5 g of NaCl = 1 mole

Number of moles in, 29.25 g of NaCl **n** =  =  = **0.5 mole**

**2. MOLES TO CONCENTRATION**

Volume of solution = **2 *l***

Concentration **C** =  =  = **0.25 mol *l* -1**

TRY THESE EXAMPLES

Calculate the concentration of the following solutions.

**1.** 7.975 g of copper(II) sulfate [CuSO4] in 100 cm3 of solution.

**2.** 5 g of sodium hydroxide [NaOH] in 500 cm3 of solution.

**3.** 273 g of zinc chloride [ZnCl2] in 1500 cm3 of solution.

**4.** 37.125 g of magnesium nitrate [Mg(NO3)2] in 400 cm3 of solution.

**5.** 59.6 g of ammonium phosphate [(NH4)3PO4] in 2 litres of solution.

**Answers :** **1.** [0.5 mol *l* -1] **2.** [0.25 mol *l* -1] **3.** [1.33 mol *l* -1] **4.** [0.625 mol *l* -1] **5.** [0.2 mol *l* -1]

|  |  |  |
| --- | --- | --- |
| **N5** | **VOLUMETRIC CALCULATIONS** | **N5** |

# TITRATIONS

# Description: buretteThe information obtained from a titration experiment can be used to calculate the concentration of one of the solutions used.

The **volume**, **v**, and **concentration**, **C**, of one of the reactants will be known.

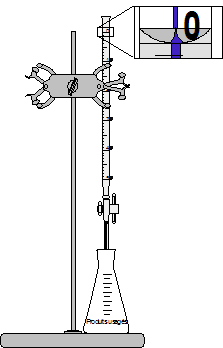
Therefore, the **number of moles**, **n**, of the reactant can be calculated.

**n =** 

Using the mole ratio from the balanced equation for the reaction the **number of moles**, **n**, of the other reactant can be calculated.

**C =** 

Knowing the **number of moles**, **n**, and the **volume**, **v**, of this reactant the **concentration**, **C**, can be calculated.

**Example: 25 cm3** of **1.0 mol *l* -1** sodium hydroxide was measured into a conical flask using a pipette.

Knowing the **C** and **v** of the NaOH, the **number of moles**, **n**, used can be calculated.

**n = ** **=** ****

**= 0.025 mole**

# The sodium hydroxide was neutralised using 16.4 cm3 of hydrochloric during a titration.

# Calculate the concentration of the hydrochloric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Write the balanced equation for the reaction. |  | HCl(aq) | + | NaOH(aq) |  | NaCl(aq) | + | H2O(*l*) |
|  |  |  |  |  |  |  |  |  |
| Write the number of moles of each reactant. |  | 1 mole |  | 1 mole |  | Knowing the **n** and **v** of the **HCl**,calculate the **concentration**, **C**.  **C** =  =  = **1.52 mol *l*-1** | | |
|  |  | HCl : NaOH react in the mole ratio 1 : 1. | | | |
|  |  |  | | | |
|  |  | Therefore, the number of moles of HCl reacted = 0.025 mole | | | |

**Example: 20 cm3** of **0.1 mol *l* -1**potassium hydroxide solution (KOH) was neutralised by  
**15.4 cm3** of sulfuric acid (H2SO4).

Calculate the concentration of the sulfuric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Write the balanced equation for the reaction. |  | H2SO4(aq) | + | 2 KOH(aq) |  | K2SO4(aq) | + | 2 H2O(*l*) |
|  |  |  |  |  |  |  |  |  |
| Write the number of moles of each reactant. |  | 1 mole |  | 2 mole |  | Knowing the **C** and **v** of the KOH, the **number of moles**, **n**, used can be calculated.  **n =**  **=**  **= 0.002 mole** |  |  |
|  |  |  |  |  |  |  |  |  |
| Insert the known information. |  | 15.4 cm3 ? mol *l*-1 |  | 20 cm3 0.1 mol *l*-1 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Work out the number of moles of H2SO4 using the mole ratio of the reactants. |  | H2SO4: KOH react in the mole ratio 1 : 2. | | | |  |  |  |
|  |  |  |  |  |  |  |  |
|  | Therefore, the number of moles of H2SO4 reacted = 0.002 ÷ 2  = 0.001 mole | | | |  |  |  |

Knowing the **n** and **v** of the **H2SO4**,calculate the **concentration**, **C**.

**C** =  =  = **0.065 mol *l*-1**

# VOLUMETRIC CALCULATIONS SUMMARY

# To calculate the concentration of a reactant from information obtained from a titration:

# 

**STEP 1**

Write the balanced equation for the reaction.

**STEP 4**

Calculate the **number of moles**, **n**, of the reactant where the **C** and **v** are known.

**STEP 3**

Insert the known information.

**STEP 2**

Write the number of moles of each reactant. reaction

**n =** 

**C =** 

**STEP 6**

Knowing the **number of moles**, **n**, and the **volume**, **v**, of the reactant calculate the **concentration**, **C**.

**STEP 5**

Using the mole ratio from the balanced equation, calculate the number of moles of the other reactant.

**Example: 20 cm3** of **0.15 mol *l*-1** sodium carbonate solution(Na2CO3) was neutralised by **12.7 cm3** of nitric acid(HNO3).

Calculate the concentration of the nitric acid.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| STEP 1Write the balanced equation for the reaction. |  | 2 HNO3(aq) | + | Na2CO3(aq) |  | 2 NaNO3(aq) | + | H2O(*l*) | + | CO2(g) |
|  |  |  |  |  |  | STEP 4 Knowing the **C** and **v** of the Na2CO3, the **number of moles**, **n**, used can be calculated.  **n =**  **=**  **= 0.003 mole** |  |  |  |  |
| STEP 2Write the number of moles of each reactant. |  | 2 mole |  | 1 mole |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| STEP 3Insert the known information. |  | 12.7 cm3 ? mol *l*-1 |  | 20 cm3 0.15 mol *l*-1 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| STEP 5Work out the number of moles of HNO3 using the mole ratio of the reactants. |  | HNO3: Na2CO3 react in the mole ratio 2 : 1. | | | |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | Therefore, the number of moles of HNO3 reacted = 0.003 × 2  = 0.006 mole | | | |  |  |  |  |  |

# STEP 6

Knowing the **n** and **v** of the **HNO3**,calculate the **concentration**, **C**.

**C** =  =  = **0.47 mol *l*-1**

TRY THESE EXAMPLES

1. 20 cm3 of 0.2 mol *l* -1 sodium hydroxide was neutralised by 14.5 cm3 of hydrochloric acid in the reaction shown below. Calculate the concentration of the hydrochloric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| HCl(aq) | + | NaOH(aq) | **** | NaCl(aq) | + | H2O(*l*) |  |  |

**2.** 25 cm3 of 0.5 mol *l* -1 lithium hydroxide was neutralised by 11.3 cm3 of nitric acid in the reaction shown below. Calculate the concentration of the nitric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| HNO3(aq) | + | LiOH(aq) | **** | LiNO3(aq) | + | H2O(*l*) |  |  |

**3.** 18.6 cm3 of 1.0 mol *l* 1 sulfuric acid neutralised 20 cm3 of potassium hydroxide in the reaction shown below. Calculate the concentration of the potassium hydroxide.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| H2SO4(aq) | + | 2 KOH(aq) | **** | K2SO4(aq) | + | 2 H2O(*l*) |  |  |

**4.** 20 cm3 of 0.5 mol *l* -1 lithium carbonate solution was neutralised by 18.5 cm3 of nitric acid in the reaction shown below. Calculate the concentration of the nitric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 HNO3(aq) | + | Li2CO3(aq) | **** | 2 LiNO3(aq) | + | H2O(*l*) | + | CO2(g) |

**5.** 23.5 cm3 of 0.3 mol *l* -1 phosphoric acid neutralised 25 cm3 of sodium carbonate solution in the reaction shown below. Calculate the concentration of the sodium carbonate solution.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 H3PO4(aq) | + | 3 Na2CO3(aq) | **** | 2 Na3PO4(aq) | + | 3 H2O(*l*) | + | 3 CO2(g) |

**6.** In the analysis of nickel(II) ions a titration using a chemical called dimethylglyoxime is carried out.  
  
In the reaction one mole of nickel(II) ions reacts with one mole of dimethylglyoxime.  
  
In a titration 10 cm3 of a solution of nickel(II) ions was titrated with 15.7 cm3 of 0.025 mol *l* -1 dimethylglyoxime solution. Calculate the concentration of the nickel(II) ions.

**Answers :** **1.** [0.28 mol *l* -1] **2.** [1.11 mol *l* -1] **3.** [1.86 mol *l* -1] **4.** [0.27 mol *l* -1] **5.** [0.42 mol *l* -1]

**6.** [0.039 mol *l*-1]

|  |  |  |
| --- | --- | --- |
| **N5** | **VOLUMETRIC CALCULATIONS – THE POWER METHOD** | **N5** |

# TITRATIONS

# Description: buretteThe information obtained from a titration experiment can be used to calculate the concentration of one of the solutions used.

The **volume**, **v**, and **concentration**, **C**, of one of the reactants will be known.

The **volume, v,** of the **second reactant** will be known, but not its **concentration.** It is this **concentration,** which will be calculated.

The balanced chemical equation for the reactions gives the **reacting mole ratio**. This **ratio** is needed to carry out the calculation.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| HCl(aq) | + | NaOH(aq) | **** | NaCl(aq) | + | H2O(*l*) |
| **1 mole** |  | **1 mole** |  |  |  |  |

Hydrochloric acid reacts with sodium hydroxide in the **mole ratio 1 : 1**.

The following relationship is used in volumetric calculations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **C1 = concentration of reactant 1** |  |  |  | **C2 = concentration of reactant 2** |
| **V2 = volume of reactant 1** | **=** | **V2 = Volume of reactant 2** |
| **n1 = mole ratio of reactant 1** |  | **n2 = mole ratio of reactant 2** |

**Example: 25.0 cm3** of **1.0 mol *l*-1** sodium hydroxide solution(NaOH) was neutralised by **16.4 cm3** of hydrochloric acid(HCl).  
  
Calculate the concentration of the hydrochloric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | REACTANT 1 |  | REACTANT 2 |  |  |  |  |
| Write the balanced equation for the reaction. |  | HCl(aq) | + | NaOH(aq) |  | NaCl(aq) | + | H2O(*l*) |
|  |  | 1 mole |  | 1 mole |  | = | | |
|  |  | C1 = ? V1  = 16.4 cm3n1 = 1 |  | C1 = 1.0 mol *l*-1 V1  = 25.0 cm3n2 = 1 |  |

Insert the information into the relationship.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **=** |  |  |  |
| **C1** × **16.4** | **=** | **25.0** |  |  |
| **C1** | **=** |  | **=** | **1.52 mol *l*-1** |

**Example: 20 cm3** of **0.1 mol *l* -1**potassium hydroxide solution (KOH) was neutralised by  
**15.4 cm3** of sulfuric acid (H2SO4).

Calculate the concentration of the sulfuric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | REACTANT 1 |  | REACTANT 2 |  |  |  |  |
| Write the balanced equation for the reaction. |  | H2SO4(aq) | + | 2 KOH(aq) |  | K2SO4(aq) | + | 2 H2O(*l*) |
|  |  | 1 mole |  | 2 mole |  | = | | |
|  |  | C1 = ? V1  = 15.4 cm3n1 = 1 |  | C1 = 0.1 mol *l*-1 V1  = 20.0 cm3n2 = 2 |  |

Insert the information into the relationship.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **=** |  |  |  |
| **C1** × **15.4** | **=** | **1.0** |  |  |
| **C1** | **=** |  | **=** | **0.065 mol *l*-1** |

**Example: 20.0 cm3** of **0.15 mol *l*-1** sodium carbonate solution(Na2CO3) was neutralised by **12.7 cm3** of nitric acid(HNO3).

Calculate the concentration of the nitric acid.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | REACTANT 1 |  | REACTANT 2 |  |  |  |  |  |  |
| STEP 1Write the balanced equation for the reaction. |  | 2 HNO3(aq) | + | Na2CO3(aq) |  | 2 NaNO3(aq) | + | H2O(*l*) | + | CO2(g) |
|  |  | 2 mole |  | 1 mole |  | = | | | | |
|  |  | C1 = ? V1  = 12.7 cm3n1 = 2 |  | C1 = 0.15 mol *l*-1 V1  = 20.0 cm3n2 = 1 |  |

Insert the information into the relationship.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **=** |  |  |  |
| **C1** × **6.35** | **=** | **3.0** |  |  |
| **C1** | **=** |  | **=** | **0.47 mol *l*-1** |

**Example: Iron(II) sulphate** reacts with potassium permanganate in the **reacting mole ratio of 5 moles** of **iron(II) sulphate** to **1 mole** of **potassium permanganate**.

In a titration **20 cm3** of **iron(II) sulphate** reacted with **22.4 cm3** of **0.02** **mol *l* -1****potassium permanganate** solution.  
  
Calculate the **concentration** of the **iron(II) sulphate** solution.

|  |  |  |  |
| --- | --- | --- | --- |
| **REACTANT 1**  **iron(II) sulphate** C1 = ? V1  = 20.0 cm3 **n1 = 5** |  | **REACTANT 2**  **potassium permanganate** C2 = 0.02 mol *l*-1 V2 = 22.4 cm3 **n2 = 1** | **=** |

Insert the information into the relationship.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **=** |  |  |  |
| **C1** × **4.0** | **=** | **0.448** |  |  |
| **C1** | **=** |  | **=** | **0.112 mol *l*-1** |

TRY THESE EXAMPLES

1. 20 cm3 of 0.15 mol *l* -1 potassium hydroxide was neutralised by 12.3 cm3 of hydrochloric acid in the reaction shown below. Calculate the concentration of the hydrochloric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| HCl(aq) | + | KOH(aq) | **** | KCl(aq) | + | H2O(*l*) |  |  |

**2.** 10 cm3 of 0.5 mol *l* -1 sodium hydroxide was neutralised by 11.3 cm3 of nitric acid in the reaction shown below. Calculate the concentration of the nitric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| HNO3(aq) | + | NaOH(aq) | **** | NaNO3(aq) | + | H2O(*l*) |  |  |

**3.** 13.7 cm3 of 0.15 mol *l* 1 sulfuric acid neutralised 20 cm3 of sodium hydroxide in the reaction shown below. Calculate the concentration of the potassium hydroxide.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| H2SO4(aq) | + | 2 NaOH(aq) | **** | Na2SO4(aq) | + | 2 H2O(*l*) |  |  |

**4.** 20 cm3 of 0.25 mol *l* -1 lithium carbonate solution was neutralised by 12.7 cm3 of nitric acid in the reaction shown below. Calculate the concentration of the nitric acid.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 HNO3(aq) | + | Li2CO3(aq) | **** | 2 LiNO3(aq) | + | H2O(*l*) | + | CO2(g) |

**5.** 15.4 cm3 of 0.2 mol *l* -1 phosphoric acid neutralised 25 cm3 of sodium carbonate solution in the reaction shown below. Calculate the concentration of the sodium carbonate solution.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 H3PO4(aq) | + | 3 Na2CO3(aq) | **** | 2 Na3PO4(aq) | + | 3 H2O(*l*) | + | 3 CO2(g) |

**6.** In the analysis of nickel(II) ions a titration using a chemical called dimethylglyoxime is carried out.  
  
In the reaction **one mole of nickel(II) ions** reacts with **one mole of dimethylglyoxime**.  
  
In a titration 20 cm3 of a solution of nickel(II) ions was titrated with 14.9 cm3 of 0.05 mol *l* -1 dimethylglyoxime solution. Calculate the concentration of the nickel(II) ions.

**Answers :** **1.** [0.24 mol *l* -1] **2.** [0.44 mol *l* -1] **3.** [0.21 mol *l* -1] **4.** [0.79 mol *l* -1] **5.** [0.18 mol *l* -1]

**6.** [0.037 mol *l*-1]

|  |  |  |
| --- | --- | --- |
| **N5** | **PERCENTAGE MASS** | **N5** |

The percentage mass of an element in a compound is the fraction the element contributes to the formula mass expressed as a percentage.

To calculate the **PERCENTAGE MASS** of an element in a compound is calculated using the following formula.

**% mass =**  **×** 

HOW TO CALCULATE THE PERCENTAGE MASS

OF AN ELEMENT IN A COMPOUND

**1.** Write the formula of the compound.

**2.** Calculate the formula mass of the compound.

**3.** For the percentage mass asked in the question, insert the mass of the element and the formula mass of the compound into the formula given above.

**Example:** Calculate the percentage mass of **nitrogen** in ammonium sulfate [(NH4)2SO4].

**(NH4)2SO4**

4 oxygen atoms = 4 × O = 4 × 16 = 64

1 sulfur atom = 1 × S = 1 × 32 = 32

8 hydrogen atoms = 8 × H = 8 × 1 = 8

**2 nitrogen atoms** = **2 × N** = **2 × 14** = **28**

**Formula mass = 132**

Mass of **nitrogen** in (NH4)2SO4 = **28**

% mass of **N** in (NH4)2SO4 =  × 

=  × 

= **21.2 %TRY THESE EXAMPLES**

**1.** Calculate the percentage mass of **iron** in iron(III) oxide [Fe2O3].

**2.** Calculate the percentage mass of **carbon** in butane [C4H10].

**3.** Calculate the percentage mass of **hydrogen** in water.

**4.** Calculate the percentage mass of **copper** in copper(II) sulfate [CuSO4].

**5.** Calculate the percentage mass of **nitrogen** in fertiliser called urea [NH2CONH2].

**Answers:** **1.** [70 %] **2.** [82.8 %] **3.** [11.1 %] **4.** [39.8 %] **5.** [46.7 %]