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Writing Chemical Formulae

The chemical formula of a compound tells us how many atoms of each element are present in the compound. The symbol for each element can be found on the periodic table.

e.g.

Water contains two atoms of hydrogen (H) and one atom of oxygen (O).

The chemical formula for water is H_2O.

Write the chemical formula for the following compounds:

1. A compound containing one atom of carbon and two atoms of oxygen.

   _____

2. A compound containing two atoms of hydrogen, one atom of sulfur and four atoms of oxygen.

   _____

3. A compound containing one atom of carbon and four atoms of hydrogen.

   _____

4. A compound containing one atom of nitrogen and three atoms of hydrogen.

   _____

5. A compound containing one atom of lithium, one atom of oxygen and one atom of hydrogen.

   _____

6. A compound containing one atom of hydrogen, one atom of nitrogen and three atoms of oxygen.

   _____

7. A compound containing two atoms of potassium, one atom of sulfur and four atoms of oxygen.

   _____

8. A compound containing one atom of copper and two atoms of chlorine.

   _____

9. A compound containing one atom of silver, one atom of nitrogen and three atoms of oxygen.

   _____

10. A compound containing two atoms of sodium, one atom of carbon and three atoms of oxygen.

    _____

Balancing Symbol Equations

Chemical equations are a simple way to describe how different substances are made in a reaction.

The equation tells us which substances have **reacted** in the reaction. These are called the **reactants** and are found on the **left-hand** side of the equation.

The equation tells us which substances are **produced** in the reaction. These are called the **products** and are found on the **right-hand** side of the equation.

e.g.

$$\mathbf{2}H_2 + O_2 \longrightarrow \mathbf{2}H_2O$$

This equation is balanced because there are 4 atoms of hydrogen and 2 atoms of oxygen on both sides of the equation.

Balance the following symbol equations:

1. ___ Li + ___ H_2O → ___ LiOH + ___ H_2
2. ___ Na + ___ HCl → ___ NaCl + ___ H_2
3. ___ Fe + ___ HCl → ___ $FeCl_2$ + ___ H_2
4. ___ Cr + ___ HCl → ___ $CrCl_3$ + ___ H_2
5. ___ K + ___ $Ca(NO_3)_2$ → ___ KNO_3 + ___ Ca
6. ___ $CaCO_3$ + ___ HNO_3 → ___ $Ca(NO_3)_2$ + ___ CO_2 + ___ H_2O
7. ___ LiOH + ___ H_2SO_4 → ___ Li_2SO_4 + ___ H_2O
8. ___ Al_2O_3 + ___ H_2SO_4 → ___ $Al_2(SO_4)_3$ + ___ H_2O
9. ___ C_3H_8 + ___ O_2 → ___ CO_2 + ___ H_2O
10. ___ Fe_2O_3 + ___ CO → ___ Fe + ___ CO_2

Relative Formula Mass

The relative formula mass (M_r) is the sum of the relative atomic masses (A_r) of all the atoms present in a compound. The relative atomic mass of each element can be found on the periodic table.

e.g.

The chemical formula for water is H_2O.

Relative atomic masses (A_r): H = 1, O = 16

Relative formula mass (M_r) = (1 × 2) + 16 = 18

Calculate the relative formula mass of the following compounds:

1. CO_2

   _____

   M_r = _____

2. H_2SO_4

   _____

   M_r = _____

3. NH_3

   _____

   M_r = _____

4. NaOH

   _____

   M_r = _____

5. HNO_3

   _____

   M_r = _____

6. B_2H_6

   _____

   M_r = _____

7. Na_2CO_3

   _____

M_r = _____

8. Al_2O_3

_____

M_r = _____

9. Fe_2O_3

_____

M_r = _____

10. $CaCO_3$

_____

M_r = _____

11. $Fe_2(SO_4)_3$

_____

M_r = _____

12. $Zn(OH)_2$

_____

M_r = _____

13. $Ca(OH)_2$

_____

M_r = _____

14. $(NH_4)_2SO_4$

_____

M_r = _____

15. $CuSO_4 \cdot 5H_2O$

_____

M_r = _____

Concentrations of Solutions in g/dm^3

$$\text{concentration (g/dm}^3\text{)} = \frac{\text{mass (g)}}{\text{volume (dm}^3\text{)}}$$

Use the equation to complete the calculations below. Give the units in your answers.

1. Calculate the **concentration** of a solution with a mass of 4.25g and a volume of 10dm^3.

   _____

   _____

   concentration = _____

2. Calculate the **concentration** of a solution with a mass of 1.25g and a volume of 5dm^3.

   _____

   _____

   concentration = _____

3. Calculate the **mass** of potassium chloride that a student would need to dissolve in 6dm^3 of water to make a 38g/dm^3 solution.

   _____

   _____

   mass = _____

4. Calculate the **mass** of potassium bromide that a student would need to dissolve in 4dm^3 of water to make a 19g/dm^3 solution.

   _____

   _____

   mass = _____

5. Calculate the **volume** of water required to add to 9.1g of solid to make 35g/dm^3 solution.

   _____

   _____

   volume = _____

6. Calculate the **volume** of water required to add to 8.4g of solid to make 1.5g/dm^3 solution.

   _____

   _____

   volume = _____

7. Calculate the **concentration** of a solution with a mass of 3.79g and a volume of 100cm^3.

concentration = _____

8. Calculate the **concentration** of a solution with a mass of 5.25g and a volume of 120cm^3.

concentration = _____

9. Calculate the **mass** of potassium chloride that a student would need to dissolve in 800cm^3 to make a 19g/dm^3 solution.

mass = _____

10. Calculate the **mass** of potassium bromide that a student would need to dissolve in 250cm^3 to make a 36g/dm^3 solution.

mass = _____

Moles (HT only)

$$\text{number of moles} = \frac{\text{mass (g)}}{\text{relative formula mass}}$$

Use the equation to complete the calculations below.

1. Calculate the number of moles in 20g of MgO.

   _____

   _____

   number of moles = _____ mol

2. Calculate the number of moles in 26g of $CaCO_3$.

   _____

   _____

   number of moles = _____ mol

3. Calculate the number of moles in 336g of $MgCO_3$.

   _____

   _____

   number of moles = _____ mol

4. Calculate the number of moles in 265g of NaOH.

   _____

   _____

   number of moles = _____ mol

5. Calculate the number of moles in 213g of Na_2SO_4.

   _____

   _____

   number of moles = _____mol

6. Calculate the number of moles in 180g of FeO.

   _____

   _____

   number of moles = _____ mol

7. Calculate the number of moles in 132g of CH_3CHO.

number of moles = _____ mol

8. Calculate the number of moles in 88.5g of C_2H_5NO.

number of moles = _____ mol

9. Calculate the number of moles in 13.25g of $BiCl_3$.
Give your answer to 2 significant figures.

number of moles = _____ mol

10. Calculate the number of moles in 30g of $CHCl_3$.
Give your answer to 2 significant figures.

number of moles = _____ mol

Calculating Mass using Number of Moles (HT Only)

$$\text{number of moles} = \frac{\text{mass (g)}}{\text{relative formula mass}}$$

Rearrange the equation to complete the calculations below.

1. Calculate the mass of 1.5 moles of K_2SO_4.

   _____

   _____

   mass = _____ g

2. Calculate the mass of 4.5 moles of HNO_3

   _____

   _____

   mass = _____ g

3. Calculate the mass of 2.2 moles of $Ca(NO_3)_2$.

   _____

   _____

   mass = _____ g

4. Calculate the mass of 3.8 moles of CaO.

   _____

   _____

   mass = _____ g

5. Calculate the mass of 0.6 moles of $HAuCl_4$.

   _____

   _____

   mass = _____ g

6. Calculate the mass of 4.6 moles of $CrCl_3$.

   _____

   _____

   mass = _____ g

7. Calculate the mass of 0.9 moles of C_2H_5OH

mass = _____ g

8. Calculate the mass of 0.5 moles of H_2SiF_6.

mass = _____ g

9. Calculate the mass of 1.9 moles of $FeCl_3$.

mass = _____ g

10. Calculate the mass of 8.2 moles of H_2O_2.

mass = _____ g

Amounts of Substances in Equations (HT only)

1. Calculate the mass of calcium oxide that is produced from 25g of calcium carbonate.

   The symbol equation for the reaction is shown below:

$$CaCO_3 \longrightarrow CaO + CO_2$$

mass = _____ g

2. Calculate the mass of sodium chloride that is produced when 21.3g of chlorine reacts with sodium.

   You will need to balance the symbol equation for the reaction.

$$\_\_\_\_\_\ Na + \_\_\_\_\_\ Cl_2 \longrightarrow \_\_\_\_\_\ NaCl$$

mass = _____ g

3. Calculate the mass of nitrogen monoxide that is produced when 32g of oxygen reacts with nitrogen.

   You will need to balance the symbol equation for the reaction.

$$\_\_\_\_\_\ N_2 + \_\_\_\_\_\ O_2 \longrightarrow \_\_\_\_\_\ NO$$

mass = _____ g

4. Calculate the mass of magnesium chloride ($MgCl_2$) that is produced when 8.4g of magnesium reacts with chlorine.

mass = _____ g

5. Calculate the mass of ammonia that is produced when 56g of nitrogen reacts with hydrogen.

mass = _____ g

6. Calculate the mass of oxygen that is required to react completely with 30g of carbon to produce carbon dioxide.

mass = _____ g

7. Calculate the mass of iron required to react with chlorine to form 19.5g of iron (III) chloride ($FeCl_3$).

mass = _____ g

Limiting Reactants (HT only)

The reactant that is completely used up in a chemical reaction is called the **limiting reactant**. The mass of product made in the reaction depends on the mass of the limiting reactant.

1. 48g of magnesium was reacted with 4 moles of sulfuric acid to produce magnesium sulfate and hydrogen.

   The symbol equation for the reaction is shown below.

   $$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$$

   a. Calculate the number of moles of magnesium.

   _____

   _____

   number of moles = _____ mol

   b. Which reactant is the limiting reactant? Explain your answer

   _____

   _____

2. 161g of sodium was reacted with 213g of chlorine to produce sodium chloride.

   a. Balance the symbol equation for the reaction:

   $$\_\_\_\_\_\ Na + \_\_\_\_\_\ Cl_2 \longrightarrow \_\_\_\_\_\ NaCl$$

   b. Calculate the number of moles of sodium.

   _____

   _____

   number of moles = _____ mol

   c. Calculate the number of moles of chlorine.

   _____

   _____

   number of moles = _____ mol

   d. Which reactant is the limiting reactant? Explain your answer.

   _____

   _____

3. 12g of magnesium was reacted with 30g of hydrochloric acid to produce magnesium chloride and hydrogen.

   a. Balance the symbol equation for the reaction.

   ____ Mg + ____ HCl → ____ $MgCl_2$ + ____ H_2

   b. Which reactant is the limiting reactant? Explain your answer.

   You must show your working.

4. 25g of calcium carbonate ($CaCO_3$) was reacted with 44g of nitric acid (HNO_3) to produce calcium nitrate, carbon dioxide and water.

   a. Balance the symbol equation for the reaction.

   ____ $CaCO_3$ + ____ HNO_3 → ____ $Ca(NO_3)_2$ + ____ CO_2 + ____ H_2O

   b. Which reactant is the limiting reactant? Explain your answer.

   You must show your working.

5. 25g of sodium hydrogen carbonate ($NaHCO_3$) was reacted with 20g of sulfuric acid (H_2SO_4).

   a. Balance the symbol equation for the reaction.

   ____ $NaHCO_3$ + ____ H_2SO_4 → ____ Na_2SO_4 + ____ CO_2 + ____ H_2O

   b. Which reactant is the limiting reactant? Explain your answer.

   You must show your working.

Percentage Yield (Chemistry only)

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

Use the equation to complete the calculations below.

1. A student calculated that 5.0g of magnesium chloride would be produced in a reaction between magnesium and hydrochloric acid. The actual yield of magnesium chloride was 3.0g. Calculate the percentage yield of the reaction.

   _____

   _____

   percentage yield = _____ %

2. A student calculated that 33g of calcium hydroxide would be produced in a reaction between calcium oxide and water. The actual yield of calcium hydroxide was 11g. Calculate the percentage yield of the reaction.

   Give your answer to 2 significant figures.

   _____

   _____

   percentage yield = _____ %

3. A student calculated that 1.5g of magnesium oxide would be produced in a reaction between magnesium and oxygen. The actual yield of magnesium oxide was 0.85g.

   Calculate the percentage yield of the reaction.

   Give your answer to 2 significant figures.

   _____

   _____

   percentage yield = _____ %

4. A student calculated that 18.9g of calcium hydroxide would be produced in a reaction between calcium oxide and water. The actual yield of calcium hydroxide was 6.6g. Calculate the percentage yield of the reaction.

   Give your answer to 2 significant figures.

   _____

   _____

   percentage yield = _____ %

5. In a chemical reaction, the percentage yield was 78%. The theoretical yield was 16.3 tonnes. Calculate the actual yield.

   Give your answer to 3 significant figures.

   _____

   _____

   actual yield = _____ tonnes

6. In a chemical reaction, the percentage yield was 45%. The theoretical yield was 48g. Calculate the actual yield.

   Give your answer to 3 significant figures.

   _____

   _____

   actual yield = _____ tonnes

7. In a chemical reaction, 20.2g of product was made. The percentage yield was 89%. Calculate the theoretical yield.

   Give your answer to 3 significant figures.

   _____

   _____

   theoretical yield = _____ g

8. In a chemical reaction, 17 tonnes of product was made. The percentage yield was 77%. Calculate the theoretical yield.

   Give your answer to 3 significant figures.

   _____

   _____

   theoretical yield = _____ g

Atom Economy (Chemistry only)

$$\text{percentage atom economy} = \frac{M_r \text{ of desired product}}{\text{total } M_r \text{ of all reactants}} \times 100$$

Use the equation to complete the calculations below. Give your answers to 2 significant figures.

1. Calculate the percentage atom economy for the formation of ethene (C_2H_4) in the reaction below.

$$C_{12}H_{26} \longrightarrow C_{10}H_{22} + C_2H_4$$

percentage atom economy = _____%

2. Calculate the percentage atom economy for the formation of iron in the reaction below.

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

percentage atom economy = _____%

3. Calculate the percentage atom economy for the formation of titanium in the reaction below.

$$TiCl_4 + 4Na \longrightarrow Ti + 4NaCl$$

percentage atom economy = _____%

4. Calculate the percentage atom economy for the formation of tungsten in the reaction below.

$$WO_3 + 3H_2 \longrightarrow W + 3H_2O$$

percentage atom economy = _____%

5. Calculate the percentage atom economy for the formation of ammonia (NH_3) in the reaction below.

$$3H_2 + N_2 \longrightarrow 2NH3$$

percentage atom economy = _____%

6. Calculate the percentage atom economy for the formation of calcium chloride in the reaction below.

You will need to balance the symbol equation for the reaction.

____ $CaCO_3$ + ____ HCl ⟶ ____ $CaCl_2$ + ____ CO_2 + ____ H_2O

percentage atom economy = _____%

7. Calculate the percentage atom economy for the formation of glucose in the reaction below.

You will need to balance the symbol equation for the reaction.

____ CO_2 +____ H_2O ⟶ ____ $C_6H_{12}O_6$ +____ O_2

percentage atom economy = _____%

Using Concentrations of Solutions in mol/dm^3 (Chemistry only) (HT only)

$$\text{concentration (mol/dm}^3\text{)} = \frac{\text{number of moles (mol)}}{\text{volume (dm}^3\text{)}}$$

1. In a titration, 20cm^3 of 0.5mol/dm^3 sodium hydroxide was needed to neutralise 25cm^3 of hydrochloric acid.

   The symbol equation for the reaction is shown below.

   $$HCl + NaOH \longrightarrow NaCl + H_2O$$

   Calculate the concentration of the hydrochloric acid.

   _____

   _____

   _____

   _____

   concentration = _____ mol/dm^3

2. In a titration, 30cm^3 of 1.5 mol/dm^3 sulfuric acid was needed to neutralise 50cm^3 of potassium hydroxide.

   a. Balance the symbol equation for the reaction.

   $$\_\_\_\_\_\ H_2SO_4 + \_\_\_\_\_\ KOH \longrightarrow \_\_\_\_\_\ K_2SO_4 + \_\_\_\_\_\ H_2O$$

   b. Calculate the concentration of the potassium hydroxide.

   _____

   _____

   _____

   _____

   concentration = _____ mol/dm^3

3. In a titration, 25cm^3 of 2.5mol/dm^3 nitric acid was neutralised by 31.3cm^3 potassium hydroxide to produce potassium nitrate (KNO_3) and water.

   a. Write the balanced symbol equation for the reaction.

   _____

   b. Calculate the concentration of the potassium hydroxide.

   _____

   _____

   _____

   _____

   concentration = _____ mol/dm^3

4. In a titration, 25cm^3 of sodium hydroxide was neutralised by 30cm^3 of 1.2mol/dm^3 acetic acid (CH_3COOH) to produce sodium acetate ($NaC_2H_3O_2$) and water.

   a. Write the balanced symbol equation for the reaction.

   _____

   b. Calculate the concentration of the sodium hydroxide.

   _____

   _____

   _____

   _____

   concentration = _____ mol/dm^3

5. In a titration, 50cm^3 of sulfuric acid was neutralised by 60cm^3 of 2.0 mol/dm^3 sodium hydroxide to produce sodium sulfate (Na_2SO_4) and water (H_2O).

   a. Write the balanced symbol equation for the reaction.

   _____

   b. Calculate the concentration of the sulfuric acid.

   _____

   _____

   _____

   _____

   concentration = _____ mol/dm^3

Calculating Gas Volume (Chemistry only) (HT only)

The volume of any gas at room temperature and pressure can be calculated using the formula:

volume of gas (dm^3) = number of moles × 24

1. Calculate the **volume** of 33 moles of carbon dioxide gas at room temperature and pressure.

   _____

   volume = _____ dm^3

2. Calculate the **volume** of 12 moles of carbon dioxide gas at room temperature and pressure.

   _____

   volume = _____ dm^3

3. Calculate the **number of moles** of gas in a balloon containing 42dm^3 of carbon dioxide gas at room temperature and pressure.

   _____

   _____

   number of moles = _____ mol

4. Calculate the number of **moles** of fluorine in 360cm^3 of gas at room temperature and pressure. Write your answer in standard form to 2 significant figures.

   _____

   _____

   number of moles = _____ mol

5. Calculate the **mass** of gas in a container that holds 60dm^3 of propane gas (C_3H_8) at room temperature and pressure.

   _____

   _____

   _____

   _____

   number of moles = _____ mol

6. Calculate the **mass** of gas in a balloon containing 1200cm^3 of oxygen gas at room temperature and pressure.

mass = _____ g

7. Calculate the **mass** of carbon dioxide that would be made by burning 4.2dm^3 of propane (C_3H_8) gas at room temperature and pressure.

$$C_3H_8 + O_2 \longrightarrow 3CO_2 + 4H_2O$$

mass = _____ g