CHEMICAL FORMULA

Exercises

Solve these problems

1. 1.82 g aluminium produces 3.4 g aluminium oxide after complete heating. Find the empirical formula of aluminium oxide. \([ \text{Al}=27, \text{O}=16]\).
2. A compound contains 40% of a metal M and 12% of carbon. The rest of it consists of oxygen. Find the empirical formula of compound. \([ M=40, C=12, O=16]\).
3. The following results were obtained in experiment conducted by a student to reduce an oxide of M with hydrogen in the laboratory.
   - Mass of crucible = 15.4 g
   - Mass of crucible + metallic oxide = 19.4 g
   - Mass of crucible + metal = 18.6 g
   If the relative atomic mass of the metal M is 64, find the empirical formula of the metallic oxide.
4. 14.72 g of compound decomposes to release 13.86 g oxygen. At the end of decomposition, hydrogen is left behind. If the relative molecular mass of the substances is 34, what is the molecular formula? \([ H=1, O=16]\)
5. The empirical formula of n-butane is given as \(\text{C}_2\text{H}_5\). If its relative molecule mass is 58, what is its formula? \([ C=12, H=1]\)
6. Calculate the percentage content of each element in the following, \([ H=1, O=16, \text{Al}=27, \text{Cl}=35.5]\)
   - (a) Methanoic acid, \(\text{HCOOH}\)
   - (b) Aluminium Chloride, \(\text{AlCl}_3\)

STOCHIOMETRY PROBLEMS

1. Hydrogen peroxide, \(\text{H}_2\text{O}_2\) decomposes to give water and oxygen. Write the chemical equation showing the reaction. If 1.7 g of hydrogen peroxide decomposes, calculate
   (a) The volume of oxygen at room temperature. \((600 \text{ cm}^3)\)
   (b) The number of molecules of oxygen produced in the reaction \([N_A = 6 \times 10^{23}]\). \((1.5 \times 10^{22})\)

2. 11.3 g of potassium chlorate, \(\text{KClO}_3\) is heated strongly to produce potassium chloride and oxygen in the laboratory. Find the volume of gas produced in s.t.p \([ 1 \text{ mole gas is equal } 22.4 \text{ dm}^3, K = 39, \text{Cl} = 35.6, O = 16]\) \((1.398 \text{ dm}^3)\)

1. Methane, \(\text{CH}_4\) can burn in limited oxygen to produce carbon and steam. If 28.8 g methane gas is burnt at room conditions, calculate
   (a) The volume of oxygen needed for the combustion \((43.2 \text{ dm}^3)\)
   (b) The mass of carbon produced \((21.6 \text{ g})\)

2. An aqueous solution of sodium thiosulphate, \(\text{Na}_2\text{S}_2\text{O}_3\) reacts with dilute hydrochloric acid to produce sodium chloride, sulphur dioxide, sulphur and water. If 15.8 g sodium thiosulphate is used calculate,
   (a) The mass of sodium chloride produced \((5.85 \text{ g})\)
   (b) The mass of sulphur produced \((3.2 \text{ g})\)
   (c) The volume of sulphur dioxide produced \((2.24 \text{ dm}^3)\)
   (d) The number of molecules of sulphur dioxide produced \((6 \times 10^{22})\)
   \([ S = 32, O = 16, \text{Na} = 23, , 1 \text{ mole of gas at s.t.p } = 22.4 \text{ dm}^3]\)

3. Ammonium is obtained through the following reaction
   \(\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3\)
   Calculate the number of moles and volumes of nitrogen and hyrogen used in the reaction if 3.2 moles of ammonia are produced at s.t.p. \((35.84 \text{ dm}^3), (107.52 \text{dm}^3)\)
A. Calculating the Molar Mass or Relative Molecular Mass (RMM) of a compound.
1. Declarative knowledge:
   Symbol of an element, chemical formula of a compound, relative atomic mass.
2. Procedural knowledge:
   Adding all mass of atoms of element in the compound.
   Step 1: Write the molecular formula or chemical formula of a compound
   Step 2: Find the relative atomic mass of every atom in the compound
   Step 3: Determine the number of an atom of each element in the compound
   Step 4: Add all mass of elements.
3. Conditional knowledge: Molar mass is used when to calculate number of mole.

B. Calculate the Empirical Formula
1. Declarative knowledge
   Mole atom, relative atomic mass, ratio of mole atom, symbol of element.
2. Procedural knowledge
   Strategy to determine the empirical formula
   Step 1: Draw a table as below,

<table>
<thead>
<tr>
<th>Elements</th>
<th>Element A</th>
<th>Element B</th>
<th>Element C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mole atom</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mole ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mole ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empirical formula</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   Step 2: Write the mass (g) is given for every elements or percentage.
   Step 3: Convert mass (g) to mole atom use formula below,
   \[
   \text{Mole} = \frac{\text{mass (g)}}{\text{Molar mass or Relative atomic mass (RAM)}}
   \]
   Step 4: Divide by smallest mole atom to give whole number
   (If the whole number is 1.5 mole, then multiply by 2)
   Step 5: Write empirical formula
   i) Write symbol of elements.
   ii) Write subscript beside symbol to show number of an atom of element.
       Example: Fe₂O₃ is empirical formula of iron(II) oxide.
3. Conditional knowledge: Empirical formula is used when to find molecular formula.

C. Writing chemical formula
   a) Ionic compound
   1. Declarative knowledge: Symbol of elements, number of an atom elements, charge of an element.
   2. Procedural knowledge
      Step 1: Write the symbol of elements in the compound
      Step 2: Determine the positive charge of elements and negative charge of elements.
      Step 3: Write the number atom of element as subscript beside the symbol atom by cross multiply.
      Step 4: Write the chemical formula of ionic compound.
      Example: Al₂O₃ – chemical formula of aluminium oxide.
      CuCO₃ – chemical formula of copper(II) carbonate
   3. Procedural knowledge:
      Chemical formula is used when to write chemical equation, or to calculate molar mass.
   b) Molecular formula
   1. Declarative knowledge:
      Symbol of elements, valence electron of each elements
   2. Procedural knowledge
      Step 1: Write the symbol of elements
      Step 2: Write the subscript as number of atom of elements to complete the outermost shell of electron is eight electron.
      Example: SO₂ is chemical formula of sulphur dioxide.
      NH₃ is chemical formula of ammonia.
3. **Conditional knowledge:**
   Molecular formula is used when to write chemical equation or to calculate molar mass.

D. **Writing chemical equation**
   1. **Declarative knowledge**
      Chemical formulae, coefficient, balance chemical equation, physical state,
   2. **Procedural knowledge**
      Step 1: Write chemical formula of reactants and products involve in equation
      Step 2: Write chemical formula of reactant at left side and chemical formula of products at right side.
      Step 3: Write an arrow between reactants and products.
      Step 4: Balance the number atom of each elements at the left side of an arrow with the number atom of each elements at right side by adding the coefficient in front of chemical formula.
   3. **Conditional knowledge**
      Balanced Chemical equation is used to solve stoichiometry problem.

E. **Solving Stoichiometry**
   1. **Declarative knowledge**
      Balanced Chemical equation, molar mass, number of mole, molar volume, Avogadro constant, chemical formula
   2. **Procedural knowledge**
      a. Analysis 1: Find the information given,
         Mass of reactant, type of the reactants and the products, Formula of reactants and formula of products, find the balance chemical equation or write the balance chemical equation.
         Analysis 2: Determine the mole ratio of reactants and the products.
      b. Planning to solve problem.
         i) Read the stoichiometry problem
         ii) Planning 1: Find the problem as the aim the find the solution
         iii) Planning 2: Convert mass (g) to mole using formula below,
             \[
             \text{Mole} = \frac{\text{mass (g)}}{\text{Molar mass}}
             \]
         iv) Planning 3: Using mole ratio from balance chemical equation, then find the mole of substance (reactant or product) and find the mole of substance that is asked from planning 1.
         v) Planning 4: Convert the mole to the mass or volume of gas or the number particles of substance that is asked by using formula below,
             Mass (g) = mole x molar mass
             Volume of gas (dm$^3$) = mole x molar volume (22.4 dm$^3$ per mole at STP or 24 dm$^3$ per mole at room condition)
             Number of particles = mole x Avogadro constant ($6.02 \times 10^{23}$).
         vi) Planning 5: Remember the formula of chemical formula or converting formula.
         vii) Planning 6: Arrange the information to calculate the answer using calculator.
      c. Monitoring:
         i) Identify the balance chemical equation is correct.
         ii) Identify using the formula is correct
         iii) Identify the converting unit is correct at the beginning
             Examples: kilogram convert to gram, centimeter to decimeter,
             Differentiate between the number of mole and the number of molecules
      d. Evaluating/ checking: Check the unit and the value of the answer is correct.
      e. **Conditional knowledge**
         To find the mass reactant /product, or volume gas of reactant / product or the number of particles of reactant / product.