General Chemistry

Matter

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Chapter Description

- **Expected Outcome:**

  At the end of the lecture, the students should be able to understand and solve the problems regarding on atoms, molecules, calculation on mole, concentration of solution and stoichiometry.

- **Reference:**
  - Chemistry for matriculation semester 1, Tan Yin Toon, Sheila Shamuganathan. Companion website.

Contents

- Atoms and Molecule
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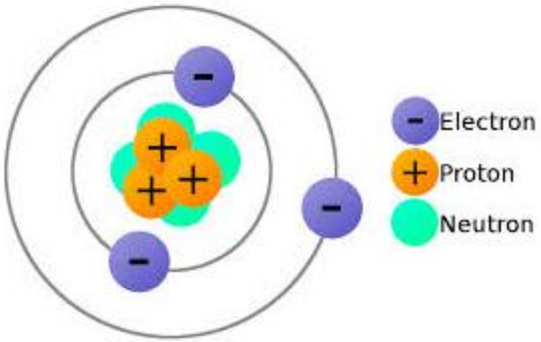
  - neutron
  - electron
- Mole Concept
- Concentration of Solutions
  - Molarity
  - Molality
  - Mole fraction
  - Percentage by volume
  - Percentage by mass
- Stoichiometry

Atoms and Molecule

- Atom- the basic unit of matter
- Come from the greek word, which mean Indivisable (smallest, cannot be divided)
- Consist of 3 particles- proton, neutron and electron



Picture source: https://learn.sparkfun.com/tutorials/what-is-electricity

Proton (p)

- Positively charged
- Located at the nucleus
- Proton number is referred as atomic number of an element
- Proton number will determine the chemical behaviour of an element
- Periodic table is arranged according to increasing atomic number.

Neutron (n)

- Contains no charge
- Located at the nucleus

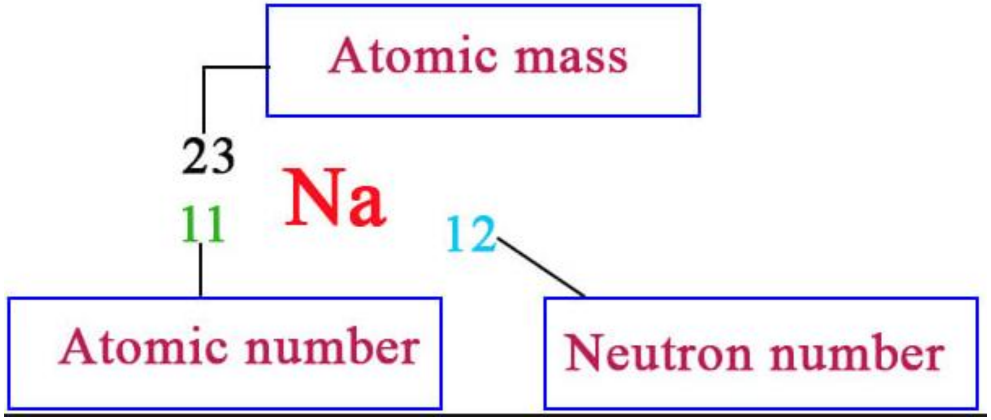
Electron (e)

- Negatively charged
- Number of electron = number of proton
- Very small compared to proton and neutron

	Relative mass	Relative charge
Proton	1	+1
Neutron	1	0
Electron	1/1836	-1

Atom

- Atomic number = Proton number = Electron number
- Neutron number = Mass number – Atomic number



[Picture source:](http://chemistry.tutorvista.com/inorganic-chemistry/proton-number.html)
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Isotopes

- Element with same proton number but different neutron number, thus, different mass number
- Eg Chlorine

$${}^{35}_{17}\mathrm{Cl} \qquad {}^{37}_{17}\mathrm{Cl}$$

- Isotopes have same chemical properties but different physical properties

Mole Concept

- Based upon carbon-12 isotope,
- Quantity of substance containing same number of particles in 12g of carbon-12.
- The number of atoms in one mole of ^{12}C is 6.02×10^{23} (Avogadro constant)

Mole

$$\text{Mole} = \frac{\text{mass (g)}}{\text{formula mass}}$$

Eg, find the number of mole of 4g KOH.

$$\text{Mole} = \frac{4}{56} = 0.07$$

Number of Atom

- Eg, find the number of atom of 0.07 mole of KOH.

$0.07 \text{ X } (6.02 \text{ X } 10^{23})$

$= 4.21 \text{ X } 10^{22}$

Concentration of Solutions

- Molarity
- Molality
- Mole fraction
- Percentage by volume
- Percentage by mass

Molarity (M)

- Number of mole of solute per liter of solution.

- Molarity = $\dfrac{\text{number of mole}}{\text{1 liter}}$

Eg :

a 0.35 M KOH solution contains 0.35 moles of potassium hydroxide in 1 liter of solution.

Molarity (M)

- Eg

Calculate the molarity of a solution that is prepared by dissolving 35 grams of NaCl into 750 mL of water.

Mole of NaCl= 35/58.44= 0.59

Molarity= 0/59/0.75= 0.79M

Molality

- Number of mole of solute per kilogram of solution.

- Molarity = $\dfrac{\text{number of mole}}{\text{1 kg}}$

Molality

- **Calculate** the **molality** of a solution that is prepared by dissolving 30 g of NaCl in 2.00 kg of water.

- Mole of NaCl= 30/58.44= 0.513
- Molality= 0.513/2= 0.256

Mole fraction

- Number of moles of a component divided by total number of moles in a solution
- Unitless (Because it is a ratio).
- The mole fraction of total component in a solution will equal to 1 when added together.

Mole fraction

- Eg

A solution is prepared by dissolving 46 g ethanol (CH_3CH_2OH) in 90 g of water. Calculate mole fraction of ethanol

Number of moles of ethanol= 46/46= 1

Number of moles of water= 90/18= 5

Mole fraction = 1/(1+5)= 0.16

Percentge by volume (%v/v)

- Volume of any component in a solution divided by total volume of the solution then multiplied by 100%.

$$(\%v/v) = \frac{\text{volume of component}}{\text{total volume of a solution}} \times 100$$

Percentge by volume (%v/v)

- A 75ml solution contains 25ml ethanol. Calculate percentage by volume of ethanol

%v/v ethanol= 25/75 X 100 = 33.33

Percentage by mass (%w/w)

- Also called weight percent
- Mass of the component divided by total mass of the solution

$$(\%w/w) = \frac{\text{mass of component}}{\text{total mass of a solution}} \times 100$$

Percentage by mass (%w/w)

- Calculate mass percentage of 5g KOH that is dissolved in 70g of water.

%w/w KOH= 5/ (5+70) X 100 = 6.66%

Stoichiometry

- Measures quantitative relationships to determine the amount of products or reactants that are produced or needed in a reaction.
- Need balancing of equation.
- To balance equation, need to know oxidation number.

Oxidation Number

- Rules in determining oxidation number:

1) In a free element, the oxidation number is zero.

   Eg:

   Na = 0 Cl_2 = 0

2) For monoatomic ion, the oxidation number is equal to the charge of the ion.

   Eg: Al^{3+} = +3 S^{2-} = -2

Oxidation Number

3) Fluorine and other halogens always have oxidation number of -1 in its compound. Only have a positive number when combine with oxygen.

Ex:

Oxidation number of F in NaF = -1

Oxidation number of Cl in Cl_2O_7 = +7

Oxidation Number

4) Hydrogen has an oxidation number of +1 in its compound except in metal hydrides where hydrogen has an oxidation number of -1

Oxidation number of H in NaH	=	-1
Oxidation number of H in MgH_2	=	-1

Oxidation Number

5) Oxygen has an oxidation number of -2 in most of its compound.

Oxidation number of O in MgO = -2

Oxidation number of O in H_2O = -2

Oxidation Number

6) In neutral molecule, the total oxidation number is equal to zero.

- Oxidation number of H_2O = 0
- Oxidation number of $KMnO_4$ = 0

Oxidation Number

7) For polyatomic ions, the total oxidation number is equal to the net charge of the ion.

Oxidation number of $KMnO_4^-$ = -1

Oxidation number of $Cr_2O_7^{2-}$ = -2

Redox Reaction

Oxidation

a) The substance loses one or more electrons.

b) Increase in oxidation number

c) Losing of hydrogen atoms

d) Gain of oxygen atoms

Reduction

a) The substance gains one or more electrons.

b) Decrease in oxidation number

c) Losing of oxygen atoms

d) Gain of hydrogen atom

Stoichiometry

Eg:

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2\,(aq)} + CO_{2\,(g)} + H_2O_{\,(l)}$

1 mole of $CaCO_3$ reacts with 2 moles of HCl to yield 1 mole of $CaCl_2$, 1 mole of CO_2 and 1 mole of H_2O.

1 mole $CaCO_3$ Ξ 2 moles HCL Ξ 1 mole $CaCl_2$
Ξ 1 moles CO_2 Ξ 1 mole H_2O

Limiting Reactant

LIMITING REACTANT

- Completely consumed in a reaction
- Will limits the amount of products formed.

EXCESS REACTANT

- Not completely consumed in a reaction

Limiting Reactant

- Zn reacts with HCl according to the equation

$Zn_{(s)} + 2HCl_{(aq)} + \rightarrow ZnHcl_{(aq)} + H2_{(g)}$

If 0.05 moles of zinc was added to 0.075 moles of HCl, identify the limiting reactant

Solution- From the equation, 1 mole of Zn reacts with 2 moles of HCl, meaning 0.05 moles of Zn will react with 0.1 mole of HCl. However, only 0.075 mole of HCl is present. Thus, HCl is the limiting reactant.

Author Information

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