

GENERAL CHEMISTRY  
SUMMARY  
FROM CHAPTER 1 TO 15

## Rules for Counting Significant Figures:

1. Nonzero integers always count as significant figures
2. classes of zeros:
  - a. (Leading zeros) are zeros that precede all the nonzero digits. These do not count as significant figures
  - b. (Captive zeros) are zeros between nonzero digits. These always count as significant figures.
  - c. (Trailing zeros) are zeros at the right end of the number. They are significant only if the number contains a decimal point.

## Accuracy

- Nearness of the measurements to the true value.

## Precision

- Nearness of the measurements to each other.

- $T_k = T_c + 273$

- $T_c = T_k - 273$

- $T_c = (T_f - 32) \times 5/9$

- $T_f = T_c \times 9/5 + 32$

▪ The atom contains:

1. Electrons: Found outside the nucleus; negatively charged.

2. Protons: Found in the nucleus; positive charge equal in magnitude to the electron's negative charge. ( $p=e$  > neutral molecule)

3. Neutrons: Found in the nucleus; no charge; virtually same mass as a proton.

nucleus is:

▪ Small compared to the overall size of the atom.

▪ Extremely dense; accounts for almost all of the atom's mass.

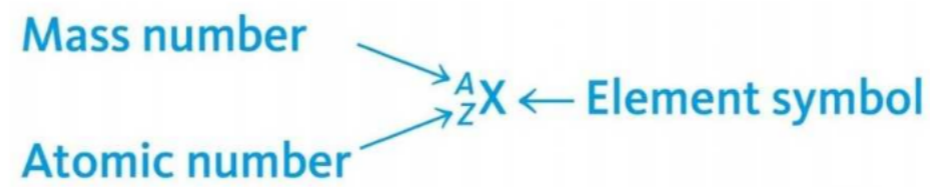
Isotopes:

▪ Atoms with the same number of protons but different numbers of neutrons.

▪ Show almost identical chemical properties; the chemistry of an atom is due to its valence electrons.

▪ In nature most elements contain mixtures of isotopes

A: is the mass number (p+n)  
Z: is the atomic number (p)



Types of Chemical Bonds:

1. Covalent Bonds: Bonds form between atoms **by sharing electrons** to form molecules

- between non-metals
- strong
- it's decided to polar (change in  $E.V > 0.5$ ) + non-polar (same element or  $E.V < 0.5$ ) covalent Bonds

2. Ionic Bonds: Bonds form due to **force of attraction** between **oppositely charged ions**

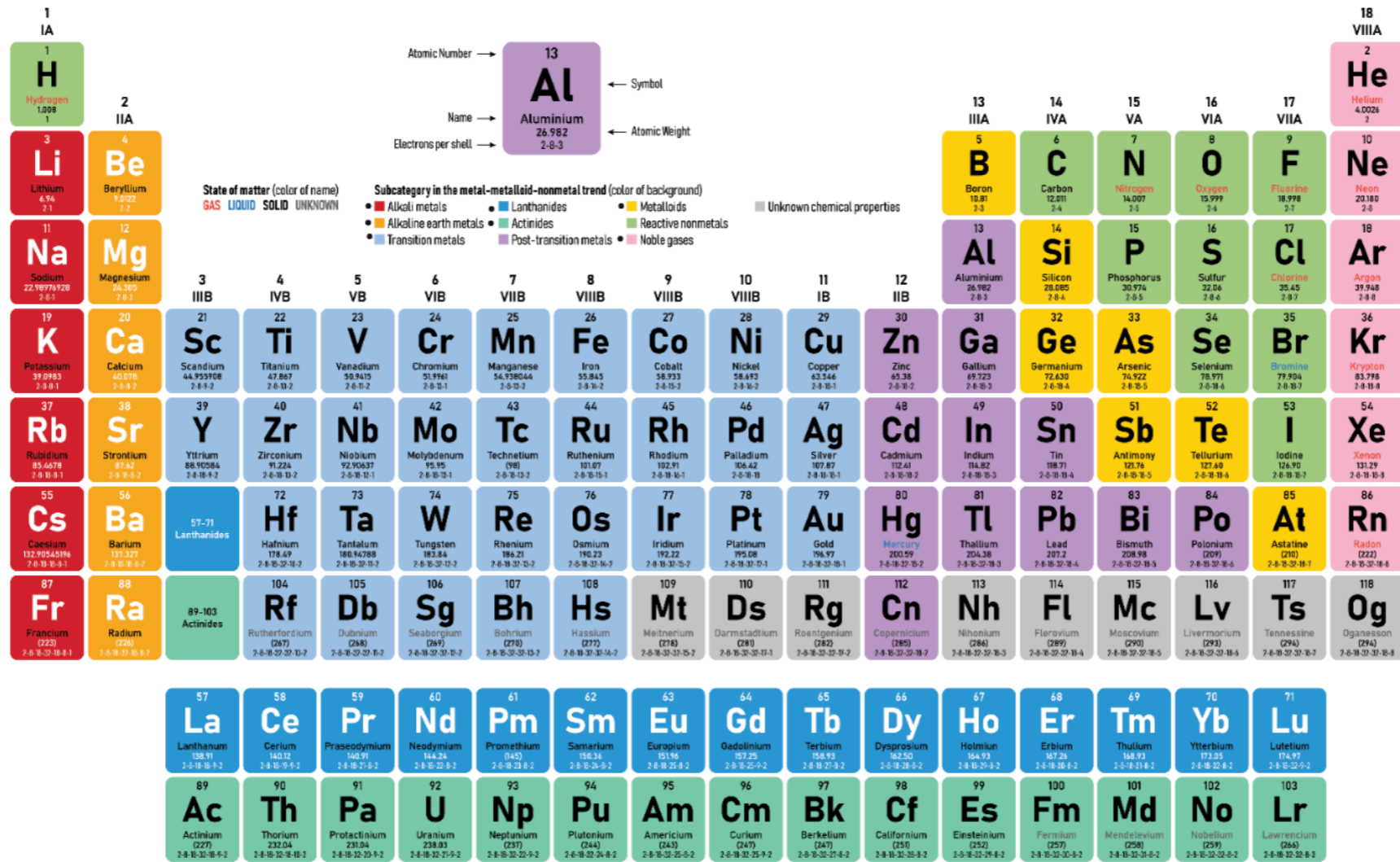
- Between metal + non-metal

Definitions:

- Ion: **atom or group of atoms** that has a net positive or negative charge. (poly atomic ions  $CO_3^{2-}$ )
- Cation: positive ion; lost electron(s).
- Anion: negative ion; gained electron(s).



# Periodic Table of the Elements



● Groups or Families: Elements in the same vertical columns; have similar chemical properties

☆ Groups like: Alkaline metals, alkaline earth metals, Halogens, noble gases.

● Periods: horizontal rows of elements

- Alkali metals
- Alkaline earth metals
- Transition metals
- Lanthanides
- Actinides
- Post-transition metals
- Metalloids
- Reactive nonmetals
- Noble gases

- G IA : +1 charge, Na<sup>+</sup>, K<sup>+</sup>, Cs<sup>+</sup> 《1》
- GIIA: +2 charge, Mg<sup>2+</sup>, Ca<sup>2+</sup>, Ba<sup>2+</sup> 《2》
- G IIIA: +3 charge like Al<sup>3+</sup> 《3》
- G VIIA: -1 charge, F<sup>-</sup>, Cl<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup> 《7》
- GVIA: -2 charge, O<sup>=</sup>, S<sup>=</sup> 《6》
- GVA: -3 charge, N<sup>-3</sup>, P<sup>-3</sup> 《5》

- Binary Compounds:
- Composed of two elements (covalent and ionic)

## ■ NAMING COMPOUNDS:

### A. Binary ionic Compounds {type one I}

- The cation (the name of the positively charge ion) is always named first and the anion second (Root+IDE)

- the cation has only one positive charge

### B. Binary ionic Compounds {type two II}

- Metals in these compounds form more than one positive charge (Fe, Cu, pb, Sn, Hg)

- Charge on the metal ion must be specified.

- Roman numeral indicates the charge of the metal cation (I, II, III, IV, V, VI, VII, VIII, IX, X)

- compounds containing polyatomic ions (cation + anion with ate or ite)

● e.g of polyatomic ions :

#  $\text{NH}_4^+$  ammonium

#  $\text{OH}^-$  hydroxide

#  $\text{SO}_4^{2-}$  sulfate /  $\text{SO}_3^{2-}$  sulfite

#  $\text{CO}_3^{2-}$  Carbonate /  $\text{HCO}_3^-$  bicarbonate

#  $\text{PO}_4^{3-}$  phosphate

#  $\text{NO}_3^-$  Nitrate /  $\text{NO}_2^-$  Nitrite

#  $\text{Cr}_2\text{O}_7^{2-}$  dichromate /  $\text{CrO}_4^{2-}$  chromate

#  $\text{CN}^-$  cyanide

#  $\text{CH}_3\text{COOH}$  Acetic acid /  $\text{CH}_3\text{COO}^-$  acetate

C. Binary Covalent Compounds (Type III) :

● The first element in the formula is named first

● The second element is named as if it were an (anion+IDE)

● the numbers of atoms present (mono, di, tri, tetra, penta, hexa, hepta, octa, nona, deca)

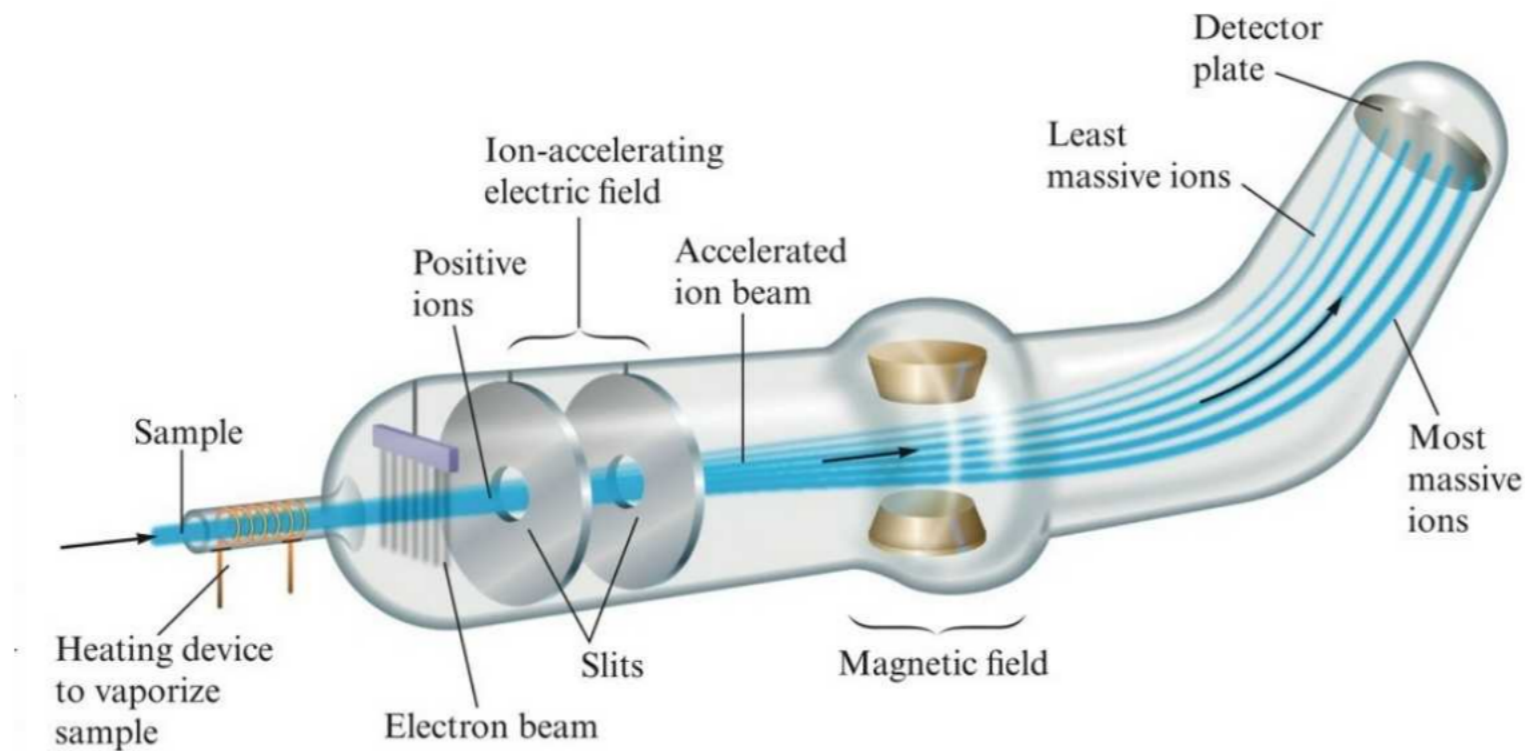
● The prefix mono- is never used for naming the first element



## Average mass of an object

- $^{12}\text{C}$  is the reference for atomic masses > Its atomic mass is exactly 12 atomic mass units (a.u)
- The ratio of the mass of an isotope found by ( mass spectrometer )
- average atomic mass =  $\Sigma (\text{atomic mass})(\text{abundance})$

كتلة كل نظير  $\times$  نسبة وجوده



## MASS SPECTROMETER

- To isolate isotopes and find their masses



- 1 mol of any substance or element =  $6.022 \times 10^{23}$  atoms
  - 1 mol of an element =  $6.022 \times 10^{23}$  = atomic mass
  - 1 mol of a compound =  $6.022 \times 10^{23}$  molecule = molar mass
  - 1 mol of C =  $6.022 \times 10^{23}$  atoms = atomic mass = 12.01
  - molar mass = (n × atomic mass) of each atom
- Mass percent of an element:
    - MASS% = mass of an element / mass of compound × 100%
  - How many grams of \_\_\_\_ in a \_\_\_\_grams of \_\_\_\_ = %of mass of an atom × grams of molecule

### Balancing Chemical Equations:

- » The number of atoms of each type of element must be the same on both sides
- » balanced equation tells us the number of moles of each of the reactants and products.
- » MASS of products = MASS of reactants
- » Coefficients are usually given as lowest integer multiples (بأبسط صورة)
- » used to relate any reactants and products together or reactants together or productstogether ( moles or masses )

● NOTE : IF THE QUESTION DETERMINE HOW MANY GRAMS OR MOLES OF A REACTANT OR A PRODUCT TO REACT OR TO PRODUCE A SUBSTANCE THERE IS NO NEED TO DETERMINE THE L.R

Limiting reactant (L.R) :

\_ the reactant that runs out first and thus limits the amounts of products that can be formed.

\_ THE EQUATION SHOULD BE BALANCED

\_ A. Stoichiometric mixing (NO L.R) : (all reactants are consumed and converted into products)

\_ B. None-stoichiometric mixing : (there is an excess reactant and limiting reactant)

\_ When the reaction is [1:1] the LR is the reactant with lower number of moles

\_ [Mixing of reactants so we should think of LR] + When grams or moles of both reactants are known

● Percentage Yield

» indicator of the efficiency of a particular laboratory

» Percentage Yield = experimental(actual) mass / theoretical mass (g)

Aqueous Solutions have a :

- Solute: Substance being dissolved
- Solvent: Liquid water

e.g : Electrolyte(salt,base,acid) : The substance that when dissolved in water produces a solution that **conducts electricity** (+ve and -ve ions are formed in water 💧)

- » A. [Strong Electrolytes]: completely ionized in water (100% dissociation) ( HCL, NaCl, MgCl<sub>2</sub>)
- » B. [Weak Electrolytes]: small degree of ionization in water
- » C. [Nonelectrolytes]: **no current flows** **Dissolves but does not produce any ions** (sugar)

● Concentration :

- Molarity =  $n/v(L)$
- concentration of an ion =  $n$  of the ion  $\times$  concentration of the strong electrolyte

● Dilution :

- the process of adding water to a concentrated or stock solution (to decrease its concentration M)

- **the number of moles CONSTANT**

- $n_i = n_f$  »  $(MV)_i = (MV)_f$



## ★ TYPES OF REACTANTS ★

### ★A\_Precipitation :

- how to know > one of the products is insoluble (ppt)
- Rules for Solubility :

#### soluble

- $\text{NO}_3^-$  salts
- group 1A alkali metals salts
- $\text{NH}_4^+$  salts
- most  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$  salts
- most sulfate salts  $\text{SO}_4^{2-}$
- $\text{OH}^-$ ,  $\text{S}^{2-}$ ,  $\text{CO}_3^{2-}$ ,  $\text{CrO}_4^{2-}$ ,  $\text{PO}_4^{3-}$   
with ( $\text{NH}_4^+$  / 1A group cations)

#### insoluble

- $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$  and  $\text{Ag}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{Hg}_2^{2+}$
- $\text{SO}_4^{2-}$  with  $\text{Ba}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Hg}^+$ ,  $\text{Pb}^{2+}$
- $\text{OH}^-$ ,  $\text{CO}_3^{2-}$ ,  $\text{CrO}_4^{2-}$ ,  $\text{S}^{2-}$ ,  $\text{PO}_4^{3-}$

• Before you solve any question » there should be a balanced equation (molecular eq)

• Equations » molecular (has only molecules)

» ionic (has ions and spectator ions)

» net ionic (has only the participant ions / spectator ions are removed)

• NOTE : INSOLUBLE MOLECULES STAY IN ITS MOLECULAR FORMULA (don't convert to ions)



## ★B\_Acid-Basic reactants :

- they are Exothermic reactants (produce HEAT 🔥)
- they are Neutralization Reactions (produce WATER 💧)

## ★C\_Oxidation-Reduction (Redox)

- How to know > one or more electron transfer

### •Rules for Assigning Oxidation States (exceptions):

» Oxygen = -2 in covalent compounds (except in peroxides (فوق الأوكاسيد) where it = -1)  
H<sub>2</sub>O<sub>2</sub>, K<sub>2</sub>O<sub>2</sub>, Na<sub>2</sub>O<sub>2</sub>)

» Hydrogen = +1 in covalent compounds (except in hydrides, -1) (hydrides are a metal from 1A, 2A, 3A + H)

» Fluorine = -1 always

» oxygen with fluorine is (+) as in (F<sub>2</sub>O its +2)

- Ions are formed upon the electron transfer

•Oxidation - increase in oxidation state, it happens by loss of electrons) (Reducing agent)

•Reduction - decrease in oxidation state it happens by gain of electrons) (oxidizing agent)

•the equation is divided to oxidation half and Reduction half > then the electrons  $e^-$  should be the same in both halves to add them together

•NOTE: remove the spectator ions from the equation

## • Properties of gases:

- ◆ Uniformly fill any container and take its shape.
- ◆ Easily compressed.
- ◆ Mixes completely with any other gas.
- ◆ Exerts pressure on its surroundings.

## • Measurement of Pressure:

- atmospheric By (barometer)
- gas confined in a container By (manometer)
- $p = \text{force} / \text{area} > (\text{N/m}^2)(\text{pascal/pa})$

## • Pressure Conversions :

$$1 \text{ atm} = 101.325 \text{ kpa} = 101325 \text{ pa} = 1.01325 \text{ bar} = 760 \text{ mm Hg} = 760 \text{ torr} = 14.7 \text{ Lb/in}^2$$

## • Variables affecting the state of a gas:

Temperature (T) in kelvin (directly with volume)

Pressure (P) in atm (inversely with volume)

Volume (V) in L

Number of moles (n) in mol (directly with volume)

• ideal gas law >  $PV = nRT$ , R(constant =  $0.08206 \text{ L}\cdot\text{atm/mol}\cdot\text{k}$ )

» if n is constant  $(PV/T)_i = (PV/T)_f$

» if P+n are constant  $(V/T)_i = (V/T)_f$

» if T+n are constant  $(PV)_i = (PV)_f$

Temperature  
in all  
calculations  
should be at  
kelvin

♥ SMV  $\gg n = 1\text{mol}, T = 0^\circ\text{C} = 273\text{K}, P = 1\text{atm}, V = 22.24\text{L}$  (1mol under STP)

♥ STP  $\gg T = 0^\circ\text{C} = 273\text{K}, P = 1\text{atm}$

♥ we can calculate (density  $d$ , molar mass  $mm$ ) from :

•  $mm = d \times R \times T / P$  (gram/mol)

•  $d = P \times mm / R \times T$  (gram/L)

♥ if there is a mixture of gases **IN THE SAME CONTAINER** ( $V_1 = V_2 = V_3$ ) (under the same conditions  $V$  and  $T$ ) :

•  $P_{\text{total}} = P_1 + P_2 + P_3 \dots$  or  $P_{\text{total}} = n_{\text{total}} \times R \times T / V$

♥ if there is a **CONTAINER WITH A VALVE** :

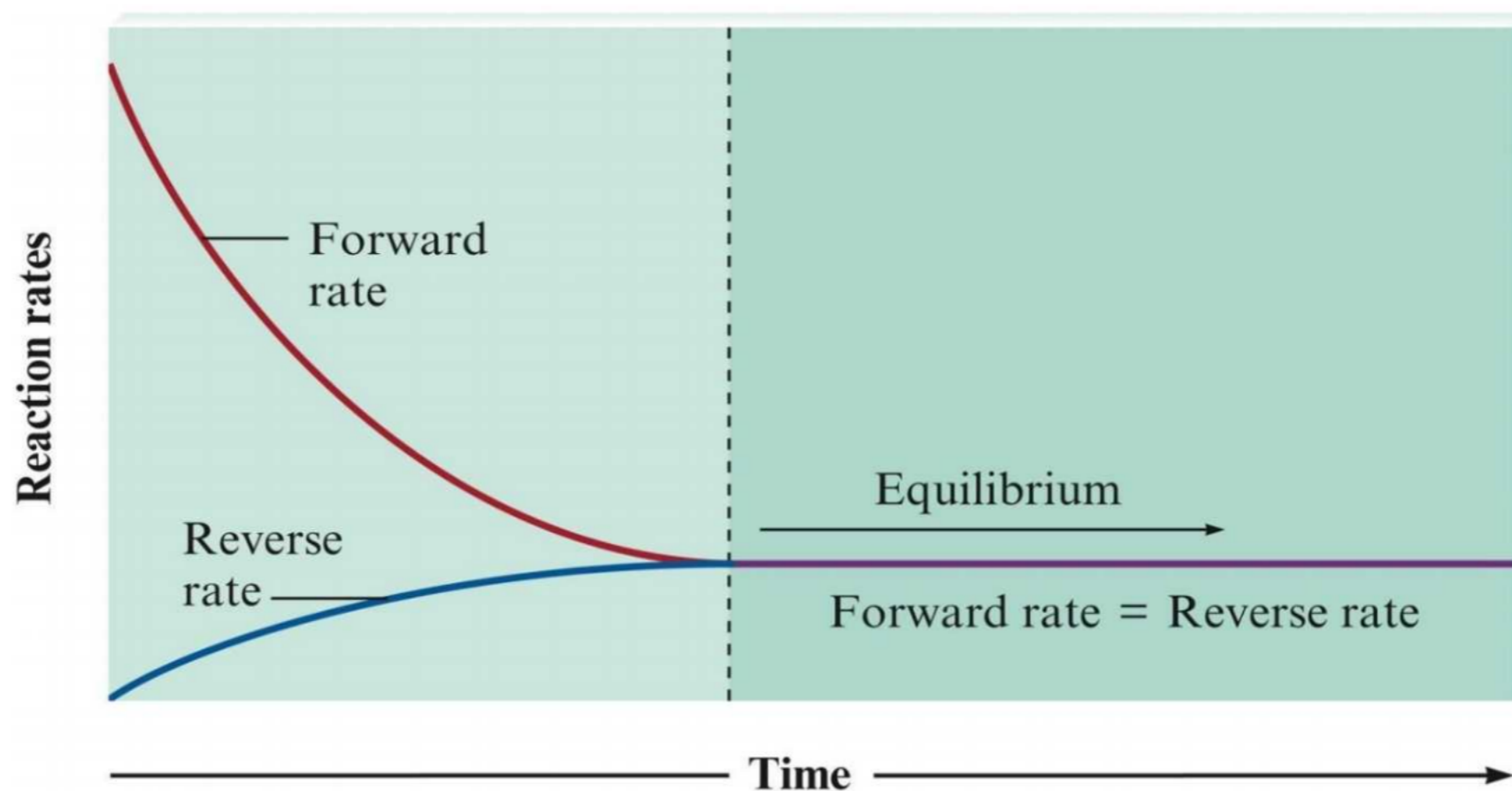
• count  $n$  of each side before the valve is closed  $\gg$  then find  $n_{\text{total}} \gg V_{\text{total}}$  is the sum of the volume at both sides  $\gg$  then find  $P_{\text{total}}$

•  $P_{\text{total}}$  will be larger than  $P$  in one side and less than  $P$  in the other side (in the middle of both  $P$ )



## ♣ Chemical Equilibrium :

- Describes reactions that do not go to completion ( $\rightarrow$  forward /  $\leftarrow$  reverse)
- the concentration of products and reactants stay constant with time
- equilibrium is dynamic
- at  $t=0$  (initially) concentration of products equal zero (before equilibrium is reached)
- After equilibrium is reached, none of the reactants or products has a concentration of zero
- at equilibrium  $>$  forward rate = reverse rate (have the same speed)
- the speed of forward rate decrease due to decreasing of concentration of reactants (with  $t$ )
- the speed of reverse rate increase due to increasing of concentration of products (with  $t$ )





♣ Equilibrium constant { K }:

»  $K = \frac{[\text{of products}]^{\text{to the power of their number of moles}}}{[\text{of reactants}]^{\text{to the power of their number of moles}}}$

• When the balanced equation for a reaction is multiplied by a factor (a) the new K is the original K to the power of the factor »  $K_{\text{new}} = (K_{\text{original}})^a$

• K is written without a unit

• K value change ONLY when the temperature is changed

• when the substances are gases it's called ( $K_p$ )

»  $K_p = \frac{(P \text{ of products})^{\text{to the power of their number of moles}}}{(P \text{ of reactants})^{\text{to the power of their number of moles}}}$

• We can calculate Molarity from »  $M = P/RT$

• we can calculate  $K_p$  from  $K_c(K)$  »  $K_p = K_c \times (RT)^{\Delta n}$  ( $\Delta n = n \text{ products} - n \text{ reactants}$ )

•  $K_c = K_p / (RT)^{\Delta n}$

■  $\Delta n$  is negative »  $K_p < K$  ■  $\Delta n$  is positive  $K_p > K$  ■  $\Delta n = \text{ZERO}$   $K_p = K$

• there are two types of equilibrium :

1. homogeneous equilibria (products and reactants have the same phase) (like gas with gas)

2. Heterogeneous Equilibria (products and reactants have different phases) (gas with solid)

**NOTE:** equilibrium does not depend on the amounts of pure solids or liquids present because their concentrations are constant • they are removed from K constant law

★ if  $K$  value  $> 1$  equilibrium of the reaction system consists of mostly products (lies to the right  $\rightarrow$ )

★ if  $K$  value  $< 1$  equilibrium of the reaction system consists of mostly reactants (far to the left  $\leftarrow$ ) (no significant extent)

★ if  $K$  value  $= 1$  (equilibrium of reaction system consists of both reactants and products 50% of each reaction)

■  $Q$  (Quotient):

• used when all initial concentrations (reactants and products) are non-zeros

• it share the same law with  $K$

•  $Q = K$  at equilibrium

•  $Q > K$  (The system shifts to the left  $\leftarrow$  After equilibrium) Consuming products and forming reactants (لتعويض النقص في المتفاعلات)

•  $Q < K$  (The system shifts to the right  $\rightarrow$  Before equilibrium) Consuming reactants and forming products (لتعويض النقص في النواتج)

## ■ CALCULATIONS :

1. IF the question gave the **initial concentrations of REACTANTS** and the **concentration at EQUILIBRIUM** > first we will look if ( $Q > K$  or  $Q < K$ )

• if  $Q < K$  » Subtract the equilibrium concentration from reactants and add it to products (اطرح تركيز الاتزان من التفاعلات واجمعه إلى تركيز النواتج) then find  $K$

• if  $Q > K$  » add the equilibrium concentration to reactants and Subtract it from products (اطرح تركيز الاتزان من النواتج واجمعه إلى تركيز المتفاعلات) then find  $K$

2. IF the **concentration of equilibrium unknown** ( $K$  MUST BE KNOWN) assume the **concentration of equilibrium is (X)** then follow the same steps in the top ^ to find  $X$

( يطلب تركيز الاتزان > بنفترض انه مجهول وبنحل المعادلة وواحدة من القيم الناتجة يتم اهمالها بناء على المنطق )

• ان لم يتم ذكر  $Q <$  فالتركيز الابتدائي للنواتج يساوي صفر

## ■ Le Châtelier's Principle

• If a change is imposed on a system at equilibrium, the position of the **equilibrium will shift** in a direction that reduces that change

• Effects of Changes on the System :

1. **Concentration** : the equilibrium will be **shifted to the opposite side of the addition**

(يرجح الاتزان الجهة الأضعف أي الجهة المعاكسة لجهة الاضافه او يرجح جهة النقص)

•  **$K$  value constant**



## 2. Temperature:

### • K value will change

• it's divided to » **Exothermic reaction**: energy is produced (heat with products ( $\Delta H < 0$  -))  
in Exothermic reactions the relation between K and T (reverse relation)

» **Endothermic reaction**: energy is a reactant ( $\Delta H > 0$  +)

in Endothermic reactions the relation between K and T is a (direct relation)

• تتم إزاحة الاتزان إلى جهة النقص في درجة الحرارة أو عكس الزيادة

## 3. Pressure at constant temperature [volume pressure]

• if the phases are gases

• the equilibrium is shifted to the side with the least number of moles

(يزاح الاتزان إلى الجهة الأقل عدد مولات)

• **NOTE**: IF THE RATIO IS 1:1 THE INCREASE OR DECREASE OF PRESSURE **WILL NEVER CHANGE THE EQUILIBRIUM POSITION** ( $n$  products =  $n$  reactants)

• K is constant

## 4. Addition of inert gas does not affect the equilibrium position

(إضافة غاز خارجي غير مشارك في التفاعل لا يغير في موقع الاتزان)

• K is constant



## ● Acids and Bases:

● **STRONG** acids and bases ionization equilibrium lies far to the **right**

● **WEAK** acids and bases ionization equilibrium lies far to the **left**

● The weaker the acid The stronger its conjugate base والعكس

● Water is amphoteric (Auto ionization) :Behaves either as an acid or as a base

● pH changes by 1 for every power of 10 change in  $[H^+]$

يعني اذا نقص تركيز ايون الهيدروجين بمقدار واحد بالعشره هذا يعني زيادة درجة واحده في درجة الحموضة والعكس

● The number of decimal places in the log is equal to the number of significant figures in the original number (eg  $[H^+] = 2.4 \times 10^{-5}$  2sf > pH = 4.62 2 numbers after the decimal point)

● if the acid or the base is **strong the major species are** (the conjugate base or acid +  $H^+$  or  $OH^- + H_2O$ )

● if the acid or the base is **weak the major species are** (the acid or the base +the conjugate acid or base +  $H_2O + H^+$  or  $OH^-$  )

●  $K_w$  is neglected due to its low value compared with  $K_a$  or  $K_b$

● the concentration of  $OH^-$  OR  $H^+$  from the water is neglected due to its low value compared with the concentration from the acid or the base

## ● The Effect of Structure on Acid-Base Properties :

### » factors for acidity in binary compounds:

• Bond Polarity (high is good) high  $\Delta E \cdot N$  stronger acid

• Bond Strength (low is good)

• length of the bond (short is good)

• repulsion between the electrons and the high E·N atom like HF (low is good) اقل تنافر أقوى

• the acid that has a oxygen atoms (oxyacid) (more O atoms attached to the central atom

stronger acid)

• H-O-X (oxyacid) The greater the ability of X to draw electrons toward itself, the greater the acidity of the molecule

## ★ OXIDES DEVIDED TO

1. non-metalic oxides » they have an acidic affect (like  $SO_2, NO_2, CO_2$ )

when they react with  $H_2O$  they produce acids ( $SO_2 + H_2O > H_2SO_3$ )

• O-X bond is strong and covalent will remain intact / H-O bond is weak it will break and release  $H^+$

2. metallic oxides » they have a basic affect like ( $K_2O, CaO$ )

• when they react with  $H_2O$  they produce a base ( $K_2O + H_2O > KOH$ ) ( $CaO + H_2O > Ca(OH)_2$  strong base )

• O-X bond is ionic it will break (X has low E·V)

## ■ Lewis

• Lewis acid may be a cation  $A^+$  or a neutral but it has a (vacant orbital فلك فارغ) (such as B)  
most of the time it's metal with positive charge (metal cation)

• Lewis base may be anion  $B^-$  or neutral with a lone pair of electrons (such as F,O,N)

Model	Definition of Acid	Definition of Base
Arrhenius	$H^+$ producer	$OH^-$ producer
Brønsted-Lowry	$H^+$ donor	$H^+$ acceptor
Lewis	Electron-pair acceptor	Electron-pair donor



## ♣ Common Ion Effect:

- Shift in equilibrium position that occurs because of the addition of an ion already involved in the equilibrium reaction
  - An application of Le Châtelier's principle
  - if we add a basic salt to an acidic solution the equilibrium will be shifted to the left  
(زيادة في تركيز القاعدة المرافقة ونقص في تركيز الحمض)
  - if we add a acidic salt to an acidic solution the equilibrium will be shifted to the right  
(زيادة في تركيز الحمض ونقص في تركيز القاعدة المرافقة)
  - if we add a basic salt to a basic solution the equilibrium will be shifted to the right  
(نقص في تركيز الحمض المرافق وزيادة في تركيز القاعدة )
  - if we add an acidic salt to a basic solution the equilibrium will be shifted to the left  
(نقص في تركيز القاعدة وزيادة في تركيز الحمض المرافق)
- يعني إضافة الملح بتزيد تركيز الي مثل نوعه وبقلل الي عكسه مثل ملح حامضي بزيد تركيز الحمض وبقلل تركيز القاعدة

## ♣ Buffered Solutions:

- Buffer solutions resist a change in pH.
- it's either A weak acid and its conjugate base OR A weak base and its conjugate acid
- For a good buffer both components should be of high concentrations
- Henderson-Hasselbalch equation  $\gg \text{pH} = \text{pK}_a + \log\left(\frac{[\text{A}^-]}{[\text{HA}]}\right)$  or  $\text{pH} = \text{pK}_b + \log\left(\frac{[\text{HB}^+]}{[\text{B}]}\right)$

- $H^+$  reacts to completion with the weak base
- $OH^-$  reacts to completion with the weak acid
- As long as this ratio remains virtually constant the pH will remain virtually constant because (HA and  $A^-$  or B and  $BH^+$ ) are large compared with amounts of  $H^+$  or  $OH^-$  added.

يعني مادامت النسبة بين الحمض وقاعده المرافقة او العكس ثابتة درجة الحموضة تبقى ثابتة حتى مع إضافة قاعدة او حمض قوي لانه التركيز المضاف من الحمض او القاعدة صغير جدا مقارنة مع تركيز الحمض او القاعدة الأصلي

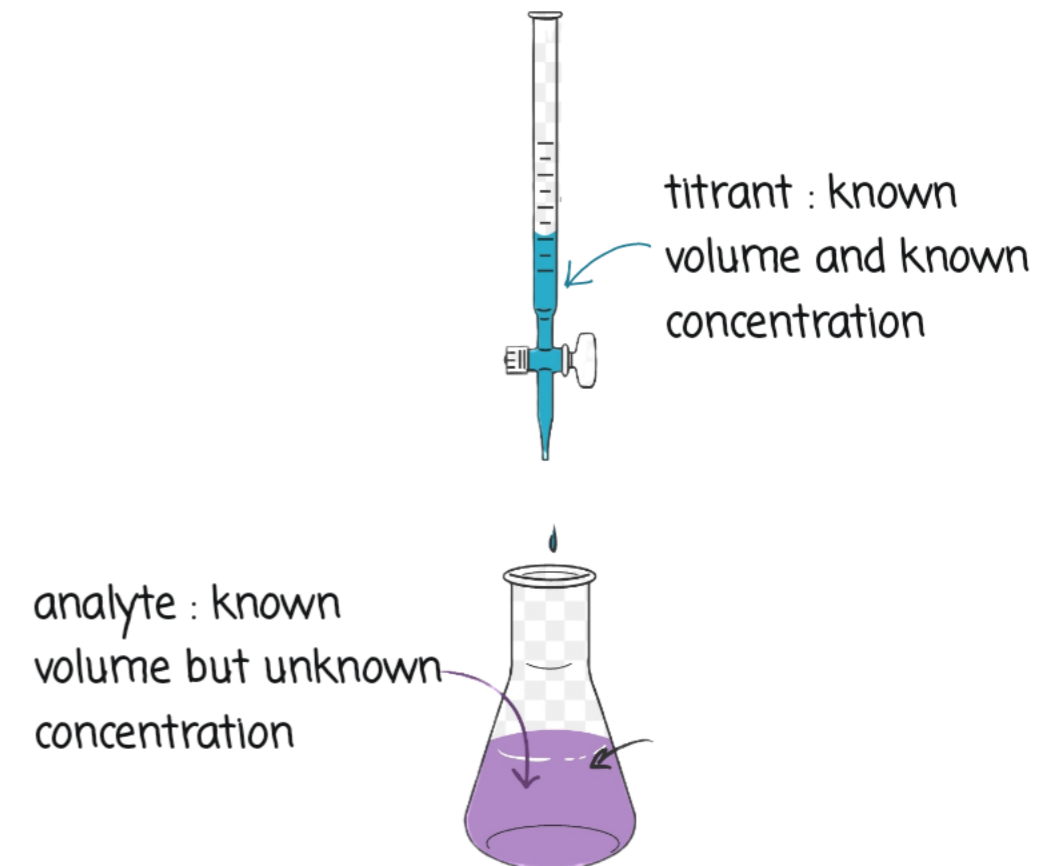
• وهذا دليل على وجود (Buffer capacity)

اي انه اذا زاد تركيز الحمض القوي او القاعدة القوية المضاف عن حد ما يفقد المحلول المنظم عملة ويتحطم ولا تبقى درجة الحموضة ثابتة

• Buffers Resist dilution

• titration :

- Plotting the pH of the solution being analyzed as a function of the amount of titrant added
- Equivalence (Stoichiometric) Point - point in the titration when enough titrant has been added to react exactly with the substance in solution being titrated
- Marks the end point of a titration by changing color
- The equivalence point is not necessarily to be same as the end point (but they are ideally as close as possible)



## ♥ Indicators:

1. Phenolphthalein : colorless in acidic solution and pink in basic solution
2. Methyl Orange : Red in acidic solution and yellow in basic solution

### ● Phenolphthalein



### ● Methyl Orange

