Date
S S M T W T F

CHEM 101

Fundamentals of Chemistry

Credit: 1.5/3.0

Total classes: 21/42 (section A/..B)

Assessment

Class Perf.	5%
CT/Assignment/H.W	20%
MT Assessment	15%
Final Exam	60%
	100%

Total marks: 300

CT: Best 2 out of 3 (one may be assignment) - 2x20 = 40

MT: 30

FE: 90X2 = 180

Attendance: 15

Individual Assignment: 15

Date

Syllabus

Solutions, Thermochem, Electrochem, Chemical Equilibrium, Phase rule, kinetics.

~~Why~~

Micro & macroscopic props of materials

Areas: Thermodynamics, electrochem, kinetics,

A blueprint for sustainable future: 17 goals

1. No poverty, 2. zero hunger, 3. Good health & wellbeing, 4. Quality edu, 5. Gender equality, 6. Clean water and sanitary, 7. Affordable & clean energy, 8. Decent work & economic growth, 9. Industry innovation & infrastructure, 10. reduced ine equalities, 11. sustainable cities, 12. responsible consumption, 13. climate action, 14. life below water, 15. life on land, 16. peace, justice, 17. Partnership from the goals

Kalundborg
symbiosis

Date

Ref books / Physical Chem

Principles of P.C → Hague and Nawab

Essentials of P-C → Bahl and Tuli

P.C → Atkins

CHEM-101

Date 11/05/23

Section A / Syllabus

Atomic Structure:

Periodic Table:

Chemical bonding:

Basic Concepts of Organic Chemistry:

Hydrocarbon

Selective Organic Reactions

Acids-Bases / Buffer solution:

STEM → Science, Technology, Engineering, Mathematics.

—

Basic of Electrochemistry

Electrochem → deals w/ the relationship between electrical energy and chemical reactions.

Electricity is the fundamental form of energy that is created w/ the move of e^-.

—

Certain chemical reaction creates electricity

- chemical energy → electrical energy ; redox

$$Cu + AgNO_3 \rightarrow Cu(NO_3)_2 + Ag$$

$$Cu \rightarrow Cu^{2+} + 2e^-$$

$$Ag^+ + e^- \rightarrow Ag$$

Et

Electricity makes ~~certain~~ certain chemical reaction happen that wouldn't happen otherwise.



Application of Electrochemistry

Seperations
- Electrodialysis
- Salt splitting

Energy
- Redox flow cells
- ~~Flu~~ Fuel cells
- Batteries

Synthesis
- Inorganic
- Organic
- Pharmaceutical

Environmental Electro-chem
- metal recovery
- water treatment

Application of E.C in W.T.P

WTP is a facility designed to remove contaminants and impurities from raw sources.

Physical, Chemical, Biological impurities.

↓ coagulating agents

Poly aluminium chloride

Alum → $Al_2(SO_4)_3 \cdot 18H_2O$

$Al(OH_3)_3$

} Pos charge দিয়ে impurities -ের সাথে যুক্ত হয়ে neutral করে দিয়ে coagulate করে।

Flocculation → larger particles

↓ agents

Poly acrylamides

Poly acrylonitrile

Raw water → coagulation (coagulants ↓)

↓

Sedimentation ← Flocculation

↓

disinfection

↓

Filtration → Treated water

house ← storage

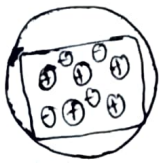
Conductor → any material that ALLOWS electric current to pass through

Insulator → → DOESN'T allow →

Pure water doesn't conduct e^-

Metalic / Electrolytic conduction

Flow of current takes place w/o the decomposition of substance



Metal lattice

Electrolyte: conducts electric current when dissolved in a solvent — water

Strong electrolytes → Sodium [hydroxide / chloride]

Weak ——————→ water

Non-electrolytes → sugar

Basis → decomposition

Applications

Production of metals

Electroplating

Electrolytic refining

Production of chemicals

Battery technology

water treatment

why anion, cation swapped in galvanic cell

electrolytic cell

~~0.1 N $C_2H_2O_4$~~

For acids, $E = \frac{\text{molecular wt}}{\text{protocity}}$

base, $E = \frac{\quad}{\text{acidity}}$

Mechanism of Electrolysis

- Electrolysis
  - Non-spontaneous
  - Electricity into chemical energy
  - Anode : Oxidation : $Cl^- \rightarrow Cl + e^-$

    cathode : Reduction : $H^+ + e^- \rightarrow H$

  - Faraday's law of Electrolysis
    - $w \propto Q$; $Q = It$

      $w = zIt$

      z = electrochemical equivalence
    - 2nd law

      for H_2SO_4, $E = \frac{M}{2}$

      H_3PO_4, $E = \frac{M}{3}$
    - combined law

      $w \propto Q$, $w \propto E$

      $w \propto Q \times E$

      $w = \frac{Q \times E}{F}$; $F = 96500\ C$

- Chemical equivalence = Electro-chemical equiv. × 96500 C

Electrochemical Cell

- Chemical energy → electrical en. or vice-versa
- Galvanic cell, Electrolytic cell
- spontaneous
- diagram / Galvanic

$Zn / Zn^{2+} \,\|\, Cu^{2+} / Cu$ (‖ : salt bridge)

- Types
  - Primary cell / Dry cell / Leclanche' cell
    - Anode: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

      Cathode: $2MnO_2 + H_2O + 2e^- \rightarrow Mn_2O_3 + 2OH^-$

      $Zn + 2MnO_2 \rightarrow Zn^{2+} + Mn_2O_3 + 2OH^-$
  - Secondary cell

★★★ - Fuel cell

SB

28/05/23

Conductance of Electrolytes (Chap 2.4)

↓

the power to conduct electric current.

- $I = \frac{E}{R}$
- $R \propto \frac{l}{A}$:

$\Rightarrow R = \rho \frac{l}{A} \Rightarrow \rho = \frac{RA}{l}$

- Specific conductance (K = Kappa)
  - $K = \frac{1}{\rho} = \frac{1}{R} \times \frac{l}{A} = \frac{1}{ohm} \times \frac{cm}{cm^2} = ohm^{-1} cm^{-1}$
- Equivalence conductance
  - $\Lambda = K \times V$

P2:

$K = \frac{l}{RA}$

$= \frac{20}{25 \times 40}$

$= 0.2\ ohm^{-1} cm^{-1}$

$l = 20$ cm

$A = 40$ sq cm

$R = 25\ \Omega$

Equiv. cond. = ?

$\Lambda = K \times \frac{1000}{N} = 0.2 \times \frac{1000}{0.5} = 40$

Ans:

$$\Lambda = K \times V$$

$$= \frac{l}{RA} \times \frac{1000}{N}$$

$$= \frac{1}{2.5 \times 10^{3}} \times 1.15 \times \frac{1000}{0.1}$$

Molar conductance

$$\Lambda = K \times V$$

$$= \frac{l}{RA} \times V$$

Factors influencing the conductivity of electrolytes -

Nature of electrolyte : Strong electrolytes ionize almost completely in the solution whereas weak electrolyte ionize to a small extent.

Size of ions : larger the ion, smaller the conduct

Nature of solvent and viscosity : Greater the polarity of the solvent, greater the conductance. Viscosity ↑ conductance ↓.

Concentration of solution : ↑concentration ↓ conduc

Temperature : ↑T ↑ conduct

Debye - Huckel Theory

Modern theory of strong electrolytes

$A_c = A_0 - (A + BA_0)\sqrt{C}$

Ostwald's law : $\alpha = \frac{\lambda_v}{\lambda_\infty}$

Finite dialation : ion, ion interaction
solvent effect

Kohlrausch's law → Next day

SB

04/06/23

Kohlrausch's Law

$$\lambda_\infty = \lambda_a + \lambda_c$$

Transport number

the transport number of cation, $t_+ = \frac{v_+}{v_+ + v_-}$

" " " " anion, $t_- = \frac{v_-}{v_+ v_-}$

$$\frac{t_+}{t_-} = \frac{v_+}{v_-} = \frac{t_+}{1 - t_+} = \pi$$

App.

$\lambda_a \propto v_1$

$\lambda_c \propto v_+$

...

...

$$\frac{\lambda_a}{\lambda_c} = \frac{t_-}{1 - t_-}$$

$$\Rightarrow \lambda_a = t_- \lambda_\infty$$

Use of Kohlrausch's Law

- Calc of molar conductivity at infinite dilution for weak electrolytes
- Calc of degree of dissociation
- calc of dissociation constant for a weak electrolyte.
- Calc of solubility

Mobility: strong acid against strong base

Ion	$u_c \times 10^5$	Ion	$u_a \times 10^5$
H^+	36.30	OH^-	20.50
Li^+	4.01	Cl^-	
Na^+	5.19	I^-	
K^+	7.61	NO_3^-	
Ca^{2+}	6.16	SO_4^{2-}	
La^{3+}	7.21		

Explanation titration curve

Titration of:

- strong acid, strong base
- " " weak acid
- weak acid, " "
- " " , strong base

Precipitation reactions:

Chapter review

SB/Chap 17: CHEMICAL EQUILIBRIUM 11/06/23

Ak Reversible reaction

Dynamic equilibrium

Nature / Features of chemical equilibrium

- consistancy of concentration
- equilibrium can be initiated from either side
- " " not be attained in open vessel
- a catalyst can not change the equilibrium point
- doesn't depend upon the initial concentration of reactants
- at equilibrium, $\Delta G = 0$ [ΔG → gibbs free energy → Thermodynamic prop]

$\Delta G = -ve$; spontaneous → heat is released → exergonic

$\Delta G = +ve$; non-spo...; heat is added → endergonic

$\Delta G = 0$; is at equilibrium, no free energy available to work

Law of mass action

- rate of reaction $\propto [A][B]$

$$k[A][B]$$

- at equilibrium

$$k_1[A][B] = k_2[C][D]$$

$$\Rightarrow K_c = \frac{[C][D]}{[A][B]}$$

$A + B \longrightarrow C + D$

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

$$K_{c_1} = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$K_{c_2} = \frac{[NO_2][O_2]}{[N_2O_5]}$$

$$K_{c_3} = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$$

Equilibrium constant expression in terms of partial pressures

- at equilibrium,

$$K_p = \frac{(P_Y)^\delta (P_Z)^2}{(P_L)^l (P_M)^m}$$

$$lL + mM \rightleftharpoons \delta Y + zZ$$

Relationship between K_p, K_c

$$K_p = K_c (RT)^{\Delta n}$$

Units

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

$K_p = K_c (RT)^{\Delta n}$

$= 6 \times 10^{-2} \times (8.315 \times 773)^{-2}$

$= 2.48 \times 10^{6}$ Pa

←

K_p at 25°C for

$2NO_{(g)} + Cl_{2(g)} \rightleftharpoons 2NOCl_{(g)}$

is 1.9×10^{3} atm^{-1}

$K_c = ?$

SB / ~~Thermo~~ 18/06/2023

Van't Hoff reaction Isotherm

Chemical potential of a substance in mixture

$$\mu = \mu_0 + RT \ln a$$

$$a\mu_A = a(\mu_A^\circ + RT \ln a)$$

~~Derivation~~ Derivation

Change in free energy for reaction

$$\Delta G = \Delta G_{products} - G_{reactants}$$

$$= (\cdots)$$

$$= \Delta G^\circ + RT \ln \frac{a_C^c \times a_D^d \times \cdots}{a_A^a \times a_B^b \times \cdots}$$

$$\Delta G^\circ = -RT \ln K_p$$

Where, ΔG° is the free energy of the reaction in standard state.

$$\Delta G^\circ = \Delta H^\circ + T\left(\frac{\delta(\Delta G^\circ)}{\delta T}\right)_P$$

$$\Rightarrow T\left(\frac{\delta(\Delta G)}{\delta T}\right)_P = \Delta G^\circ - \Delta H^\circ$$

$$\frac{\Delta H}{RT^2} = \frac{d(\ln K_p)}{dT}$$

By integrating,

$$\log K_p = -\frac{\Delta H}{2.303RT} + C$$

$$\ln K_p = -\frac{\Delta H}{RT} + C$$

$$\ln \frac{K_{P_2}}{K_{P_1}} = -\frac{\Delta H}{R}\left[\frac{T_2 - T_1}{T_1 T_2}\right]$$

$$\Delta G^\circ = -RT \ln K_p$$

1.

~~$\Delta G^\circ = -RT \ln K_p$~~

$$\ln \frac{0.21}{20.2} = -\frac{\Delta H}{R}\left[\frac{1065 - 945}{1065 \times 945}\right]$$

$\therefore \Delta H = 54737.894$

2.

$\Delta G^\circ = -RT \ln K_p$

$= -R \times 298 \times \ln |5.04 \times 10^{17}|$

$= -100940.60$

3. K_p for the reaction at 25°C

$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)} + 173$

kJ

SB 25/06/23

Le Chatelier's Principle

reactant conc. ↑ temp. ↑ pressure ↑

favors prod ↑

★★★ Synthesis of Ammonia (Haber Process)

Chemical Kinetics

Overview

Kinetic order, molecularity integrated rate law, collision theory, transition state theory, factors affecting rate of a reaction

—

concentration

—

Reaction rate :

The rate law :

Factors affecting rate of a reaction

Molecular orientation, Temp, Catalyst, surface area, Conc, pressure, reactant state of Matter

Temp ↑ rate ↑

thermodynamic → feasibility of a reaction

Kinetics → rate of reaction

Catalyst & surface area increase



Order of reaction, determining them on

Chap 26

SB

09/07/23

Order of a Reaction

$$\text{rate} = k[A]^m[B]^n$$

$$\text{order} = m+n$$

Molecularity of a Reaction

=

=

-

Orders vs. Molecularity

It is the sum of the powers of the concentration term

It is the number

Zero order reaction

Whose reaction rate is independent of conc.

A	→	Prod
Init. con. a		0
final con. $a-x$		x

in terms of reactant

$$\text{rate} = \frac{-d[A]}{dt} = k_0[A]^0 = k_0[A]^0$$

$$\Rightarrow \frac{d}{dx} = \frac{-d(a-x)}{dt} = \ln(a-x) \rightarrow = k_0$$

$$\Rightarrow$$

or,

$$k_0 = \frac{x}{t} \text{ or } k = k_0 t$$

in terms of prod

$$\frac{dx}{dt} = k_p$$

$$\int dx = k \int dt$$

$$x = k_1 (t-0)$$

First order of reaction

$$\ln [A]_t = -kt + \ln [A_0]$$

$$\Rightarrow -\frac{dA}{dt} = -k_0$$

$$\Rightarrow \frac{d[A]}{dt} = k dt$$

$$\Rightarrow \int \frac{d[A]}{[A]} = k_0 \int_0^t dt$$

$$\Rightarrow \ln [A]_t \; \ln A = k_0 t$$

$$\Rightarrow \ln [A]_t = -k_0 t + \ln [A]$$

graph

H.W

Second order of reaction in terms of reacta

SB

13/07/23

Determining order of concentration ~~(graph)~~

ln → neg → first order

A → pos → zeroth order

(0,0) → line → second order

} graph

Using half life period

$t_{1/2} \propto \frac{1}{[A]^{n-1}}$ → n^{th} order of.

$t_{1/2} \propto \frac{1}{[A]}$ → second order

}

The Differential method

$$-\frac{dc}{dt} = Kc^n$$

Half life of a Reaction

the one that is independent from initial conc and

" " " " + depends on initial con.

zero

$$t_{1/2} = \frac{[A]_0}{2k}$$

$\downarrow$

$\frac{mol}{litre} \times \frac{1}{time}$

$\downarrow$

$mol\,L^{-1}\,time^{-1}$

first

$$\frac{0.693}{k}$$

second order

$$\frac{1}{k[A_0]}$$

$\downarrow$

$L\,mol^{-1}\,time^{-1}$

$2N_2O_5 \longrightarrow 4NO_2 + O_2$

$[N_2O_5]$, 90% reacts in 300 s

Numericals / 01 :

$$\ln \frac{a}{a-x} = \ln \frac{[A]_0}{[A]_t} = kt$$

$$t_{1/2} = \frac{0.693}{k}$$

$$\Rightarrow k = \frac{0.693}{100} = 0.00693$$

$$k = \frac{2.303}{t} \log \frac{[A]_0}{[A]_t}$$

$$= \frac{2.303}{t} \ln \frac{[A]_0}{0.25[A]_0}$$

$$= 200 \text{ sec}$$

2)

$$\frac{1}{[A]_t} = \frac{1}{[A]_0} + kt$$

$$\Rightarrow \frac{1}{.75[A]_0} - \frac{1}{[A]_0} = 600k$$

$$\Rightarrow k = \frac{\frac{1}{.75[A]_0} - \frac{1}{[A]_0}}{600}$$

$$= \frac{0.000555}{[A]_0}$$

Theories of Reaction rate

Collision theory

—

Temp dependence of reaction rate and Arrhenius equation

$$K = Ae^{-Ea/RT}$$

A → Arrhenius factor / Pre-Exponential factor

P Z → collision freq.

↓

fraction of molecules w/ proper orientation

$$\ln k = -\frac{E_a}{R}\left(\frac{1}{T}\right) + \ln A$$

$$y = mx + b$$

Limitations

Transition state theory

Transition State Theory

Potential energy diagram for exo / endothermic

exo - more stable → less energy

Activation energy & catalysis

Chap 14

Solutions & unit of concentration

—

homogeneous

Classification

—

Type of solutions

—

Dilute Based on concentration

Based on Nature

Based on size ; solution → colloid → suspension



SB 20/07/23

Colloid

Solution	Colloid	Suspension
$< 10^{-9}$ m	$\geq 10^{-9}$ & $\leq 10^{-6}$	$\geq 10^{-6}$

Types of Colloidal Systems

Sols → Lyophilic (solvent-loving)
Lyophobic (solvent-hating)

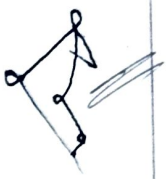
Numericals

What is the molarity of a solution that contains 0.25 mole of NaCl in 500 mL soln?

How much NaCl is required to prep 500 mL of a 0.1M soln of NaCl.

A soln of HCl has a molarity of 0.5 M. What vol of this soln is required to react completely with 25 mL of 0.1M NaOH?

Calculate the normality of a 0.2M soln of H_2SO_4 ?



Calc the Vol of 0.1N HCl required to neutralize 25 mL 0.05N NaOH soln

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Molarity / Molality

SB 23/07/23

Solubility

Solubility curve: continuous, discontinuous

Effects of pressure & solubility

Henry's Law: $C \propto P$

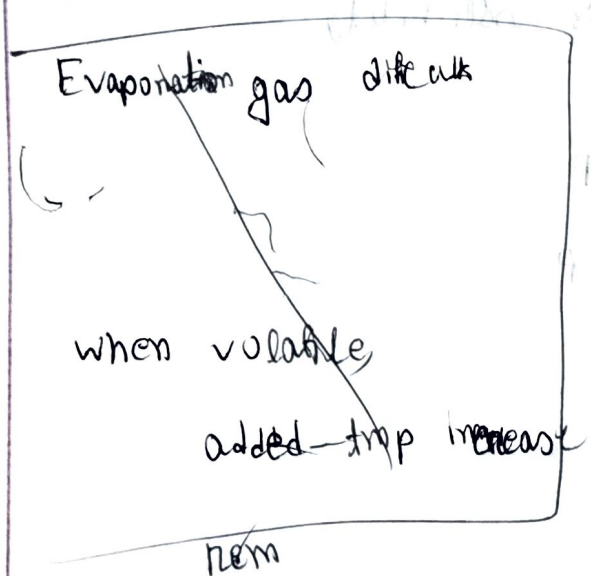
$\Rightarrow C = KP$



Chap 15/ Colligative Props

Colligates

Lowering of Vapour Pressure



Evaporation gas difficult

When volatile,

added, pressure ↑

removed, ↓

non volatile ↑

pressure ↓

Derivation of Roault's Law

$P_s \propto \frac{N}{n+N}$

P_s → Vapour pressure of soln.

n → moles of solvent

N → moles of soln.

$\Rightarrow P_s = K \frac{N}{n+N}$; $P \propto \frac{N}{n+N}$

Boiling point: temp at which vapour pressure equals to atmospheric pressure

---

non volatile → disturb → freezing point → ↓

boiling point → ↑

ideal soln- no volume changes, no heat forms/absorb
disorp happens & follows Raoult's law.

Determination of Molecular mass from vapour Pressu
Lowering

No of moles of solute (n) : $\frac{w}{m}$

→ solvent (N) = $\frac{w}{m}$

Substituting these in Roultes law

$$\frac{P-P_s}{P_s} = \frac{\frac{w}{m}}{\frac{w}{m}+\frac{W}{M}} = \frac{wM}{mW}$$

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27/07/23

Deviation from Raoult's Law

$\frac{P-P_s}{P} \quad \frac{wM}{Wm}$

Elevation Boiling Point

$$T - T_b = \Delta T$$

$\Delta T \propto P - P_s$

$\Delta T \propto \frac{P - P_s}{P}$

$\frac{P - P_s}{P} \propto \frac{wM}{Wm}$

$\frac{P - P_s}{P} \propto \frac{w}{}$

$\Delta T = k_b \times \frac{w}{m} \quad \frac{1}{w}$ $\quad (\Delta T_b = k_b m)$

$\Delta T = k_b \times \frac{w}{m} \times \frac{1}{w/1000}$

$m = \frac{1000 \times k_b \times w}{\Delta T \times w}$

Depression of Freezing Point.

$T_f - T_1 = \Delta T$

$\frac{DF}{EC} = \frac{BD}{BE}$; $\Delta T = P - P_s$

Solved prob 1,

2

SB

30/07/23

Osmotic Pressure

Reverse osmosis

Boyle - van't Hoff Law

- $\pi V = nRT$

---

what is osmosis / pressure

derive equation

what is colligative properties

Assignment → all maths ; next next thursday

SB

03/08

Thermochemistry

Internal energy : Summation of kinetics energy and potential en

$$\Delta E = E_{products} - E_{reactants}$$

$$= E_p - E_r$$

internal energy U → thermal energy

binding energy

chemical "

excitation "

Enthalpy

$H = E + PV$

- E → internal energy
- P → pressure
- V → volume

$\Delta H = H_p - H_r$

$= \Delta E + P\Delta V$; at const pressure

$= \Delta E + \Delta n RT$

$\Delta V = \Delta n \times V$

$\Rightarrow P\Delta V = P(\Delta n \times V)$

$=$

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

1 mol 3 mol 2 mol negligible

$\Delta n = -2$

Exothermic and Endothermic Reaction

$\Delta H = H_p - H_r$

↙ system ↘ surrounding

Exo → $-\Delta H$

Endo → $+\Delta H$

Enthalpy Diagram

Heat of Formation

The heat of combustion of ethyl alcohol is -330 kcal. If the heat of formation of CO_2 (g) & H_2O (l) be -94.3 kcal and -68.5 kcal respectfully, calculate the heat of ethyl alcohol.

$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$, $\Delta H = -330.0$ kcal — (i)

$C + O_2 \longrightarrow CO_2$, $\Delta H = -94.3$ kcals (ii)

$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$, $\Delta H = -68.5$ kcal — (iii)

$2C + 3H_2 + \frac{1}{2}O_2 \rightarrow C_2H_5OH$; $\Delta H = ?$ — (iv)

$2C + 3H_2 + \frac{1}{2}O_2 \longrightarrow C_2H_5OH$

(i) × 2 + (iii) × 3 ⇒

$2C + 3H_2 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O$, $\Delta H = -394$ kcal — (v)

(v) - (iv) → $-394 - (3 \times 68.5)$

Standard Heat of Formation

—

$\Delta H^\circ = \Delta H^\circ_f(\text{prod}) - \Delta H^\circ_f(\text{reactants})$

$= [2\times(-393.5) + 3(-285.5)] - [-277.0 - 0]$ | $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

$= -1643.5 - (-277)$

$= -1366.5\ KJ$

Heat of combustion

(i) $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$, $\Delta H = 2220.2\ kJ\ mol^{-1}$

(ii) $C + O_2 \longrightarrow CO_2$, $\Delta H = -393.5\ kJ\ mol^{-1}$

(iii) $H + \frac{1}{2}O_2 \longrightarrow H_2O$, $\Delta H = -285.8\ kJ\ mol^{-1}$

(ii) × 3

Heat of Neutralization

Hess's Law

Applications of Hess's law

- Determination

Phase

Understanding Phases

Phase terms

Components: Chemically distinct or distinced and in-dependent substance that can exist independently in a system is called --

Degr Degrees of freedom (DoF)

Number of variable that can be changed while keeping the system in equilibrium.

A.k.A variance

$F = C - P + 2$

P → Phase

C → components

SB

13/08

Derivation of Phase Rule

Independent conc. variables for one phase w/ r to the component = C-1 [∵ the conc. of last variable is independent]

∴ Independent conc. variable for phases w/ r to the comp. = P(C-1)

Total number of variable = P(C-1) +2

Chemical potential is the driving force for chemical reaction and the tendency of a substance to move from one phase

Phase transition occurs when the chemical potential of a substance in one phase is equal the chemical potential of a substance in another

For a given component,

~~In phase~~ ,

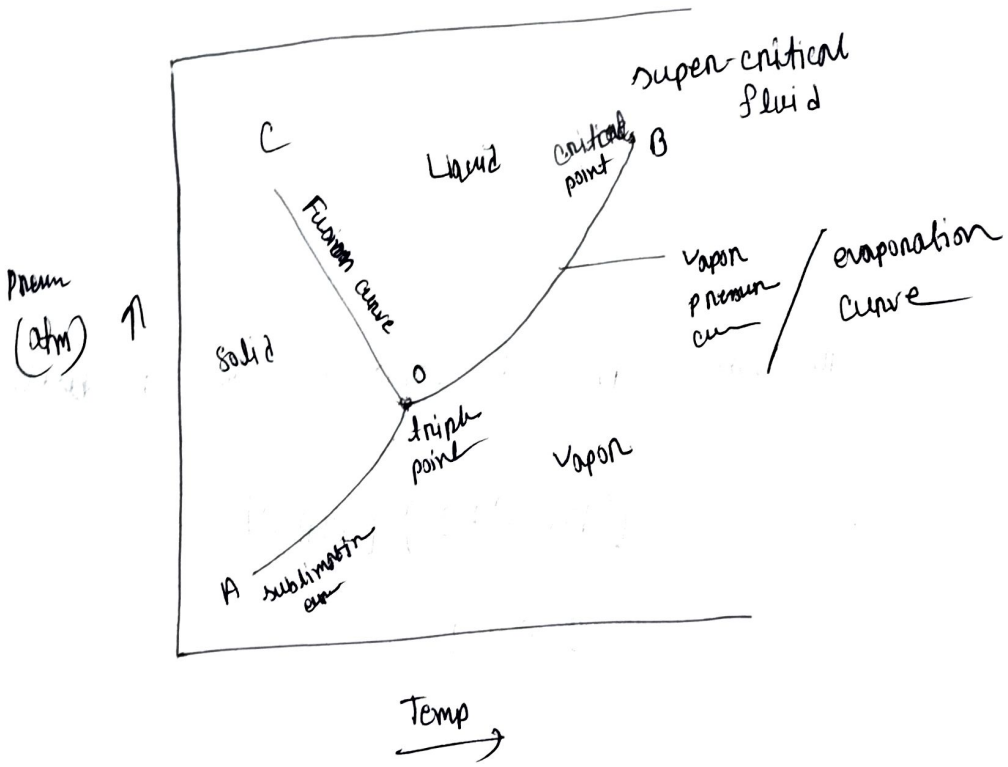
In γ

Degree of Freedom = No. of variable - No of equations

$$= [P(C-1)+2] - [C(P-1)]$$

$$= C - P + 2$$

Phase diagram of H_2O



AOB → vapor phase

AOC → solid "

BOC → Liquid

Metastable curve

- what is phase rule
- define phase, components & degrees of freedom with example.
- derive phase rule
- draw the phase diagram of H_2O w/ explanation
- definitions —