

श्री नाथ जी बुक डिपो

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मातृ छाया होस्टल शॉप नं. 2 ऐलन सत्यार्थ गेट नं. 2 के
सामने, जवाहर नगर, कोटा (राज.) मो. 7014774207

* Mole Concept :-

↳ Ostwald

↳ It means a half heap or pile.

↳ It is basic S.I. unit for amount of substance.

↳ It provides us a quantitative relationship b/w
the no. of particles and the mass substance.

$$\begin{aligned} 1 \text{ Mole} &= \text{No. of atoms present in } 12 \text{g of C-12 isotope} \\ &= 6.022 \times 10^{23} \text{ entities (atoms, molecules, ions)} \\ &\quad e^-, p, n \\ &= \text{Avogadro no. } (N_A) \end{aligned}$$

By Mass Spectrometry :-

$$\text{Mass of one C-12 atom} = 1.99 \times 10^{-23} \text{ g}$$

$$\begin{aligned} \text{No. of atoms present} \\ \text{in } 12 \text{g of C-12 isotope} &= \frac{12}{1.99 \times 10^{-23}} \end{aligned}$$

$$= 6.022 \times 10^{23} \text{ atoms}$$

Ex - 1 mole K^+ ions = N_A ions

1 mol H_2 molecules = N_A molecules
= $2N_A$ atoms

* Atomic Mass Unit (AMU) :-

↳ It is a reference unit of mass that is used to express mass of smaller entities like atoms and molecules.

$$1 \text{ amu} = \left(\frac{1}{12}\right)^{12} \text{ part of mass of one atom of C-12 isotope.}$$

$$\Rightarrow 1.67 \times 10^{-24} \text{ g} = 1.67 \times 10^{-27} \text{ kg}$$

$$\Rightarrow \left(\frac{1}{N_A}\right) \text{ g} = 1 \text{ dalton}$$

$$\Rightarrow 1 \text{ U (unified mass)}$$

$$1 \text{ amu} = \left(\frac{1}{N_A}\right) \text{ g}$$

$$1 \text{ amu} \times N_A = 1 \text{ g}$$

$$1.67 \times 10^{-24} \text{ g} \times 6.022 \times 10^{23} \\ 10^N \times 10^{-1} = 10^0 \Rightarrow 1 \text{ g}$$

Atomic Mass:—

↳ Mass of an atom expressed in amu.

Ex - Mass of H-atom = 1 amu

Mass of O-atom = 16 amu.

Molecular Mass

↳ Mass of a molecules expressed in amu.

Ex - Mass of O₂ molecules = 32 amu

Mass of CO₂ molecules = 44 amu

Gram Atomic Mass (GAM):—

↳ Mass of 1 mole atoms expressed in grams.

Ex - Mass of O-atom = 16 amu (Atomic Mass)

Mass of one mole O-atoms = 16 amu \times N_A

= 16 \times 1 amu \times N_A

= 16 g (GAM)

Gram Molecular Mass (GMM)

→ Mass of 1 mole molecules expressed in ~~mole~~ molecules.

Ex - Mass of O_2 molecules = 32 amu (Molecular Mass)
 Mass of one mole = 32 amu $\times N_A$
 O_2 -molecules = 32g (GMM)

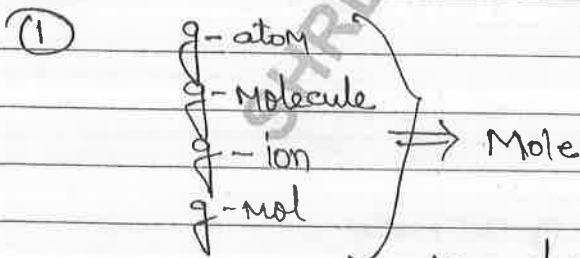
Actual Mass :-

Mass of an atoms or a molecules expressed in grams.

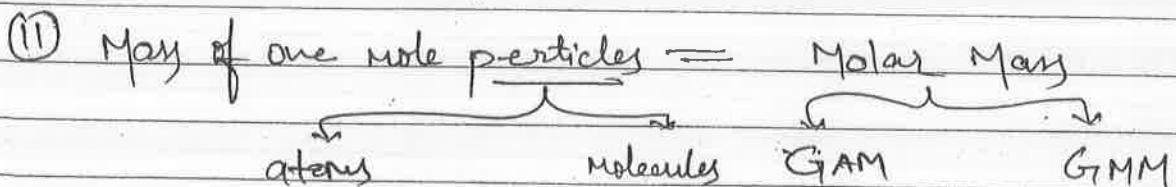
Atomic Mass of H-atom = 1 amu
 Actual mass of H-atom = $1 \times 1.67 \times 10^{-24} g$
 = $1.67 \times 10^{-24} g$

Molecular Mass of H_2O molecule = 18 amu
 Actual mass of H_2O molecule = $18 \times 1.67 \times 10^{-24} g$
 = $2.9910^{-24} g$

 Note :-



18g of H_2O molecule = 1 mol
 18g - molecule of H_2O = 18 mole.



Relation for Mole-concept :-

$$1 \text{ mole} = N_A \text{ particles} = \text{Molar Mass} = \underline{22.4 \text{ L at STP}}$$

(only for gases)

$$\text{No. of Moles} = \frac{\text{No. of particles}}{N_A (\text{particles mol}^{-1})} = \frac{\text{Given Mass (g)}}{\text{Molar Mass (g mol}^{-1})}$$

$$\frac{\text{Volume at STP (L)}}{22.4 (\text{L mol}^{-1})}$$

(only for gas)

Ques Calculate the no. moles in the following?

(i) 3.01×10^{19} molecules of H_2SO_4

(ii) 64g of NaOH

(iii) 2.8L of CO_2 gas at STP

(i) No. of moles = $\frac{3.01 \times 10^{19}}{6.22 \times 10^{23}}$
 $= 0.5 \times 10^{-4} = 5 \times 10^{-5} \text{ mol}$

(ii) No. of moles of NaOH = $\frac{64}{40} = 1.6 \text{ mole}$

(iii) No. of moles = $\frac{2.8}{22.4} = 0.125 \text{ moles}$

Ques for ~~5.6~~ 3.25 mol of SO_2 gas Calculate?

- (i) No. of molecules
- (ii) Mass
- (iii) Volume at STP.

(i) No. of molecules = Moles \times N_A
 $= 3.25 \times 6.22 \times 10^{23}$
 $= 19.5 \times 10^{23}$
 $= 1.95 \times 10^{24}$ Molecules

(ii) Mass = Moles \times Molar Mass
 $= 3.25 \times 64$
 $= 208$ g

(iii) Volume of at STP = Moles \times 22.4 L
 $= 3.25 \times 22.4$
 $= 72.8$ L

Ques for 5.6 ml of SO_2 gas at STP, Calculate?

- (i) Mass
- (ii) No. of molecules
- (iii) ~~Volume~~

(i) ~~Mass = $\frac{80}{22.4} \times 5.6 \text{ ml}$~~ Moles of $\text{SO}_2 = \frac{5.6 \times 10^{-3}}{22.4} = 2.5 \times 10^{-4}$ mol.

~~$= 19.999$~~

Mass = Moles \times Molar Mass
 $= 2.5 \times 10^{-4} \times 80$
 $= 2 \times 10^{-2}$ g

(ii) No. of molecules = Moles \times N_A
 $= 2.5 \times 10^{-4} \times 6.2 \times 10^{23}$
 $= 1.5 \times 10^{20}$ molecules

Ques for 1.8×10^{21} atoms of He, Calculate

- (i) Mass
 (ii) Volume at STP in mL

(i) Moles of He = $\frac{1.8 \times 10^{21}}{6 \times 10^{23}} = 3 \times 10^{-3} \text{ mol}$

Mass = $3 \times 10^{-3} \times 4$
 $= 1.2 \times 10^{-2} \text{ g}$

(ii) Volume at STP = Moles \times 22.4 L
 $= 3 \times 10^{-3} \times 22.4$
 $= 67.2 \times 10^{-3} \text{ L}$
 $= \underline{67.2 \text{ mL}}$

Atomicity :-

No. of atoms present in molecules.

Molecules \rightarrow Atomicity



\Rightarrow for 'n' No of moles of molecules :-

No. of molecules = $n \times N_A$

No. of atoms = $n \times \text{Atomicity} \times N_A$

$$\text{No. of } e/p/n = n \times \underset{\substack{\downarrow \\ \text{Moles} \\ \text{of atoms} \\ \text{molecules or} \\ \text{ions.}}}{\text{no. of } e/p/n} \times N_A$$

present per:
atom, molecules
OR, ions

EX- 2 mol CaCO_3

$$\text{No. of molecules} = 2 \times N_A$$

$$\text{No. of atoms} = 2 \times 5 = 10 \text{ mol}$$

$$\text{No. of atoms} = 10 \times N_A$$

Ques. For 1.7 mg of NH_3 , Calculate

- (i) No. of moles
- (ii) No. of molecules
- (iii) No. of moles of atoms
- (iv) No. of atom
- (v) No. of moles of N & H atoms
- (vi) No. of moles of $e/p/n$
- (vii) Sum of no. of $e/p/n$

$$(i) \text{ No. of moles} = \frac{1.7 \times 10^{-3}}{17} = 10^{-4} \text{ moles}$$

$$(ii) \text{ No. of molecules} = \text{Moles} \times N_A \\ = 10^{-4} \times 6 \times 10^{23} \\ = 6 \times 10^{19}$$

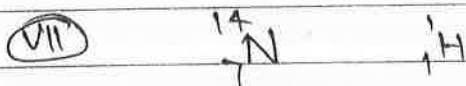
$$(iii) \text{ No. of moles of atom} = n \times \text{Atomicity} \\ = 10^{-4} \times 4 \\ = 4 \times 10^{-4}$$

(iv) No. of atom = $4 \times 10^{-4} \times 6 \times 10^{23}$
= 2.4×10^{20} atoms

(v) No. of moles of N atoms = $10^{-4} \times 1$
= 10^{-4} mol
No. of moles of H atoms = $10^{-4} \times 3$
= 3×10^{-4} moles

(vi) No. of N atoms = $10^{-4} \times 6 \times 10^{23}$
= 6×10^{19} atoms

(vii) No. of H atoms = ~~$10^{-4} \times 3 \times 10^{23}$~~
= 1.8×10^{20} atoms



~~$P = 7 \times 1 + 1 \times 3 = 10$~~
 $P = 7 \times 1 + 1 \times 3 = 10$
 $e^- = 7 \times 1 + 1 \times 3 = 10$
 $\eta = 7 \times 1 + 0 \times 3 = 7$

Moles of P = $10^{-4} \times 10 = 10^{-3}$ mol
Moles of e^- = $10^{-4} \times 10 = 10^{-3}$ mol
Moles of η = $10^{-4} \times 7 = 7 \times 10^{-4}$ mol

(viii) No. of P = $10^{-3} \times 6 \times 10^{23} = 6 \times 10^{20}$
No. of e^- = $10^{-3} \times 6 \times 10^{23} = 6 \times 10^{20}$
No. of η = $7 \times 10^{-4} \times 6 \times 10^{23} = 4.2 \times 10^{20}$

Sum of $(e^- + P + \eta) = 16.2 \times 10^{20}$
= 1.62×10^{21}

Ques. for 8.4 mg. of N^{3-} , Calculate

- (i) No. of ions
- (ii) No. of e^- & P

(i) ~~No. of ions~~ Moles = $\frac{8.4 \times 10^{-3}}{14} = 6 \times 10^{-4}$

$$\begin{aligned} \text{No. of } N^{3-} \text{ ions} &= n \times N_A \\ &= 6 \times 10^{-4} \times 6 \times 10^{23} \\ &= 3.6 \times 10^{20} \text{ ions} \end{aligned}$$

(ii) $P = 7$ ${}^{14}_7N^{3-}$
 $e^- = 7 + 3 = 10$
 No. of $e^- = Z - \text{charge on ions.}$

(ii) No. of $e^- = 6 \times 10^{-4} \times 10 \times 6 \times 10^{23}$
 $= 3.6 \times 10^{21}$

No. of P = $6 \times 10^{-4} \times 7 \times 6 \times 10^{23}$
 $= 2.52 \times 10^{21}$

Ques. Calculate the no. of gram atom of Oxygen present in 1120 cm³ of CO₂ at STP.

$$\text{Moles of CO}_2 = \frac{1120}{22400} = \frac{1}{20} = 0.05 \text{ Mol}$$

$$\text{Moles of O-atoms} = 0.05 \times 2 = 0.1 \text{ Mol or } 0.1 \text{ gram}$$

Ques. Calculate the no. of H, S & O-atoms present in 9.8×10^{-18} g of H_2SO_4 .

$$\text{Moles of } H_2SO_4 = \frac{9.8 \times 10^{-18}}{98} = 1 \times 10^{-19} \text{ Mol}$$

$$\begin{aligned} \text{No. of H-atoms} &= 1 \times 10^{-19} \times 2 \times 6 \times 10^{23} \\ &= 1.2 \times 10^5 \text{ atoms} \end{aligned}$$

$$\begin{aligned} \text{No. of S-atoms} &= 1 \times 10^{-19} \times 1 \times 6 \times 10^{23} \\ &= 6 \times 10^4 \text{ atoms.} \end{aligned}$$

$$\begin{aligned} \text{No. of O-atoms} &= 1 \times 10^{-19} \times 4 \times 6 \times 10^{23} \\ &= 24 \times 10^4 \\ &= 2.4 \times 10^5 \end{aligned}$$

Ques. Calculate the no. of moles of $Ca_3(PO_4)_2$ that contain 0.04 moles of O-atoms.

$$\begin{aligned} \text{Moles of atoms} &= \text{Moles of molecules} \times \text{Atomicity} \\ 0.04 &= n \times 8 \\ n &= \frac{0.04}{8} = 5 \times 10^{-3} \text{ Moles.} \end{aligned}$$

Ques. Calculate the mass of $N_2SO_4 \cdot 7H_2O$ that contain 6.02×10^{22} atoms of Oxygen.

$$MM = 268 \text{ g mol}^{-1}$$

~~Mass of $N_2SO_4 \cdot 7H_2O$~~

$$\text{Mole of O-atoms} = \frac{6.02 \times 10^{22}}{6.02 \times 10^{23}} = 0.1 \text{ mol.}$$

$$\begin{aligned} \text{Moles of atoms} &= \text{Moles of molecules} \times \text{Atomicity} \\ 0.1 &= n \times 11 \end{aligned}$$

$$n = \frac{0.1}{11} = \frac{1}{110} \text{ Mol}$$

$$\text{Mass of } \text{N}_2\text{SO}_4 \cdot 7\text{H}_2\text{O} = \frac{1}{110} \times 268$$

$$= 2.49 \text{ g}$$

Ques. How many moles of e^- has a mass of 1 kg.

(i) $9.1 \times 10^{31} \times N_A$

(ii) $\frac{1}{9.1 \times 10^{31}} \times N_A$

(iii) $\frac{1}{9.1 \times 10^{31} \times N_A}$

(iv) N.O.T.

$$\text{Mass of } e^- = 9.1 \times 10^{-31} \text{ kg}$$

$$\text{No. of } e^- = \left(\frac{1}{9.1 \times 10^{-31}} \right) e^-$$

$$\text{Moles of } e^- = \frac{1/9.1 \times 10^{-31}}{N_A}$$

$$= \frac{1}{9.1 \times 10^{-31} \times N_A}$$

Ques. Equal masses of O_2 , H_2 & Methane (CH_4) will have a mole ratio of

(i) 1:16:2

(ii) 2:16:1

(iii) 1:16:1

(iv) 16:1:8



$$1 : 1 : 1 \quad \text{[Mass ratio]}$$

$$\frac{1}{32} : \frac{1}{2} : \frac{1}{16}$$

$$\frac{32}{32} : \frac{32}{2} : \frac{32}{16}$$

$$1 : 16 : 2$$

Ques from 2.8L of CO_2 at STP 1.5×10^{22} molecules are removed then determine the remaining mass of CO_2

Solⁿ:— ^{Initial} Moles of $\text{CO}_2 = \frac{2.8}{22.4} = 0.125 \text{ mol}$

$$n_{\text{removed}} = \frac{1.5 \times 10^{22}}{6 \times 10^{23}} = 0.025 \text{ mol}$$

$$n_{\text{remaining}} = 0.125 - 0.025 = 0.1 \text{ mol}$$

Remaining mass
of $\text{CO}_2 = 0.1 \times 44 = 4.4 \text{ g}$

Ques. Two element X and Y combined together to form two different XY_2 and X_2Y_3 . If 0.05 mole of XY_2 has a mass of 5g and 3.01×10^{23} molecules of X_2Y_3 has a mass of 85g, then determine atomic masses of X and Y.

Solⁿ:—

$$\begin{aligned} \text{XY}_2 &= 0.05 \text{ mol} \rightarrow 5 \text{ g} \\ 1 \text{ mol} &= \frac{5}{0.05} = 100 \text{ g} \end{aligned}$$

$$X + 2Y = 100 \quad \text{--- (1)}$$

$$\begin{aligned} \text{X}_2\text{Y}_3 &= 3.01 \times 10^{23} \text{ molecules} \rightarrow 85 \text{ g} \\ 6.02 \times 10^{23} \text{ molecules} &\rightarrow 170 \text{ g} \end{aligned}$$

$$2X + 3Y = 170 = \text{(2)}$$

$$\text{(1)} \times 2 \rightarrow 2X + 4Y = 200$$

$$\text{(2)} \times 1 \rightarrow 2X + 3Y = 170$$

$$Y = 30$$

$$X = 40$$

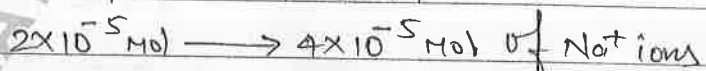
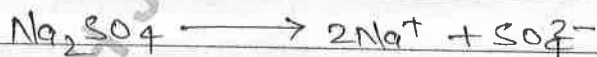
Q. ~~Calculate~~ Calculate no. of g-atoms and g-molecules present in 64g of oxygen.

$$\begin{aligned} \text{No. of g-molecules} \\ \text{Moles of } O_2 \text{ molecules} &= \frac{64}{32} = 2 \text{ g-molecules.} \end{aligned}$$

$$\begin{aligned} \text{No. of g-atoms} &= \text{not } 64 \\ \text{Moles of O-atoms} &= \frac{64}{16} = 4 \text{ g-atoms.} \end{aligned}$$

Q. Calculate the no. of Na^+ present in 2.84mg Na_2SO_4

$$\begin{aligned} \text{Moles of } Na_2SO_4 &= \frac{2.84 \times 10^{-3}}{142} \\ &= 2 \times 10^{-5} \text{ mol} \end{aligned}$$



$$\begin{aligned} \therefore \text{No. of } Na^+ \text{ ions} &= 4 \times 10^{-5} \times 6 \times 10^{23} \\ &= 2.4 \times 10^{19} \text{ ions.} \end{aligned}$$

Ques. Which of the following will have ~~2~~ no. atom. least

(i) 5.6L of $NH_3(g)$ at STP

(ii) 4g $O_2(g)$

(iii) 3.01×10^{22} molecules of H_2SO_4

(iv) 2.24g of $H_2(g)$

$$\begin{aligned} \text{(i) No. of atoms} &= \text{Moles} \times \text{Atomicity} \times N_A \\ &= \frac{5.6}{22.4} \times 4 \times N_A = N_A \end{aligned}$$

$$\text{(ii) } \frac{4}{32} \times 2 \times N_A = 0.25 N_A$$

$$\text{(iii) } \frac{3.01 \times 10^{22}}{6.02 \times 10^{23}} \times 7 \times N_A = 0.35 N_A$$

(iv)

$$(iv) \frac{2.24}{2} \times 2 \times N_A = 2.24 N_A$$

Ques. Calculate the no. of atoms in the following

(i) 4amu of He = 1 atom

(ii) 4g of He

(iii) 4g-atom of He

(ii) $\frac{4}{4} = 1 \text{ mol} = N_A \text{ atoms}$

↳ (iii) $4 N_A \text{ atoms.}$

F Ideal Gas Equations: —

$$PV = nRT$$

P = Pressure

V = Volume

n = No. of moles

R = Universal gas constant

$$= 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$$

$$= 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$$

$$= 2 \text{ Cal mol}^{-1} \text{ K}^{-1}$$

Use: —

$$R \times 273 = 22.4$$

$$R \times 300 = 24.6$$

$$\text{When, } R = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$$

(i) for calculation of no. of moles of gases at any given condition of P. and T: —

$$n = \frac{PV}{RT}$$

② for 1 mol ideal gas at STP/NTP $\Rightarrow V = \frac{nRT}{P}$
 $= \frac{1 \times 0.821 \times 273}{1}$

③ Avogadro's Law: —

$V = 22.4 \text{ L}$ Molar Volume at STP

→ This law states that under the same condition of pressure & Temperature equal volume of all gases contains equal no. of moles & molecules.

for 2 ideal gases A & B

$$\frac{P_A V_A}{P_B V_B} = \frac{n_A R T_A}{n_B R T_B}$$

Under same condition P & T

$$P_A = P_B \quad \& \quad T_A = T_B$$

$$\frac{V_A}{V_B} = \frac{n_A}{n_B}$$

Equal volume of all gases

So, $V_A = V_B$

$$\therefore n_A = n_B$$

$$1 \text{ Mol } \text{CO}_2 = 1 \text{ Mol } \text{SO}_2$$

$$N_A \text{ Molecules} = N_A \text{ Molecules}$$

~~$$3N_A \text{ atoms} = 3N_A \text{ atoms}$$~~

$$3N_A \text{ atoms} = 4N_A \text{ atoms}$$

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मातृ छाया होस्टल शॉप नं. 2 ऐलन सत्यार्थ गेट नं. 2 के
सामने, जवाहर नगर, कोटा (राज.) मो. 7014774207

Ques. Calculate the no. of atom present in Nitrogen gas that occupies the volume of 2.46L at pressure of 380 mm Hg & $T = 27^\circ\text{C}$

$$V = \cancel{2.46} 2.46\text{L}$$

$$P = 380\text{MM Hg} = \frac{380}{760} = 0.5\text{atm}$$

$$T = 27^\circ\text{C} = 300\text{K}$$

$$\eta = \frac{PV}{RT} = \frac{(0.5) \times 2.46}{0.821 \times 300}$$

$$= 0.05\text{ mol of } \text{N}_2\text{ gas}$$

$$\text{No. of N-atoms} = 0.05 \times 2 \times N_A$$

$$= 0.1 \times 6 \times 10^{23}$$

$$= \boxed{6 \times 10^{22} \text{ atoms}}$$

Q. Calculate the actual mass of an atom of a tri-atomic gas whose 1g occupies the volume of 5.6ml at a pressure of 760 torr. and 27°C temp.

$$V = 5.6 \times 10^{-3}$$

$$P = 760 = 1\text{atm}$$

$$T = 546\text{K}$$

$$= (273 \times 2)\text{K}$$

$$\eta = \frac{PV}{RT}$$

$$= \frac{1 \times 5.6 \times 10^{-3}}{(0.821)(273 \times 2)}$$

$$= \frac{5.6 \times 10^{-3}}{22.4 \times 2}$$

$$= \frac{1}{8} \times 10^{-3} \text{ Mol}$$

$$\text{Moles} = \frac{\text{Mass}}{\text{Molar Mass}}$$

$$\text{Molar Mass} = \frac{\text{Mass}}{\text{Moles}}$$

$$= \frac{1}{\frac{1}{8} \times 10^{-3}} = 8 \times 10^3 \text{ g mol}^{-1}$$

$$N_A \text{ molecules} \rightarrow 8 \times 10^3 \text{ g}$$

$$\frac{1 \text{ molecule}}{3 \text{ atoms}} \rightarrow \frac{8 \times 10^3}{N_A} \text{ g}$$

$$\text{Mass of one atom} = \frac{8 \times 10^3}{3 N_A}$$

$$\frac{8 \times 10^3}{3 \times 6 \times 10^{23}} = \frac{8 \times 10^3}{3 \times 6 \times 10^{23}}$$

$$= 4.4 \times 10^{-21} \text{ g}$$

Ques. Four identical vessels contains He, O₃, H₂ & NH₃ gases respectively under the same condition P & T then determine the ratio of atom and molecules in the vessels respectively.

	He	O ₃	H ₂	NH ₃
Ratio of molecules =	1	1	1	1
" " atoms =	1	3	2	4

Ques. 2 identical vessels contains 0.11 mg of CO₂ gas and 0.07 mg of an unknown gas respectively under the same condition of P & T then determine the unknown gas will be.

- (i) N₂ (ii) CO₂ (iii) C₂H₄ (iv) All of these

$$n_{CO_2} = n_{unknown}$$

$$\text{Moles of } CO_2 = \frac{0.11 \times 10^{-3}}{\cancel{44}} = \frac{0.77 \times 10^{-3}}{M}$$

$$= \cancel{0.77 \times 10^{-3}}$$

$M = 28$

Density & Vapour Density :-

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad \left(\text{valid for solid, liquid, gas} \right)$$

$$\text{Vapour Density (V.D)} = \frac{\text{Density of gas}}{\text{Density of } H_2 \text{ gas}} \quad \left(\text{Both gases are at same P \& T} \right)$$

$$\text{Density of } H_2 \text{ gas at STP} = 0.0899 \text{ g L}^{-1}$$

$$= 0.000899 \text{ g mL}^{-1}$$

As we know,

$$PV = nRT$$

$$PV = \left(\frac{\text{mass}}{\text{Molar mass}} \right) RT$$

$$P(\text{molar mass}) = \left(\frac{\text{Mass}}{\text{Vol.}} \right) RT$$

$$\therefore \boxed{PM = dRT}$$

Density of a gas at any condition of P & T.

$$V.D. = \frac{\rho_{\text{gas}}}{\rho_{\text{H}_2}} = \frac{PM_{\text{gas}}/RT}{PM_{\text{H}_2}/RT}$$

$$= \frac{M_{\text{gas}}}{M_{\text{H}_2}} = \frac{M_{\text{gas}}}{2}$$

$$\therefore M_{\text{gas}} = 2 \times V.D.$$

Ques. Calculate the density of 1 mol Nitrogen gas at NTP.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{28}{22.4} = 1.25 \text{ g/L}$$

Ques. Calculate the v.d. of a gas whose ~~volume~~ whose 5g occupies the volume of 2.8L at STP.

$$V.D. = \frac{5}{2.8 \times 2}$$

$$\frac{\text{Mass}}{MM} = \frac{\text{Vol. at STP}}{22.4 \text{ L}}$$

$$\frac{5}{2 \times V.D.} = \frac{2.8}{22.4}$$

$$V.D. = 20$$

Ques. Calculate the volume of one molecule of $H_2O(l)$ given ($D=1g/ml$)

$$\text{Mass of } N_A \text{ molecules of } H_2O = 18g$$

$$\begin{aligned} \text{Mass of 1 molecule of } H_2O &= \frac{18}{N_A} g \\ &= \frac{18}{6 \times 10^{23}} = 3 \times 10^{-23} g \end{aligned}$$

$$\begin{aligned} \therefore \text{Volume of 1 molecule of } H_2O &= \frac{\text{Mass}}{\text{Density}} \\ &= \frac{3 \times 10^{-23}}{1g/ml} = 3 \times 10^{-23} ml \end{aligned}$$

Ques. Calculate the no. of atoms present 1 drop of water having a volume of 3.6 mL.

$$\begin{aligned} \text{Mass of 1 drop of water} &= \text{Density} \times \text{Volume} \\ &= 1g/ml \times 3.6 mL \\ &= 3.6 mL = 3.6g \end{aligned}$$

$$\text{Moles of } H_2O = \frac{3.6}{18} = 0.2 \text{ mol}$$

$$\begin{aligned} \text{No. of atoms} &= 0.2 \times 3 \times N_A \\ &= 0.6 \times 6 \times 10^{23} \\ &= 3.6 \times 10^{23} \text{ atoms} \end{aligned}$$

Ques. Calculate the molecular weight of a volatile substance that has the vapour density of 4 w.r.t Methane

$$V.D = \frac{d_{\text{gas}}}{d_{\text{CH}_4}} = \frac{PM_{\text{gas}}/RT}{PM_{\text{CH}_4}/RT}$$



श्री नाथ जी बुक डिपो

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मातृ छाया होस्टल शॉप नं. 2 ऐलन सत्यार्थ गेट नं. 2 के
सामने, जवाहर नगर, कोटा (राज.) मो. 7014774207

$$V.D. = \frac{M_{\text{gas}}}{M_{\text{CH}_4}}$$

$$M_{\text{gas}} = 4 \times 16 \\ = 64$$

Ques. Completely evacuated vessels has a mass of 50g when this vessel is completely filled with a liquid having density of 0.98 g/ml then the mass of vessel is found to be 148g. Now when the vessel is filled with an ideal gas at a pressure of 760 mm Hg & 300K Temperature then the mass of vessel is found to be 50.5g then determine the molar mass of the ideal gas.

$$\text{Mass of liquid} = 148 - 50 \\ = 98 \text{ g}$$

$$\text{Vol. of liquid} = \frac{98}{0.98} = 100 \text{ mL} \\ = 0.1 \text{ L} = \text{Vol. of vessel}$$

$$\text{Mass of gas} = 50.5 - 50 \\ = 0.5 \text{ g}$$

$$PV = nRT$$

$$1(0.1) = \frac{0.5}{M} \times 0.0821 \times 300$$

$$M = 123 \text{ g mol}^{-1}$$

Percentage Composition: — (By Mass)

3 Red
2 Blue
1 Green
<u>100g</u>

$1R = 10g$
 $1B = 20g$
 $1G = 30g$

$$\% \text{ of Red} = \frac{10 \times 3}{100} \times 100 = 30\%$$

$$\% \text{ of Blue} = \frac{20 \times 2}{100} \times 100 = 40\%$$

$$\% \text{ of Green} = \frac{30 \times 1}{100} \times 100 = 30\%$$

2-H atom
1-O atom

$H_2O = 18 \text{amu}$

$$\% \text{ of H} = \frac{1 \times 2}{18} \times 100 = 11.11\%$$

$$\% \text{ of O} = \frac{16 \times 1}{18} \times 100 = 88.89\%$$

H_2O

2:16

1:8

$$\frac{1}{9} \times 100 : \frac{8}{9} \times 100$$

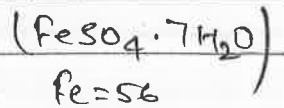
11.11% : 88.89%

* Mass % of element = $\frac{\text{Total mass of element}}{\text{Total mass of compound}} \times 100$
(For any given mass of compo.)

* Mass % of element = $\frac{\text{Atomic wt. of element} \times \text{Atomicity}}{\text{Mol. wt. of compound}} \times 100$

* Note: - The percentage composition by mass or by mass of an element in a compound is always fix.

Ques. Calculate % by mass of O & H in green vitriol.



$$\begin{aligned} \% \text{ of O} &= \frac{16 \times 11}{278} \times 100 \\ &= 63.3\% \end{aligned}$$

$$\begin{aligned} \% \text{ of H} &= \frac{1 \times 14}{278} \times 100 \\ &= 5\% \end{aligned}$$

Ques. Calculate the % composition of FeO in magnetite (Fe_3O_4)

$$\begin{aligned} \% \text{ Composition of FeO} &= \frac{72}{232} \times 100 \\ &= 31.03\% \end{aligned}$$

Ques. (a) The molecular wt. of a compd. is 500amu. If the compound contains 50.4% carbon by mass then determine the no. of C-atoms each molecule of compound.

$$50.4\% = \frac{12 \times x}{500} \times 100$$

$$x = 21$$

Ques. Calculate the minimum molecular wt. of a compd that contains 28.9% Nitrogen by mass.

$$28.9 = \frac{14 \times 1}{M} \times 100$$

$$M = 48.44\%$$

$$\frac{14}{28.9} \times 100$$

$$2 \times 24.4$$

Ques. A compound is used to making Nylon has 43.8% Oxygen by mass. Then determine the no. molecules present in 2.92 g of this compd. If 4-O-atoms are present per molecules of compound.

$$43.8 = \frac{16 \times 4}{M} \times 100$$

$$M = \frac{6400}{43.8} = 146$$

$$\text{Moles} = \frac{2.92}{146} = 0.02 \text{ Mol}$$

$$\text{No. of molecules} = 0.02 \times 6 \times 10^{23}$$

$$= 1.2 \times 10^{22} \text{ molecules}$$

Ques. 30g of $\text{N}_2\text{SO}_4 \cdot x\text{H}_2\text{O}$ on heating releases 15.1g ^{water} ~~vapour~~ ^{water} vapours. Then determine the value of x.

$$\% \text{ of } \text{H}_2\text{O} = \frac{15.1}{30} \times 100$$

(in given mass)

$$\% \text{ of } H_2O = \frac{18x}{142+18x} \times 100$$

$$\frac{15.1}{30} \times 100 = \frac{18x}{142+18x} \times 100$$

$$\frac{1}{2} = \frac{9x}{71+9x}$$

$$x = \frac{71}{9} = 8$$

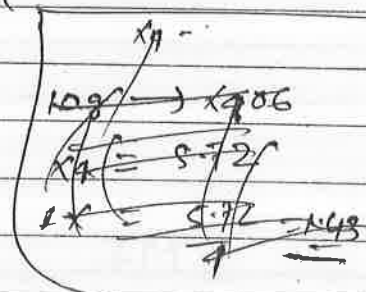
Ques. 10g of a compound ~~24~~ x_4O_6 contains 5.72g of x then determine the atomic wt. of x

$$\% \text{ of } x \text{ (in given mass)} = \frac{5.72}{10} \times 100$$

$$\% \text{ of } x \text{ (per molecule)} = \frac{4x}{4x+96} \times 100$$

$$\frac{5.72}{10} \times 100 = \frac{4x}{4x+96} \times 100$$

$$\frac{5.72}{10} = \frac{x}{x+24} \Rightarrow x = 32$$



Molecular & Empirical formula :-

M.F. — It represents the actual no. of atoms of various elements present in a molecule of a compound.

E.F. — It represents simplest ratio of atoms of various elements present in a molecule of a compound.

Ex. — M.F. \Rightarrow $C_6H_{12}O_6$
Actual = 6 : 12 : 6
Simplest = 1 : 2 : 1
ratio
E.F. = CH_2O

M.F.	M.F. Mass	E.F.	E.F. Mass	$n = \frac{M.F.M.}{E.F.M.}$
$C_6H_{12}O_6$	180	CH_2O	30	$n = \frac{180}{30} = 6$
C_6H_6	78	CH	13	$n = 6$
C_2H_6	30	CH_3	15	$n = 2$
CH_3COOH	60	CH_2O	30	$n = 2$
CH_4	16	CH_4	16	$n = 1$

$$\boxed{M.F. = \eta \times E.F.} \quad \eta = +ve \text{ integer}$$

$$\eta = \frac{M.F.M.}{E.F.M.}$$

Ex. — $M.F. = \eta \times E.F.$
 $= 2 \times (CH_3)$
 $= C_2H_6$

Note:—

If two or more compd. have same empirical formula than their percentage composition by Mass will be the same.

Ques. Determine the E.F. of a compound that contain 38.8% Carbon, 16% H and rest Nitrogen by mass.

	A.R.	S.R.
C = 38.8%	$38.8/12 = 3.2$	$3.2/3.2 = 1$
H = 16%	$16/1 = 16$	$16/3.2 = 5$
N = $100 - 54.8$ $= 45.2$	$\frac{45.2}{14} = 3.2$	$3.2/3.2 = 1$

E.F. = CH_5N

Ques. Determine the molecular formula of compd that contain 57.8%, 3.6% Hydrogen and rest of oxygen by mass (given V.D. of compound is equal to 83)

Mass.	A.R.	S.R.
C = 57.8	$57.8/12 = 4.8$	$\frac{4.8}{2.4} = 2 \times 2 = 4$
H = 3.6	$3.6/1 = 3.6$	$\frac{3.6}{2.4} = 1.5 \times 2 = 3$
O = 29.6	$\frac{29.6}{16} = 1.85$	$\frac{2.4}{2.4} = 1 \times 2 = 2$

$\frac{57.8}{3.6}$
 $\frac{17.17}{61.4}$

1 . 4 . 2

$$M.F. = n \times E.F.$$

$$= 2(C_4H_3O_2)$$

$$= \underline{C_8H_6O_4}$$

$$E.F.M. = 83$$

$$n = \frac{M.F.M.}{E.F.M.}$$

$$= \frac{2 \times V.D.}{83} = \frac{2 \times 83}{83} \Rightarrow \underline{2}$$

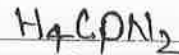
Ques. Determine the E.f. of a compound that contain H, C, O & N in the ratio of 1:3:4:7 ~~mass~~ by mass respectively.

$$H = \frac{1}{1} = 1 \times 4 = 4$$

$$C = \frac{3}{12} = \frac{1}{4} \times 4 = 1$$

$$O = \frac{4}{16} = \frac{1}{4} \times 4 = 1$$

$$N = \frac{7}{14} = \frac{1}{2} \times 4 = 2$$



Ques. Determine the E.f. of a compo. that contain 0.5×10^{21} atoms phosphorus and 37.5×10^{20} atoms of oxygen.

$$P = \frac{0.5 \times 10^{21}}{1.5 \times 10^{21}} = 1 \times 2 = 2$$

$$O = 37.5 \times 10^{20}$$

$$= \frac{3.75 \times 10^{21}}{1.5 \times 10^{21}} = 2.5 = 5$$



Ques. Determine the E.F. of a compound that contain 9.81g Zn
 1.8×10^{23} atoms of C₂ and 0.6 mole of oxygen atoms.

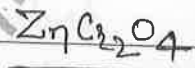
$$\text{Zn} = \frac{9.81}{65} = \frac{0.15 \text{ mol}}{0.15} = 1$$

$$\text{Zn} = 65$$

$$\text{C}_2 = 52$$

$$\text{C}_2 = \frac{1.8 \times 10^{23}}{6 \times 10^{23}} = \frac{0.3 \text{ mol}}{0.15} = 2$$

$$\text{O} = 0.6 = \frac{0.6 \text{ mol}}{0.15} = 4$$



Ques. An organic compound contain C, H & N. If the % of Carbon is 6 times of the % of H and the ~~sum~~ of % of C & H is 1.5 times of the percent of Nitrogen then Determine the E.F. of compound.

$$\begin{array}{ccc} \text{C} : \text{H} : \text{N} & & 7x = 1.5y \\ 6x & x & y \\ & & y = \frac{7x}{1.5} \end{array}$$

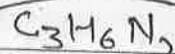
$$6x : x : \frac{7x}{1.5} \text{ (Max Ratio)}$$

$$\frac{6x}{12} : \frac{x}{1} : \frac{7x}{1.5 \times 14}$$

$$\frac{1}{2} : 1 : \frac{1}{3} \text{ (A.R.)}$$

$$\frac{1}{2} \times 6 : 1 \times 6 : \frac{1}{3} \times 6$$

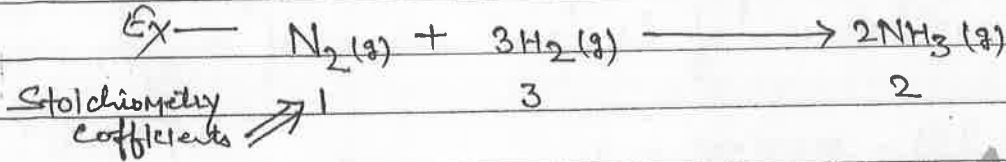
$$3 : 6 : 2$$



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Stoichiometry: —

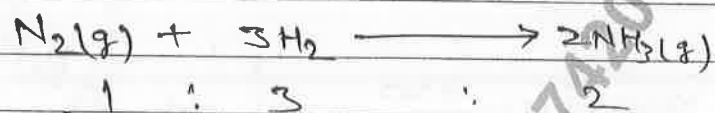


	1 mole	3 mole	2 mole	} For Solid, Liquid, gas
	1 molecule	3 molecules	2 molecules	
	22.4 L	67.2 L	44.8 L \rightarrow At STP	
	1 L	3 L	2 L	
Gay Lussac's of gases volumes.	1 volume	3 volume	2 volume	} only for gases under same cond ⁿ of P & T
	1 g	3 g	2 g	
	28 g	6 g	34 g	

\hookrightarrow Stoichiometry provides us quantitative relationship b/w the amount of reactants & products. It required a balanced chemical rxn in which the co-efficient of reactant & products gives the simplest ratio in which the reactants reacts the ~~reacted~~ products are formed.

Note: Stoichiometry co-efficient can be related with Mole, No of molecules, volume but Not with mass so to use mass, convert it into Mole.

Ques. 1.4 Mg of N completely react with H to produce NH₃. Then calculate the required No. of molecules of H and volume of NH₃ gas produced at STP during the reaction.



$$\text{Moles of N}_2 = \frac{1.4 \times 10^{-3}}{28} = 5 \times 10^{-5} \text{ Moles}$$

$$\text{Moles of H}_2 = 3 \times 5 \times 10^{-5} = 1.5 \times 10^{-4} \text{ Moles}$$

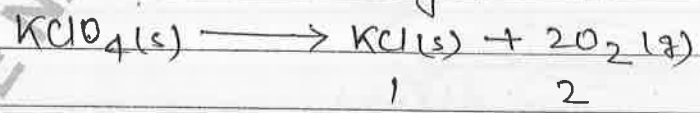
$$\text{Moles of NH}_3 = 2 \times 5 \times 10^{-5} = 10^{-4} \text{ Mol}$$

$$\text{No. of H}_2 \text{ Molecules} = 1.5 \times 10^{-4} \times 6 \times 10^{23} = 9 \times 10^{19} \text{ Molecules}$$

$$\text{Vol. of NH}_3 \text{ at STP} = 10^{-4} \times 22.4 = 2.24 \times 10^{-3} \text{ L}$$

Ques. 18.625g of KCl is produced on the decomposition of KClO₄ as follow. then determine the vol. of O₂(g) produced at STP during the rxn.

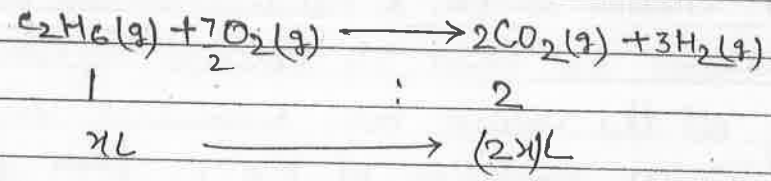
At wt. K=39
Cl=35.5



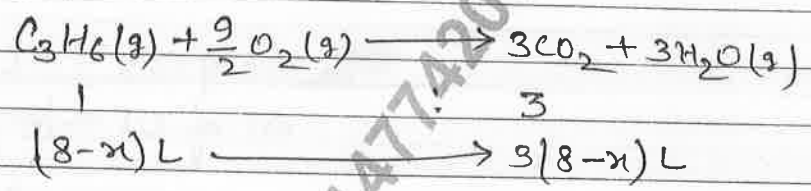
$$\text{Moles of KCl} = \frac{18.625}{74.5} = 0.25 \text{ Mol}$$

$$\text{Moles of O}_2 = 2 \times 0.25 = 0.5 \text{ Mol}$$

$$\text{Vol. of O}_2 \text{ at STP} = 0.5 \times 2 \times 22.4 = 11.2 \text{ L}$$



Let, vol of $\text{C}_2\text{H}_6 = x\text{L}$
 Vol. of $\text{C}_3\text{H}_8 = (8-x)\text{L}$



$\text{C}_2\text{H}_6 = 3\text{L}$
 $\text{C}_3\text{H}_8 = 5\text{L}$

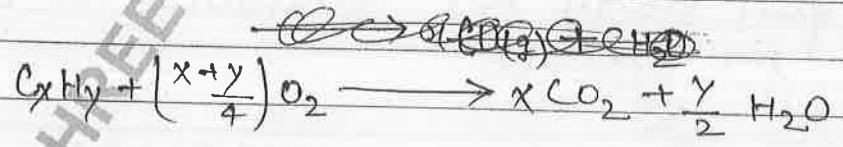
Vol. of CO_2 produced = 21L

$$2x + 3(8-x) = 21$$

$$2x + 24 - 3x = 21$$

$$x = 3$$

Ques. 200ml of gasses hydrocarbon on complete combustion produces 800ml of CO_2 and 600ml of water vapour under the same condition P & T then determine the molecular formula of hydrocarbon.



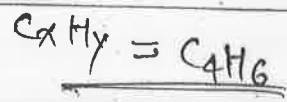
$$\begin{array}{ccccccc}
 1 & ; & \left(\frac{x+y}{4}\right) & ; & x & ; & \frac{y}{2} \\
 \text{Vol} & ; & \left(\frac{x+y}{4}\right)\text{Vol} & ; & x\text{Vol} & ; & \frac{y}{2}\text{Vol}
 \end{array}$$

$$\begin{array}{ccccccc}
 200\text{ML} & ; & \left(\frac{x+y}{4}\right) & ; & 800\text{ML} & ; & 600\text{ML} \\
 1\text{ML} & \text{---} & & & 4\text{ML} & & 3\text{ML}
 \end{array}$$

$$x = 4$$

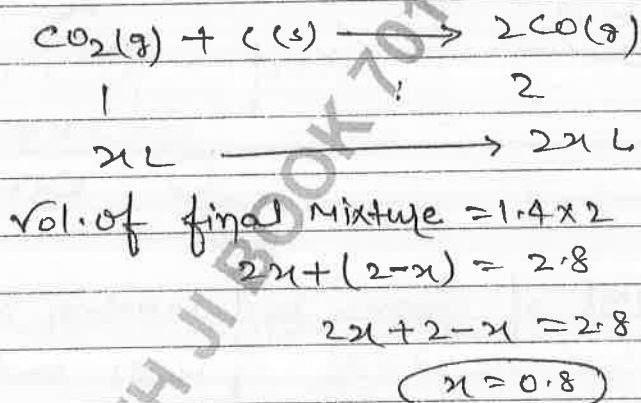
$$\frac{y}{2} = 3$$

$$y = 6$$



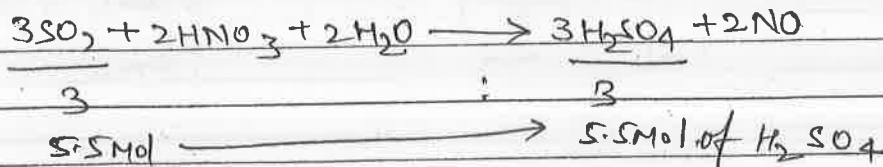
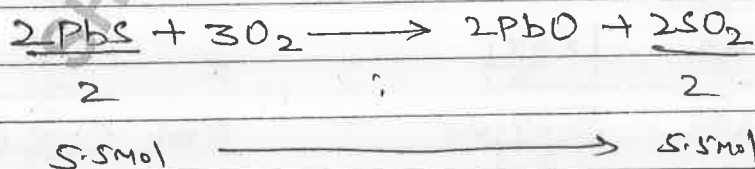
Ques. 2L mixture of CO_2 & CO is passed over red hot charcoal so that its volume becomes 1.4 times. If all the volume are measured under ~~similar~~ similar condition of P & T then find out the composition of initial mixture.

$$\begin{aligned} \text{Vol. of } \text{CO}_2 &= x \text{ L} \\ \text{Vol. of } \text{CO} &= (2-x) \text{ L} \end{aligned}$$



Ques. Calculate the mass of H_2SO_4 that will be produced from 1320g PbS according to the following rxn sequence.

Pb = 208



$$\text{Mole of PbS} = \frac{1320}{240}$$

$$= 5.5 \text{ mol}$$

$$\text{Mass of } H_2SO_4 = 5.5 \times 98$$

$$= 539 \text{ g}$$

Ques. Calculate the no. of moles of P that are required to produce 100 moles of ~~V~~ acc. to following rxn sequence.



$$R = \frac{S.O.P}{S.O.R}$$

$$n_P = n_R \times R_1 \times R_2 \times R_3$$

S.O.P = stoichiometry of Product

$$100 = n_R \times \left(\frac{2}{5}\right) \times \left(\frac{2}{3}\right) \times \left(\frac{3}{5}\right)$$

$$n_R = \frac{2500}{4} = 625 \text{ mol}$$

Percent Purity: —



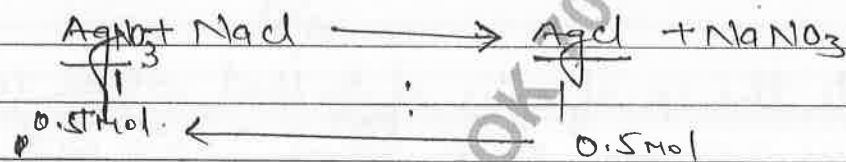
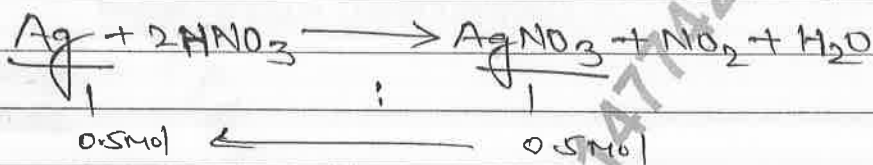
$$100 \text{ g} \qquad \qquad 56 \text{ g} \quad 44 \text{ g}$$

↓ 50%

$$50\% \longrightarrow 28 \text{ g} \quad 22 \text{ g}$$

$$\% \text{ purity} = \frac{\text{Actual (pure) Mass of Sample}}{\text{Total Mass of Sample}} \times 100$$

Ques. 90g of silver coin is dissolved in concentrated HNO_3 and after that excess of NaCl is added to it. As a result 71.75g of silver chloride is precipitated and then determine the percentage of silver in the coins. $\text{Ag} = 108$

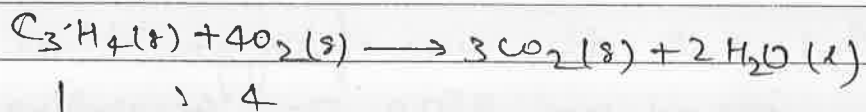


$$\begin{aligned} \text{Moles of AgCl} &= \frac{71.75}{143.5} \\ &= 0.5\text{mol} \end{aligned}$$

$$\begin{aligned} \text{Actual (pure) mass of Ag} &= 0.5 \times 108 \\ &= 54\text{g} \end{aligned}$$

$$\begin{aligned} \% \text{ purity} &= \frac{54}{90} \times 100 \\ &= 60\% \end{aligned}$$

Ques. Calculate the volume of air required at STP for the complete combustion 0.5kg of propyne having 20% impurity



$$1\text{mol C}_3\text{H}_4 \longrightarrow 4\text{mol O}_2$$

$$\text{Vol. of O}_2 \text{ at STP} = 4 \times 22.4$$

$$\text{Vol. of air} = 5 \times \text{Vol. of O}_2$$

$$= 5 \times 4 \times 22.4$$

$$= 4480\text{L}$$

$$80 = \frac{21}{500} \times 100$$

$$= 410\text{g}$$

Actual mass of C_3H_4

← Moles of $C_3H_8 = \frac{400}{40} = 10 \text{ Mol}$

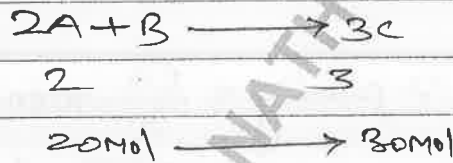
Percent Yield: —

$$\% \text{ yield} = \frac{\text{Actual Mass/Moles of Product}}{\text{Theoretical Mass/Moles of Product}} \times 100$$

~~जो मिल रहा है~~
~~जो मिलना चाहिए~~

Ques. Calculate the no. of moles of C that will be produced from 20 moles of A that reacts with excess of B according to the rxn $2A + B \rightarrow 3C$ having a 180% yield.

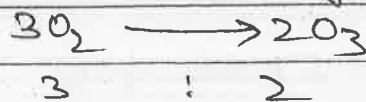
→ 30



$$30 = \frac{x}{30} \times 100$$

$$x = 24$$

Ques Calculate the mass of oxygen that is required to produce 960g O_3 according to the rxn $3O_2 \rightarrow 2O_3$ having a 50% yield.



$$\text{Moles of } O_3 = \frac{960}{48}$$

$$= 20 \text{ Mol}$$

~~$$3 \text{ Mol } O_2 \rightarrow 2 \text{ Mol } O_3$$~~

$$n \text{ Mol of } O_2 \xrightarrow{100\%} \frac{2}{3} n \text{ Mol of } O_3$$

$\xrightarrow{50\%} 20 \text{ Mol}$ (Actual mole)

$$50 = \frac{20}{\frac{2}{3}x} \times 100$$

$$x = 60 \text{ Mol of } O_2$$

\therefore Mass of $O_2 = 60 \times 32$

$$= 1920 \text{ g}$$

Ques. 6.8g of Hydrogen sulphide react with excess of SO_2 to produce 8.2g sulphur then determine the percent yield of S



$$\text{Mole of } H_2S = \frac{6.8}{34}$$

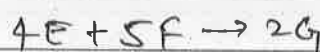
$$= 0.2 \text{ Mol} \longrightarrow 0.3 \text{ Mol of } S \text{ (Theoretical moles)}$$

$$\text{Actual moles of } S = \frac{8.2}{32} \text{ Mol}$$

$$\% \text{ yield} = \frac{8.2/32}{0.3} \times 100$$

$$= \frac{8.2}{9.6} \times 100 = 85.4\%$$

Ques. Calculate the moles of G that will be produced from 8 mole of A according to following rxn sequence $3A + B \longrightarrow 4C$



If 1^{st} rxn 100% & 2^{nd}

80% has 40%

50% and 60%

yield respectively.

$$\eta_p = \eta_R \times R_1 \times R_2 \times R_3 \times Y_1 \times Y_2 \times Y_3$$

$$= 8 \times \frac{4}{3} \times \frac{8}{5} \times \frac{2}{4} \times \frac{40}{100} \times \frac{50}{100} \times \frac{60}{100}$$

$$\eta_p = 0.384 \text{ mol}$$

Limiting Reagent :- (LR)

* The reactant which get completely ^{consumed} during the rxn is known as the limiting reagent

* All calculation are done on the basis of LR because it control ~~the~~ entire rxn.

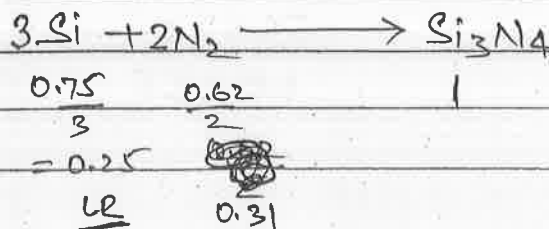
Determination of LR

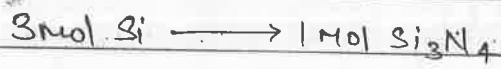
$$\text{Ratio} = \frac{\text{Given amount of reactant}}{\text{Stoichiometric coefficient}}$$

Moles, No. of molecules
mol. of gases but not mass

* The reactant for which the value of above given ratio is found to be minimum will be the LR.

Ques. Calculate the no. of moles Si_3N_4 that will be produced when 0.75 mol of silicon react with 0.62 mole of N

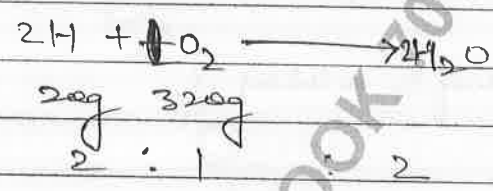




$$0.75 \text{ Mol} \longrightarrow \frac{1}{3} \times 0.75 = 0.25 \text{ Mol}$$

Moles of N_2 reacted = $0.25 \times 2 = 0.5 \text{ Mol}$.
(Remaining Mol of N_2)

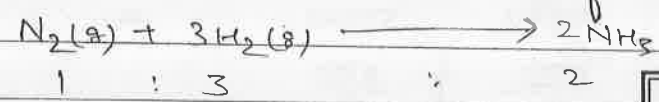
Ques. Calculate the mass of water that will be produced when 20g H_2 react with 320g O_2



$\frac{20}{2}$		$\frac{320}{32}$
= 10 Mol		10 Mol
Ratio 10		10
2		1
<u>550</u> LP		= 10

Moles of $\text{H}_2\text{O} = 5 \times 2 = 10 \text{ Mol}$
Mass of $\text{H}_2\text{O} = 10 \times 18 = 180$

Ques. Calculate the vol. of NH_3 produced at STP when 7mg of N_2 react with 1.5×10^{21} molecules of H_2 .



Moles = $\frac{7 \times 10^{-3}}{28}$		Moles = $\frac{1.5 \times 10^{21}}{6 \times 10^{23}}$
= $2.5 \times 10^{-4} \text{ mol}$		= $2.5 \times 10^{-3} \text{ mol}$
Ratio = 2.5×10^{-4}		= $2.5 \times 10^{-4} \text{ mol}$
= $\frac{1}{2.5 \times 10^{-4}}$		Ratio = $\frac{2.5 \times 10^{-4}}{3}$
<u>LP</u>		= 8.3×10^{-4}

Moles of $\text{NH}_3 = 2.5 \times 10^{-4} \times 2 = 5 \times 10^{-4} \text{ mol}$

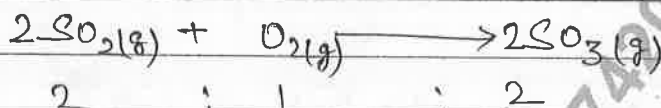
Vol. of NH_3 at STP = $5 \times 10^{-4} \times 22.4 = 11.2 \times 10^{-4} \text{ L}$

श्री नार जी बुक डिपो

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मातृ आरा हेरिस्टल शॉप नं. 2 रेलवे सत्रघार रोड नं. 2 के
साकने, जवाहर नगर, कोटा (राज.) मो. 7014774207

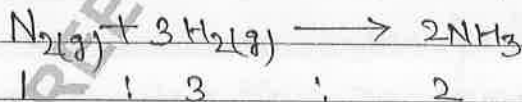
Ques. 15ml SO_2 gas completely react with $\text{O}_2(\text{g})$ to produce $\text{SO}_3(\text{g})$.
If at the end of rxn 45ml of $\text{O}_2(\text{g})$ was left unreacted then determine the original vol. of O_2 gas.



Initial \Rightarrow 15ml	x ml
final \Rightarrow 0	(x-7.5)

Remaining vol. of $\text{O}_2 = 45\text{ml}$
 $x - 7.5 = 45\text{ml}$
 $x = 52.5\text{ml}$

Ques. 200ml N_2 react with 500ml H_2 to produce NH_3 then determine the vol. of NH_3 is produced and the remaining vol. of excess reagent.



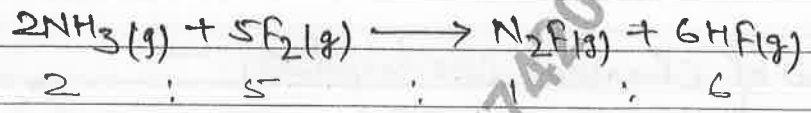
Given -	200ml	500ml	*
Ratio -	$\frac{200}{1}$	$\frac{500}{3}$	
	$= 200$	$= \boxed{166.6}$ LR	

Vol. of NH_3 produced = $166.6 \times 2 = \boxed{333.3\text{ml}}$

Vol. of N_2 reacted = $166.6 \times 1 = 166.6\text{ml}$

Remaining $\text{N}_2 = 200 - 166.6 = \boxed{33.4\text{ml}}$

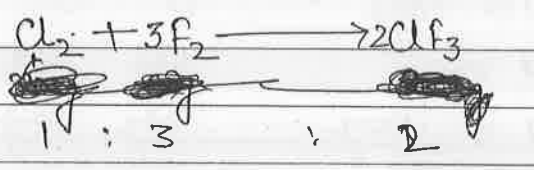
Ques. In the rxn $2\text{NH}_3(\text{g}) + 5\text{F}_2(\text{g}) \rightarrow \text{N}_2\text{F}_4(\text{g}) + 6\text{HF}(\text{g})$
 8.5g of NH_3 react with 19g of F_2 then determine the vol. of HF produced at STP and the mass of remaining of excess reagent.



Given Mole ratio $\Rightarrow \frac{8.5}{17}$ $= 0.5 \text{ mol}$ Ratio $= \frac{0.5}{2}$ $= 0.25$	19g Mole $\Rightarrow \frac{19}{38}$ $= 0.5 \text{ mol}$ $= \frac{0.5}{5}$ $= 0.1$ LR	Mole of $\text{HF} = 0.1 \times 6 = 0.6 \text{ mol}$ Vol. of HF at STP $= 0.6 \times 22.4$ $= 13.44 \text{ L}$
--	---	--

Moles of NH_3 reacted $= 0.1 \times 2 = 0.2 \text{ mol}$
 Remaining mol of $\text{NH}_3 = 0.5 - 0.2 = 0.3 \text{ mol}$
 Remaining mass of $\text{NH}_3 = 0.3 \times 17 = 5.1 \text{ g}$

* Ques. 30.8g ClF_3 is produced when 35.5g of Cl_2 react with 38g of F_2 then determine the % yield of the rxn.



Moles $= \frac{35.5}{71} \quad \frac{38}{38}$

$= 0.5 \quad = 1$

Ratio $= \frac{0.5}{1} \quad \frac{1}{3} = 0.33$
 $= 0.5 \quad \text{LR}$

Thero. Moles of $CF_3 = 0.83 \times 2 = 0.66 \text{ ML}$
Actual moles of $CF_3 = \frac{30.8}{92.5} = 0.33$

% yield = $\frac{0.33}{0.66} \times 100$
= 50%

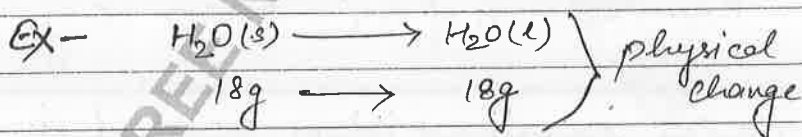
Law of chemical combination:—

① Law of conservation of Mass:—

Given by \Rightarrow Lavoisier
Tested by \Rightarrow Comdolt (H-shaped tube exp.)

This law state that in a closed system during any physical or chemical change the mass remains conserved.

i.e. Mass Before \equiv Mass After
 rxn rxn



Initial \Rightarrow 100g 0 0

① final \Rightarrow 0 56g 44g (Reactant are completely consumed)

② final \Rightarrow 50g 28g 22g (Reactant are partially consumed)

Note:— This law is not valid for nuclear rxn because in nuclear rxn some mass is lost in the form of energy Acc. to Einstein eqn.

$E = mc^2$

② Law of Definite proportion :—
or Constant Composition

Given by — Proust

This law states that a compound is always made up of same elements combined together in ~~the~~ a fix ratio by mass irrespective of the source of compound.

Ex —	H_2O	CO_2
	2:16	12:32
	1:8 (By Mass)	3:8 (by mass)

Note:—

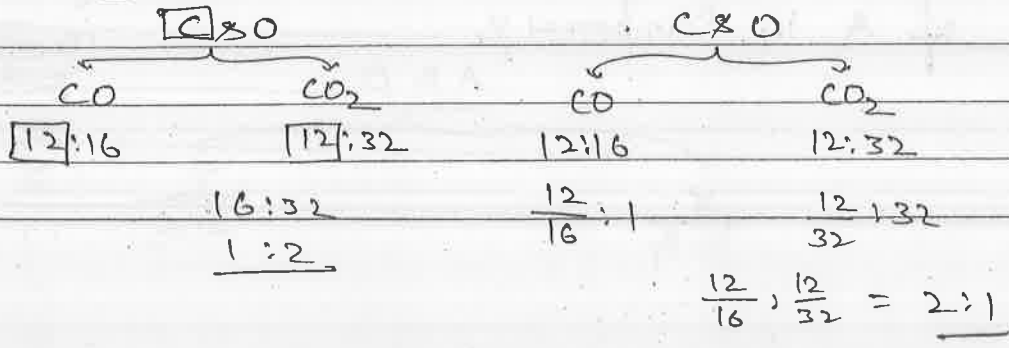
This law is not valid for isotopes and non-stoichiometric compound.

$^{12}CO_2$	$^{14}CO_2$
12:32	14:32
6:8	7:16

③ Law of multiple proportion :—

Given by — John Dalton

This law states that when two elements combined together to form two or more compound then the mass of one elements that combined with the fix mass of other elements in different compounds bears a small whole number ratio.



This law is not valid for isotopes & non-stoichiometric compound.

IV) Law of Gaseous volume: —

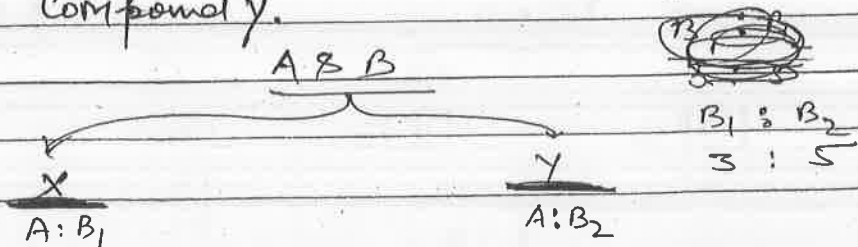
Given by — Gay Lussac

This law states that in a rxn when gases combined and are produced then they do so in a simple ratio of their volume provided that all gases are present under the same condition P & T.

Ques. Which of the pair of compd. illustrates the law of multiple proportion.

- ① $MgCl_2$: $BaCl_2$
- ② H_2O : D_2O
- ③ $NaCl$: KCl
- ④ PCl_3 : PCl_5

Ques. Two elements combined together to form two different compd X and Y. The ratio of mass of B that combined with the fix mass of A in X and Y is found to be 3:5. If 32 parts by mass of A combined with 84 parts by mass of B in X then determine how many parts by mass with B combination with 16 parts by mass of A in compound Y.



$$32 : 84$$

$$16 : B_2$$

$$\boxed{16} : 42$$

$$\boxed{16} : B_2$$

$$\frac{B_1}{B_2} = \frac{3}{5}$$

$$\frac{42}{B_2} = \frac{3}{5}$$

$$\boxed{B_2 = 70}$$

Ques. Calculate the mass of A that react with 10.6g of B to produce 6.8g of C and 12.6g of D acc. to the rxn $2A + 3B \rightarrow C + 2D$



$$x + 10.6$$

$$6.8 + 12.4$$

$$\boxed{x = 8.6g}$$

Equivalent Concept:—

* Equivalent weight:—

→ It is define as the weight of a substance that combines with or displaces directly or indirectly 1.008 parts by mass hydrogen, 8 parts by mass of oxygen, 35.5 parts by mass of chlorine or 108 parts by mass of silver.

Ex— SO_2

$$32g \text{ of O} \rightarrow 32g \text{ of S}$$

$$8g \text{ of O} \rightarrow \underline{8g \text{ of S}}$$

Eq. wt.

H_2S

$$2g \text{ of H} \rightarrow 32g \text{ S}$$

$$1g \text{ of H} \rightarrow \underline{16g \text{ S}}$$

Eq. wt.



$$\begin{aligned}
 106.5 \text{ g of Cl} &\longrightarrow 31 \text{ g of P} \\
 35.5 \text{ g Cl} &\longrightarrow \frac{31}{106.5} \times 35.5 \\
 &= \frac{31}{3} \text{ g of P} \\
 &\text{Eq. wt.}
 \end{aligned}$$

↳ Eq. wt. is define as the weight of a substance that has a tendency to lose or gain 1 mole of electron (i.e. 1 mole of charges).

Note:—

↳ Atomic wt and molecular wt are fixed but Eq. wt. is variable.

Equivalent weight of various substances:—

$$\text{Equivalent weight} = \frac{\text{Molar Mass}}{\text{Valency factor}}$$

① For ions:—

$$\text{Eq. wt.} = \frac{\text{formula wt.}}{\text{Charge on ion}}$$

Ex. — $Al^{+3} = \frac{27}{3} \Rightarrow 9$

$NH_4^+ = \frac{18}{1} = 18$

$SO_4^{2-} = \frac{96}{2} = 48$

$PO_4^{3-} = \frac{95}{3} = 31.6$

② For Acid:—

$$\text{Eq. wt.} = \frac{\text{Molecular wt.}}{\text{Basicity}}$$

Basicity = No. of replaceable H^+ ions.

Ex. —

$$\text{HNO}_3 = \frac{63}{1} = 63$$

$$\text{H}_3\text{PO}_2 = \frac{66}{1} = 66$$

$$\text{H}_2\text{SO}_4 = \frac{98}{2} = 49$$

~~HCOOH~~

$$\text{HCOOH} = \frac{46}{1} = 46$$

$$\text{H}_2\text{CO}_3 = \frac{62}{2} = 31$$

$$*\text{H}_3\text{PO}_3 = \frac{82}{2} = 41$$

$$\text{H}_3\text{PO}_4 = \frac{98}{3} = 32.6$$

$$\text{CH}_3\text{COOH} = \frac{60}{1} = 60$$

जितने CH_3 group उतने ही Basicity.

Basicity of Phosphorus = (No. of O-atoms - 1)

$$*\text{H}_3\text{BO}_3 = \frac{62}{1} = 62$$

$$\text{(COOH)}_2 = \frac{90}{2} = 45$$

③ For Basic:—

$$\text{Eq. wt.} = \frac{\text{Mol. wt.}}{\text{Acidity}}$$

Acidity = No. of replaceable OH^- ions

$$\text{Ex- NaOH} = \frac{40}{1} = 40$$

$$\text{Ca(OH)}_2 = \frac{74}{2} = 37$$

$$\text{Al(OH)}_3 = \frac{78}{3} = 26$$

⑥ For oxidising & Reducing agent :-

$$\text{Eq. wt.} = \frac{\text{Mol. wt.}}{\text{No. of } e^- \text{ lost or gained by 1 molecule}}$$

Ex. —



$$\text{Eq. wt.} = \frac{158}{5} \\ = \underline{\underline{41.6}}$$

Important relations for Equivalent Concept :-

$$\text{Molarity (M)} = \frac{\text{No. of moles of solute}}{\text{Vol. of solution (L)}} \left. \begin{array}{l} \text{Mol}^{-1} \\ \text{or} \\ \text{M} \end{array} \right\}$$

$$\text{Normality} = \frac{\text{No. of equivalents (g-equivalent)}}{\text{Vol. of solution (L)}} \left. \begin{array}{l} \text{eqL}^{-1} \\ \text{or} \\ \text{geqL}^{-1} \\ \text{or} \\ \text{N} \end{array} \right\}$$

$$\text{Normality} = \text{Molarity} \times \text{Valency factor}$$

$$\text{No. of equivalents} = \frac{\text{weight}}{\text{Eq. wt}} = \left(\frac{\text{Weight}}{\text{Molar mass}} \right) \times \text{V.F.}$$

$$\text{No. of equivalents} = \text{No. of moles} \times \text{V.F.}$$

$$\text{No. of equivalents} = \text{Normality} \times \text{Vol. of sol}^n \text{ (L)}$$

Law of Equivalence: —



a mole of A reacts with b moles of B to produce c mole of C & d mole of D

a eq. of A reacts with a eq. of B to produce a eq. of C & a eq. of D

$$\text{Eq. of A} = \text{Eq. of B} = \text{Eq. of C} = \text{Eq. of D}$$

↳ This law states that in a reaction the no. of equivalents of each reactant that react and the no. of equivalent of each product is formed are always equal.

Ques. Calculate the mass of H_2SO_4 i.e. is required for the complete neutralisation of 2g of NaOH

Solⁿ:-



1 : 2

moles of $\text{H}_2\text{SO}_4 = \frac{2}{20} \times \frac{1}{2}$	moles of $\text{NaOH} = \frac{2}{40} = \frac{1}{20} \text{ mol}$
---	---

$$= \frac{1}{40} \text{ mol}$$

$$\text{Mass of } \text{H}_2\text{SO}_4 = \frac{1}{40} \times 98 = 2.45 \text{ g}$$

OR

$$\text{Equiv. of } \text{H}_2\text{SO}_4 = \text{Equiv. of NaOH}$$

$$\text{Moles} \times \text{v.f} = \text{Moles} \times \text{v.f}$$

$$\frac{w}{98} \times 2 = \frac{2}{40} \times 1$$

$$w = 2.45 \text{ g}$$

Ques Calculate the volume of 0.3M molar $\text{Ca}(\text{OH})_2$ i.e. required for the complete neutralization of 3.1g of H_2CO_3 .

$$\text{Eq. of } \text{H}_2\text{CO}_3 = \text{Eq. of } \text{Ca}(\text{OH})_2$$

$$\text{Moles} \times \text{v.f} = N \times \text{Vol. (L)}$$

$$\frac{3.1}{62} \times 2 = \cancel{0.3} \times (0.3 \times 2) \times \text{Vol}$$

$$\text{Vol} = \frac{1}{6} \text{ L}$$

Ques Calculate the mass BaCl_2 that will be produced when 171g ~~171g~~ $\text{Ba}(\text{OH})_2$ react with 36.5g HCl .

$$\text{Eq. of } \text{Ba}(\text{OH})_2 = \text{Eq. of } \text{BaCl}_2$$

$$\begin{array}{r} 171 \\ 2 \\ \hline 86 \\ 171 \\ \hline 203 \end{array}$$

$$\begin{aligned} \text{Eq. of HCl} &= n \times \text{v.f} \\ &= \frac{36.5}{36.5} \times 1 = 1 \text{ eq.} \end{aligned}$$

$$\text{Eq. of } \text{Ba}(\text{OH})_2 = \frac{171}{171} \times 2 = 2 \text{ eq.}$$



Initial	$\frac{1 \text{ eq}}{1 \text{ R}}$	2 eq	—	—
---------	------------------------------------	------	---	---

final	0	1 eq	1 eq	1 eq
-------	---	------	------	------

$$\text{Eq. of } \text{BaCl}_2 = 1 \text{ eq} = \text{moles} \times \text{v.f}$$

$$1 = \frac{w}{208} \times 2$$

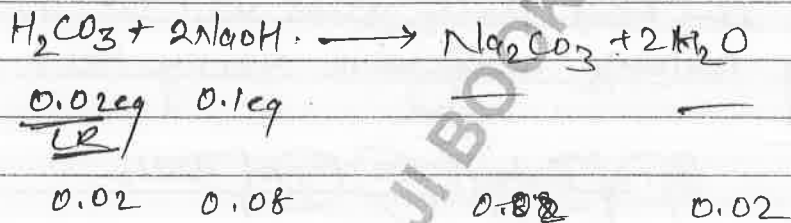
$$w = 104 \text{ g}$$

Ques. Calculate the mass of Na_2CO_3 that will be produced when 100ml 0.2 Normal H_2CO_3 react with 6.02×10^{23} molecules of NaOH .

~~Eq. of $\text{H}_2\text{CO}_3 = N \times V \times 1000$~~
~~Eq. of $\text{H}_2\text{CO}_3 = N \times V \times 1000$~~
 ~~$= 0.2 \times 100$~~
 ~~$= 0.4$~~
~~Eq. of $\text{NaOH} = N \times V \times 1000$~~
 ~~$= 0.1 \times 1000$~~

Eq. of $\text{H}_2\text{CO}_3 = N \times V$
 $= 0.2 \times 100$
 1000
 $= 0.02 \text{ eq.}$

Eq. of $\text{NaOH} = \text{moles} \times \text{V.F.}$
 $= \frac{6.02 \times 10^{23}}{6 \times 10^{23}} \times 1$
 $= 0.1 \text{ eq.}$

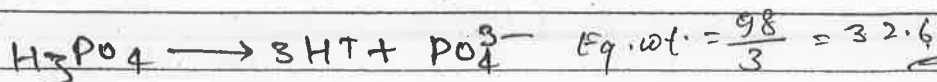
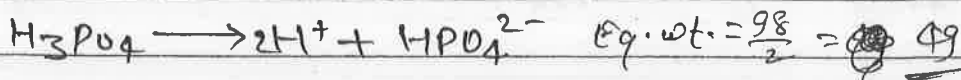
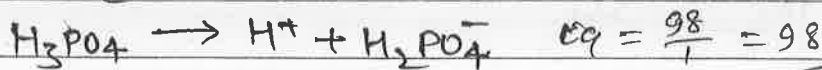


Eq. of $\text{Na}_2\text{CO}_3 = 0.02 = \text{moles} \times \text{V.F.}$

$$0.02 = \frac{w}{106} \times 2$$

$w = 1.06 \text{ g}$

Ques. Determine the eq. wt of H_3PO_4 in the following rxn.



Ques. Calculate the molarity of 0.2L NaOH solution that react with 12g of NaH_2PO_4 so that it convert in Na_3PO_4



$$\begin{aligned} \text{Eq. of NaH}_2\text{PO}_4 &= \text{Eq. of NaOH} \\ \text{moles} \times \text{V.F.} &= N \times \text{Vol(L)} \\ \frac{12}{120} \times 2 &= M \times 1 \times 0.2 \end{aligned}$$

$$M = 1 \text{ mol L}^{-2}$$

Ques. 2g of a base is completely neutralized by 100ml 0.2N acid then determine the equivalent wt. of the base.

$$\begin{aligned} \text{Eq. of acid} &= \text{Eq. of base} \\ N \times \text{Vol(L)} &= \frac{W}{E} \end{aligned}$$

$$0.2 \times \frac{100}{1000} = \frac{2}{E}$$

$$E = 100 \text{ g eq}^{-1}$$

Ques. 0.45g of an acid (M.Wt. 90) is completely neutralized by 100ML 0.1N base then determine the basicity of acid.

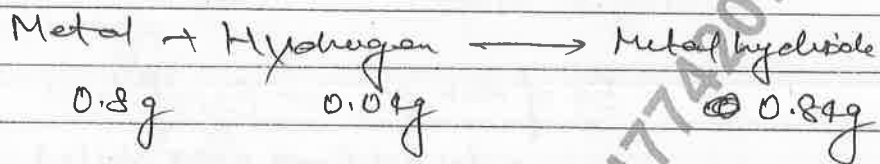
$$\begin{aligned} \text{Eq. of acid} &= \text{Eq. of base} \\ \frac{W}{E} &= N \times \text{Vol(L)} \\ \frac{0.45}{E} &= 0.1 \times \frac{100}{1000} \end{aligned}$$

$$\begin{aligned} \text{Eq. of acid} &= \text{Eq. of base} \\ \text{moles} \times \text{V.F.} &= N \times \text{Vol(L)} \\ \frac{0.45}{90} \times x &= 0.1 \times 0.1 \end{aligned}$$

$$x = 2$$

Ques 0.84g of a Metal hydride contain 0.04g of Hydrogen
 then determine the Equivalent wt. of Metal.

Eq. of Metal hydride = Eq. of



Eq. of Metal = Eq. of Hydrogen

$$\frac{W}{E} = \frac{W}{E}$$

$$\frac{0.8}{E_M} = \frac{0.04}{1}$$

$$E_M = 20\text{g eq}^{-1}$$

Ques A Metal oxide contains 20% oxygen then determine the Eq. wt. of Metal.



Eq. of Metal = Eq. of oxygen

$$\frac{W}{E} = \frac{W}{E}$$

$$\frac{80}{E_M} = \frac{20}{8}$$

$$E_M = 32\text{g eq}^{-1}$$

* The compounds having similar molecular and identical crystal structure are known as isomerplism compd.

* This law is based on ^{the} fact that the elements in isomerplism compound show the same valency.

③ Dulong & Petit's law:—
(Only for solid except Be, B, Si & C)

$$\text{Atomic wt} \times \text{Specific Heat} \approx 6.4$$

$$\text{Approx At. wt.} = \frac{6.4}{\text{Specific heat (calg}^{-1}\text{c}^{\circ}\text{-1)}}$$

④ Specific Heat Method:—

$$\text{Poisson's ratio} \Rightarrow \gamma = \frac{C_p}{C_v} = \frac{\text{Heat capacity at const. P.}}{\text{Heat capacity at const V}}$$

$$\text{If } \gamma = 1.66 = \text{Atomicity} = 1$$

$$\gamma = 1.44 = \text{Atomicity} = 2$$

$$\gamma = 1.33 = \text{Atomicity} = 3$$

$$\text{At. wt.} = \frac{\text{Mol. wt}}{\text{Atomicity}}$$

Molecular weight :-

(1) Mol. wt. = $2 \times V.D.$

(2) Victor Meyer's Method :-

(Form volatile substances at STP)

$$\text{Molar mass} = \frac{\text{Mass (g)}}{\text{Volume (L)}} \times 22.4 \text{ (L mol}^{-1}\text{)}$$

(3) Average Mol. wt. for mixture of gases :-

$$\text{Avg. Mol. wt.} = \frac{w_1 x_1 + w_2 x_2}{x_1 + x_2}$$

where,

w_1 & w_2 = Mol. wt. of gases 1 & 2 respectively

x_1 & x_2 = % occurrence / Relative abundance / Moles of gases 1 & 2 respectively.

Ques. Calculate the molecular wt. of air that contain 80% N_2 and 20% Oxygen by volume.

$$\text{Avg. mol wt.} = \frac{(28 \times 80) + (32 \times 20)}{100}$$

$$\Rightarrow \underline{28.8}$$

Ques. Calculate the mass % of O_2 present in the mixture of O_2 & O_3 that has an average molar mass of $40g/mol$.

$$O_2 = x\% \quad O_3 = (100-x)\%$$

$$40 = \frac{32x + 48(100-x)}{100}$$

$$x = 50\% \text{ (by mole)}$$

1 mol mixture.

$$\rightarrow \frac{1}{2} \text{ mol } O_2 = 16g$$

$$\rightarrow \frac{1}{2} \text{ mol } O_3 = 24g$$

Mass %

$$\text{of } O_2 = \frac{16}{40} \times 100$$

$$= 40\%$$

Ques. In Victor Meyer's method $0.2g$ of volatile substance displaces $56ml$ of air at STP then determine the molar mass of volatile substance.

$$\text{Molar Mass} = \frac{\text{Mass}}{\text{Volume}}$$

$$= \frac{0.2}{56 \times 10^{-3}} \times 22.4$$

$$= 80g/mol$$

Ques. The specific heat capacity of a gas at constant pressure and constant volume is found to be 0.12 & $0.09 \text{ cal/g}^\circ\text{C}$ then determine the atomic wt. of a gas if its vapour density is found to be 48 .

$$\gamma = \frac{C_p}{C_v} \Rightarrow \frac{1.2}{0.9} = \frac{4}{3} \Rightarrow 0.33 \Rightarrow \text{Atomicity} = 3$$

$$\text{At. wt.} = \frac{\text{Mol. wt}}{\text{Atomicity}} = \frac{2 \times V.D.}{3}$$

$$= \frac{2 \times 48}{3} = \underline{\underline{32}}$$

Ques. An element combines with 7.1g of Cl_2 to produce 9.5g of its chloride. If the chloride form is isomorphous with CaCl_2 determine the at. wt. of element.

$$\text{At. wt.} = \text{Eq. wt.} \times \text{Valency}$$

$$= 12 \times 2$$

$$\underline{\underline{\text{CaCl}_2}} \quad \underline{\underline{24}}$$

Eq. of element = Eq. of chloride

$$\frac{W}{E} = \frac{W}{E}$$

$$\frac{2.4}{E} = \frac{9.5}{E+35.5}$$

$$\underline{\underline{E = 12g \text{ eq}^{-1}}}$$

Ques. The equivalent wt of metal is 9. If the metal forms the chloride that 66.75 then determine the atomic wt. of metal.

$$\underline{\underline{\text{Eq. wt.} = 9}}$$

$$\text{At. wt.} = \text{Eq. wt} \times \text{Valency}$$

$$= 9 \times 3 \Rightarrow 9 \times 3 = \underline{\underline{27}}$$

Let metal chloride be MCl_x

$$\text{Mol. wt of } \text{MCl}_x = \left(\frac{\text{At. wt}}{\text{of M}} \right) \times 1 + x \times \left(\frac{\text{At. wt}}{\text{of Cl}} \right)$$

$$2 \times 66.75 = 9x + 35.5x$$

$$133.5 = 44.5x$$

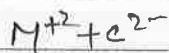
$$x = \frac{133.5}{44.5} = \underline{\underline{3}}$$

* In the case of metal chloride :-

$$x = \frac{2 \times V.D}{E + 35.5}$$

Ques. 1g of Metal oxide is completely convert into 2g metal carbonate if the specific heat of metal is found to be $0.14 \text{ cal g}^{-1} \text{ } ^\circ\text{C}^{-1}$ then determine the ~~exact~~ ^{exact} At.wt. of metal.

Eq. of Metal oxide = Eq. of Metal carbonate



$$\frac{E_M + 16}{2}$$

$$\frac{E_M + 8}{1}$$

$$\frac{W}{E} = \frac{W}{E}$$

$$\frac{1}{E_M + 8} = \frac{2}{E_M + 30}$$

$$E_M = 14 \text{ g eq}^{-1}$$

$$\text{Approx. at. wt.} = \frac{64}{0.14} = 457$$

$$\text{Valency} = \frac{\text{At. wt}}{\text{Eq. wt}} = \frac{45.7}{14} = 3.2 \approx \underline{\underline{3}}$$

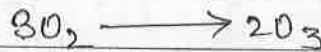
$$\begin{aligned} \text{At. wt} &= \text{Eq. wt} \times \text{Valency} \\ &= 14 \times 3 = \underline{\underline{42}} \end{aligned}$$

Eudiometry: —

Solvent	Absorbed gases
Turpentine oil	O_3
Alkaline pyrogallol	O_2
H_2O	$HCl; NH_3$
Anhy. $CaCl_2 / CuSO_4$ & H_2SO_4	H_2O
$KOH(aq)$	$CO_2; SO_2; Cl_2$
Ammonical Cu_2Cl_2	CO

EX#3

Ques. 14



3 : 2

90 ml

Initial

90 ml - 10%

↓

final

81 ml

GML = 81 ml

final

81 ml

= (81 ml)

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Chemical Equilli.

Derivation of Equilibrium Constant (K_{eq}): —

For a reversible rxn,



Acc. to LMA

$$\text{Rate}_f \propto [A]^a \cdot [B]^b$$

$$\text{Rate}_f = k_f [A]^a \cdot [B]^b \quad \text{--- (i)}$$

Similarly,

$$\text{Rate}_b = k_b [C]^c \cdot [D]^d \quad \text{--- (ii)}$$

At eqm

$$\text{Rate}_f = \text{Rate}_b$$

$$k_f [A]^a [B]^b = k_b [C]^c [D]^d$$

$$K_{eq} = \frac{k_f}{k_b} = \frac{[C]_{eq}^c \cdot [D]_{eq}^d}{[A]_{eq}^a \cdot [B]_{eq}^b}$$

K_{eq} = Equilibrium Constant.

k_f & $k_b \Rightarrow$ forward & backward

Rate constant respectively

$[A], [B]$ = Active mass

$[C], [D]$ of reactant & product at eqm.

* Def:- Equilibrium constant is defined as the ratio of the active masses of product to the active masses of reactant at equilibrium raised to the power their stoichiometric coefficients.

Types of K_{eq} :-

→ In terms of molar concentration $\Rightarrow K_c = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b}$; $[A], [B], [C], [D] \Rightarrow$ Molar concentration at eqm.
Unit - $(\text{mol L}^{-1})^{\Delta n}$

→ In terms of partial pressure $\Rightarrow K_p = \frac{P_C^c \cdot P_D^d}{P_A^a \cdot P_B^b}$;

P_A, P_B, P_C, P_D } Partial pressure at eqm.
Unit = $(\text{atm})^{\Delta n}$

$$\Delta n = \underbrace{(c+d)}_{\text{S.P.R}} - \underbrace{(a+b)}_{\text{S.O.R}}$$

Relation b/w K_c & K_p :-



$$K_c = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b} \quad \text{--- (1)}$$

$$K_p = \frac{P_C^c \cdot P_D^d}{P_A^a \cdot P_B^b} \quad \text{--- (2)}$$

As, we know,

$$PV = nRT$$

$$P = \left(\frac{n}{V}\right) RT$$

$$P = MRT$$

$$P = [A] RT$$

$$P = [B] RT$$

$$P = [C] RT$$

$$P = [D] RT$$

$$K_p = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b} (RT)^{(c+d) - (a+b)}$$

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

$R = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$
 $K_p = \text{atm}, K_c = \text{mol/L}$
 $T = \text{Kelvin}$

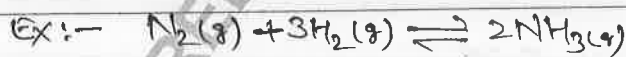
$$\Delta n_g = \underbrace{(c+d)}_{\text{stoichiometry of gaseous products}} - \underbrace{(a+b)}_{\text{stoichiometry of gaseous reactant}}$$

Case-1 If $\Delta n_g > 0 \Rightarrow K_p > K_c$



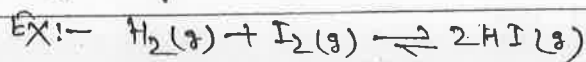
$$\Delta n_g = 2 - 1 = 1$$

Case-2 If $\Delta n_g < 0 \Rightarrow K_p < K_c$



$$\Delta n_g = 2 - 4 = -2$$

Case-3 If $\Delta n_g = 0 \Rightarrow K_p = K_c$



$$\Delta n_g = 2 - 2 = 0$$

Special case :- If $RT=1$

i.e. $\Rightarrow T = \frac{1}{R} = \underline{12.18K}$

So,

$$K_p = K_c \left(R \cdot \frac{1}{R} \right)^{\Delta n_g}$$

$$\therefore \underline{K_p = K_c}$$

Relation b/w K_p and K_x :-



$$K_p = \frac{P_B^b}{P_A^a} \quad \text{--- (1)}$$

$$K_x = \frac{X_B^b}{X_A^a} \quad \text{--- (2)}$$

Mole fr. const. in
 terms of Mole fraction.

As, we know

$$\text{Partial Pressure} = \text{Mole fraction} \times \text{Total pressure}$$

$$\left. \begin{aligned} P_A &= X_A \cdot P_T \\ P_B &= X_B \cdot P_T \end{aligned} \right\} \text{Put in eq (1)}$$

$$K_p = \frac{(X_B \cdot P_T)^b}{(X_A \cdot P_T)^a}$$

$$K_p = \frac{X_B^b}{X_A^a} (P_T)^{(b-a)}$$

$$\therefore \boxed{K_p = K_x \cdot (P_T)^{\Delta n_g}} \quad P_T = \text{Total pressure at eqm.}$$

Relation b/w K_c & K_x :-

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

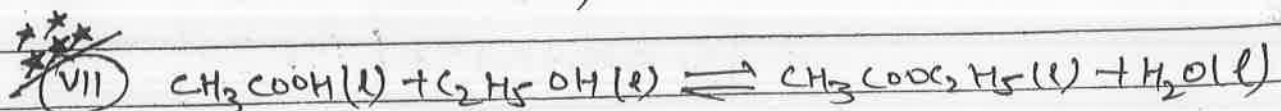
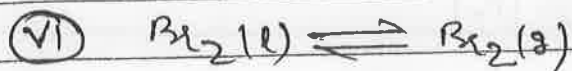
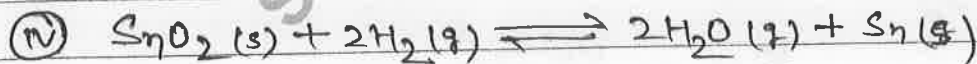
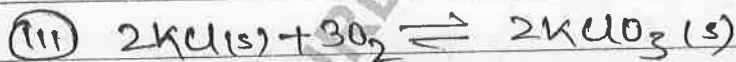
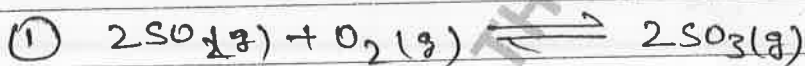
$$K_p = K_x (P_T)^{\Delta n_g}$$

$$K_c (RT)^{\Delta n_g} = K_x (P_T)^{\Delta n_g}$$

$$K_c = K_x \left(\frac{P_T}{RT} \right)^{\Delta n_g}$$

$$K_c = K_x (c)^{\Delta n_g}^*$$

Ques for the following rxn write the expression of K_p & K_c and also the relation b/w them.



$$(i) K_c = \frac{[SO_3]^2}{[SO_2]^2 \cdot [O_2]} ; K_p = \frac{P_{SO_3}^2}{P_{SO_2}^2 \cdot P_{O_2}}$$

$$\Delta n_g = 2 - 3 = -1$$

$$\therefore K_p < K_c$$

$$(ii) K_c = \frac{[CaO] \cdot [CO_2]}{[CaCO_3]} ; K_p = [P_{CO_2}]$$

$$\Delta n_g = 1 - 0 = 1 \quad (K_p > K_c)$$

$$(iii) K_c = \frac{1}{[O_2]^3} ; K_p = \frac{1}{[P_{O_2}]^3}$$

$$\Delta n_g = 0 - 3 = -3 \quad (K_p < K_c)$$

$$(iv) K_c = \frac{[H_2O]^2}{[H_2]^2} ; K_p = \frac{P_{H_2O}^2}{P_{H_2}^2}$$

$$\Delta n_g = 2 - 2 = 0 \quad \therefore K_p = K_c$$

$$(v) K_c = \frac{[ZnSO_4]}{[CuSO_4]} ; K_p = \frac{[ZnSO_4]}{[CuSO_4]}$$

$K_p = \text{Not define}$

$$(vi) K_c = [P_{Br_2}]$$

$$K_p = P_{Br_2}(g)$$

$$\Delta n_g = 1 - 0 = 1$$

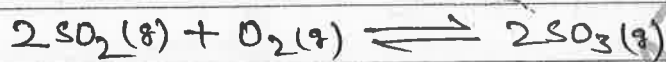
$$\therefore K_p > K_c$$

$$(vii) K_c = \frac{[CH_3COOC_2H_5] [H_2O]}{[CH_3COOH] [C_2H_5]} \neq 1$$

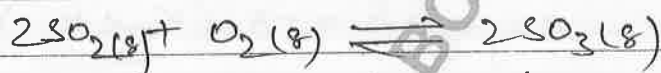
$K_p = \text{Not define}$

Note → If a rxn is homogenous in liquid state then the active masses of reactant and product are not as unity.

Ques. for a rxn the amount of reactant and product at equilibrium are given as following.



At eqm :- $\begin{matrix} 32\text{g} & 32\text{g} & 40\text{g} \end{matrix}$
 then determine K_c if the rxn is occurring in a 5L vessel.



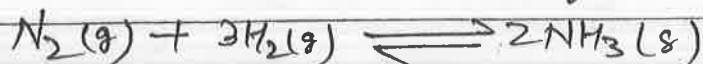
At eqm :- $\begin{matrix} 32\text{g} & 32\text{g} & 40\text{g} \end{matrix}$

$n_{\text{eqm}} :- \begin{matrix} \frac{32}{64} & \frac{32}{32} & \frac{40}{80} \\ 0.5\text{mol} & 1\text{mol} & 0.5\text{mol} \end{matrix}$

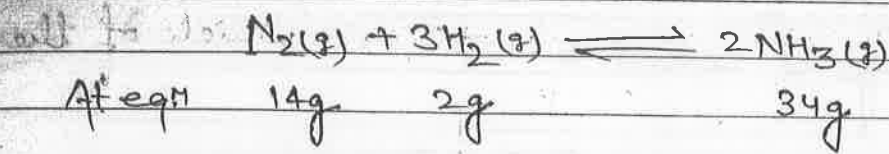
$$\left(\frac{n}{V}\right)_{\text{eq}} = \frac{0.5}{5} = 0.1\text{M} \quad \frac{1}{5} = 0.2\text{M} \quad \frac{0.5}{5} = 0.1\text{M}$$

$$K_c = \frac{[0.1]^2}{[0.1]^2 [0.2]} = 5 (\text{mol L}^{-1})^{-1} = 5 \text{ mol}^{-1} \text{ L}$$

Ques for a rxn the amount of reactant and product at eqillim. are given as follows:-



At eqm :- $\begin{matrix} 14\text{g} & 2\text{g} & 34\text{g} \end{matrix}$
 then determine the value of K_p if the



n_{eqm}	$\frac{14}{28}$ $= 0.5 \text{ mol}$	$\frac{2}{2}$ $= 1 \text{ mol}$	$\frac{34}{17}$ $= 2 \text{ mol}$
$P_{\text{eqm}} = X \cdot P_T = \frac{0.5}{3.5} \times 7$	$\frac{1}{3.5} \times 7$ $= 1 \text{ atm}$	$\frac{1}{3.5} \times 7$ $= 2 \text{ atm}$	$\frac{2}{3.5} \times 7$ $= 4 \text{ atm}$

$$K_p = \frac{P_{\text{NH}_3}^2}{P_{\text{N}_2} \cdot P_{\text{H}_2}^3} = \frac{(4)^2}{(1)(2)^3} = 2 \text{ atm}^{-2}$$

Ques.

for a gaseous rxn $x + y \rightleftharpoons z$, the value of $K_c = 2 \times 10^4 \text{ mol}^{-1}$.
If at eqm concentration of $[x]_{\text{eq}} = \frac{1}{2} [y]_{\text{eq}} = \frac{1}{2} [z]_{\text{eq}}$
then determine the equilibrium concentration of z.
 $K_c = 2 \times 10^4 \text{ mol}^{-1} \text{ L}$

$$K_c = \frac{[z]}{[x][y]} = 2 \times 10^4 \text{ mol}^{-1} \text{ L}$$

$$= \frac{[z]}{\frac{[z]}{2} \cdot [z]}$$

$$= \frac{2}{[z]} = 2 \times 10^4$$

$$[z] = 10^4 \text{ mol}^{-1} \text{ L}$$

Ques. for a rxn $2\text{SO}_3(\text{g}) \rightleftharpoons 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g})$. Which of the following is correct

- (I) $K_p - K_c = 0$
 (II) $K_p - K_c = -ve$
~~(III) $K_c - K_p = -ve$~~
 (IV) $K_p + K_c = 0$

$$\Delta n_g = 3 - 2 = 1$$

$$\text{As } \Delta n_g > 0$$

$$K_p > K_c$$

Ques for the rxn $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$ the relation $2K_p = K_c$ is possible when

- (I) $T = 6.09\text{K}$
 (II) $T = 12.18\text{K}$
~~(III) $T = 24.36\text{K}$~~
 (IV) None of these

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

$$K_p = 2K_p (RT)^{-1}$$

$$RT = 2$$

$$T = \frac{2}{R}$$

$$T = 2 \left(\frac{1}{R} \right)$$

$$= 2 \times 12.18$$

$$= 24.36\text{K}$$

Ques for a gaseous rxn $2\text{A} + \text{B} \rightleftharpoons 4\text{C}$ at 27°C temp. the value of $K_c = 3 \times 10^{-5} \text{ mol}^2 \text{ L}^{-1}$ then find out the value of K_p in terms of R .

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

$$= 3 \times 10^{-5} (R \times 300)^1$$

$$= 9 \times 10^3 R$$

Ques. for a gaseous rxn $A + B \rightleftharpoons C$ at 0°C temp the value of $K_p = 0.1 \text{ atm}^{-1}$ and the forward rate constant is $2.24 \times 10^2 \text{ M}^{-1} \text{ s}^{-1}$ then determine the backward rate constant.

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

$$(0.1) = K_c (0.0821 \times 273)^{-1}$$

$$K_c = 2.24 \text{ M}^{-1}$$

$$K_c = \frac{K_f}{K_b}$$

$$K_b = \frac{K_f}{K_c} \Rightarrow \frac{2.24 \times 10^2 \text{ M}^{-1} \text{ s}^{-1}}{2.24 \text{ M}^{-1}}$$

$$K_b \Rightarrow 10^2 \text{ s}^{-1}$$

Ques. The equation $\log \frac{K_p}{K_c} + \log \frac{1}{RT} = 0$ is valid for which of the following rxn.

- (i) $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$
- (ii) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
- (iii) $2\text{SO}_2 + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$
- (iv) $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$

$$\log \frac{K_p}{K_c} + \log \frac{1}{RT} = 0$$

$$\log \frac{K_p}{K_c} + \log 1 - \log(RT) = 0$$

$$\log \frac{K_p}{K_c} = \log(RT)$$

$$\frac{K_p}{K_c} = (RT)$$

$$K_p = K_c (RT)^{\Delta n} \quad \text{--- (1)}$$

$$\text{As } K_p = K_c (RT)^{\Delta n} \quad \text{--- (2)}$$

On comparing $\Delta n = 1$

Ques. for a gaseous rxn $A \rightleftharpoons 2B$ at 27°C temp. the value of $K_x = 2.46 \times 10^{-3}$ and the total pressure at equilibrium is 5 atm then determine the value of K_c

$$K_x = 2.46 \times 10^{-3}$$

$$T = 300\text{K}$$

$$K_c = K_x (c)^{\Delta n}$$

~~$$K_c = K_x (c)^{\Delta n}$$~~

$$= 2.46 \times 10^{-3}$$

$$K_c = K_x \left(\frac{P_T}{RT} \right)^{\Delta n}$$

$$= 2.46 \times 10^{-3} \left(\frac{5}{0.0821 \times 300} \right)^1$$

$$= 5 \times 10^{-4} \text{ mol/L}$$

Factor Effecting K_{eq} :-

(1) Temperature :-

Von Hoff equation :-

$$\log \left(\frac{K_2}{K_1} \right) = \frac{\Delta H}{2.303R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

K_1 & $K_2 \Rightarrow$ Equilibrium constant at T_1 & T_2 temp. respectively.

$\Delta H =$ change in enthalpy

* On increasing temp :-

$$\text{i.e. } T_2 > T_1 \Rightarrow \left(\frac{1}{T_1} - \frac{1}{T_2} \right) > 0$$

(i) for Endothermic rxn

As $\Delta H = +ve$

$$\text{so, } \log \left(\frac{K_2}{K_1} \right) > 0$$

$$\log K_2 - \log K_1 > 0$$

$$\log K_2 > \log K_1$$

$$\therefore \boxed{K_2 > K_1}$$

(ii) for Exothermic rxn

As, $\Delta H = -ve$

$$\text{so, } \log \left(\frac{K_2}{K_1} \right) < 0$$

$$\log K_2 - \log K_1 < 0$$

$$\log K_2 < \log K_1$$

$$\therefore \boxed{K_2 < K_1}$$

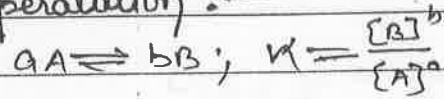
Trick !!

$$\text{Endo} = K \propto T$$

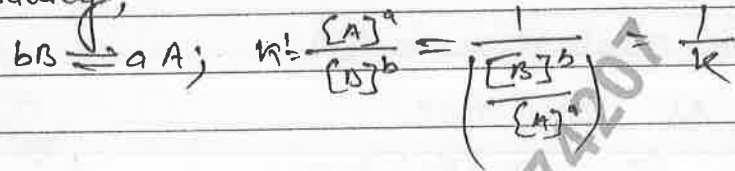
$$\text{Exo} \Rightarrow K \propto \frac{1}{T}$$

→ On increasing the temp. of an endothermic rxn the value of equilibrium constant increasing and for exothermic rxn the value of equilibrium constant decreases & vice-versa.

② Mode of reparation: —



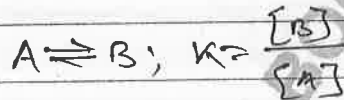
On reversing,



∴ On reversing the rxn

$$\Rightarrow K' = \frac{1}{K}$$

③ Stoichiometry of rxn: —



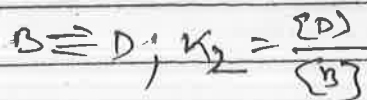
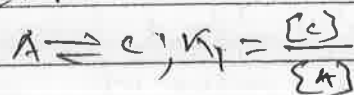
* On multiply by 'n'



$$K' = \frac{[B]^n}{[A]^n} = \left(\frac{[B]}{[A]}\right)^n = (K)^n$$

∴ On multiply a rxn by a factor 'n' $\Rightarrow K' = (K)^n$

④ Multi-step rxn



$$K = \frac{[E] \cdot [D]}{[A] \cdot [B]}$$

$$\therefore K = K_1 \times K_2$$

* On adding the rxn \Rightarrow $K = K_1 \times K_2$

Ques. For a rxn $P + 2Q \rightleftharpoons 3R$ the value of equilibrium constant is 16 then determine the value of equilibrium constant of the following rxns.

① $6R \rightleftharpoons 2P + 4Q$; K_1 $2 \times 3R \rightleftharpoons P + 2Q$; $\frac{1}{K}$
 $K = \frac{1}{K_1}$ $6R \rightleftharpoons 2R + 4Q$; $\frac{1}{K}$
 $= \frac{1}{(16)^2} = \frac{1}{256}$

② $\frac{1}{2}P + Q \rightleftharpoons \frac{3}{2}R$; K_2
 $K_2 = (K)^{1/2}$
 $= (16)^{1/2} = 4$

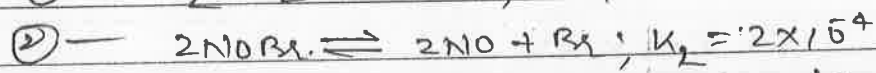
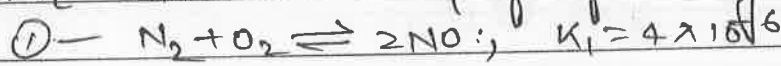
③ $\frac{3}{2}R \rightleftharpoons \frac{3}{2}P + 3Q$; K_3
 $K_3 = \frac{1}{(K)^{1/3}}$
 $= \frac{1}{(16)^{1/2}}$
 $= \frac{1}{(4)^3} = \frac{1}{64}$

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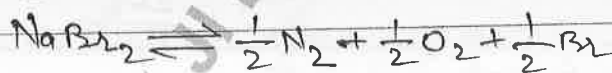
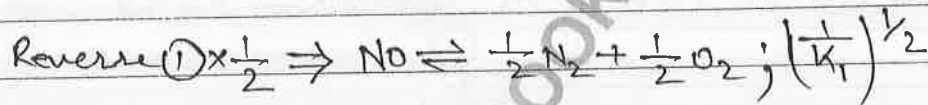
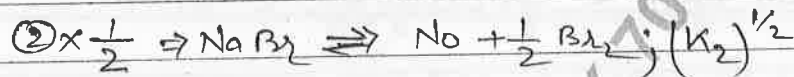
मातृ छाया होस्टल शॉप नं. 2 ऐलन सत्यार्थ गेट नं. 2 के
समने, जवाहर नगर, कोटा (राज.) मो. 7014774207

Ques. ~~With the help of following rxn~~ With the help of following rxn



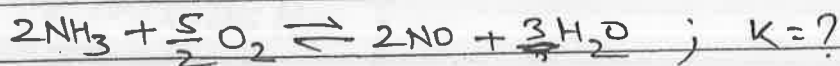
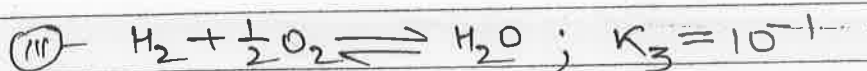
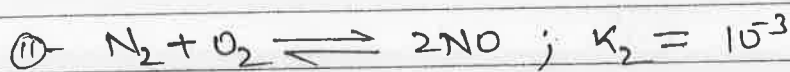
then determine

the value of equilibrium constant of the following

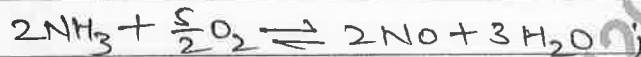
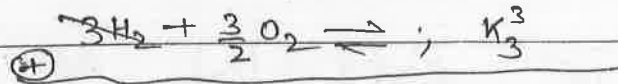
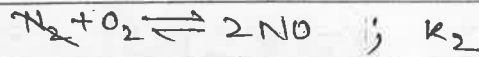
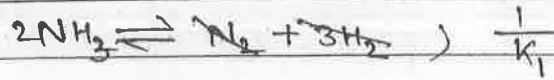


$$K = (K_2)^{1/2} \cdot \frac{1}{(K_1)^{1/2}} \Rightarrow \left(\frac{K_2}{K_1} \right)^{1/2} = \left(\frac{2 \times 10^4}{4 \times 10^6} \right)^{1/2}$$

$$\Rightarrow (50)^{1/2} = 7.1$$



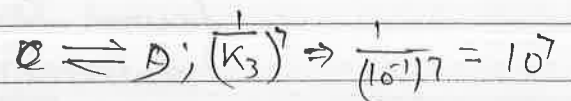
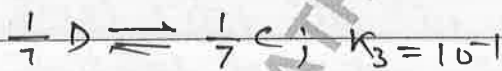
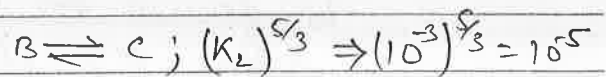
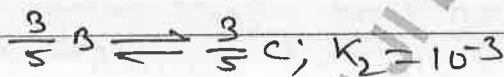
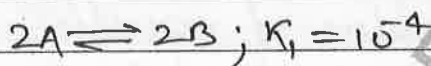
~~Reverse ①~~



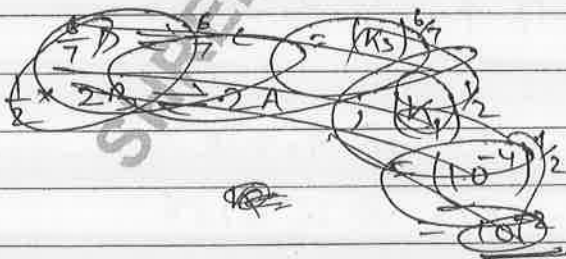
$$K = \frac{K_2(K_3)^3}{K_1}$$

$$= \frac{(10^{-3})(10^1)^3}{10^{-2}} = 10^{-4}$$

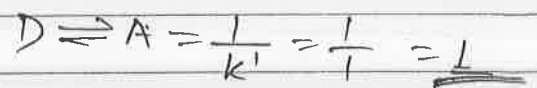
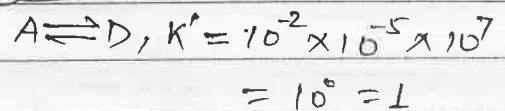
Ques.

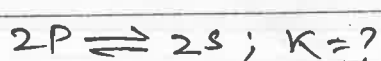
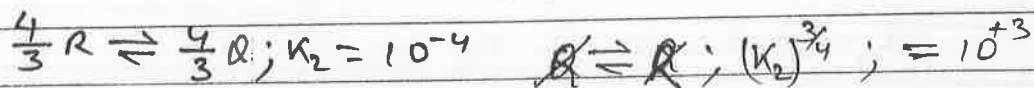
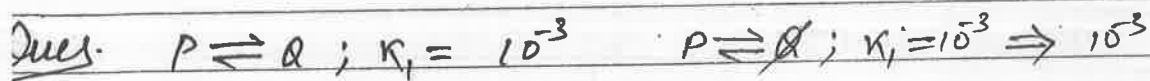


~~Ques.~~



~~Ques.~~





$$K' = 10^{-3} \times 10^3 \times 10^5$$

$$= 10^5$$

$$2P \rightleftharpoons 2S ; K = (K')^2 = (10^5)^2$$

$$= 10^{10}$$

Ques. For a reversible rxn the value of equilibrium constant is found to be 10^{-4} at 100°C temp. for the same rxn the value of equilibrium constant is found to be 10^{-6} at 150°C temp. then determine the nature of reaction.

$\downarrow K \propto \frac{1}{T} \uparrow$ Exothermic

$T_1 = 100^\circ\text{C} \Rightarrow K_1 = 10^{-4}$

$T_2 = 150^\circ\text{C} \Rightarrow K_2 = 10^{-6}$

Ques. For a rxn the value of enthalpy changes 27.6 kcal/mol . If the value of equilibrium constant is 10^9 at 27°C temp. then determine the value of equilibrium constant for the rxn at 327°C temp.

$$K_1 = 10^{-9}$$

$$T_1 = 27^\circ\text{C}$$

$$K_2 = ?$$

$$T_2 = 327^\circ\text{C}$$

$$\log\left(\frac{K_2}{K_1}\right) = \frac{\Delta H}{2.303R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

~~$$\log\left(\frac{K_2}{10^{-9}}\right) = \frac{27.6}{2.303 \times 8.314} \left(\frac{1}{300} - \frac{1}{600} \right)$$

$$= \frac{27.6}{19.189} \left(\frac{300 - 600}{300 \times 600} \right)$$~~

$$\log\left(\frac{K_2}{10^{-9}}\right) = \frac{27.6 \times 1000}{2.303 \times 2} \left(\frac{1}{300} - \frac{1}{600} \right)$$

$$= \frac{27.06 \times 1000}{4.606} \left(\frac{300 - 600}{300 \times 600} \right)$$

$$\log\left(\frac{K_2}{10^{-9}}\right) = \frac{276}{27.6} \times 10$$

$$\frac{K_2}{10^{-9}} = \text{Antilog}(10) = 10^{10}$$

$$K_2 = 10^{10} \times 10^{-9}$$

$$= 10$$

Non-Effecting factor of K_{eq} :-

- (i) Concentration of reactant & products
- (ii) Pressure
- (iii) Volume
- (iv) ~~Presence~~ Presence of catalyst
- (v) Presence of ~~inert~~ inert materials.

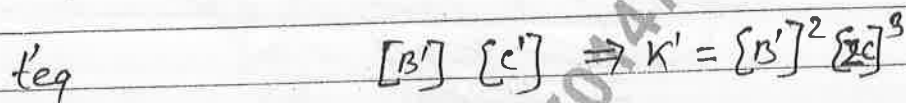
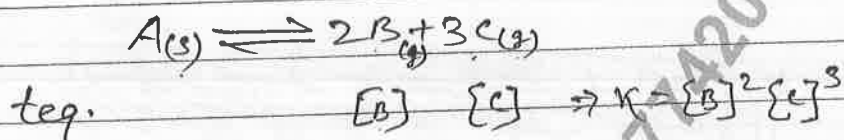
EX#1 1-37

EX#2 2, 4, 6, 8, 10, 11, 12, 14, 17, 18

PAGE NO. 20/22

DATE: / /

Ques. for a rxn $A(s) \rightleftharpoons 2B(g) + 3C(g)$ If the concentration of C at equilibrium is ~~is~~ increase by a factor by 2 then it will caused the equilibrium constant of B to change to



$$K = K'$$

$$[B]^2 [C]^3 = [B']^2 \cdot 8 [C]^3$$

$$[B']^2 = \frac{1}{8} [B]^2$$

$$\underline{[B']} = \frac{1}{2\sqrt{2}} [B]$$

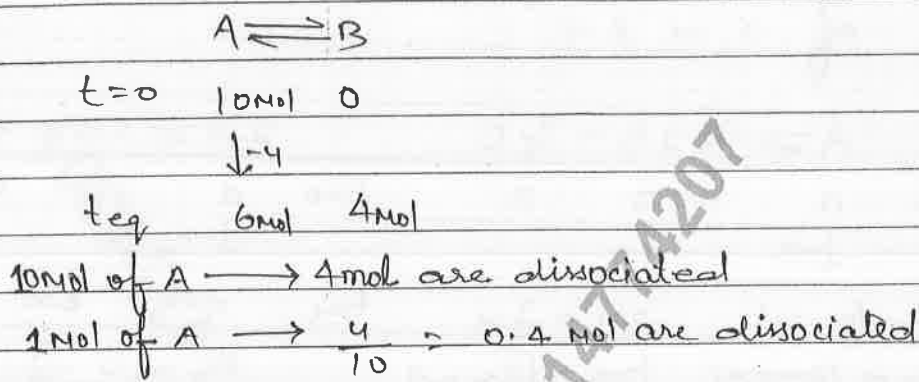
Ques. for a rxn $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ the value of eqm constant is K if the value of container is reduce to half of initial volume then the value of equilibrium constant for the rxn at the same temp will be.

K (Temp remains same)

Note

→ The value of equilibrium constant depends only on temp.

Degree of Dissociation (α):



$$\alpha = \frac{4}{10} = 0.4$$

$$\alpha \% = 0.4 \times 100 = 40\%$$

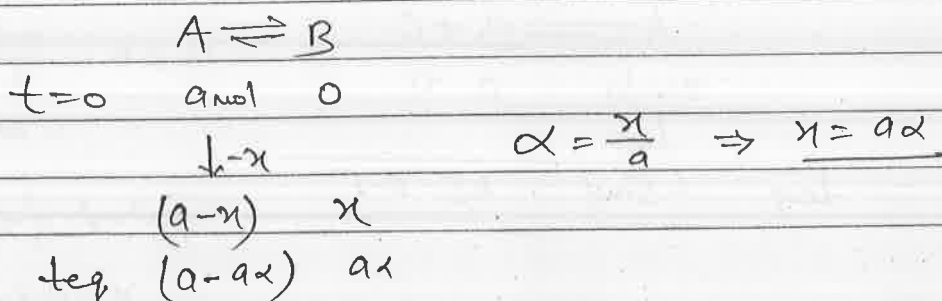
$$\text{D.O.D. } (\alpha) = \frac{\text{No. of dissociated moles}}{\text{No. of initial moles}}$$

$$\% \text{ D.O.D.} = \alpha \times 100$$

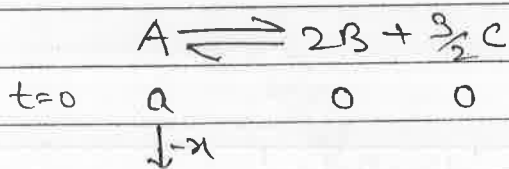
$$\alpha \leq 1 \quad (\text{But for equilib}^m \Rightarrow \alpha < 1)$$

D.O.D. is define for reactants.

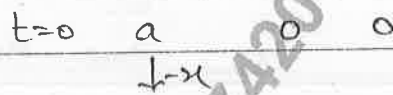
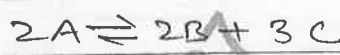
Defⁿ - D.O.D. is define as the no. of moles dissociated per moles at equilibrium or it can be define as the ratio of no the no. of dissociated moles to the initial moles.



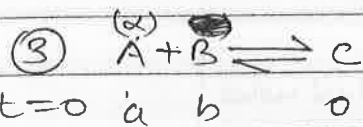
Ques for the following rxn determine the amount of reactant & product at equilibrium in terms of a, α & η .



t_{eq} = (a-x) 2x + $\frac{3}{2}x$
t_{eq} = (a- αa) (2 αx) ($\frac{3}{2}\alpha x$)
 $\therefore \alpha = \frac{x}{a} \Rightarrow x = \alpha a$



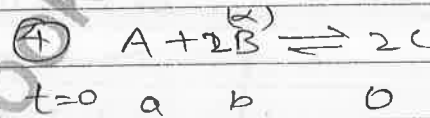
t_{eq} a-x 2x $\frac{3x}{2}$
 $\therefore \alpha = \frac{x}{a} \Rightarrow x = \alpha a$
t_{eq} = (a- αa) (αx) ($\frac{3}{2}\alpha x$)



t_{eq} (a-x) (b-x) x

t_{eq} = (a- αx) (b- αx) (αx)

$\alpha = \frac{x}{a} \Rightarrow x = \alpha a$

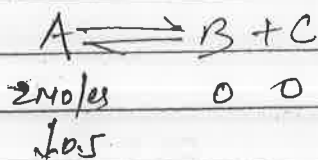


t_{eq} (a- $\frac{x}{2}$) (b-x) (x)

t_{eq} (a- $\frac{bx}{2}$) (b-bx) (bx)

$\alpha = \frac{x}{b} \Rightarrow x = \alpha b$

Ques for a rxn $A \rightleftharpoons B + C$ initially 2 moles of A are present if at equilibrium 0.5 mol of A are dissociated then determine the D.O.D of A and Total moles at equilibrium.



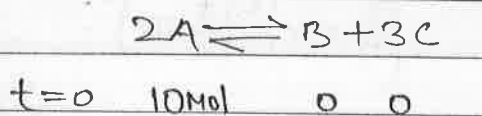
t_{eq} 1.5 mol 0.5 0.5

D.O.D = $\frac{0.5}{2}$
= 0.25

Total mole of eq^m = 2.5 mol

$x = 0.5 \text{ mol}$

Ques. for a rxn $2A \rightleftharpoons B + 3C$ initially 10 mol of A are present. If at equilibrium the sum of moles of products is found to be 12 then determine %age D.O.D of A.



$$t=0 \quad 10 \text{ mol} \quad 0 \quad 0$$

$$\text{eq.} \quad (10-x) \quad \frac{x}{2} \quad \frac{3x}{2}$$

Sum of moles of product = 12

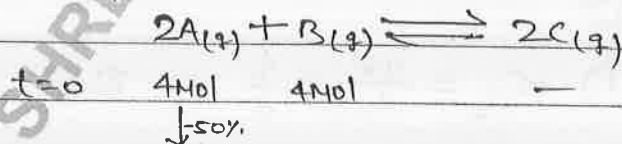
$$\frac{x}{2} + \frac{3x}{2} = 12$$

$$\underline{x = 6}$$

$$\begin{aligned} \% \text{ D.O.D.} &= \alpha \times 100 \\ &= \frac{6}{10} \times 100 \end{aligned}$$

$$\underline{= 60\%}$$

Ques. for a rxn $2A(g) + B(g) \rightleftharpoons 2C(g)$ initially 4 moles each of A and B are present. If D.O.D of A is 50%. then determine the D.O.D. of B and total moles at equilibrium also calculate K_p and K_c if the rxn occurring in 2l vessels and the total pressure at equilibrium is 14 atm.



$$t=0 \quad 4 \text{ mol} \quad 4 \text{ mol} \quad -$$

↓ 50%

$$\text{eq.} \quad 2 \text{ mol} \quad (4-x) \text{ mol}$$

$$\rightarrow 2 \text{ mol} \quad 3 \text{ mol} \quad 2 \text{ mol}$$

$$\alpha_A = \frac{x}{a}$$

$$0.5 = \frac{x}{2}$$

$$\underline{x = 2}$$

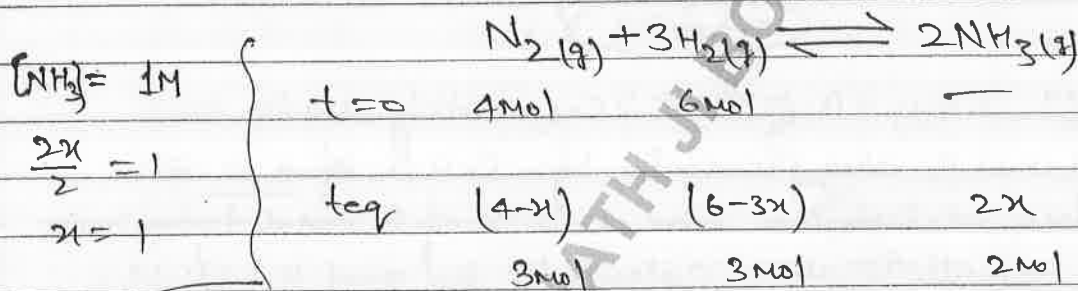
① Total moles at eqm = 7 mol

$$\text{② } \alpha_B = \frac{x/2}{a} = \frac{1}{4} = 0.25$$

$$(3) K_c = \frac{[C]^2}{[A]^2[B]} = \frac{\left(\frac{2}{2}\right)^2}{\left(\frac{2}{2}\right)^2 \left(\frac{3}{2}\right)} = \frac{2}{3}$$

$$(4) K_p = \frac{P_C^2}{P_A^2 \cdot P_B} = \frac{\left(\frac{2}{7} \times 14\right)^2}{\left(\frac{2}{7} \times 14\right)^2 \left(\frac{3}{7} \times 14\right)} = \frac{1}{6}$$

Ques. for a rxn $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ initially 4 moles of N_2 and 6 moles H_2 are present in 2L container if at equilibrium the concentration of NH_3 of 1M then determine D.O.F of N_2 and H_2 and also determine value of K_c .

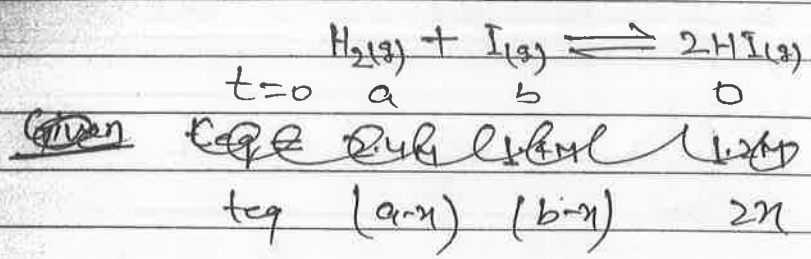


$$(i) \alpha_{N_2} = \frac{x}{a} = \frac{1}{4} = 0.25$$

$$(ii) \alpha_{H_2} = \frac{3x}{a} = \frac{3}{6} = 0.5$$

$$(iii) K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{\left[\frac{2}{2}\right]^2}{\left(\frac{3}{2}\right)\left(\frac{3}{2}\right)^3} = \left(\frac{16}{81}\right)$$

Ques for a rxn $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ at equilibrium the concentration of H_2 , I_2 & HI is 2.4M, 1.4 & 7.2M respectively then determine the value K_p , α_{H_2} and initial moles of H_2 and I_2 if the rxn is occurring in 2 vessels.



$$\begin{aligned}
 [\text{HI}] &= 1.2 \text{ M} \\
 \frac{2x}{2} &= 1.2 \\
 x &= 1.2
 \end{aligned}$$

③ $\alpha_{\text{H}_2} = \frac{x}{a} = \frac{1.2}{6} = 0.2$ i.e. 20%

$$\begin{aligned}
 [\text{H}_2] &= 2.4 \text{ M} \\
 \frac{a-x}{2} &= 2.4
 \end{aligned}$$

④ $\Delta_{\text{ng}} = 0$

$$\begin{aligned}
 K_p &= K_c = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} \\
 &= \frac{(1.2)^2}{(2.4)(1.6)} \\
 &= \frac{3}{8}
 \end{aligned}$$

$$\begin{aligned}
 a-x &= 4.8 \\
 a &= 4.8+x
 \end{aligned}$$

① $a = 6 \text{ mol}$

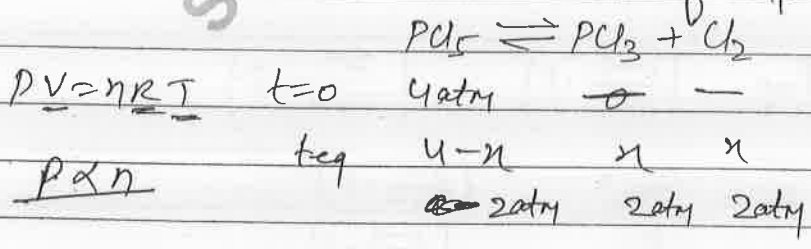
$$[\text{I}_2] = 1.6 \text{ M}$$

$$\frac{b-x}{2} = 1.6$$

$$b-x = 3.2$$

② $b = 4.4 \text{ mol}$

Ques. for a rxn $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$ the initial pressure is 4 atm at equilibrium the total pressure is 6 atm then determine the volume of K_p & D.O.F of PCl_5



$$\begin{aligned}
 P_T &= 6 \text{ atm} \\
 4-x+x+x &= 6 \\
 x &= 2 \text{ atm}
 \end{aligned}$$

(i) ~~$\alpha_{PCl_5} = \frac{x}{P_0} = \frac{2}{4} = 0.5$~~

(ii) $K_p = \frac{P_{Cl_2} \times P_{Cl_2}}{P_{PCl_5}} = \frac{2 \times 2}{2} \Rightarrow 2$

Ques. for rxn $N_2O_4 \rightleftharpoons 2NO_2(g)$ find out the relation b/w D.O.D (α); K_p and Total pressure at equilibrium (P)

(i) $\alpha = \sqrt{\frac{K_p}{4P}}$

(ii) $\alpha = \sqrt{\frac{4P}{K_p}}$

~~(iii) $\alpha = \sqrt{\frac{K_p}{K_p + 4P}}$~~

(iv) $\alpha = \sqrt{\frac{4P + K_p}{K_p}}$

$\alpha = \frac{x}{a}$
 $x = a\alpha$

$\alpha = \frac{x}{P_0}$
 $x = P_0 \alpha$

	$N_2O_4(g)$	\rightleftharpoons	$2NO_2(g)$
t=0	a		0
t _{eq}	a-x		2x
t _{eqm}	a-a α		2a α

X_{eq} $\frac{a-a\alpha}{a+a\alpha}$ $\frac{2a\alpha}{a+a\alpha}$

X_{eq} $\frac{1-\alpha}{1+\alpha}$ $\frac{2\alpha}{1+\alpha}$

P_{eq} $\left(\frac{1-\alpha}{1+\alpha} \cdot P\right)$ $\left(\frac{2\alpha}{1+\alpha} \cdot P\right)$

$K_p = \frac{P_{NO_2}^2}{P_{N_2O_4}} = \frac{\left(\frac{2\alpha}{1+\alpha} \cdot P\right)^2}{\left(\frac{1-\alpha}{1+\alpha} \cdot P\right)}$

$= \frac{4\alpha^2 P^2}{(1+\alpha)^2} \cdot \frac{1}{\left(\frac{1-\alpha}{1+\alpha} \cdot P\right)} = \frac{4\alpha^2 P}{(1+\alpha)(1-\alpha)}$

In the above question.

$$K_p = \frac{4\alpha^2 P}{(1-\alpha^2)} \longrightarrow \text{If } \alpha \ll 1$$

$$\therefore 1 - \alpha^2 \approx 1$$

$$\text{So, } K_p = 4P\alpha^2$$

$$K_p - K_p\alpha^2 = 4P\alpha^2$$

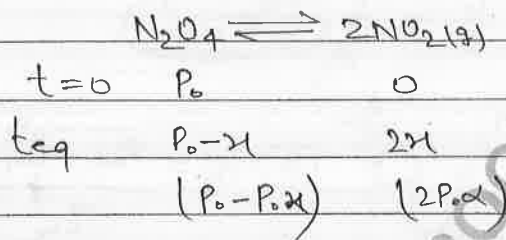
$$K_p = 4P\alpha^2 + K_p\alpha^2$$

$$K_p = (4P + K_p)\alpha^2$$

$$\alpha = \sqrt{\frac{K_p}{4P + K_p}}$$

$$\alpha = \sqrt{\frac{K_p}{4P}}$$

OR



Total pressure at eqm = P

$$P_0 - P_0\alpha + 2P_0\alpha = P$$

$$P_0 + P_0\alpha = P$$

$$P_0(1 + \alpha) = P$$

$$P_0 = \frac{P}{1 + \alpha}$$

$$K_p = \frac{(2P_0\alpha)^2}{(P_0 - P_0\alpha)} = \frac{4P_0^2\alpha^2}{P_0(1-\alpha)} = \frac{4P_0^2}{P_0(1+\alpha)(1-\alpha)}$$

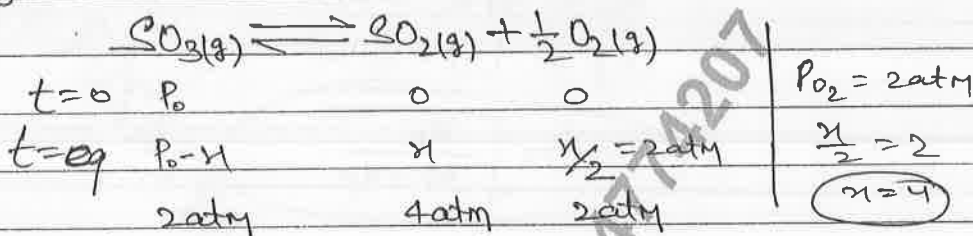
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मातृ छाया होस्टल शॉप नं. 2 फेलन सत्यार्थ गेट नं. 2 के
सामने, जवाहर नगर, कोटा (राज.) मो. 7014774207

Mol% = Mole fraction $\times 100$ For gases
 Vol% = Mole%

Ques: $\text{SO}_3(g) \rightleftharpoons \text{SO}_2(g) + \frac{1}{2} \text{O}_2(g)$ at equilibrium the partial pressure of O_2 2 atm and total pressure is 8 atm then calculate K_p initial pressure of system and D.O.D of SO_3 .



(2) $\alpha_{\text{SO}_3} = \frac{x}{P_0} = \frac{4}{6} = \frac{2}{3} \Rightarrow 0.66$

$P_T = 8 \text{ atm}$

$P_0 - x + x + \frac{x}{2} = 8$

$P_0 + \frac{4}{2} = 8$

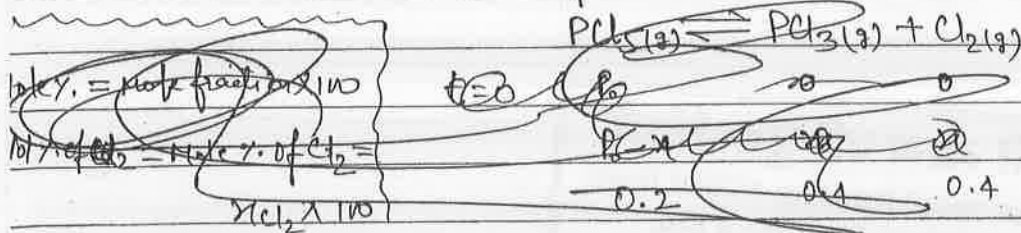
(1) $P_0 = 6 \text{ atm}$

(3) $K_p = \frac{P_{\text{SO}_2} \cdot P_{\text{O}_2}^{1/2}}{P_{\text{SO}_3}}$

$= \frac{(4)(2)^{1/2}}{2}$

$= 2\sqrt{2}$

Ques: for the rxn $\text{PCl}_5(g) \rightleftharpoons \text{PCl}_3(g) + \text{Cl}_2(g)$ at equilibrium the gaseous mixture contains 40% Cl by volume. Determine the value of K_p if the total pressure at equilibrium is 2 atm at 247°C temp.

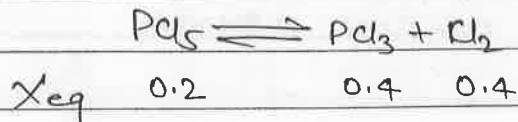


Mole % of $\text{Cl}_2 = 40\%$

$$\text{Vol\% of Cl}_2 = \text{Mole\% of Cl}_2 = x_{\text{Cl}_2} \times 100$$

$$40 = x_{\text{Cl}_2} \times 100$$

$$x_{\text{Cl}_2} = 0.4$$



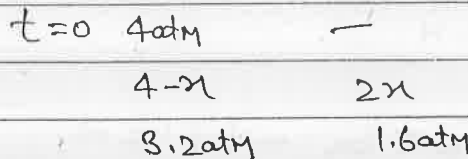
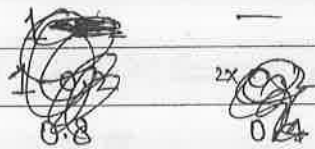
$$K_p = \frac{P_{\text{PCl}_3} \cdot P_{\text{Cl}_2}}{P_{\text{PCl}_5}}$$

$$= \frac{(0.4 \times 2)(0.4 \times 2)}{(0.2 \times 2)}$$

$$= \frac{(0.8)(0.8)}{0.4} = 1.6$$

Ques: 1 mole of N₂O₄ is initially present at 1 atm and 300 K on heating 1200 K 20% N₂O₄ are dissociated and equilibrium is attained then calculate the total pressure at equilibrium and the value of K_p from x₁.

~~20% = x₁ × 100~~
~~x₁ = 0.2~~
~~K_p = 0.8~~



$$\alpha = \frac{x}{P}$$

$$x = P \cdot \alpha$$

$$= 4(0.2)$$

$$= 0.8$$

① Total pressure at eqm = 4.8 atm

② $K_p = \frac{(1.6)^2}{3.2} = 0.8$

$$P_1 = 1; T_1 = 300\text{K}$$

$$P_2 = ?; T_2 = 1200\text{K}$$

$$PV = nRT$$

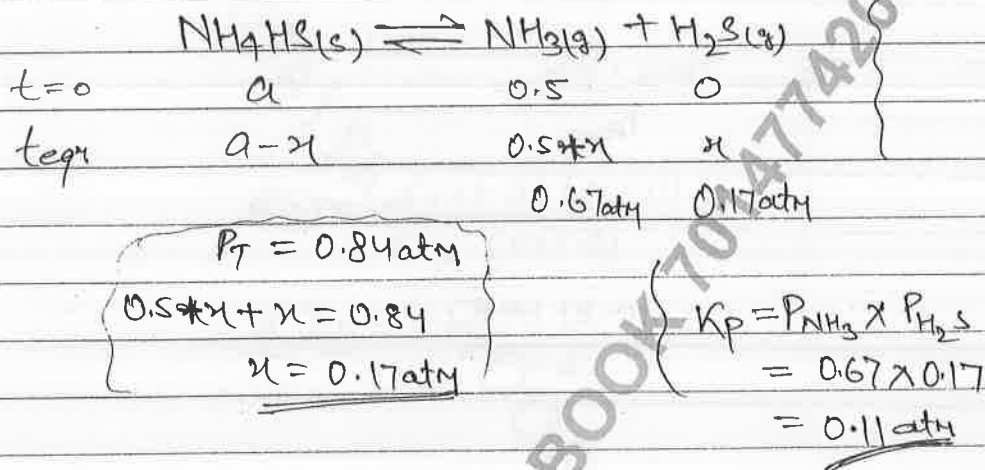
$$P \propto T$$

$$\frac{P_1}{P_2} = \frac{T_1}{T_2}$$

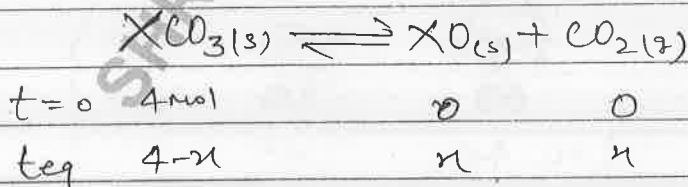
$$\frac{1}{P_2} = \frac{300}{1200}$$

$$P_2 = 4 \text{ atm}$$

Ques. In rxn $\text{NH}_4\text{HS}(s) \rightleftharpoons \text{NH}_3(g) + \text{H}_2\text{S}(g)$ if NH_4HS is placed in a container already containing NH_3 at initially pressure 0.5 atm then calculate K_p if the total equilibrium pressure 0.84 atm.



Ques. for a rxn $\text{XCO}_3(s) \rightleftharpoons \text{XO}(s) + \text{CO}_2(g)$ the value of $K_p = 1.642 \text{ atm}$ at 727°C temp. If 4 mole of XCO_3 were taken in sol container and heated upto 727°C temp then determine the mole % of XCO_3 unreacted at eqm.



$$K_p = P_{\text{CO}_2} = 1.642 \text{ atm}$$

$$V = \text{sol}; T = 727^\circ\text{C} = 1000\text{K}$$

$$PV = nRT$$

$$(1.642 \times 150) = (x)(0.0821)(1000)$$

$$x = 1 \text{ mol}$$

$$M_{\text{avg}} = \frac{(a - a\alpha) + (n a \alpha)}{(a - a\alpha) + n a \alpha}$$

Acc. to law of mass conservation:

Mass before rxn = mass after rxn

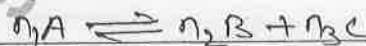
$$a \cdot M_A = (a - a\alpha) M_A + (n a \alpha) M_B$$

$$\therefore M_{\text{avg}} = \frac{a \cdot M_A}{a - a\alpha + n a \alpha} = \frac{M_A}{1 - \alpha + n \alpha}$$

$$\alpha = \frac{M_T - M_0}{(n-1) M_0}$$

$$\alpha = \frac{D_T - D_0}{(n-1) D_0}$$

for general rxn



$$\alpha = \frac{\eta_1}{\Delta \eta} \left(\frac{M_T - M_0}{M_0} \right)$$

$$\alpha = \frac{\eta_1}{\Delta \eta} \left(\frac{D_T - D_0}{D_0} \right)$$

$$\Delta \eta = \underbrace{(\eta_2 + \eta_3)}_{\text{S.O.P}} - \underbrace{(\eta_1)}_{\text{S.O.R}}$$

$$D_T = \frac{M_T}{2} \left. \right\} \phi D_T \text{ \& } M_T \Rightarrow \text{Theoretical vapour density, \& } \\ \text{Molar} \\ \text{Mass i.e. of reactant.}$$

$$D_o = \frac{M_o}{2} \left. \right\} D_o \text{ \& } M_o \Rightarrow \text{Observed v.D. \& } \text{Molar} \\ \text{Mass i.e. of eqm mixture}$$

Ques: for rxn $2\text{SO}_3 \rightleftharpoons 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g})$ the observed vapour density 30 then determine the %age D.O.D of SO_3 .

$$D_o = 30 \quad \& \quad D_T = \frac{M_T}{2} = \frac{80}{2} = 40$$

$$\alpha = \frac{n_1}{\Delta n} \left(\frac{40 - 30}{30} \right)$$

$$= \frac{2}{3-2} \left(\frac{10}{30} \right) = 0.66 \\ = 66.6\%$$

Ques: for rxn $2\text{NH}_3 \rightleftharpoons \text{N}_2(\text{g}) + 3\text{H}_2(\text{g})$ the D.O.D. of NH_3 is 70%. then determine the value of $\frac{D}{d} \stackrel{D_T}{=} ? \stackrel{D_o}{\downarrow}$

$$\alpha = 70\%$$

$$0.7 = \frac{2}{4-2} \left(\frac{D-d}{d} \right) = \frac{D}{d} = 1$$

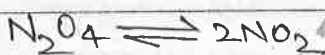
$$\therefore \frac{D}{d} = 1.7$$

Ques. for rxn $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ if $\frac{D}{d} = 1.5$ then find out the %age of NO_2 by volume in equilib^m mixture



$$\alpha = \frac{1}{2-1} \left(\frac{D-d}{d} \right) = \frac{D}{d} - 1$$

$$= 1.5 - 1 = 0.5$$



$$t=0 \quad 1 \text{ mol}$$

$$t_{eq} \quad 1-\alpha \quad 2\alpha$$

$$t_{eq} \quad 0.5 \text{ mol} \quad 1 \text{ mol}$$

$$\text{Mol\% of } NO_2 = \frac{1}{1.5} \times 100 = 66.67\%$$

Ques for a rxn $A \rightleftharpoons B+C+D$ if the v.d of the equilib^m mixture is 50 when the A undergoes 10% dissociation then find out the molar mass of A.

$$0.1 = \frac{1}{3-1} \left(\frac{D_T - 50}{50} \right)$$

$$0.1 = \frac{1}{2} \left(\frac{D_T - 50}{50} \right)$$

$$0.1 = \frac{D_T - 50}{100}$$

$$10 = D_T - 50$$

$$D_T = 60$$

$$\begin{aligned}
 M_T &= 2 \times D_T \\
 &= 2 \times 60 \\
 &= \underline{120}
 \end{aligned}$$

Ques for a rxn $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ at $27^\circ C$ and 1 atm N_2O_4 20% dissociation in NO_2 then determine the density of the equilibrium mixture?
gases



$$0.2 = \frac{1}{2-1} \left(\frac{M_T - M_0}{M_0} \right)$$

$$0.2 = \frac{92 - M_0}{M_0} = \frac{92}{M_0} - 1$$

$$\frac{92}{M_0} = 1.2$$

$$M_0 = \frac{92}{1.2} = \frac{230}{3}$$

As we know,

$$PM = dRT$$

$$(1) \left(\frac{230}{3} \right) = d (0.0821) (300)$$

$$d = \underline{3.11 \text{ g/L}}$$

Application of Equilibrium Constant:—

(1) To Determine Extent of reaction:—

(a) If ~~equilibrium~~ $K_{eq} > 10^3 \Rightarrow$ Products predominant over reactant i.e. If K_{eq} is large, then rxn almost proceeds to completion.

(b) If $K_{eq} < 10^{-3} \Rightarrow$ Reactant predominates over products
 i.e. If K_{eq} is small, then rxn proceeds slowly

(c) If K_{eq} is in the range of 10^3 to 10^5 , then appreciable concentrations of both reactant & product are present.

(2) ~~Stability~~ Stability of reactant & product:

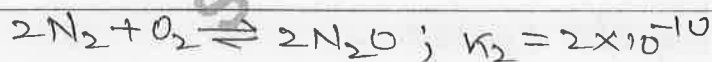
$$K = \frac{(\text{Product})}{(\text{Reactant})}$$

$$K \uparrow = [P] \gg [R]$$

$$K \downarrow = [P] \ll [R]$$

$K \propto$ Stability of product

$$K \propto \frac{1}{\text{Stability of Reactant}}$$



As, $K_1 > K_2$

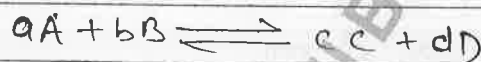
NO is more stable

- Ques: ① $A \rightleftharpoons B + C$; $K_1 = 10^4$
 ② $2A \rightleftharpoons B + C$; $K_2 = 10^8$
 ③ $A \rightleftharpoons 2B + C$; $K_3 = 10^{10}$
 ④ $A \rightleftharpoons B + 2C$; $K_4 = 10^{-15}$

In which the following rxn is least stable.

$$\uparrow K = \frac{1}{\text{stability of reactant}} \downarrow$$

② To determine the direction of reaction:—
 * Reaction Quotient (Q)

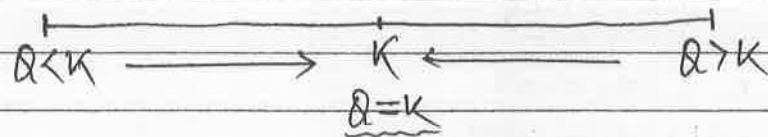


$$K = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b} \left. \begin{array}{l} \text{Active masses} \\ \text{are at equilibri}^m \end{array} \right\}$$

$$Q = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b} \left. \begin{array}{l} \text{Active masses are} \\ \text{at any instant of time} \end{array} \right\}$$

↳ At any instant of time the ratio the active masses of product to the active masses reactant raised to the power their stoichiometric coefficient is known as reaction quotient.

	$A \rightleftharpoons B$		
t=0	10	0	$\Rightarrow Q = \frac{0}{10} = 0$
2 min	9	1	$\Rightarrow Q = \frac{1}{9}$
4 min	8	2	$\Rightarrow Q = \frac{2^2}{8} = \frac{1}{4}$
teqM \Rightarrow 6 min	7	3	$\Rightarrow Q = \frac{3^2}{7} = K$



(i) If $Q < K$:-

R^{xn} moves in forward direction

(ii) If $Q = K$:-

~~R^{xn}~~ Equilli^m has been attained.

(iii) If $Q > K$:-

R^{xn} moves in backwards direction

Ques. for a R^{xn} $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $K_c = 6 \text{ mol}^{-2} \text{ L}^2$ if at certain time the concentration of N_2 , H_2 & NH_3 are found to be 0.1 , 0.2 & 0.3 mol L^{-1} respectively then determine the direction of R^{xn} .



$$Q_c = \frac{[NH_3]^2}{[N_2] \cdot [H_2]^3}$$

$$= \frac{[0.3]^2}{[0.1] \cdot [0.2]^3} = \frac{900}{8}$$

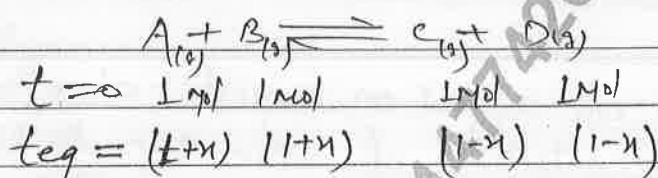
$$Q_c = ~~112.5~~ 112.5 \text{ mol}^{-2} \text{ L}^2$$

As, $Q_c > K_c$

Backwards

Ques for rxn $A(g) + B(g) \rightleftharpoons C(g) + D(g)$ $K_c = 0.25$ If 1mol each of A, B, C & D are taken in a 10l container then determine the equilibrium concentration of A.

$$K_c = 0.25$$



$$Q_c = \frac{\frac{1}{10} \times \frac{1}{10}}{\frac{1}{10} \times \frac{1}{10}}$$

$$= 1$$

As $Q_c > K_c$
Backwards

$$K_c = 0.25 = \frac{(1-x)^2}{(1+x)^2}$$

$$0.5 = \frac{1-x}{1+x}$$

$$x = \frac{1}{3}$$

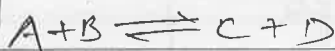
$$[A]_{eq} = \frac{(1-x)}{10} = \frac{(1-\frac{1}{3})}{10}$$

$$= 0.133M$$

Le-Chatelier's Principle:—

This principle states that if a system at equilibrium is subjected to a change then the equilibrium ~~of~~ ~~the~~ adjust itself in such a way so as to cancel out the effect of that change.

Effect of change in Concentration:—



(i) $K = \frac{[C] \cdot [D]}{[A] \cdot [B]}$ $\Rightarrow Q < K$ = Equilibrium shifts in forward direction.

(ii) $K = \frac{[C] \cdot [D] \uparrow}{[A] \cdot [B] \downarrow} \Rightarrow Q > K \Rightarrow \text{Equilibrium shifts in backward direction.}$

→ On increasing the concentration of reactant or decreasing the concentration of product the equilibrium shifts forward direction and vice-versa.

Note:- There is no effect on equilibrium due to the change in concentration of solid & pure liquid.

Effect of change in Pressure or Volume: —
(for gases $\Rightarrow P \propto \frac{1}{V}$)

(i) $\Delta n_g = 0$
 $A \rightleftharpoons B$
 $K = \frac{[B]}{[A]} = \frac{\left(\frac{n_B}{V}\right)}{\left(\frac{n_A}{V}\right)} = \frac{n_B}{n_A}$

If Vol. is doubled
 $Q = \frac{f(B)}{f(A)} = \frac{\left(\frac{n_B}{2V}\right)}{\left(\frac{n_A}{2V}\right)} = \frac{n_B}{n_A} = K$

(ii) $\Delta n_g < 0$
 $A + B \rightleftharpoons C$
 $K = \frac{\frac{n_C}{V}}{\frac{n_A}{V} \cdot \frac{n_B}{V}} \Rightarrow \left(\frac{n_C}{n_A \cdot n_B}\right) V$

\Rightarrow On \uparrow ing P, Vol. \downarrow es
 $\therefore Q < K \Rightarrow$ forward shifts
& vice-versa

(iii) $\Delta n_g > 0$
 $A \rightleftharpoons B + C$
 $K = \frac{\frac{n_B}{V} \cdot \frac{n_C}{V}}{\frac{n_A}{V}} \Rightarrow \left(\frac{n_B \cdot n_C}{n_A}\right) V$

\Rightarrow On \uparrow ing P, Vol. \downarrow es
 $\therefore Q > K \Rightarrow$ Backward shift & vice-versa.

Effect of Catalyst

↳ No effect

Ques. In a rxn $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -ve$ determine the effect on equilibrium due to the following changes.

- (i) Inc the concentration of H_2
- (ii) Inc the Pressure
- (iii) Inc the Temp.
- (iv) Adding Ne at constant volume
- (v) Adding of catalyst

Ans

- (i) backward
 - (ii) forward
 - (iii) forward
 - (iv) No effect
 - (v) No effect
- $\Delta H = -ve$ (Exo)
 $\uparrow K \propto \frac{1}{T \downarrow}$

Ques. for a rxn $pA + qB \rightleftharpoons rC$ if ^{pressure} low and high temp. are the favorable condition for product formation then pick out the correct relation.

- (i) $(p+q) > r$; $\Delta H > 0$ $P \downarrow \rightarrow n \uparrow$
 - (ii) $(p+q) > r$; $\Delta H < 0$ $(p+q) < r$
 - (iii) $(p+q) < r$; $\Delta H > 0$ $T \uparrow \rightarrow K \uparrow$
 - (iv) $(p+q) < r$; $\Delta H < 0$ $K \propto T$ (Endo)
- $\Delta H > 0$

Q. for a rxn $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ determine the favorable condition for the formation of $SO_3(g)$

- (i) $P \uparrow$; $T \uparrow$
 - (ii) $P \downarrow$; $T \downarrow$
 - (iii) $P \uparrow$; $T \downarrow$
 - (iv) $P \downarrow$; $T \uparrow$
- $\uparrow K \propto \frac{1}{T \downarrow}$
Exo: -

Ques. For a rxn $\text{CaCO}_3(s) \rightleftharpoons \text{CaO}(s) + \text{CO}_2(g)$; $\Delta H = +ve$ determine the effect on equilibrium due to the following changes.

- (i) Raising concentration of CO_2
- (ii) Raising the pressure
- (iii) Raising the temp.
- (iv) Adding He at constant pressure
- (v) Adding of CaCO_3

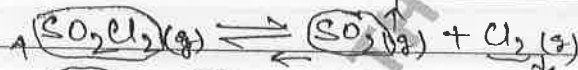
Ans

- (i) ← backwards
- (ii) forwards →
- (iii) forwards →
- (iv) forwards →
- (v) No effect

Endo; $K \propto T \uparrow$

श्री नाथ जी बुक डिपो
Zerox, Spiral Baining, NCERT Book,
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Hand Writing Notes, Online Form
मातृ छाया होस्टल शॉप नं. 2 ऐलन सत्यार्थ गेट नं. 2 के
सामने, जवाहर नगर, कोटा (राज.) मो. 7014774207

Ques. Two simultaneous equilibria are attained in a container as follows:



$\uparrow \text{CO}(g) + \text{Cl}_2(g) \rightleftharpoons \text{COCl}_2(g)$ If at equilibrium $\text{SO}_2(g)$ is added then what effect will be observed.

- (i) $[\text{SO}_2\text{Cl}_2] \uparrow$ & $[\text{CO}] \uparrow$
- (ii) $[\text{SO}_2\text{Cl}_2] \uparrow$ & $[\text{CO}] \downarrow$
- (iii) $[\text{SO}_2\text{Cl}_2] \downarrow$ & $[\text{CO}] \downarrow$
- (iv) $[\text{SO}_2\text{Cl}_2] \downarrow$ & $[\text{CO}] \uparrow$

Ques. For a rxn $\text{CO}(g) + \text{H}_2(g) \rightleftharpoons \text{CO}_2(g) + \text{H}_2(g)$ If the volume of vessels is decreased at equilibrium then find out the effect on the concentration of CO & CO_2

(A) Increases

(B) Decreases

(C) No change

(D) No-T.

$$\uparrow P \propto \frac{1}{V \downarrow}$$

Physical Equilli^m :-

physical equilli^m is a condition at which the different physical states of a substance are in equilli^m with each other.

NOTE → In physical equilli on increasing the pressure the equilli^m shifts in that direction where the volume is decreasing or vice-versa.

* Generally, the order of volume is —
 $\text{Vol. (solid)} < \text{Vol. (liquid)} < \text{Vol. (gas)}$

* But in case of H₂O
 $\text{Vol. (H}_2\text{O)}_{\text{liquid}} < \text{Vol. H}_2\text{O (solid)} < \text{Vol. H}_2\text{O (gas)}$

(i) $\text{Solid} \rightleftharpoons \text{Liquid}$; $\Delta H = +ve$
 $\text{Vol. (s)} < \text{Vol. (l)}$

↳ On ↑ing P

↳ Backward shift (because Vol. is ↓ing in that direction)

↳ More solid is formed

↳ ∴ M.P. ↑es.

* But in case of H₂O

$\text{H}_2\text{O (s)} \rightleftharpoons \text{H}_2\text{O (l)}$; $\Delta H = +ve$

$\text{Vol. (s)} > \text{Vol. (l)}$

↳ On ~~↑~~ ↑ing P

↳ Forward shift

↳ More liquid is formed

↳ ∴ M.P. ↓es



$\text{Vol}(l) < \text{Vol}(g)$

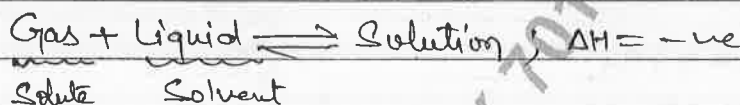
↳ On ↑ing P

↳ Backwards shift

↳ More liquid is formed

↳ ∴ B.P. ↑s.

Solubility of gases in liquid :-



(Vol. is ↓ing in forward direction)

↳ At high P & low T ⇒ forward shift ⇒ Solubility ↑s

↳ At low P & high T ⇒ Backward shift ⇒ Solubility ↓s

Ques $\text{C}(\text{diamond}) \rightleftharpoons \text{C}(\text{graphite}); \Delta H = -1.9 \text{ kJ}$ determine the feasible condition for the formation of diamond if the density of diamond and graphite are 3.5 g/cc and 2.3 g/cc respectively.

$d = 3.5 \text{ g/cc} > d = 2.3 \text{ g/cc}$

$\text{Vol.}(\text{dia}) < \text{Vol.}(\text{grap})$

$\underline{P \uparrow} = \underline{V \downarrow}$. Backward

Exo. ⇒ $\underline{K} < \frac{1}{T \uparrow}$

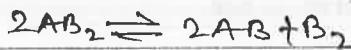
High P & high T

Trick !!

If $\alpha \lll 1$, then -

$$(\alpha) \propto (\alpha) \propto (V)^{\frac{\Delta n_g}{S.O.P}} \propto \left(\frac{1}{P}\right)^{\frac{\Delta n_g}{S.O.P.}}$$

Ex #2
Q. 3



$$(\alpha) \propto \left(\frac{1}{P}\right)^{1/3}$$

Ques. for a rxn $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ if the vol. of container is increased 4 times then α is becomes

$$\alpha \propto (V)^{1/2} \propto \frac{1}{(V)^{1/2}} \quad \text{--- (1)}$$

$$\alpha' \propto (4V)^{-1/2} \propto \frac{1}{(4V)^{1/2}} \quad \text{--- (2)}$$

$$\frac{\alpha}{\alpha'} = \frac{(4V)^{1/2}}{(V)^{1/2}} = 2$$

$$\alpha' = \frac{\alpha}{2}$$

Ques. For a rxn $2A_{(g)} + 2B_{(g)} \rightleftharpoons 3C_{(g)}$ at equilibrium if the pressure of system is increased 8 times then dissociation will become.

$$\alpha \propto \left(\frac{1}{P}\right)^{1/3} \quad \text{--- (1)}$$

$$\alpha' \propto \left(\frac{1}{8P}\right)^{1/3} \quad \text{--- (2)}$$

$$\frac{\alpha}{\alpha'} = \frac{(8P)^{1/3}}{(P)^{1/3}} = 2$$

$$\alpha' = \frac{\alpha}{2}$$

Ex #1
Q.44

X_2	Y_2
1mol	2mol
1L	2L

$$X_2 + Y_2 = 2XY$$

1mol 2mol

$$t = \infty \quad 1-x \quad 2-x \quad 2x$$

$$t_{eq} = \frac{1-0.9}{3} \quad \frac{2-0.9}{3}$$

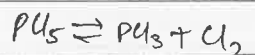
$$(XY) = 0.6M$$

$$\frac{2x}{3} = 0.6$$

$$x = 0.9$$

$$t_{eq} = \left(\frac{1}{3} - 0.3\right) \left(\frac{2}{3} - 0.3\right)$$

Q.50



$$t_{eq} \quad 0.6 \quad 0.3 \quad 0.2 \Rightarrow K$$

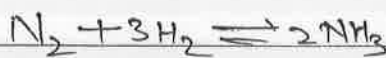
$$t_{eq'} \quad x \quad 0.6 \quad 0.4 \Rightarrow K'$$

$$K = K'$$

$$\frac{0.3 \times 0.2}{0.6} = \frac{0.6 \times 0.4}{x}$$

$$x = 2.4$$

Ques 45



$$t=0 \quad 1mol \quad 3mol \quad -$$

$$x_{t=0} \quad \frac{1}{4} \quad \frac{3}{4}$$

$$P_{t=0} \quad \frac{1}{4} \times 100 \quad \frac{3}{4} \times 100$$

$$P_{t=0} \quad 25atm \quad 75atm \quad -$$

$$t_{eq} \quad 25-x \quad 75-3x \quad 2x$$

$$10 \rightarrow a_n$$

$$x = P_0 \alpha$$

$$= 25(0.2)$$

$$= 5$$

$$\textcircled{54} \begin{array}{c} A+B \Rightarrow (1+1) \\ 4 \quad 4 \quad \leftarrow \leftarrow \\ 2 \quad 4-4 \quad 4-4 \quad x \quad x \end{array}$$

$\textcircled{58}$

$$\begin{array}{l} 2x = 3 \\ x = \frac{3}{2} = 1.5 \end{array}$$

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$$4 - \frac{8}{3} = \frac{4}{3}$$

$$R = 4 = \frac{x^2}{(4-x)^2}$$

$$x = \frac{x}{4-x}$$

$$x = \frac{8}{8}$$

$$H_2 + J_2 \Rightarrow 2H_2$$

$$4.5 \quad 4.5 \quad 0$$

$$4.5 \cdot x \quad 4.5 \cdot x \quad 2x = 3$$

$$3 \times 3$$

$$3 \times 3$$

$$x = \frac{3}{2} = 1.5$$

$\frac{4}{3} + 2$
 $\textcircled{7}$ $\frac{10}{3}$

SHREE NATH JI BOOK 7014774207

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Logarithm :-
↳ Properties of log

$$\log(axb) = \log a + \log b$$

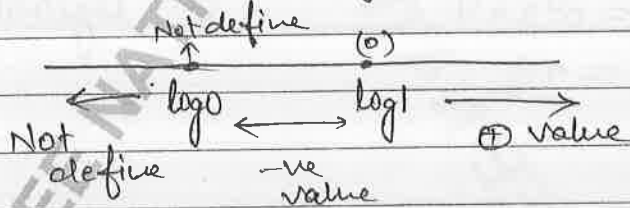
$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log a^n = n \log a$$

$$\ln a = \log_e a = 2.303 \log_{10} a$$

Some values of log :-

$\log 1 = 0$	$\log 6 = 0.78$
$\log 2 = 0.3$	$\log 7 = 0.84$
$\log 3 = 0.48$	$\log 8 = 0.9$
$\log 4 = 0.6$	$\log 9 = 0.96$
$\log 5 = 0.7$	$\log 10 = 1$



Ques Determine the logarithm of following value?

- | | |
|---------------------|-------------------------|
| (1) 30 | (7) 3×10^{-5} |
| (2) 1000 | (8) 0.006 |
| (3) $\sqrt{5}$ | (9) 15×10^{-7} |
| (4) $\frac{27}{5}$ | |
| (5) $3^{3/2}$ | |
| (6) 2×10^4 | |

$$\begin{aligned} & \log(3 \times 10) \\ \textcircled{1} \quad & \log 3 + \log 10 \\ & = 0.48 + 1 \\ & = 1.48 \end{aligned}$$

$$\begin{aligned} \textcircled{3} \quad & \log 5^{\frac{1}{2}} \\ & = \frac{1}{2} \log 5 \\ & = \frac{1}{2} \times 0.7 \\ & \Rightarrow 0.35 \end{aligned}$$

~~$$\textcircled{1} \quad \log 5$$~~

$$\begin{aligned} \textcircled{2} \quad & \log(10)^3 \\ & = 3 \log 10 \\ & = 3 \end{aligned}$$

$$\begin{aligned} \textcircled{5} \quad & \log 3^{\frac{3}{2}} = \frac{3}{2} \log 3 \\ & = \frac{3}{2} (0.48) \\ & = 0.72 \end{aligned}$$

$$\begin{aligned} \textcircled{4} \quad & \log\left(\frac{27}{5}\right) = \log 27 - \log 5 \\ & = 3 \log 3 - \log 5 \\ & = 3(0.48) - (0.7) \\ & = 0.74 \end{aligned}$$

$$\begin{aligned} \textcircled{7} \quad & \log 3 \times 10^5 = \log 3 - 5 \log 10 \\ & = 0.48 - 5 \\ & = -4.52 \end{aligned}$$

$$\begin{aligned} \textcircled{6} \quad & \log 2 \times 10^4 = \log 2 + \log 10^4 \\ & = \log 2 + 4 \log 10 \\ & = 0.3 + 4 \\ & = 4.3 \end{aligned}$$

$$\begin{aligned} \textcircled{8} \quad & \log(0.006) = \log 6 - 3 \log 10 \\ & = 0.78 - 3 \\ & = -2.22 \end{aligned}$$

$$\begin{aligned} \textcircled{9} \quad & \log 15 \times 10^{-7} = \log 5 + \log 3 + 7 \log 10 \\ & = 0.7 + 0.48 - 7 \\ & = -5.82 \end{aligned}$$

Ques Determine the logarithm of the following value?

$$\textcircled{i} \quad 31$$

$$\textcircled{iv} \quad 5.63$$

$$\textcircled{ii} \quad 17$$

$$\textcircled{v} \quad 2.32$$

$$\textcircled{iii} \quad 13$$

$$\textcircled{vi} \quad 7.23 \times 10^4$$

$$\textcircled{vii} \quad 3.81 \times 10^6$$

① $\log 31$

$\log 30$ $\log 31$ $\log 32$
 $\underline{1.48}$ 1.49 $= \log(2)^5$
 $= 5 \log 2$
 $= 5 \times 0.3$
 $= \underline{1.5}$

② 17

$\log 16$ $\log 18$
 $\log(2^4)$ $\log(2 \times 3^2)$
 $4 \log 2$ $\log 2 + 2 \log 3$
 4×0.3 $0.48 + 2 \times 0.48$
 1.2 1.23
 $\underline{1.23}$

④ $\log 5.63$

$\log 5$ $\log 5.63$ $\log 6$
 $\log 5$ 0.74 $\log 6$
 $\log 5.63 = 0.75$

③ $\log 13$

$\log 12$ $\log 14$
 $\log(4 \times 3)$ $\log(2 \times 7)$
 $\log 4 + \log 3$ $\log 2 + \log 7$
 $0.6 + 0.48$ $0.3 + 0.85$
 1.08 1.13
 $\underline{1.11}$

⑤ $\log 2.32$

$\log 2$ $\log 2.32$ $\log 3$
 $\log 2$ 0.39 $\log 3$
 0.3 $\log 2.32 = 0.35$ 0.48

⑥ $\log(7.23 \times 10^4) = \log 7.23 + 4 \log 10$

$\log 7$ $\log 8$
 $\log 7$ 0.87 $\log 8$
 0.85 0.87 0.90
 0.85 4.85

⑦ $\log(3.81 \times 10^{-6}) = \log 3.81 + 6 \log 10$

$\log 3$ $\log 4$
 $\log 3$ 0.58 $\log 4$
 0.48 0.58 0.6

$= 0.58 - 6 = -5.42$

Antilog:—

$\log = 2$
 $\text{Antilog}(2) = 100 = 10^2$

$\log 0.01 = -2$
 $\text{Antilog}(-2) = 0.01 = 10^{-2}$

$\text{Antilog}(x) = 10^x$
 $\text{Antilog}(-x) = 10^{-x}$

Some value for Antilog:—

As we know,

$\log 2 = 0.3 \Rightarrow \text{Antilog}(0.3) = 2 = 10^{0.3}$	$7 = 10^{0.84}$
$3 = 10^{0.48}$	$8 = 10^{0.9}$
$4 = 10^{0.6}$	$9 = 10^{0.96}$
$5 = 10^{0.7}$	$10 = 10^1$
$6 = 10^{0.78}$	

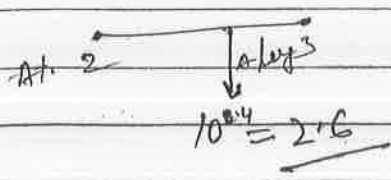
Ques. Determine the ~~ending~~ antilog of following value?

- (i) -5.7
- (ii) 4.4
- (iii) -3.63
- (iv) 11.24
- (v) -12.82
- (vi) -15.0

(i) $\text{Antilog}(-5.7) = 10^{-5.7}$
 $= 10^{(-6+0.3)}$
 $= 10^6 \times 10^{0.3}$
 $= 10^6 \times 10^{0.3}$
 $= 2 \times 10^6$

(ii) $\text{Antilog}(4.4) = 10^{4.4}$
 $= 10^{(4+0.4)}$
 $= 10^4 \times 10^{0.4}$
 $= 2.6 \times 10^4$

~~$= 10^5 \times 10^4$
 $= 10^9$
 $= 10^{(5+0.6)}$
 $= 10^5 \times 10^{0.6}$
 $= 10^5 \times 10^{0.6}$~~



(III) -3.63

$$10^{-3.63} = 10^{(-4+0.37)}$$

$$= 10^{-4} \times 10^{0.37}$$

$$= 2.4 \times 10^{-4}$$

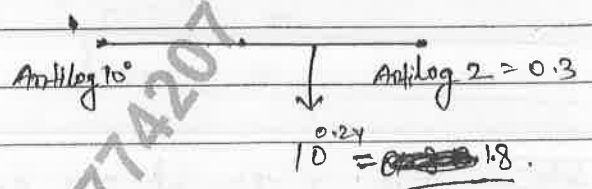


Antilog $\frac{37}{100} = 2.4$

(IV) $11.24 = 10^{(11+0.24)}$

$$= 10^{11} \times 10^{0.24}$$

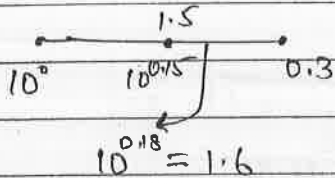
$$= 1.8 \times 10^{11}$$



(V) $10^{-12.82} = 10^{(-13+0.18)}$

$$= 10^{-13} \times 10^{0.18}$$

$$= 1.6 \times 10^{-13}$$



(VI) $-15.0 = 10^{-15}$

Ques. Determine the value of the following:-

(i) $\sqrt{10^{-5}}$

(ii) $\sqrt[3]{10^{-11}}$

(iii) $\sqrt[4]{10^{22}}$

(iv) $\sqrt[5]{10^{-27}}$

(i) $\sqrt{10^{-5}}$

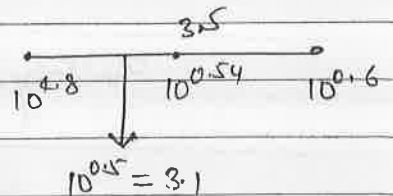
$$= (10^{-5})^{1/2}$$

$$= 10^{-2.5}$$

$$= 10^{(3+0.5)}$$

$$= 10^3 \times 10^{0.5}$$

$$= 3.1 \times 10^3$$



(ii) $\sqrt[3]{10^{-11}}$

$$= (10^{-11})^{1/3}$$

$$= 10^{-3.66}$$

$$= 10^{(-4-0.34)}$$

$$= 2.2 \times 10^{-4}$$

(iii) $\sqrt[4]{10^{22}}$

$$= (10^{22})^{1/4}$$

$$= 10^{(5+0.5)}$$

$$= 10^5 \times 10^{0.5}$$

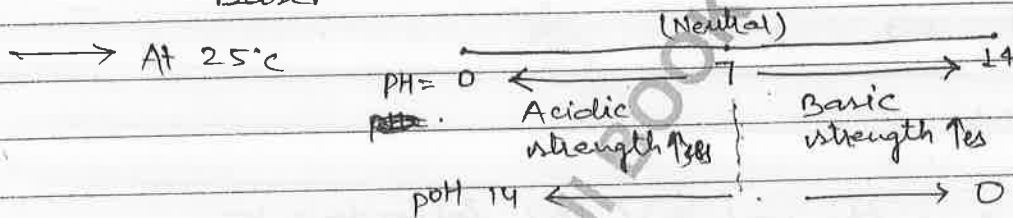
$$= 3.1 \times 10^5$$

$$\begin{aligned}
 & \textcircled{4} \sqrt[5]{10^{-27}} \\
 & \cdot 10^{-27/5} \\
 & = 10^{-5.4} \\
 & = 10^{-(6+0.6)} \\
 & = 10^{-6} \cdot 10^{0.6} \\
 & = 4 \times 10^{-6}
 \end{aligned}$$

Introduction of PH scale:—

→ Also called Sorenson scale.

→ Used to measure the strength of an acid & base.



$$pX = -\log X$$

$$\text{Antilog}(-pX) = X = 10^{-pX}$$

Similarly,

$$pH = -\log (H^+)$$

$$\text{Antilog}(-pH) = [H^+] = 10^{-pH}$$

$$pOH = -\log (OH^-)$$

$$\text{Antilog}(-pOH) = [OH^-] = 10^{-pOH}$$

* Relation b/w pH & pOH: —

At 25°C,

$$\boxed{\text{pH} + \text{pOH} = 14}$$

$$(-\log[\text{H}^+]) + (-\log[\text{OH}^-]) = 14$$

$$\log([\text{H}^+] \cdot [\text{OH}^-]) = 14$$

$$[\text{H}^+] \cdot [\text{OH}^-] = \text{Antilog}(-14)$$

$$\therefore \boxed{[\text{H}^+] \cdot [\text{OH}^-] = 10^{-14}}$$

Ques Calculate the pH of a solution having the $[\text{H}^+]$ concentration is $5.63 \times 10^{-4} \text{ M}$

$$\begin{aligned} \text{pH} &= -\log 5.63 \times 10^{-4} \\ &= -(\log 5.63 - 4 \log 10) \\ &= -(0.75 - 4) \\ &= 3.25 \end{aligned}$$

$$\begin{aligned} \text{OR } \text{pH} &= -\log(a \times 10^{-b}) = b - \log a \\ &= -\log(5.63 \times 10^{-4}) = 4 - \log 5.63 \\ &= 4 - 0.75 \\ &= 3.25 \end{aligned}$$

Ques Calculate the $[\text{OH}^-]$ concentration of a solution having a pH of 11.52

$$\begin{aligned} \text{pOH} &= 14 - 11.52 \\ &= 2.48 \end{aligned}$$

$$\begin{aligned} [\text{OH}^-] &= 10^{\text{pOH}} \\ &= 10^{2.48} \\ &= 10^{(-3+0.52)} \\ &= 10^{-3} \times 10^{0.52} \\ &= 3.4 \times 10^{-3} \text{ N or M} \end{aligned}$$

MF=1

Ques. Calculate the value of pOH for a solution having the (H^+) concentration equal to $7.32 \times 10^{-5} N$

$$\begin{aligned}
 \cancel{pH} &= -\log(7.32 \times 10^{-5}) \\
 pH &= -\log(7.32 \times 10^{-5}) \\
 &= 5 - \log 7.32 \\
 &= 5 - 0.86 \\
 &= 4.14
 \end{aligned}$$

$$\begin{aligned}
 pOH &= 14 - 4.14 \\
 &= \underline{9.86}
 \end{aligned}$$

For weak electrolytes:—

$$\left. \begin{aligned} \alpha &\lll 1 \\ \therefore 1 - \alpha &\approx \end{aligned} \right\} \approx 5\%$$

$$K_a = c\alpha^2$$

$$\alpha = \sqrt{\frac{K_a}{c}}$$

pH of solution:—

$$[H^+] = c\alpha$$

$$[H^+] = c \sqrt{\frac{K_a}{c}}$$

$$[H^+] = \sqrt{K_a \cdot c}$$

$$pH = \frac{1}{2} pK_a - \frac{1}{2} \log c$$

Ques. Calculate the degree of ionisation & pH of 0.1M weak monobasic acid having the value of ionisation constant equal to 4.9×10^{-8}

$$\begin{aligned}
 V.F. &= 1 & \alpha &= \sqrt{\frac{K_a}{C}} \\
 & & &= \sqrt{\frac{4.9 \times 10^{-8}}{0.1}} \\
 & & &= \sqrt{\frac{4.9 \times 10^{-8}}{0.1}} = 7 \times 10^{-4}
 \end{aligned}$$

$$\alpha \% = 7 \times 10^{-4} \times 100 = 7 \times 10^{-2} \%$$

$$\begin{aligned}
 [H^+] &= \sqrt{K_a \cdot C} \Rightarrow \sqrt{4.9 \times 10^{-8} \times 0.1} \\
 &= 7 \times 10^{-5} N
 \end{aligned}$$

$$\begin{aligned}
 pH &= -\log(7 \times 10^{-5}) \\
 &= 5 - \log 7 \\
 &= \underline{4.16}
 \end{aligned}$$

Ques. 4×10^{-4} moles of NH_4OH are present in a 2l solution then determine the pH of solution & degree of ionisation is 1%.

$$[NH_4OH] = C \Rightarrow M \times V.F.$$

$$C = \frac{4 \times 10^{-4}}{2} = 2 \times 10^{-4} N$$

$$\alpha = 1\% = 0.01$$

$$\begin{aligned}
 [OH^-] &= C \alpha \Rightarrow (2 \times 10^{-4}) (0.01) \\
 &= 2 \times 10^{-6} N
 \end{aligned}$$

$$pOH = -\log(2 \times 10^{-6}) \Rightarrow 6 - \log 2$$

$$= 5.7$$

$$pH = 14 - 5.7$$

$$\Rightarrow 8.3$$

ex. Calculate the degree of ionisation and pKa value for 0.1N HCN solution having pH = 3

↳ decinormal

$$[H^+] = 10^{-3} N$$

$$[H^+] = c\alpha$$

$$\alpha = \frac{[H^+]}{c}$$

$$1 = \frac{10^{-3}}{10^{-2}} = 10^{-2}$$

$$\alpha \% = 1$$

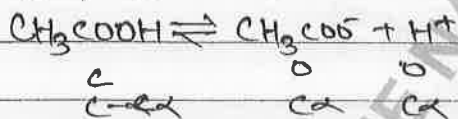
$$pH = \frac{1}{2} pK_a - \frac{1}{2} \log c$$

$$= \frac{1}{2} (pK_a - \log 10^{-1})$$

$$6 = pK_a + 1$$

$$pK_a = 5$$

ex. Calculate the pH of a 2L solution of CH₃COOH if 5.9 mg of acetate ion are present in the solution.



$$[H^+] = [CH_3COO^-] = M \times v \times r$$

$$= \frac{5.9 \times 10^{-3}}{5.9 \times 2}$$

$$= 5 \times 10^{-5} N$$

$$pH = -\log(5 \times 10^{-5})$$

$$= 5 - \log 5$$

$$= 4.3$$

ex. The pH of 10L aqueous solution of NH₄OH ammonium hydroxide is 9.7 then calculate the mass of NH₄⁺ in mg present in the solution.

$$pH = 9.7 \Rightarrow pOH = 0.3$$

$$[OH^-] = 10^{-4.3} \Rightarrow 10^{-5 + 0.7}$$

$$= 10^{-5} \times 10^{0.7}$$

$$[OH^-] = [NH_4^+] = 5 \times 10^{-5} N$$

$$[OH^-] = [NH_4^+] = 5 \times 10^{-5} = \frac{\text{mass of } NH_4^+}{18 \times 10} \times 1$$

$$\therefore \text{mass of } NH_4^+ = 900 \times 10^{-5} g$$

$$= 9 \times 10^{-3}$$

$$\Rightarrow 9 \text{ mg}$$

Ques. Calculate the value of H₂O what must be added to 200 ml of 0.2M acetic acid (CH₃COOH) so that its degree of ionisation is double.

$$\alpha \propto \sqrt{V}$$

$$\frac{\alpha_1}{\alpha_2} = \sqrt{\frac{V_1}{V_2}}$$

$$\frac{2\alpha}{\alpha} = \sqrt{\frac{200}{V_2}}$$

$$\frac{1}{2} = \frac{300}{V_2}$$

$$V_2 = 1200 \text{ ml}$$

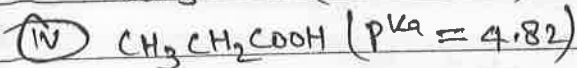
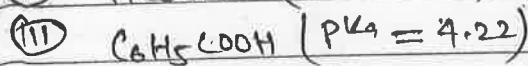
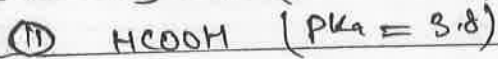
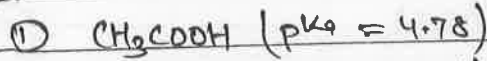
$$\text{Vol} = 1200 - 200$$

$$\text{of H}_2\text{O} = 900 \text{ ml}$$

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Ques. W.O.F. is the strongest acid.

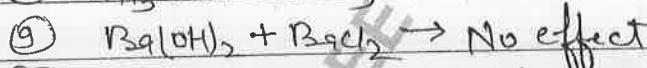
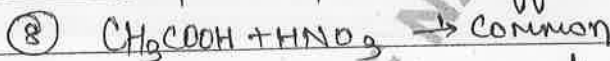
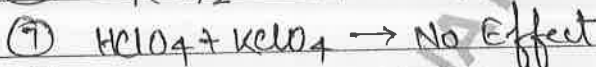
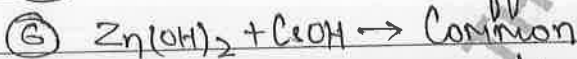
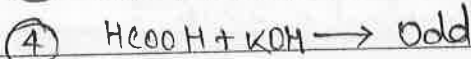
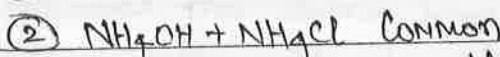
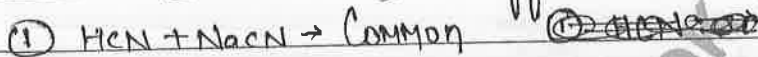


for ~~strong~~ acid strength

$$A.S \propto [H^+] \propto \frac{1}{pH} \propto K_a \propto \frac{1}{pK_a}$$

$$B.S \propto [OH^-] \propto \frac{1}{pOH} \propto pH \propto K_b \propto \frac{1}{pK_b}$$

Ques. In the following combination determine the common ions or odd ion effect.

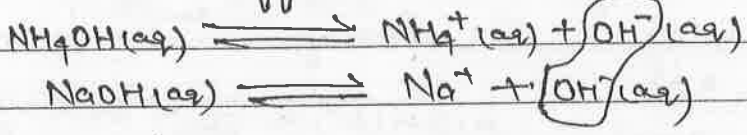


(ii)

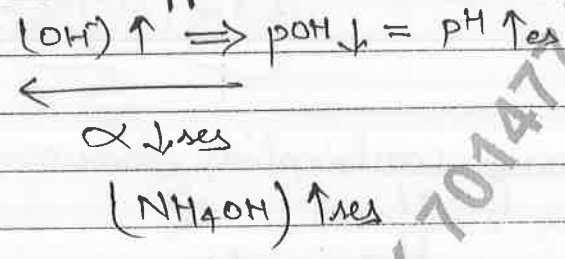
(iii)

(iv)

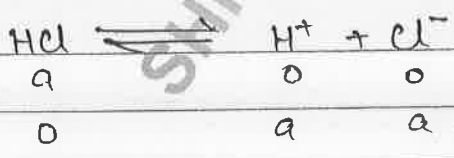
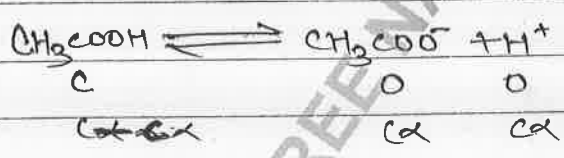
Q. If NaOH is added to a aqueous solution of ammonium hydroxide then what effect will be observed.



Common ions effect

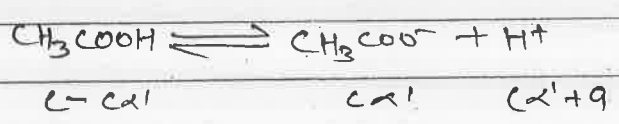


Q. Calculate the Degree of ionisation and acetate ion concentration present in 0.1M acetic acid solution in the presence of 0.1M HCl. (given ionisation constant = 2×10^{-5})



$$\left. \begin{array}{l} (\text{HCl}) = a = 0.1 \text{ M or } N \\ (\text{CH}_3\text{COOH}) = c = 0.1 \text{ M or } N \end{array} \right\} \begin{array}{l} \text{V.F.} \\ = 1 \end{array}$$

Let the New D.O.I. be α'



$$K_a = \frac{(\text{CH}_3\text{COO}^-)(\text{H}^+)}{(\text{CH}_3\text{COOH})}$$

$$K_a = \frac{a\alpha^2}{1-\alpha}$$

If $\alpha \ll 1$
 $1 - \alpha \approx 1$

So,

$$K_a = a\alpha^2 + a\alpha$$

Neglecting higher power of α

$$\therefore K_a = a\alpha$$

$$\alpha = \frac{K_a}{a} = \frac{2 \times 10^{-5}}{0.1} = 2 \times 10^{-4}$$

$$\begin{aligned} [\text{CH}_3\text{COO}^-] &= a\alpha \\ &= (0.1) (2 \times 10^{-4}) \\ &= 2 \times 10^{-5} \text{ Normal} \\ &\quad \text{V.F.} = 1 \end{aligned}$$

Ques If the pOH value of a solution is greater than 7 then the nature of the solⁿ will be.

- (i) Acidic
- (ii) Basic
- (iii) Neutral
- (iv) Any of these

$$\text{pOH} > 7$$

$$\text{pH} < 7$$

Ques If the OH^- ions concentration of solution is greater than 10^{-7} M then the nature of solution will be.

- (i) Acidic
- (ii) Basic
- (iii) Neutral

$$[\text{OH}^-] > 10^{-7} \text{ N}$$

$$\text{pOH} < 7$$

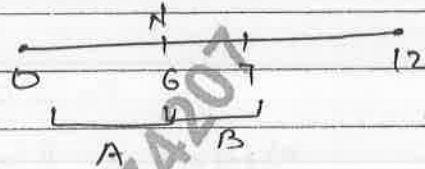
$$\text{pH} > 7$$

Ques. At 90°C if the pOH value for a solution is greater than 5 then the nature of solution will be —

- (I) Acidic
- (II) Basic
- (III) Neutral
- (IV) Any of these

$pOH > 5$

$pH < 7$



Ques At 90°C if the OH⁻ ion concentration is found to be greater than 10⁻⁴ N then the nature of solution will be.

- (I) Acidic
- (II) Basic
- (III) Neutral
- (IV) Any of these

~~pOH~~ $[OH^-] > 10^{-4} N$

$pOH < 4$

$pH > 8$

Ques At 90°C the sum of H⁺ and OH⁻ concentration in water is equal to.

(i) 2×10^{-12}

(ii) 2×10^{-6}

(iii) 10^{-12}

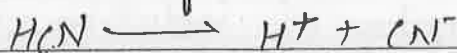
(iv) 10^{-4}

$[H^+] + [OH^-]$

$10^{-6} + 10^{-6} \Rightarrow 2 \times 10^{-6}$

Relation b/w conjugate Acid-Base pair: —

Calculate the ionisation constant of hydrogen cyanide if the pK_b value of CN⁻ ion is 9.7.



Acid

CB

K_a

K_b

$$pK_b(\text{CN}^-) = 9.7$$

$$pK_a(\text{HCN}) = 14 - 9.7$$

$$= 4.3$$

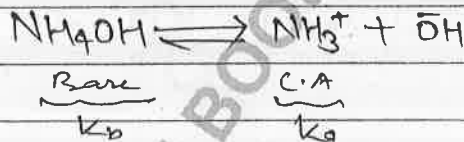
$$K_a = 10^{-pK_a} = 10^{-4.3}$$

$$= 10^{-5 + 0.7}$$

$$= 5 \times 10^{-5}$$

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सामने, जवाहर नगर, कोटा (राज.) मो. 7014774207

Ques The ionisation constant of NH_4OH is 1.8×10^{-5} then determine the pK_a value of NH_4^+ .



$$K_b(\text{NH}_4\text{OH}) = 1.8 \times 10^{-5}$$

$$pK_b = -\log K_b \Rightarrow -\log(1.8 \times 10^{-5})$$

$$= 5 - \log 1.8 = 5 - 0.24$$

$$= \underline{4.76}$$

$$pK_a(\text{NH}_4^+) = 14 - 4.76$$

$$= \underline{9.24}$$

Q The pH of 10^{-2} M formic acid solution is found to be 4 then determine the ionisation constant of formate ions.



$$\text{pH} = \frac{1}{2} pK_a - \frac{1}{2} \log c$$

$$4 = \frac{1}{2} pK_a - \frac{1}{2} \log 10^{-2}$$

$$= \frac{1}{2} (pK_a + 2 \log 10)$$

$$8 = pK_a + 2 \quad pK_a = 6$$

$pK_a + pK_b = 14$ $pK_b = 8$ $(K_b = 10^{-8})$

OR
 $pH = 4 \Rightarrow [H^+] = 10^{-4} N$
 $C = \frac{10^{-2} M \times N}{v.f. = 1}$

$[H^+] = \sqrt{K_a \times C}$

$10^{-4} = \sqrt{K_a \times 10^{-2}}$

$10^{-8} = K_a \times 10^{-2}$

$K_a(HCOOH) = 10^{-6}$

~~K_b~~ $K_b(HCOO^-) = \frac{K_w}{K_a} = \frac{10^{-14}}{10^{-6}} = \frac{10^{-8}}{1}$

Hydrolysis of salt:—

Ques. Which of the following salt which never goes hydrolysis

- (I) $Cu(NO_3)_2$ S A W B
- (II) CH_3COONH_4 W A W B
- (III) $BaSO_4$ = S A S B
- (IV) Na_2CO_3 = W A S B

Ques. W.O.f. salts will undergoes anion hydrolysis.

- (I) K_2SO_4 = S A S B
- (II) $HCOONH_4$ = W A W B Anionic = W A S B
- (III) $(CH_3COO)_2Ba$ = W A S B
- (IV) $NaCl$ = S A S B

Ques. W.O.F. the undergoes maximum hydrolysis.

- (I) 0.001M NH_4Cl
- (II) 0.01M NH_4Cl
- (III) 0.1M NH_4Cl
- (IV) Same

SAWA salt

$$h = \sqrt{\frac{K_h}{c}}$$

$$\uparrow h \propto \frac{1}{\sqrt{c}} \downarrow$$

Ques W.O.F. salts undergoes maximum hydrolysis

- (I) 0.1M NH_4CN
- (II) 0.01M NH_4CN
- (III) 0.001M NH_4CN
- (IV) Same

WASB

h does not depend upon concentration.

Ques W.O.F. is maximum hydrolysis

- (I) NaCl
- (II) NaCN ($K_a = 10^{-4}$)
- (III) CH_3COONa ($K_a = 10^{-3}$)
- (IV) HCOONa ($K_a = 10^{-4}$)

WASB

$$h = \sqrt{\frac{K_w}{K_a \cdot c}}$$

$$\uparrow h \propto \frac{1}{\sqrt{K_a}} \downarrow$$

Ques W.O.F. solution will have the maximum pH?

- (I) NaCl SASB \Rightarrow Neutral \Rightarrow pH \approx 7
- (II) NH_4Cl SAWB \Rightarrow Acidic \Rightarrow pH $<$ 7
- (III) HCOONa WASB \Rightarrow Basic pH $>$ 7
- (IV) KCl SASB \Rightarrow Neutral \Rightarrow pH \approx 7

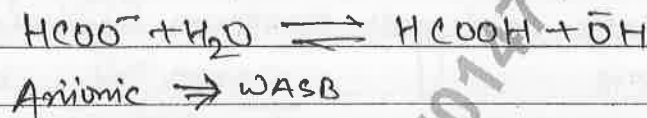
ues. for the rxn $\text{HCOO}^- + \text{H}_2\text{O} \rightleftharpoons \text{HCOOH} + \text{OH}^-$ pick out the correct relation.

~~(I) $K_h = \frac{K_w}{K_a \times K_b}$~~

(II) $K_h = \frac{K_w}{K_b}$

~~(III) $h = \sqrt{\frac{K_h}{c}}$~~

(IV) Both (II) & (III)



ues. Calculate the degree of hydrolysis, hydrolysis constant and pH 10^{-2}M KCN solution if the pK_b value of CN^- is 9.3.

$pK_a = 4.7$
KCN
WASB Salts

$pK_b(\text{CN}^-) = 9.3$

$pK_a(\text{HCN}) = 4.7$

$K_a = 10^{-4.7} = 10^{-5 + 0.3}$

$K_a = 2 \times 10^{-5}$

(1) $K_h = \frac{K_w}{K_a} = \frac{10^{-14}}{2 \times 10^{-5}} = 5 \times 10^{-10}$

$= 10^{-2} \text{M}$ OR N

(for salt \Rightarrow Total +ve or -ve charge)

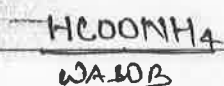
(2) $h = \sqrt{\frac{K_h}{K_a \cdot c}} = \frac{\sqrt{5 \times 10^{-10}}}{10^{-2}} \Rightarrow 2.2 \times 10^{-4}$

(3) $\text{pH} = 7 + \frac{1}{2}(4.7) + \frac{1}{2} \log(10^{-2})$

$= 7 + 2.35 - 1$

$= 8.35$

Ques Calculate pH, K_n & h of $0.00004M$ $HCOONH_4$ solution if the ionisation constant of formic acid & ammonium hydroxide is 10^{-6} & 10^{-5} respectively.



$$K_a(HCOOH) = 10^{-6}$$

$$pK_a = 6$$

$$K_b(NH_4OH) = 10^{-5}$$

$$= 5$$

$$(1) \text{ pH} = 7 + \frac{1}{2} pK_a - \frac{1}{2} pK_b$$

$$= 7 + \frac{1}{2}(6) - \frac{1}{2}(5)$$

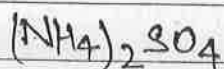
$$= 7.5$$

$$(2) K_n = \frac{K_w}{K_a \cdot K_b} = \frac{10^{-14}}{10^{-6} \times 10^{-5}} = 10^{-3}$$

$$(3) h = \sqrt{K_n} = \sqrt{10^{-3}} = \sqrt{10 \times 10^{-4}}$$

$$= 3.1 \times 10^{-2}$$

Ques Calculate the mass of ammonium sulphate dissolved in solution of pH equal to 6.2 at $25^\circ C$ temp. (given = pK_b of $NH_4OH = 5$)



SAAB salt

~~$$pH = 7 - \frac{1}{2} pK_b$$~~

$$pH = \frac{1}{2} pK_b - \frac{1}{2} \log C$$

$$6.2 = 7 - \frac{1}{2}(5) - \frac{1}{2} \log C$$

$$6.2 = 4.5 - \frac{1}{2} \log C$$

$$1.7 = -\frac{1}{2} \log c$$

$$\log c = -3.4$$

$$c = \text{Antilog}(-3.4) = 10^{-3.4}$$

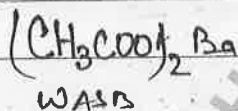
$$c = 10^{-4+0.6} = 4 \times 10^{-4} \text{ N}$$

$$N = M \times v.f.$$

$$4 \times 10^{-4} = \frac{\text{mass of } (\text{NH}_4)_2 \text{SO}_4}{\frac{132 \times 1}{66}}$$

$$\begin{aligned} \text{Mass of } (\text{NH}_4)_2 \text{SO}_4 &= 66 \times 4 \times 10^{-4} \\ &= 264 \times 10^{-4} \\ &= \cancel{264 \times 10^{-4}} \\ &= 26.4 \text{ mg} \end{aligned}$$

Ques Calculate the pH of 2×10^{-4} molar Barium acetate solution if the ionisation constant of acetic acid is 2×10^{-5} .



$$K_a(\text{CH}_3\text{COOH}) = 2 \times 10^{-5}$$

$$K_a = 4.7$$

$$c = M \times v.f.$$

$$= 2 \times 10^{-4} \times 2$$

$$= 4 \times 10^{-4}$$

$$\text{pH} = 7 + \frac{1}{2} \text{p}K_a + \frac{1}{2} \log c$$

$$= 7 + \frac{1}{2}(4.7) + \frac{1}{2} \log(4 \times 10^{-4})$$

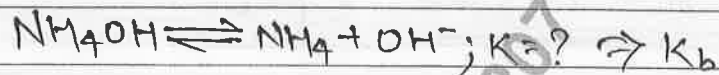
$$= 7 + 2.35 + \frac{1}{2}(\log 4 - 4 \log 10)$$

$$= 7 + 2.35 + \frac{1}{2}(-3.4)$$

$$= 7 + 2.35 - 1.7$$

$$= 7.65$$

Ques Calculate the value of equilibrium constant for the following rxn $\text{NH}_4\text{OH} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$; $K = ?$
 If the value of equilibrium constant for the rxn $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4\text{OH} + \text{H}^+$; $K = 5.5 \times 10^{-10}$.



$$K_h = \frac{K_w}{K_b} \Rightarrow K_b = \frac{K_w}{K_h}$$

$$= \frac{10^{-14}}{5.5 \times 10^{-10}}$$

$$= 1.5 \times 10^{-5}$$

Ques The nature of aqueous solution of KCOO (potassium formate) will be. WASB salt

- (I) Weakly acidic
- (II) Weak Basic
- (III) Strongly Acidic
- (IV) —» — Basic

→ The nature of aqueous salt solution can be weakly acidic or weakly basic except SASB whose solution whose nature is always neutral.

Buffer solution:—

(i) Simple buffer:—

$$\text{pH} = 7 + \frac{1}{2} \text{p}K_a - \frac{1}{2} \text{p}K_b$$

Ex. Calculate the pH of a solution prepared by mixing 10^{-2} M HCN and 10^{-3} M NaCN if the ionisation constant of HCN is 10^{-6} .

Sol:—

$$V_1 F_1 = V_2 F_2$$

$$K_a(\text{HCN}) = 10^{-6}$$

$$\text{p}K_a = 6$$

$$\text{pH} = \text{p}K_a + \log \frac{(\text{Salt})}{(\text{Acid})}$$

$$= 6 + \log \left(\frac{10^{-3}}{10^{-2}} \right)$$

$$= 6 - 1 = 5$$

Ques. Calculate the pH of solution prepared by mixing $2.5 \times 10^{-3} \text{ M}$ (NH_4Cl) with $1.5 \times 10^{-3} \text{ M}$ NaOH. If the $\text{p}K_a$ value of NH_4^+ ion is 9.3.

Sol:

$$\text{p}K_a = 9.3$$

$$\text{p}K_b(\text{NaOH}) = 4.7$$

$$\text{pH} = \text{p}K_b + \log \frac{2.5 \times 10^{-3}}{1.5 \times 10^{-3}}$$

$$= 4.7 + \log \left(\frac{2.5 \times 10^{-2}}{1.5 \times 10^{-2}} \right)$$

$$= 4.7 + \log \frac{5}{3}$$

$$= 4.7 + \log 5 - \log 3$$

$$= 4.92$$

$$\text{pH} = 14 - 9.08$$

$$= 4.92$$

Ques. Calculate the pH of a solution prepared by mixing 400 mL $\frac{N}{20}$ CH_3COOH with 600 mL $\frac{N}{10}$ CH_3COONa . If the ionisation constant of (CH_3COOH) is 2×10^{-5} .

$$[\text{CH}_3\text{COOH}] = \frac{\frac{1}{20} \times 400}{1000}$$

$$= \frac{20}{1000} \text{ N}$$

$$[\text{CH}_3\text{COONa}] = \frac{\frac{1}{10} \times 600}{1000}$$

$$= \frac{60}{1000} \text{ N}$$

$$K_a(\text{CH}_3\text{COOH}) = 2 \times 10^{-5}$$

$$pK_a = 4.7$$

$$\text{pH} = pK_a + \log \frac{(\text{Salt})}{(\text{Acid})} = \frac{N_1 V_1}{V_1 + V_2} = \frac{N_1 V_2}{N_2 V_2}$$

$$= 4.7 + \log \left(\frac{60/1000}{20/1000} \right)$$

$$= 4.7 + \log 3$$

$$= 5.18$$

Ques. Calculate the pH of a solution prepared by mixing 2L of 10^{-3} M NH_4OH with $x \text{ L}$ of 10^{-2} M NH_4Cl is found to be 9.4 then determine x if K_b of NH_4OH is 10^{-6} .

$$\left. \begin{array}{l} 2 \text{ L } 10^{-3} \text{ M } \text{NH}_4\text{OH} \\ x \text{ L } 10^{-2} \text{ M } \text{NH}_4\text{Cl} \end{array} \right\} \text{v.f.} = 1$$

$$\text{pH} = 9.4 \Rightarrow \text{pOH} = 4.6$$

$$K_b = (\text{NH}_4\text{OH}) = 10^{-6} \Rightarrow pK_b = 6$$

$$\text{pOH} = pK_b + \log \frac{(\text{Salt})}{(\text{Base})}$$

$$4.6 = 6 + \log \left(\frac{x \times 10^{-2}}{2 \times 10^{-3}} \right)$$

$$\leftarrow -1.4 = \log(5x)$$

$$5x = \text{Antilog}(-1.4)$$

$$5x = 10^{-1.4} = 10^{-2+0.6}$$

$$5x = 4 \times 10^{-2}$$

$$x = 8 \times 10^{-3} \text{ L}$$

Ques. The pH of a solution prepared by mixing 2×10^{-2} Mole of HCN with 2.5×10^{-3} Mole of $\text{Ba}(\text{CN})_2$ is found to be 3.9 then find the ionisation constant of HCN.



~~Reaction~~

~~Reaction~~

$$\text{pH} = \text{pKa} + \log \left(\frac{\text{Salt}}{\text{Acid}} \right)$$

$$\begin{aligned} (\text{HCN}) \text{ No. of eq} &= \text{mole} \times \text{v.f} \\ &= 2 \times 10^{-2} \times 1 \\ &= 2 \times 10^{-2} \text{ eq} \end{aligned}$$

$$= \text{cat} + \log 2$$

$$\begin{aligned} \text{No. of eq. } (\text{Ba}(\text{CN})_2) &= 2.5 \times 10^{-3} \times 2 \\ &= 5 \times 10^{-3} \end{aligned}$$

$$\text{pH} = \text{pKa} + \log \left(\frac{\text{Salt}}{\text{Acid}} \right)$$

$$3.9 = \text{pKa} + \log \frac{5 \times 10^{-3}}{2 \times 10^{-2}}$$

$$3.9 = \text{pKa} + \log \left(\frac{1}{4} \right)$$

$$3.9 = \text{pKa} - 0.6$$

$$\text{pKa} = 4.5$$

$$K_a = 10^{-\text{pKa}} = 10^{-4.5}$$

$$K_a = 10^{-5+0.5}$$

$$K_a = 3.2 \times 10^{-5}$$