Units and Dimenson

Base Unit :⇒

Basic quantity के लिए जिस unit का प्रयोग किया जाता है उन्हे Basic unit कहते है।

Ex :- Length , Mass , time , temperature.

Deriviect Unit :⇒

जो unit Basic unit की सहायता से बनायी जाती है उन्हे Derivied unit कहते है।

Ex :- $Meter^2$, Meter/second , Newton/m^2 .

Multyple Units :⇒

Hour , Minuts , Second ,e.t.c.

Unit System

Units	Unit System				
	S.I	M.K.S.A	C.G.S	F.P.S	Symbal
Length	Meter (M)	Meter (M)	Centimeter (C.M)	Foot (Ft)	L
Mass	Kilogram (kg)	Kilogram (kg)	Gram (gm)	Pound (lb)	M
Time.	Second (S)	Second (S)	Second (S)	Second (S)	T
Temperature	Kelvin (°K)	Calsius (°C)	Celsius (°C)	Farenhite (°F)	θ

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Length System

1 Km = 1000 m

1 Kg = 1000 gm

1 inch = 1" = 2.54 c.m

1 Foot = 12" = 30.48 c.m = 0.3048 m

1 lb = 453.6 gm

1 Cal = 4.18 joule.

1 atm = 760 mm Hg

1 atm = 101.325 K pascal Hg

1 BTU = 252 Calori

1 CHU = 0.4536 Kg Calori

Q1 kgf → N

$g = 9.807 m/sec^2$

Q2. lbf → N

$g = 32.17 lb$

1 horse power = 746 W

For Converting temperature from one scale to other scale. :—

100°C	212°F	80°R	373°K
0°C	32°F	0°R	273

$$\boxed{\frac{°C}{100} = \frac{°R}{80} = \frac{°F-32}{180} = \frac{°K-273}{100}}$$

$$\boxed{1°C = 1.8°F = 0.8°R}$$

°R = 70, °C = 80, & °F = 120 into change °C, °R, °F.

we know that :—

$$\boxed{\frac{°C}{100} = \frac{°F-32}{180} = \frac{°R}{80}}$$

when, °R = 70

$$\frac{C}{100} = \frac{70}{80} \qquad \frac{F-32}{180} = \frac{70}{80}$$

$$\boxed{°C = 87.5} \qquad \boxed{F = 189.5}$$

when °C = 80

$$\frac{180}{100} = \frac{R}{80} \qquad \frac{80}{100} = \frac{F-32}{180}$$

[illegible] [illegible]

① $2ft \longrightarrow m$

$1 foot = 30.48 cm$
$= 0.3048 m$

$2 \times 0.3048 = 0.6096 m$ Ans

② $1 m/s \longrightarrow ft/hour$

$1 m = 100 cm$ $\quad$ $1 hour = 3600 sec$

$1 foot = 30.48 cm$ $\quad$ $1 sec = \frac{1}{3600} hour$ — (ii)
$= 0.3048 m$

$1 m = \frac{1}{0.3048} ft$ — (i)

eqn (i) & (ii)

$= \frac{1/0.3048 \ ft}{1/3600 \ hour}$

$= 11811.02 \ ft/hour$ Ans

③ $\frac{lb}{ft-s} \longrightarrow \frac{kg}{m-s}$

$1 lb = 453.6 gm = 0.4536 kg$
$1 ft = 30.48 cm = 0.3048 m$

$= \frac{0.4536 \ kg}{0.3048 \ m\text{-}s}$

$= 1.488 \frac{kg}{m-s}$ Ans

④ $lb/ft^3 \longrightarrow kg/m^3$

$1 lb = 0.4536 kg$
$1 ft^3 = (0.3048)^3 m^3$
$= 0.0283 m^3$

$lb/ft^3 = \frac{0.4536 \ kg}{0.0283 \ m^3}$

$= 16.02 \ kg/m^3$ Ans

⑤ $\frac{lb}{hr} \longrightarrow \frac{kg}{sec}$

$1 lb = 0.4536 kg$
$1 hr = 3600 sec$

$\frac{lb}{hr} = \frac{0.4536 \ kg}{3600 \ sec}$

$= 1.26 \times 10^{-4} \frac{kg}{sec}$ Ans

⑥ $\frac{ft}{hr} \longrightarrow \frac{m}{sec}$

$1 ft = 0.3048 m$
$1 hr = 3600 sec$

$\frac{ft}{hr} = \frac{0.3048 \ m}{3600 \ sec}$

$= 8.466 \times 10^{-5} \ m/sec$

$127\ lb/ft^3 \longrightarrow g/cm^3$

$1\ lb = 453.6\ g$

$1\ ft = (30.48)^3\ cm^3$

$= 28316.84\ cm^3$

$127\ lb/ft^3$

$= \frac{127 \times 453.6\ g}{28316.84\ cm^3}$

$= 2.034\ g/cm^3$ Ans

1 Kg force :⇒ 1 Kg mass के पिण्ड को पृथ्वी 9.807 m/sec² के त्वरण से अपनी ओर खिंचती है इसे 1 kg force कहते हैं।

⑧ $1\ Kgf \longrightarrow lbf/sec^2$

$1 \times Kg \times 9.807\ m/s^2$

$Kg \times 9.807 \times \frac{1}{0.3048}\ ft/sec^2$

$\frac{1}{0.4536} \times \frac{9.807}{0.3048}\ foot\ lb/sec^2$

$= 70.933\ lbf/sec^2$ Ans

$1\ kg = 1000\ g$

$1\ lb = 453.6\ g$

$1\ foot = 0.3048\ m$

$1\ m = \frac{1}{0.3048}\ ft$

$1\ lb = 453.6 \times \frac{1}{1000}\ kg$

$1\ lb = 0.4536\ kg$

$1\ kg = \frac{1}{0.4536}\ lb$

⑨ $1\ Kgf \longrightarrow N$

$1\ kg \times 9.807\ m/s^2$

$= 9.807\ \frac{kg\,m}{sec^2}$

$= 9.807\ N$ Ans

⑩ $1\ lbf \longrightarrow N \longrightarrow \frac{kg\,m}{sec^2}$

$= 1\ lb \times 32.17\ ft/sec^2$

⑪ $1\ N \longrightarrow lbf$

$1\ N = \frac{kg\,m}{sec^2}$

$1\ lb = 453.6\ gm$

$1\ gm = \frac{1}{453.6}\ lb$ —(i) $1\ Kg = \frac{1}{0.4536}\ lb$

$1\ ft = 0.3048\ m$

$1\ m = \frac{1}{0.3048}\ ft$

$lbf = \frac{1}{0.4536} \times \frac{1}{0.3048}\ lbf = \frac{1}{0.4536} \times \frac{1}{0.3048}\ lbf$

$= 7.233\ lbf$ Ans

Calori :⇒ 1 gram के water का 1°C temperature बढ़ाने के लिए आवश्यक Heat energy की मात्रा calori कहलाती है।

1 Calori = 4.18 joule

1 kg calori = 4.180 joule.

Energy :⇒ कार्य करने की क्षमता को ऊर्जा कहते हैं।

$W = F \cdot d$

$W = N \cdot M$

$= 10^5 \, dyne \times 10^2 \, cm$

$= 10^7 \, dyne \cdot cm$

$\boxed{W = 10^7 \, erg}$ $[1N = 10^5 \, dyne]$

British Thermal Unit (B.T.U) :⇒ 1 pound water का ताप 1°F बढ़ाने के लिए जितनी ऊर्जा की आवश्यकता होती है B.T.U कहलाती है।

$1 \, B.T.U = 252 \, Calori$

$1 \, BTU = 252 \times 10^{-3} \, Kg \, Cal$

Centrigrate Heat Unit (CHU) :⇒ 1 pound water का tempr. 1°C बढ़ाने पर जो energy निकलती है CHU कहलाता है।

$1 \, CHU = 1 \, lb \times 1°C$

$= 0.4536 \, Kg \, Calori$

Pressure :⇒ $P = \frac{F}{A} = N/m^2 = Pascal \, (Pa)$

- 1 ATM = 760 mm Hg
- 1 Atm = 76 cm Hg
- 1 Atm = 0.76 m Hg
- 1 Atm = 101325 pascal (Pa) Hg
- 1 Atm = 101.325 kpa. Hg.
- 1 Atm = 0.101325 M Pa
- 1 Atm = 29.92" Hg in inch
- 1 Atm = 34 ft Hg , in ft.
- 1 Atm = 10.36 M of H_2O
- 1 Atm = 1.033 Hg force/cm^2
- 1 Atm = 14.7 lbf/$inch^2$
- 1 Atm = 760 torr

Ques:- 1450 MMHg को kpa में convert करो।

we know that - 1 Atm = 760 mmHg.

1 Atm = 101.325 kpa

760 mm Hg = 101.325 kpa.

$1 \, mm \, Hg = \frac{101.325}{760} \, kpa$

$1450 \, mmHg = 1450 \times \frac{101.325}{760} \, kpa$

$\boxed{1450 \, mmHg = 193.3 \, kp}$

Chapter - 2

Basic Chemical Calculations

Atomic Weight :⇒ कार्बन के एक Atom जिसका Atomic weight 12 होता है किसी Atom का Atomic weight कार्बन (C) के $\frac{1}{12}$ भाग से कितना गुना है वही उस Atom का Atomic weight कहलाता है।

यादि.

$$3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2\uparrow$$
$$3\times56 + 4(16+2) \longrightarrow 56\times3+16\times4+4\times2$$
$$168 + 72 \longrightarrow 168 + 64 + 8$$
$$248 \longrightarrow 248$$

Element Name	Symble	Atomic Number	Atomic weight
Hydrogen	H	1	1.008
Helium	He	2	4
Lithium	Li	3	7
Berelium	Be	4	9
Boran	B	5	10.8
Carbon	C	6	12
Nitrogn	N	7	14
Oxigen	O	8	16
Florin	F	9	19

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Sodium	Na	11	23
Magnesium	Mg	12	24.3
Aluminium	Al	13	27
Silicon	Si	14	28
Phosphorous	P	15	31
Sulpher	S	16	32
chlorin	Cl	17	35.5
Argon	Ar	18	4.0
Potassium.	K	19	39.1
Calcium	Ca	20	40.08
Scandium	Sc	21	45
Titanium	Ti	22	47.9
Vanadium	V	23	50.5
chromium.	Cr	24	52
Manganese	Mn	25	55
Iron (Feric)	Fe	26	56
Cobalt	Co	27	59
Nickel	Ni	28	60
Cupper	Cu	29	63.54
	Zn	30	66

2, 8, 8, 1

Arsenic	As	33	75
Bromin	Br	35	80
Silver	Ag	47	108.87
Tin	Sn	50	119
Iodine	I	53	127
Barium	Ba	56	137.34
Gold	Au	79	197
Mercury	Mg	80	200.58 = 201
Led	Pb	82	207.19
Urenium.	U	92	238

Atom (परमाणु) :⇒ Element का वह छोटा-छोटा कण है, जो किसी भी रासायनिक अभिक्रिया मे भाग ले सकता है परन्तु स्वतन्त्र अवस्था मे नही रह सकता है।

Molecule (अणु) :⇒ Element तथा compound का वह छोटा-छोटा कण है जो स्वतन्त्र अवस्था मे रह सकता है अणु कहलाता है।

Molecular weight :⇒ किसी पदार्थ का अणु भार वह संख्या है जो यह प्रदर्शित करती है कि उस पदार्थ का एक Molecule कार्बन -12 के एक Atom के 1/12 भाग से कितना गुना भारी है।

Gram Atom :⇒

1 gram atom of any element = Atomic weight of Element

The amount of any element substion which is numerically equal to its atomic weight in gram.

अर्थात, किसी element का 1 gram atom उस element के Atomic weight के बराबर है, जो gram में है।

$$168 g\ Fe = 3 g\ atom$$

$$1 g\ atom = \frac{168}{3} g\ Fe$$

$$1 g\ atom = 56 g\ Fe$$

$$\boxed{\text{gram atom of an element} = \frac{\text{The weight in gram}}{\text{atomic weight.}}}$$

$$\boxed{\text{weight in Gram} = \text{Gram atom} \times \text{atomic weight}}$$

$$\boxed{\text{Kg atom of element} = \frac{\text{The weight in kg}}{\text{Atomic weight.}}}$$

Note :⇒

☆- weight, mass or amount which is numerically eq
☆ to the moleculers weight of substance.

☆. Mass = weight

☆. gmole = mole = mol

☆- mole ≠ moliculers.

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Gram Mole :⇒

किसी ~~Moleculer weight~~ का gmole उसके moleculer weight के बराबर होता है अथवा moleculer weight gram मे हो।

$$\boxed{\text{Gram moles of compound} = \frac{\text{weight of substance in gram}}{\text{Moleculer weight.}}}$$

$$\boxed{\text{Kilogram mole of compound} = \frac{\text{weight in kilogram}}{\text{Moleculer weight.}}}$$

$$\boxed{\text{lb - Mole} = \frac{\text{weight of substance in lb}}{\text{Moleculer weight.}}}$$

9

Ques :⇒ Calculate the Kilogram atoms of carbon which weight 36 kg.

Solve

36 kg of Carbon.

Atomic weight of carbon = 12

$$\text{Kg atom of Carbon} = \frac{\text{weight in kg of carbon}}{\text{Atomic weight of carbon.}}$$

$$= \frac{36}{12}$$

or- $\boxed{\text{Kg atom of Carbon} = 3}$ Ans

Question :⇒ Calculate the kilogram of Na of which the amount is specified as 3 katom.

Solve

Atomic weight of Na = 23

kg atom of Na = 3 katm.

$$\text{Kg atoms of Na} = \frac{\text{weight in kg of Na}}{\text{Atomic weight of Na}}$$

$$3 = \frac{\text{wt in kg of Na}}{23}$$

or- $\boxed{\text{wt. in kg of Na} = 69}$ Ans

Question :⇒ How many Kilograms of Ethane are there in 210 kmol.

$C_2H_6 \rightarrow M.W = 30$

$$\text{Kmol. of Ethane} = \frac{\text{weight in kgram}}{\text{Moleculer weight}}$$

210

Kilogram of Ethane = Kmole × Moleculer weight.

$= 210 \times 30$

$= 6300$ Ans

Question :⇒ Convert 88kg of carbon dioxide into its amount in malar units.

Salve —

$$\text{Kg Malar units} = \frac{\text{weight of substance in kg}}{\text{Moleculer weight}}$$

weight of CO_2 = 88kg.

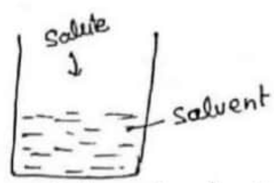
or Moleculer weight of $CO_2 = 12 + 16 \times 2 = 44$

or Kg Malar units $= \frac{88}{44}$

$= 2$

or • 88kg of CO_2 = 2kmal CO_2. Ans

Salute + salvent = salution



Salute + salvent = solution

Ques :⇒ Find the mole of oxygen present in 500 grams.

Salve 500g of Oxygen.

Molecular weight of $O_2 = 2 \times 16 = 32$

Moles of $O_2 = \frac{500}{32} = 15.625$ mol. Ans

IT

Ques :⇒ Find moles of K_2CO_3 that will contain 117 kg of K.

Salve.

117 kg of K.

Atomic weight of K = 39

Atoms of K $= \frac{117}{39} = 3$ katm

Each mole of K_2CO_3 contains 2 atm of K.

2 atm of K = 1 mole of K_2SO_3

2 atom of K = 1 Kmole of K_2SO_3

Moles of $K_2CO_3 = \frac{1}{2} \times 3 = 1.5$ kmol.

Valency :⇒ किसी element के बाहरी कोश मे उपस्थित electrons की संख्या को उस element का valency कहलाता है अर्थात element को compound बनाने या अष्टक पूरा करने के लिए आवश्यक electrons की संख्या उस element का valency कहलाता है।

Exp :→

$_{11}Na = 1s^2\ 2s^2\ 2p^6\ 3s^1$

इसके बाहरी कोश मे $1e^-$ है अतः इसकी valency 1 होगी।

$_8O = 1s^2\ 2s^2\ 2p^4$

इसको अष्टक या compound बनाने के लिए $2e^-$ की आवश्यकता होती है अतः इसकी valency 2 होगी।

Valence :⇒ किसी chemical compound की वह Properties जिससे कि वह कितना $OH^{\ominus}$ donated (निकालना) या $H^{\oplus}$ accepted करता है वह valence कहलाता है।

Exp:-

HCl की valence = 1

$H_2SO_4 \longrightarrow 2H^+ + SO_4^- \quad = 2$

$KMnO_4 + H_2O \longrightarrow KOH + Mn(OH)_2$

$H_2O \longrightarrow H^+ + OH^-$

$H_2O \longrightarrow 2H^+ + O^{--}$

$2H^{\oplus} = O^{--}$

$2H^{\oplus} = 1OH^{-}$

$8H^{\oplus} = 8(OH)$

$KMnO_4 \rightarrow KMn(OH)_8 \rightarrow KOH + Mn(OH)_2 + 5OH^-$

∵ इसमें $5OH^-$ बचा है अतः इसकी valence

$$\boxed{\text{Equivalent weight} = \frac{\text{Molecular weight}}{\text{Valence}}}$$

Calculate the equivalent weight of the following -

(i) NaOH (ii) $CaCl_2$ (iii) $KMnO_4$ (iv) $FeCl_2$ (v) H_3PO_4
(vi) HCl (vii) Na_2CO_3 (viii) $Al(SO_4)_3$

Solve

(i) NaOH → Molecular weight of NaOH = 23+16+1
= 40

Valence of NaOH = 1

Equivalent weight = $\frac{40}{1}$ = 40 Ans

(ii) $CaCl_2$ ⟶ Molecular weight = 1×40+2×35.5
= 111

Valence = 2

Equivalent weight = $\frac{111}{2}$ = 55.5 Ans

(iii) $KMnO_4$ ⟶

Molecular weight = 39+55+4×16
= 158

Valence = 5

Equivalent weight = $\frac{158}{5}$ = 31.6 Ans

(iv) $FeCl_2$ ⟶

Molecular weight = 56 + (35.5)×2
= 127

Valence = 2

(v). H_3PO_4 $\longrightarrow$

Molecular weight $= 3\times1 + 31 + 4\times16$
$= 98$

Valence $= 3$

Equivalent weight $= \frac{98}{3} = 32.667$ Ans

(vi). HCl $\longrightarrow$

Molecular weight $= 1 + 35.5$
$= 36.5$

Valence $= 1$

Equivalent weight $= \frac{36.5}{1} = 36.5$ Ans

(vii) $\rightarrow$ Na_2CO_3 $\longrightarrow$

Molecular weight $= 2\times23 + 12 + 16\times3$
$= 106$

Valence $= 2$

equivalent weight $= \frac{106}{2} = 53$ Ans

(viii). $Al_2(SO_4)_3$ $\longrightarrow$

Molecular weight $= 2\times27 + (3\times32) + (4\times16)\times3$
$= 342$

Valence $= 6$

equivalent weight $= \frac{342}{6}$
$= 57$ Ans

Normality :⇒ [N] नॉर्मलता

It is defined as the number of gram equivalents of solute dissolved in one litre of solution.

It is represent by "N".

किसी 1 liter solution में solute (विलेय) का जितना 1 gram equivalent घोलने पर उसकी Normality 1 (one) होती है। Normality solution की concentration (सान्द्रता) की मात्रा को बताती है अर्थात उसमे कितनी solute (विलेय) की मात्रा घुली (dissolved) है।

$$\boxed{\text{Normality} = \frac{\text{Gram-equivalents of solute}}{\text{Volume of solution in litre}}}$$

$$\boxed{\text{Normality} = \frac{\text{weight of solute in gram}}{\text{equivalents of solute} \times \text{Volume of solution in liter}}}$$

या. $N = \frac{W}{E \cdot V}$

या. $N = \frac{\text{विलयन की सान्द्रता } (g/l)}{\text{तुल्यांकी भार}} = \frac{1000 \times W}{E \cdot V}$

या. $\boxed{N = \frac{1000\, W}{E \cdot V}}$ where →

N = Normality.
W = weight of solute in gram
E = Equivalent wt.
V = Volume of solution in litre

13

Molarity [M] (मोलरता) :⟹

It is defined as the number of gram moles of solute dissolved in one litre of solution.

It is represent by the symble. 'M'

Solution के One litre पर 1000 ml मे Solute की जितनी Mole dissolved (घुली) होती है उसे उस solution का मोल/लीटर मे सान्द्रता या Molarity कहते है।

$$\boxed{\text{Molarity} = \frac{\text{Gram-moles of Solute}}{\text{Volume of solution in litre}}}$$

$$\text{मोलरता (M)} = \frac{\text{विलेय के मोलों की संख्या}}{\text{विलयन का आयतन (लीटर मे)}} \quad \text{mole/lit.}$$

$$\boxed{\text{Mole} = \frac{\text{weight in Gram}}{\text{Moleculer weight}} = \frac{\text{भार (ग्राम मे)}}{\text{अणुभार}}}$$

$$\boxed{\chi_m = \frac{1000 \times W}{V \times M}} \qquad \because C = \frac{W}{\text{leter}} = \frac{g}{l}$$

$$\boxed{\chi_m = \frac{C}{M}}$$

where -

χ_m = Solution की Molarity.

W = Solute का weight in gram.

M = Moleculer weight of substance.

V = Volume of Solution in ml.

C = सान्द्रता (g/leter)

Molality (मोललता) :⟹ [m]

It is defined as the number of gram-moles (mol) of solutes dissolved in one Kilogram of solvent.

विलायक (Solvent) के one Kilogram या 1000 g मे solute का जितना mole घुला हो उसे उस solution की molality कहते है।

$$\boxed{\text{Molality} = \frac{\text{gram-mole of Solute}}{\text{Mass of solvent in kg.}}}$$

$$\text{मोललता} = \frac{\text{विलेय के मोलों की संख्या}}{\text{विलायक का भार (ग्राम मे)}}$$

$$\boxed{\text{Concentration (g/L)} = \text{Normality} \times \text{Equivalent weight}}$$

$$\text{सान्द्रता (g/L)} = \text{नर्मलता} \times \text{तुल्यांकी भार}$$

Question :⟹ 98 grams of sulphuric acid (H_2SO_4) are dissolved in water to prepare one litre of solution. find normality and molarity of solution.

$$\left[\text{Normality} = \frac{\text{gram equivalent weight of } H_2SO_4}{\text{Volume of solution in liter.}}\right]$$

~~given that~~ -

$$H_2SO_4 \rightarrow \left[\text{equivalent weight} = \frac{\text{Moleculer weight}}{\text{Valence}}\right] = \frac{98}{2} = 49$$

$$H_2SO_4 \rightarrow \text{Moleculer weight} = 2 \times 1 + 32 + 4 \times 8 = 98$$

$$\text{Valence} = 2.$$

$$\text{Gram-equivalent of } H_2SO_4 = \frac{\text{wt in gram}}{\text{Equivalent weight}}$$

14

$$= \frac{98}{49}$$

$$= 2$$

$$\text{Normality} = \frac{2}{1} = 2$$

$\boxed{\text{Normality} = 2}$ Ans

$$\left[\text{Malarity (M)} = \frac{\text{Gram-Mole of } H_2SO_4}{\text{Valume of solution in l.}}\right]$$

or $\quad$ $$\text{g. Mole} = \frac{\text{wt in Gram}}{\text{Moleculer weight}} = \frac{98}{98} = 1$$

or $\quad$ $$\text{Molarity} = \frac{1}{1} = 1$$

$\boxed{\text{Molarity} = 1}$ Ans

Question :⇒ Find gram of HCl needed (आवश्यक) to prepare 1 litre 2N HCl solution.

Solve $\quad$ 1 litre 2N HCl solution.

$$\text{Normality} = \frac{\text{g. eq of HCl.}}{\text{Valume of solution in l.}}$$

$$\text{g. e.q of HCl} = \frac{\text{wt in gram}}{\text{Equivalent weight.}} \quad -(1)$$

$$\text{Equivalent weight} = \frac{\text{Moleculer weight}}{\text{Valence.}} = \frac{36.5}{1}$$

$$= 36.5.$$

$HCl \rightarrow$ Moleculer weight $= 1 + 35.5$

$= 36.5$

Valence $= 1$

or → $$\text{Normality} = \frac{\text{g. eq. of HCl}}{\text{Volume of Solution in l.}}$$

or → $$2N = \frac{\text{g. e.q of HCl}}{1}$$

or. $\quad$ g. e.q. of HCl $= 2$.

समी० (1) से-

weight in gram (HCl) $= 2 \times 36.5$

$= 73.$

$\boxed{\text{weight in gram (HCl)} = 73}$ Ans

Question 8 ⇒ The concentration of an aqueous solution of acetic acid is specified as 30% on weight basis.

- Find the molality of the solution.

Solve:-

$$\text{Malality (m)} = \frac{\text{g-mole of solute}}{\text{mass of solvent in kg.}}$$

माना कि , Solution = 100kg.

30% of CH_3COOH अर्थात $= 30\,kg = 30 \times 10^{+3}$ g. solute

∴ तो solvent of solution = 70kg

moleculer weight of $CH_3COOH = 60$

$$\text{Mole of } CH_3COOH = \frac{\text{wt in g}}{\text{Moleculer weight}} = \frac{30 \times 10^3}{60}$$

Or → Molality (m) = $\frac{\text{g.mole of acetic acid}}{\text{Kg of Solvent}}$

Or $m = \frac{500}{70}$

Or $\boxed{m = 7.142}$ Ans

imp

Ques :⇒ H_2SO_4 Solution has a molarity of 11.24 and molality of 94. Calculate the density of solution.

Solve

1 litre of solution.

Molarity = 11.24

Molality = 94

Molecular wt = $2\times1+32+2\times16$
$= 2+32+32\times2$
$= 2+32+34$
$= 98$

Or → Molarity = $\frac{\text{gram moles of } H_2SO_4}{\text{Volume of solution in } l.}$

Or → $11.24 = \frac{\text{gram moles of } H_2SO_4}{1}$

Or → gram moles of H_2SO_4 = 11.24 mol

Or → wt in gram of H_2SO_4 = g mole × Molecular weight.
= 11.24 × 98
= 1.101 kg.

Or → Molality = $\frac{\text{gram-mole of Solute}}{\text{Mass of solvent in kg.}}$

Or → Molality = $\frac{11.24}{\text{Mass of solvent in kg.}}$

Or → $94 = \frac{11.24}{\text{mass of Solvent in kg.}}$

Mass of solvent in kg = $\frac{11.24}{94}$ = 0.1195 kg.

Total Amount of solution = Solvent + Solut.
= 0.1195 + 1.101
= 1.2205 kg.

Density of H_2SO_4 Solution = $\frac{1.2205}{1}$ = 1.2205 kg/L

Ans

imp

Exp. → 2 Litres of NH_3 at 303 K (30°c) and 20.265 kPa is neutralised by 135 ml of solution of H_2SO_4. Find the normality of the acid.

Solve

2 Litres of NH_3

$PV = nRT$

∴ n = Mole of NH_3 = $\frac{PV}{RT}$

where, $P = 20.265$ kpa, $V = 2l$, $R = 8.31451\ m^3.\text{kpa}/(\text{kmol}\,k)$
$T = 303$ K

Mole of NH_3 = $\frac{20.265\times2}{8.31451\times303}$ = 0.01609 mol.

$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$

For neutralization of 2 moles of NH_3, 1 mole of H_2SO_4 is:

Mole of H_2SO_4 required = $\frac{1}{2}\times0.01609$
= 8.045×10^{-3} mol.

Amount of H_2SO_4 required = $8.045\times10^{-3}\times98 = 0.788$

Gram-equivalent of H_2SO_4 required = $\frac{0.788}{49}$ = 0.0

Volume of H_2SO_4 solution = 135 ml = 0.135 l.

Normality of the acid = $\frac{0.01609}{0.135}$ = 0.12 N

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Ex ⇒ Do the following conversions :

(a) → 294 g/l H_2SO_4 to normality.

$$\text{Normality} = \frac{\text{gram equivelent of } H_2SO_4}{\text{volume of solution in leter}}$$

$$\text{g. Equivelent of } H_2SO_4 = \frac{\text{wt in gram of } H_2SO_4}{\text{Equvelent wt of } H_2SO_4}$$

$$= \frac{294}{49} = 6$$

$$\text{Equivalent wt} = \frac{\text{Moleculer wt}}{\text{Valence}}$$

$$= \frac{98}{2} = 49$$

or. $N = \frac{6}{1} = 6N$

or. $\boxed{N = 6N}$ Ans

(b). 5N H_3PO_4 to g/l.

Moleculer weight H_3PO_4 = 98

Valence of H_3PO_4 = 3

$$\text{Equivalent weight} = \frac{98}{3} = 32.67$$

$$N = \frac{\text{विलयन की सान्द्रता } (g/l)}{\text{तुल्यांकी भार}} =$$

$$\text{विलयन की सान्द्रता} = \text{Equivalent wt} \times N$$

$$= 32.67 \times 5$$

$$= 163.35 \text{ g/l}$$

(c). $54.75\ g/l$ HCl to Molarity.

Solve

$$\text{Molarity} = \frac{\text{Gram-Mole of solute}}{\text{volume of solution in l}}$$

$$\text{Mole of HCl} = \frac{\text{wt in gram}}{\text{Molecular wt.}} = \frac{54.75}{36.5}$$

or Mole of HCl $= 1.5$ mol.

or $M = \frac{1.5}{1}$

or. $\boxed{M = 1.5\ M}$ Ans

(d). $3M\ K_2SO_4$ to g/l :

Solve $1l$ of Solution.

Moleculer wt $= 174$

wt in gram = Mole × M.wt.

$= 3 \times 174$

$= 522 g$.

विलयन की सान्द्रता (g/l) = Molarity × Moleculer wt.

$= 3 \times 174$

$= 522\ g/l$. Ans

या

$$\text{विलयन की सान्द्रता} = \frac{\text{विलेय का भार (gram में)}}{\text{volume of Solution in litre}}$$

$= \frac{522}{1}$

(e) $4.8\ mg/ml\ CaCl_2$ to normality.

Basis. $1l$ of Solution.

$4.8\ mg/ml\ CaCl_2 = 4.8\ g/l\ CaCl_2$

$CaCl_2$ in Solution $= 4.8\ g/l$.

Molecular weight of $CaCl_2 = 111$

equivalent weight of $CaCl_2 = \frac{111}{2} = 55.5$

$$\text{Normality} = \frac{\text{gram equivalent of } CaCl_2}{\text{Volume of Solution in l.}}$$

$$\text{gram equivalent of } CaCl_2 = \frac{\text{weight in gram}}{\text{equivalent wt}} = \frac{4.8}{55.5}$$

$= 0.0864$

$$\text{Normality} = \frac{0.0864}{1}$$

$= 0.0864 N$ Ans

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Weight percent :⇒

It is the weight of any component expressed as a percentage of the total weight of the system

$$\boxed{\text{weight \% of } A = \frac{\text{weight of } A}{\text{Total weight of system}} \times 100}$$

$$\boxed{\text{weight \% of } A = \frac{W_A}{W} \times 100}$$

where, W_A = wt of the component A

$W = W_A + W_B + \ldots$

Volume Percent :⇒

It is the pure component volume of any component expressed as a percentage of the total volume of the system.

$$\boxed{\text{Volume \% of } A = \frac{\text{Pure component volume of } A}{\text{Total Volume of System.}} \times 100}$$

$$\boxed{\text{Volume \% of } A = \frac{V_A}{V} \times 100}$$

where, V_A = Volume of the component.

$V = V_A + V_B + \ldots$

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Mole percent :⇒ It is the moles of any componet expressed as a percentage of the total mole of the system ⇒

$$\boxed{\text{Mole \% of } A = \frac{\text{Moles of } A}{\text{Total moles of system}} \times 100}$$

$$\boxed{\text{Mole \% of } A = \frac{\frac{W_A}{M_A}}{\frac{W_A}{M_A} + \frac{W_B}{M_B} + \frac{W_C}{M_C} + \frac{W_D}{M_D}} \times 100}$$

where.

W_A = wt of Component A
W_B = " " " B
W_C = " " " C
W_D = " " " D

M_A = Moleculer weight of componet A
M_B = " " " " B
M_C = " " " " C
M_D = " " " " D

Mol % = 100

Weight Fraction :⇒ It is the ratio of the wt of a particular component to the total wt of a system.

$$\boxed{\text{weight fraction of } A = \frac{\text{weight of } A}{\text{Total weight of system}}}$$

$$\boxed{x_A = \frac{W_A}{W_A + W_B + W_C}}$$

$$\boxed{\text{weight \% of } A = \text{weight fraction of } A \times 100}$$

where, x_A = weight fraction of A.

2011,10

Mole Fraction :⇒ It is the ratio of the number of moles of a particular component to the total moles of a system.

$$\boxed{\text{Mole fraction of } A = \frac{\text{Moles of } A}{\text{Total moles of system}}}$$

$$x_A = \frac{W_A/M_A}{W_A/M_A + W_B/M_B}$$

$$\boxed{\text{Mole \% of } A = \text{Mole fraction of } A \times 100}$$

$$\boxed{\sum_{i=1}^{n} x_i = 1}$$

where. x_A = Mole fraction of A
x_B = Mole fraction of B

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Question :⇒ NaCl weighing 200 kg is mixed with 600 kg potassium chloride (KCl). Calculate the composition of the mixture in
2004
(1). weight % and Mole %

weight of NaCl = 200 kg.

weight of KCl = 600 kg.

Solve

weight percetage $= \frac{\text{wt of component A}}{\text{Total wt of system}} \times 100$

Total wt of mixture = 200+600
= 800 kg.

weight % of NaCl $= \frac{200}{800} \times 100$
= 25 Ans

weight % of KCl $= \frac{600}{800} \times 100$
= 75 Ans

Mole % of A $= \frac{\text{Mole of A}}{\text{Total Mole of system}} \times 100$

Mole of NaCl $= \frac{\text{wt of NaCl}}{\text{Molecular wt}} = \frac{200}{58.5} = 3.418$ kMol.

Mole of KCl $= \frac{600}{74.5} = 8.053$ kmol.

Total mol of mixture = 11.471

Mole % of NaCl $= \frac{3.418}{11.471} \times 100 = 29.796$ Ans

Mole % of KCl $= \frac{8.053}{11.471} \times 100 = 70.203$ Ans

Que :⇒ A saturated solution of salicylic acid (HOC_6H_4COOH) in Methanol (CH_3OH) contains 64 kg salicylic acid per 100 kg methanol at 298 K (25°C). Find the composition of solution in (a) wt% and (b) Mol%.

given that.

wt of salicylic acid = 64 kg.

wt of Methenol = 100 kg.

Total wt of Mixture = 64+100 = 164 kg.

Solve

wt % of $HOC_6H_4COOH = \frac{64}{164} \times 100$
= 39.024 Ans

wt % of $CH_3OH = \frac{100}{164} \times 100$
= 60.975 Ans

Mole % of A $= \frac{\text{Mole of A}}{\text{Total Mole of A system}} \times 100$

Mole of $HOC_6H_4COOH = \frac{64}{138} = 0.463$ kmol

Mole of $CH_3OH = \frac{100}{32} = 3.125$

∴ Total mole of mixture = 3.588

Mole % of $HOC_6H_4COOH = \frac{0.463}{3.588} \times 100$
= 12.904 Ans

Mole % of $CH_3OH = \frac{3.125}{3.588} \times 100$
= 87.095 Ans

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Que :⇒ Ethanol and water form a Azeotrope containing 96% ethanol wt. Find the composition of azeotrope by Mole%.

Basis - 100 kg of Mixture (Ethanol + water)

It contains 96% of ethanol = 96 kg of Ethanol

4 kg of water.

H_2O of wt. M_1 = 18

C_2H_5OH of M.wt = $2\times12+5+16+1 = 46$

Mole of C_2H_5OH = $\frac{\text{wt in Ethanol}}{\text{Molecular wt.}} = \frac{96}{46}$

= 2.086 KMol.

Mole of water = $\frac{4}{18}$ = 0.222 kMol.

Total mole of Mixture = 2.086 + 0.222
= 2.302

Mole % of Ethanol = $\frac{\text{Mole of Ethanol}}{\text{Total mole of System}} \times 100$

= $\frac{2.086}{2.302} \times 100$

= 90.616 Ans

Mole % of H_2O = $\frac{\text{Mole of } H_2O}{\text{Total mole of system}} \times 100$

= $\frac{0.222}{2.302} \times 100$

= 9.652 Ans

Que :⇒ Aqueous solution contains 15% ethanol by volume. Find the weight % ethanol. If density of ethanol and water are 0.79 g/c.m³ and 1.0 g/c.m³ respectively.

Basis -

Total aqueous solution 100 c.m³

15% Volume of Ethanol = 15 c.m³

Volume of water = 100 − 15 = 85 c.m³

Mass of Ethanol = Density × Volume.

$D = \frac{M}{V}$

$M = D \cdot V$

$= 0.79 \times 15$

$m = \frac{0.79\ g}{c.m^3} \times 15\ c.m^3$

m = 11.85 g.

Mass of water = Density × Volume.

$m = \frac{1.0\ g}{c.m^3} \times 85\ c.m^3$

m = 85 g

Total wt of aqueous = weight of (Ethanol + water)

= 11.85 + 85

= 96.85 g

wt % of C_2H_5OH = $\frac{\text{weight of Ethanol}}{\text{Total wt of System}} \times 100$

= $\frac{11.85}{96.85} \times 100$

= 12.235 Ans

wt % of H_2O = $\frac{\text{weight of } H_2O}{\text{Total wt of system}} \times 100$

= $\frac{85}{96.85} \times 100$

87.764 Ans

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Ideal gas:

(I) An ideal gas is compressed of partical that have a point mass

(II) molecules have negligible volume in comparission to the total volume of the gas.

(III) Collision b/w two molecules is elastic

(IV) There is no mutual force of attraction or repulsion b/w the molecules

(V) Ideal gas obey $PV = nRT$
(Ideal gas equation)

Ideal gas law is the eqn of state of a hypothetical eal gas. It is good behaviorr of many gases
t is first stated by Emile Clapeyron in 1834
Cambination of Boyle's Law, charle's law and Avogadro's law → $PV = nRT$

आदर्श गैस (Ideal Gas) :⇒

जो गैस, ताप व दाब की सभी परिस्थियो मे गैसीय नियमो का पूर्ण रूप से पालन करती है Ideal Gas कहलाती है परन्तु सभी ज्ञात गैसो मे कोई भी गैस आदर्श गैस नही है अत: आदर्श गैस एक काल्पनिक Gas है।

Ideal Gas Law :⇒

Boyle's law ⇒ Boyle's law states that for a given mass of an ideal gas, the product of the pressure and volume, is constant at a constant temperature i.e.

$$\boxed{P \cdot V = \text{constant}}$$

where,
P = absolute pressure.
V = volume.

Boyle's law (बॉयल का नियम) :⇒

स्थिर ताप पर किसी Gas की निश्चित मात्रा का volume, pressure के व्युत्क्रमानुपाती होता है।

$$\boxed{V \propto \frac{1}{P}}$$ (स्थिर ताप पर)

$$V = \frac{K}{P}$$

$$\boxed{PV = K = \text{constant}}$$

$$\boxed{P_1V_1 = P_2V_2 = \text{Constant}}$$

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Charle's law (चार्ल्स का नियम) :⇒

Constant pressure पर किसी Gas की निश्चित मात्रा का आयतन परम ताप के समानुपाती होता है।

$\boxed{V \propto T}$ (स्थिर दाब पर)

BNA
CVT

$V = KT$

or. $\boxed{\frac{V}{T} = constant}$

or. $\frac{V_1}{T_1} = \frac{V_2}{T_2} = constant$

or. $\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$

2010

Ideal gas equation (आदर्श गैस समी०) :⇒

$V \propto \frac{1}{P}$ (बॉयल) — ①

$V \propto T$ (चार्ल्स) — ②

$V \propto n$ (एवोगेड्रो) — ③

or. $V = \frac{RTn}{P}$

or. $\boxed{PV = nRT}$

where,
P = Pressure.
V = Volume.
n = Number of Moles.
R = गैस नियतांक
T = Temperature.

n = मोलो की संख्या
R = गैस नियतांक

The value of R in different units is given below:-

Numerical value of R	Units.
8.31451	$m^3.Kpa/(Kmol.K)$
0.008314	$m^3.Mpa/(Kmol.K)$
0.08206	$l.atm/(Mol.K)$
0.08206	$m^3.atm/(Kmol.K)$
1.987	$Kcal/(Kmol.K)$
8.31451	$J/(Mol.K)$

2011, 10

Dalton's law :⇒ या

Dalton's law of Partial pressure (डाल्टन के आंशिक दाब के नियम)

:⇒ स्थिर temperature पर दो या दो से अधिक Gas के Mixture का total pressure उनके partial pressure (आंशिक दाब) के sum (योग) के बराबर होता है।

अर्थात.

$$\boxed{P = P_A + P_B + P_C + \dots}$$

where,
P = Total pressure.
P_A = Pressure of Component A.
P_B = Pressure of Component B
P_C = " " " C

Amagat's law :⇒ It state that the total volume occupied by a gaseous mixture is equal to the sum of pure component volume. It expresses the additive nature of pure component volumes of component gases.

अर्थात. Mathematically.

$$\boxed{V = V_A + V_B + V_C + \ldots}$$

where.

V = Total Volume
V_A = Volume of component A.
V_B = Volume of component B
V_C = Volume of component C.

Relationship between Partial Pressure; Mole fraction of component Gas to total Pressure. :⇒

It in the gas mixture component gases A, B and C then Partial Pressure of component A, B and C = $\bar{P}_A$, $\bar{P}_B$ and $\bar{P}_C$ & number of moles n_A, n_B and n_C

Total pressure, $P = \bar{P}_A + \bar{P}_B + \bar{P}_C$

Total number of mole $= n = n_A + n_B + n_C$

$$\boxed{PV = nRT}$$

For component A

$$\bar{P}_A = \frac{n_A RT}{V} \quad \text{--- (I)}$$

For component B.

$$\bar{P}_B = \frac{n_B RT}{V} \quad \text{--- (II)}$$

For component C

$$\bar{P}_C = \frac{n_C RT}{V} \quad \text{--- (iii)}$$

Sum of equ^n (I), (ii) & (iii).

$$P_A + P_B + P_C = (n_A + n_B + n_C)\frac{RT}{V} \quad \text{--- (iv)}$$

Dividing Equation (I) by Equation (iv)

or. $$\frac{P_A}{P_A + P_B + P_C} = \frac{n_A \frac{RT}{V}}{(n_A + n_B + n_C)\frac{RT}{V}}$$

or. $$\frac{P_A}{P_A + P_B + P_C} = \frac{n_A}{(n_A + n_B + n_C)} \quad \text{--- (V)}$$

or. $$\frac{P_A}{P} = \frac{n_A}{n} \quad \because [P_A + P_B + P_C = P]$$

or. $$\boxed{P_A = P \cdot X_A} \quad \because [X_A = \text{Mole fraction of component A}]$$

from equ^n (V).

partial pressure of component A = Mole fraction of component A.

partial pressure % of component A = Mole fraction of component.

or. $\boxed{\text{Pressure \%} = \text{Mole \%}}$

Relation between Volume % & Mole % :⇒

If in the gas mixture component A, B, C then volume of component A, B, C $= V_A + V_B + V_C$

and.

Number mole n_A, n_B, n_C

Total Mole $n = n_A + n_B + n_C$

Total Volume $V = V_A + V_B + V_C$

we know that.

$$PV = nRT$$

$$V_A = \frac{n_A RT}{P} \quad \text{— (I)}$$

$$V_B = \frac{n_B RT}{P} \quad \text{— (II)}$$

$$V_C = \frac{n_C RT}{P} \quad \text{— (III)}$$

Sum of eqn (I) + (II) + (III)

$$V_A + V_B + V_C = \frac{n_A RT + n_B RT + n_C RT}{P}$$

$$VP = (n_A + n_B + n_C) RT \quad \text{— (iv)}$$

Dividing equation (I) by equation (iv) :-

$$\Rightarrow \frac{V_A}{VP} = \frac{\frac{n_A RT}{P}}{(n_A + n_B + n_C) RT}$$

$$\Rightarrow \frac{V_A}{V\cancel{P}} = \frac{n_A \cancel{RT}}{(n_A + n_B + n_C) \cancel{RT}\cancel{P}}$$

$$\Rightarrow \boxed{\frac{V_A}{V} = \frac{n_A}{n}} \quad \text{— (5)}$$

Volume of component A = Mole fraction A

or $\frac{V_A}{V} \times 100 = \frac{n_A}{n} \times 100$

Volume % of component A = Mole fraction % of A.

$$\boxed{\text{Volume \%} = \text{Mole \%}}$$

or

$$\boxed{\text{Pressure \%} = \text{Mole \%} = \text{Volume \%}}$$

Average Molecular weight of Gas Mixture :⇒

If a mixture component A, B, C

Molecular weight of component A, B & C $= M_A, M_B, M_C$

Mole fraction of component A, B, C $= x_A, x_B, x_C$

$$\boxed{M_{avg} = M_A \cdot x_A + M_B \cdot x_B + M_C \cdot x_C \ldots}$$

$$M_{avg} = \frac{\text{Total weight of mixture}}{\text{Total Number of mole mixture}}$$

or $\boxed{M_{avg} = \sum_{i=1}^{n} M_i x_i}$ where,

M_i = Molecular weight of i^{th} component gas

x_i = Mole fraction of component gas

Density of Gas Mixture :→

The density of a gas mixture at a given temperature and pressure is very easily calculated by using the ideal gas law. For calculating the density, one must know average molecular weight of gas mixture.

The ideal gas equation -

$$PV = nRT$$

or- $$\frac{P}{RT} = \frac{n}{V}$$

or- $$\frac{n}{V} = \frac{P}{RT}$$ $\because M_{avg} = \frac{\text{Total wt of mixture}}{\text{Total number of mole (n)}}$

$$\left(\frac{\text{Total wt of mixture}}{M_{avg}}\right) \cdot \frac{1}{V} = \frac{P}{RT}$$

or- $$\boxed{\frac{\text{Total weight of mixture}}{\text{(V) Total volume of mixture}} = \frac{P}{RT} \cdot M_{avg}}$$

$$\boxed{\rho_{mix} = \text{Density of gas mixture} = \frac{\text{Mass (weight)}}{\text{Volume}}}$$

$$\boxed{\rho_{mix} = \frac{P}{RT} \cdot M_{avg}}$$

where -
- n = Kmol of gas mixture.
- V = Volume of gas mixture, m^3.
- R = universal gas constant 8.3151 $m^3 \cdot kPa/(kmol \cdot k)$
- T = temperature k.
- P = pressure in kPa.

Specific ~~Density~~ gravity :⇒

किसी गैस का specific ~~density~~ gravity उसकी Density और Air की Density का Ratio होता है

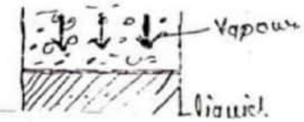
$$\boxed{\text{Specific gravity} = \frac{\text{Density of the gas}}{\text{Density of Air at the same T and P.}}}$$

$$\boxed{\text{Specific Gravity} = \frac{\text{Molecular weight of the gas.}}{\text{Molecular weight of air.}}}$$

Vapour pressure :⇒

किसी Contener में Fixed temperature पर equilibrium condition (Rate of equation = Rate of condition) में किसी liquid के Vapour से बने pressure को Vapour pressure कहते हैं।

- ☆- Vapour pressure pure liquid का होता है।
- ☆- Vapour pressure absolute pressure होता है।
- ☆- Vapour pressure को P_A से show करते हैं।
- ☆- Vapour pressure temperature के Directaly proportional होता है।
- ☆- जब हम temperature बढ़ाते हैं, तो vapour pressure बढ़ता है।



2011,10

Raoult's law :⇒

इस नियम के अनुसार 'किसी fixed temperature पर Binary mixture के component A का partial pressure vapour pressure मे तथा उसी component A का mole fraction liquid phase के Directaly proportional होता है।

$$\bar{P}_A \propto x_A$$

$$\boxed{\bar{P}_A = P_A \cdot x_A}$$

- where, $\bar{P}_A$ = partial pressure of component A. (Vapour Phase)
  $\dot{P}_A$ = Vapour pressure of pure liquid.
  x_A = Mole fraction of component A. (Liquid Phase)

Henry's law :⇒

इस नियम के अनुसार 'किसी Fixed temperature पर किसी Binary mixture के component A का liquid phase मे mole fraction उसी component A के vapour phase मे partial pressure के Directaly proportional होता है।

$$x_A \propto \bar{P}_A$$

or

$$\boxed{x_A = \frac{1}{H_A} \cdot \bar{P}_A}$$

where. x_A = Mole fraction of component A.
H_A = Henry's Constant.
$\bar{P}_A$ = Partial pressure of component A.

Raoult's law :⇒

It state that at a given temperature the (equilibrium) partial pressure of a component A of a solution of the component A in the vapour is equal to the product of the mole fraction of the component A in the solution (liquid phase) and the vapour pressure of pure component A.

$$P_A = P_A^\circ x_A$$

where, P_A = Partial pressure of component A (Vapour Phase)
P_A° = Vapour pressure of pure liquid.
x_A = Mole fraction of component A (liquid Phase).

Henry's law :⇒

It state that the mole fraction of a solute gas dissolved in a liquid is directly proportional to the equilibrium partial pressure of the solute gas above the liquid surface.

$$x_A \propto P_A$$

$$x_A = \frac{1}{H_A} P_A$$

where, x_A = Mole fraction of A in liquid
H_A = Henry's law constant.
P_A = Partial pressure. of component A.

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Normal Boiling Point :⇒ वह temperature जिस पर vapour की value बढ़कर 760 mm Hg और 1 atm के बराबर हो जाता है, तो उस Point ~~pollate~~ पर liquid Boiling करने लगता है Normal Boiling point कहलाता है।

Saturation temperature :⇒ (संतृप्त ताप)
स्थिर दाब पर वह maximum temperature जिस पर पानी की अवस्था का भाप (स्टीम) में परिवर्तन होता है संतृप्त ताप कहलाता है।

At a constant pressure maximum temperature which water phase is change into the ~~stim~~ steam that is called Saturation temperature.

~~Saturation temperature~~ (

Saturation pressure (संतृप्त दाब) :⇒ स्थिर ताप पर वह maxim pressure जिस पर पानी की अवस्था बदल जाती है संतृप्त दाब कहलाता है।

At a constant temperature maximum pressure which water phase is change into the another state of water that is called saturation pressure.

Phase :⇒ किसी system का Homogenious and physicaly part से Distinct (अलग-२) जो surface द्वारा घिरा होता है और system के दूसरे part से अलग होता है उसे phase कहते हैं।

Density :⇒ Density of any substance as define the ratio of mass of the substance to volume of the substance. It is denoted by ρ. 28

$$\boxed{\text{Density } (\rho) = \frac{\text{mass of the substance}}{\text{Volume of the substance}}} \quad kg/m^3$$

यह एक Thermodynamic properties है और यह temperature and pressure पर Dipned (निर्भर) करती है।

Specific weight :⇒ It is the weight of the substance per unit volume.
unit → kg/m^3

$$\text{specific weight} = Mg/V \qquad \because \frac{M}{V} = \rho$$

or. $\boxed{S.W = \rho . g}$

Specific Volume :⇒ Specific volume of a substance is the inverse. inverse of mass density of substance. It is denoted by. V_s

$$V_s = \frac{1}{\rho} \qquad \text{unit} \rightarrow m^3/kg.$$

or. $\boxed{V_s = \frac{V}{M}}$

Ques :- A Mixture of H_2SO_4 containing 11.1% H_2O by weight

calculate (a). Average Molecular wt of gas mixture.

(b). Partial pressure of O_2 & H_2 at 100 kpa and 303 Temp.

Basis — Total wt of Gas mixture = 100 kg.

According to Ques. Total wt of H_2 = 11.1 kg.

Total wt of O_2 = 88.9 kg.

$$\text{Mole fraction of } H_2 = \frac{\text{Mole of } H_2}{\text{Total mole of system}}$$

$$\text{Mole of } H_2 = \frac{11.1}{2} = 5.55$$

$$\text{Mole of } O_2 = \frac{88.9}{32} = 2.778$$

Total mole of Mixture = 8.33

$$\text{Mole fraction of } H_2 = \frac{5.55}{8.33} = 0.666 = x_{H_2}$$

$$\text{Mole fraction of } O_2 = \frac{2.77}{8.33} = 0.33 = x_{O_2}$$

(a)- Average Molecular

$$M_{avg} = x_{H_2}M_{H_2} + x_{O_2}M_{O_2}$$

$$= 0.666 \times 2 + 0.33 \times 32$$

$$\boxed{M_{avg} = 11.90}$$ Ans

(b) we know that -

Raoult law . $\boxed{\bar{P}_A = P_A \cdot x_A}$ where. $P_A = 100 kpa$

Partial pressure of H_2 = 100 × 0.666 = 66.60 kpa Ans

Partial pressure of O_2 = 100 × 0.33 = 33.0 kpa Ans

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Ques. Calculate the Density of air. Contenuing 21% O_2 & 79% N_2 by volume at 503 kalvin Temp. and 1519.875 kpa Pressure.

we know that-

$$\boxed{\text{Mole \%} = \text{Volume \%} = \text{Pressure\%}}$$

Mole % = Volume %.

So.

Mole of O_2 = 21% or. Mole of O_2 = 21

Mole of N_2 = 79% or. Mole of N_2 = 79.

Totale mol of (O_2+N_2) Air = 100

- Mole fraction of $O_2 = \frac{21}{100} = 0.21$

Mole % = Mol fr

Mole fraction of $N_2 = \frac{79}{100} = 0.79$

$$M_{avg} = x_{O_2} M_{O_2} + x_{N_2} M_{N_2}$$
$$= 0.21 \times 32 + 0.79 \times 28$$
$$= 6.72 + 22.12$$
$$M_{avg} = 28.84$$

$$\text{Density } (\rho) = \frac{P \cdot M_{avg}}{RT}$$

$P = 1519.825$ kpa

$T = 503$ K

$R = 8.3145$

$$\rho = \frac{1519.875 \times 28.84}{8.3145 \times 503}$$

$$\boxed{\rho = 10.4809 \ kg/m^3}$$ Ans

Q. :- A Mixture of CH_4 and C_2H_6 has density 1.0 kg/m³ at 273 K (0°C) and 101.325 kpa pressure. Calculation of mole% and weight% of CH_4 and C_2H_6 in the mixture

Basis - 1 kg/m³ density of gas mixture at 273 K and 101.325 k

Density of gas mixture. $\rho = \frac{P M_{avg}}{RT}$

$$M_{avg} = \rho \cdot \frac{RT}{P}$$

where $\rho = 1 \ kg/m^3$, $T = 273K$, $P = 101.325$ kpa, $R = 8.31451 \ m^3 \cdot kpa/(kmol \cdot k)$

$$M_{avg} = 1 \times \frac{8.31451 \times 273}{101.325}$$
$$= 22.4$$

Let x_{CH_4} and $x_{C_2H_6}$ be the mole fraction of CH_4 and C_2H_6 respectively.

$$M_{avg} = \Sigma x_i M_i = M_{CH_4} x_{CH_4} + M_{C_2H_6} \cdot x_{C_2H_6}$$
$$22.4 = 16 x_{CH_4} + 30 x_{C_2H_6}$$

$$\boxed{\Sigma x_i = 1}$$

$$x_{C_2H_6} + x_{CH_4} = 1$$
$$x_{C_2H_6} = 1 - x_{CH_4}$$

$$\Rightarrow 22.4 = 16 x_{CH_4} + 30 - 30 x_{CH_4}$$
$$\Rightarrow 22.4 = -14 x_{CH_4} + 30$$
$$\Rightarrow \boxed{x_{CH_4} = 0.542}$$

$$\boxed{x_{C_2H_6} = 0.458}$$

Mole % of $CH_4 = x_{CH_4} \times 100$

$= 0.543 \times 100 = 54.3$ Ans

Mole % of $C_2H_6 = x_{C_2H_6} \times 100$

$= 0.457 \times 100 = 45.7$ Ans

weight of CH_4 in 1 kmol mixture $= 54.3 \times 16 = 8.69$ kg.

weight of C_2H_6 in 1 kmol mixture $= 45.7 \times 30 = 13.71$ kg.

weight of gas mixture = 22.4 kg.

weight % of CH_4 in mixture $= \frac{8.69}{22.4} \times 100$

$= 38.8$ Ans

weight % of C_2H_6 in mixture $= \frac{13.71}{22.4} \times 100$

$= 61.20$ Ans

Expt 2.61: A gas mixture contains 0.274 kmol of HCl, 0.337 kmol of N_2 and 0.089 kmol of O_2. Calculate.

(a): Average molecular weight of gas and,

(b): Volume occupied by this mixture at 405.3 kPa and 303 K (30°C)

Basis: A gas mixture containing 0.274 kmol HCl, 0.337 kmol N_2 and 0.089 kmol O_2.

Total moles of the gas mixture $= 0.274 + 0.337 + 0.089$

$= 0.7$ kmol.

$$M_{avg} = \sum M_i x_i$$

$$= M_{HCl} \cdot x_{HCl} + M_{N_2} \cdot x_{N_2} + M_{O_2} \cdot x_{O_2}.$$

Mole fraction of HCl (x_{HCl}) $= \frac{0.274}{0.7}$ $\boxed{= \frac{\text{Mole of A}}{\text{Total mole of system}}}$

$= 0.391$

Mole fraction of N_2 (x_{N_2}) $= \frac{0.337}{0.7} = 0.481$

Mole fraction of O_2 (x_{O_2}) $= \frac{0.089}{0.7} = 0.127$

Molecular weight of HCl $= M_{HCl} = 36.5$, Molecular wt of $N_2 = M_{N_2} = 28$, Molecular weight of $O_2 = M_{O_2} = 32$.

$$\boxed{M_{avg} = \sum M_i x_i}$$

$$= M_{HCl} \cdot x_{HCl} + M_{N_2} \cdot x_{N_2} + M_{O_2} \cdot x_{O_2}.$$

$$= 36.5 \times 0.391 + 28 \times 0.981 + 32 \times 0.127.$$

(a): $\boxed{M_{avg.} = 31.80}$ Ans

(b):

$$PV = nRT$$

$$V = \frac{nRT}{P}$$

$$V = \frac{0.7 \times 8.31451 \times 303}{405.3}$$

$$\boxed{V = 4.35}$$

Expt 2.62 ⇒ In case of gas mixture cited in previous example, calculate the partial pressure of each component gas at 405.3 kpa and 303 K (30°C)

Solve Basis :- Given gas mixture

Total pressure = 405.3 kpa.

Mole fraction of HCl = x_{HCl} = 0.391

Mole fraction of N_2 = x_{N_2} = 0.481

Mole fraction of O_2 = x_{O_2} = 0.127

Roult law $\boxed{\bar{P}_A = P x_A}$

partial pressure of O_2 –

$$P_{O_2} = x_{O_2} \cdot P$$

$$P_{O_2} = 0.127 \times 405.3$$

$$\boxed{P_{O_2} = 51.47\ KPa}$$ Ans

partial pressure of N_2 –

$$P_{N_2} = x_{N_2} \cdot P$$

$$= 0.481 \times 405.3$$

$$\boxed{P_{N_2} = 194.95\ kpa}$$ Ans

partial pressure of HCl –

$$P_{HCl} = P \cdot x_{HCl}$$

$$= 0.127 \times 405.3$$

$$\boxed{P_{HCl} = 51.47\ kpa}$$ Ans

Expt 2.63 :- A Mixture of H_2 and O_2 contains 11.1% by weight. Calculate.

(a) ⇒ Average Molecular weight of gas mixture

(b) ⇒ partial pressure of O_2 and H_2 at 100 kpa, 303 K (30°C).

Solve Basis, 100 kg of gas Mixture.

weight of H_2 = 11.1 kg, Mole of H_2 = $\frac{weight}{Mol. wt}$ = $\frac{11.1}{2}$ = 5.55 kmol

weight of O_2 = 88.9 kg,

Total mole of system = 5.55 + 2.78 = 8.33 kmol. Mole of O_2 = 2.78 kmol

$$\boxed{M_{avg} = \Sigma M_i \cdot x_i}$$

$$= M_{H_2} \cdot x_{H_2} + M_{O_2} \cdot x_{O_2}.$$

Mole fraction of H_2 = x_{H_2} = $\frac{\text{mole of A}}{\text{Total mole of system}}$

$$= \frac{5.55}{8.33} = 0.67.$$

Mole fraction of O_2 = x_{O_2} = $\frac{2.78}{8.33}$ = 0.33.

Molecular weight of H_2 = 2.

" " " O_2 = 32.

$$M_{avg} = M_{H_2} \cdot x_{H_2} + M_{O_2} \cdot x_{O_2}.$$

$$= 2 \times 0.67 + 32 \times 0.33$$

(a)- $\boxed{M_{avg} = 11.9}$ Ans

(b) partial pressure = P = 100 kpa.

partial pressure of H_2 = P_{H_2} = $x_{H_2} \cdot P$

$$P_{H_2} = 0.67 \times 100$$

$$\boxed{P_{H_2} = 67\ kpa}$$ Ans

partial pressure of O_2 = $P_{O_2} = x_{O_2} \cdot P$

$$P_{O_2} = 0.33 \times 100$$

2019

Exp: 265 ⇒ A Mixture of CH_4 and C_2H_6 has the average Molecular weight of 22.4. Find Mole % CH_4 and C_2H_6 in the mixture.

Basis:- Average Molecular weight of 22.4 of gas mixture.

$\boxed{M_{avg} = 22.4}$

C_2H_6 and CH_4 = 22.4.

$\boxed{M_{avg} = \Sigma M_i x_i}$

$M_{avg} = M_{CH_4} x_{CH_4} + M_{C_2H_6} x_{C_2H_6}$.

∴ $22.4 = 16 \times x_{CH_4} + 30 \cdot x_{C_2H_6}$

Mole fraction $\Sigma x_i = 1$

$x_{CH_4} + x_{C_2H_6} = 1$

$x_{CH_4} = 1 - x_{C_2H_6}$

⇒ $22.4 = 16(1 - x_{C_2H_6}) + 30 \cdot x_{C_2H_6}$

⇒ $22.4 = 16 - 16x_{C_2H_6} + 30 \cdot x_{C_2H_6}$

⇒ $14 x_{C_2H_6} = 6.4$

⇒ $C_2H_6 = \frac{6.4}{14} = 0.4571$

⇒ $\boxed{x_{C_2H_6} = 0.4571}$

$x_{CH_4} = 1 - x_{C_2H_6}$

$= 1 - 0.4571$

$\boxed{x_{CH_4} = 0.5429.}$

Mole % of A = $\frac{\text{Mole of A}}{\text{Total mole of system}} \times 100$.

= Mole of fraction × 100.

Mole % of C_2H_6 = $0.4571 \times 100 = 45.70$ Ans

Mole % of CH_4 = $0.5429 \times 100 = 54.30$ Ans

2003, 2004, 2006

Exp: 266 :- Assuming air to contain 79% N_2 and 21% O_2 by volume, calculate the density of air at NTP.

Basis:- Air containing 21% O_2 and 79% N_2 by volume.

Formula: Density of the air $\rho = \frac{P M_{avg}}{RT}$.

For ideal gases, $\boxed{\text{Mole \%} = \text{Volume \%}}$

Mole % of N_2 = 79 ; Mole % of O_2 = 21

$M_{avg} = \Sigma x_i M_i = M_{N_2} \cdot x_{N_2} + M_{O_2} x_{O_2}$.

∵ Mole % = $\frac{\text{Mole of A}}{\text{Total mole of system}} \times 100$.

Mole fraction में change करेंगे

$\boxed{\text{Mole \%} = \text{Mole fraction} \times 100.}$

Mole fraction = $\frac{\text{Mole \% of } N_2}{100}$.

Mole fraction N_2 = $\frac{79}{100} = 0.79$.

Mole fraction of O_2 = $\frac{21}{100} = 0.21$.

$M_{avg} = 28 \times 0.79 + 32 \times 0.21$.

$M_{avg} = 28.84$

Density of the air $\rho = \frac{P M_{avg}}{RT}$

$\rho = \frac{101.325 \times 28.84}{8.31451 \times 273}$

$\boxed{\rho = 1.2874 \text{ kg/m}^3}$ Ans

Exp. 2.67: A mixture of CH_4 and C_2H_6 has density 1.0 kg/m^3 at 273 K (0°C) and 101.325 kPa pressure. Calculate the mole % and weight % of CH_4 and C_2H_6 in the mixture.

Solve:- Basis: 1 kg/m^3 density of gas mixture at 273 K and 101.325 kPa pressure.

Density of gas mixture.

$$\rho = \frac{P\,M_{avg}}{RT}$$

$$1.0 = \frac{101.325\,M_{avg}}{8.3145 \times 273}$$

$$1.0 \times 8.3145 \times 273 = 101.325\,M_{avg}$$

$$\frac{2{,}269.8585}{101.325} = M_{avg}$$

$$22.40176 = M_{avg}$$

$$M_{avg} = 22.4$$

$$M_{avg} = \Sigma x_i M_i$$

$$M_{avg} = M_{CH_4} \cdot x_{CH_4} + M_{C_2H_6} \cdot x_{C_2H_6}$$

$$22.4 = 16 \cdot x_{CH_4} + 30\,x_{C_2H_6}$$

$$\Sigma x_i = 1$$

$$\Sigma x_i = 1$$

$$x_{CH_4} + x_{C_2H_6} = 1$$

$$x_{CH_4} = 1 - x_{C_2H_6}$$

$$22.4 = 16(1 - x_{C_2H_6}) + 30\,x_{C_2H_6}$$

$$22.4 = 16 - 16\,x_{C_2H_6} + 30\,x_{C_2H_6}$$

$$22.4 - 16 = 14\,x_{C_2H_6}$$

$$\boxed{0.457 = x_{C_2H_6}}$$

$$x_{CH_4} = 1 - 0.457$$

$$\text{Mole\%} = \frac{\text{Mole of component}}{\text{Total mole of system}} \times 100$$

$$\text{Mole\%} = \text{Mole fraction of } CH_4 \times 100$$

$$\text{Mole\% of } CH_4 = 0.543 \times 100$$

$$\boxed{\text{Mole\% of } CH_4 = 54.3}\ \text{Ans}$$

$$\text{Mole\% of } C_2H_6 = 0.457 \times 100$$

$$\boxed{\text{Mole\% of } C_2H_6 = 45.7}\ \text{Ans}$$

$$\text{weight\%} = \frac{\text{weight of component}}{\text{Total wt of system}} \times 100$$

$$\boxed{\text{weight\%} = \text{weight fraction} \times 100}$$ — ये formula यहाँ use नहीं है।

~~weight % of CH_4 = weight~~

ये आप करना पड़ेगा की कैसे wt निकालते हैं।

weight of CH_4 in 1 kmol mixture $= 0.543 \times 16 = 8.69$ kg.

weight of C_2H_6 in 1 kmol mixture $= 0.457 \times 30 = 13.71$ kg.

weight of gas mixture $= 22.4$ kg.

$$\text{weight\% of } CH_4 \text{ in Mixture} = \frac{8.69}{22.4} \times 100$$

$$= 38.8 \quad \text{Ans}$$

$$\text{weight\% of } C_2H_6 \text{ in mixture} = 100 - 38.8$$

$$= 61.2 \quad \text{Ans}$$

Note

(weight निकालने के लिए क्या करते हैं कि - kmol या % में या Mole fraction जो भी दिया रहता है उसमें उसी के component के molecular wt से Multiply कर देते हैं।)

Question ⇒ A gas mixture has following composition by Volume.

$O_2 = 15.1\%$, $CO_2 = 3.7\%$, $N_2 = 75\%$, $H_2O = 6.2\%$.

find. (a): composition by weight.

(b): density of gas mixture at 100.658 kPa and 303 K (30°C)

Basis ⇒ 100 kmol of gas.

~~It contains 15.1 kmol of CH_4, 10 kmol of C_2H_6 and 6 kmol of N_2.~~

~~Mole fraction of CH_4~~ =

It contains. 15.1 kmol of O_2, 3.7 kmol of CO_2, 75 kmol. of N_2, 6.2 kmol of H_2O.

Mole fraction of $O_2 = \frac{15.1}{100} = 0.151$

Mole fraction of $CO_2 = \frac{3.7}{100} = 0.037$.

Mole fraction of $N_2 = \frac{75}{100} = 0.75$.

Mole fraction of $H_2O = \frac{6.2}{100} = 0.062$.

Molecular wt of $O_2 = 32$ $M_{avg} = \Sigma x_i M_i$

" " $CO_2 = 44$ $M_{avg} = 32 \times 0.151 + 44 \times 0.037 + 28 \times 0.75 + 18 \times 0.062$.

" " $N_2 = 28$

" " $H_2O = 18$ $M_{avg} = 28.576$

Density of gas $\rho = \frac{PM_{avg}}{RT} = \frac{101.325 \times 28.576}{8.31451 \times 303}$

$= 1.1493$

$\boxed{\text{Density of gas} = 1.1493\ kg/m^3}$ Ans

O_2 in gas $= 15.1 \times 32 = 483.2$

CO_2 in gas $= 3.7 \times 44 = 162.8$

N_2 in gas $= 28 \times 75 = 2{,}100$.

H_2O in gas $= 6.2 \times 18 = 111.6$.

weight % $O_2 = \frac{kg\ of\ O_2}{kg\ of\ gas} \times 100 = \frac{483.2}{2{,}857.6} \times 100$

$= 16.909\%$ Ans

weight % of $CO_2 = \frac{162.8}{2857.6} \times 100 = 5.697$

$= 5.7\%$ Ans

weight % of $N_2 = \frac{2100}{2857.6} \times 100 = 73.48824$.

$= 73.5\%$ Ans

weight % of $H_2O = \frac{111.6}{2857.6} \times 100 = 3.905$.

$= 3.9\%$ Ans

CHAPTER ⇒ 3

Material Balance without chemical Reaction

Material Balance :⇒ किसी भी Industrial process का Material Balance एक exact accounting होता है जो भी Material एक दिये हुये Time interval के दौरान system मे enter करता है और leave करता है।

$$\boxed{\text{input} = \text{Output}}$$

I- Material Balance calculation law of conservation of mass पर Based होता है। law of conservation mass के दौरान Matter को न ही creat किया जा सकता है और न ही destroyed किया जा सकता है।

I- The total mass of all substance taking part in a process remains constant.

- अथवा

Total mass जो भी process मे भाग ले रहा है वह पूरे process के दौरान स्थिर होना चाहिए।

Material Balance are important to calculate the following :⇒

D:- Material Balance का प्रयोग material and energy के consaption invalate करने के लिए किया जाता है।

(2):- Energy and Material consuption का involvetion का प्रयोग ~~हम करते है वह~~ हम storage ~~faipelity~~ facility के capacity को Determined करने मे किया जा सकता है।

Classification of Material Balance :⇒

The material balance problem are classified in two categories as follows:

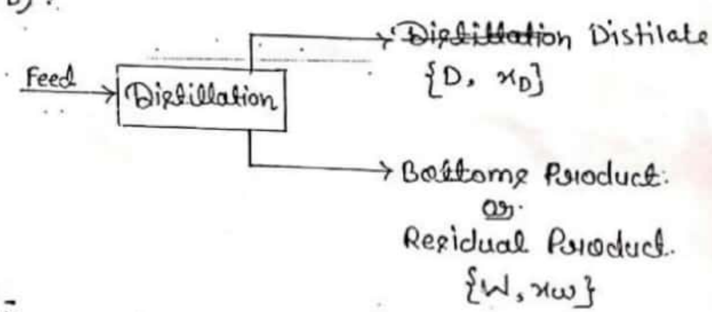
(1). The Material balance Problem without chemical reaction.

(2). The Material balance problem with chemical reaction.

Distillation :⇒

Distillation एक Unit operation है। जिसमे हम किसी liquid mixture के component (constituent) को thermal energy का प्रयोग करके separate किया जाता है।

Block diagram of distillation operation for binary system of (A + B):



Basicaly difference in vapour pressure or boilling point of different component at same temperature is responsible for such sepration.

Over all Material Balance :-

Feed = Distillate + Bottom (on weight or mole basis)

$$\boxed{F = D + W}$$

Material balance of component A.

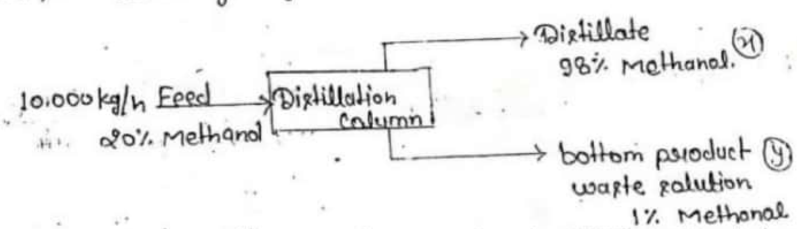
$$\boxed{F x_F = D x_D + W x_W}$$

A in Feed = A in distillate + A in bottoms.

or ⇒ $$\boxed{x_F \cdot F = x_D \cdot D + x_W \cdot W}$$

Exp 3.15 :⇒ 10,000 Kg/h of solution containing 20% methanol is continuously fed to a distillation column. Distillate (product) is found to contain 98% methanol and waste solution from the column carries 1% methanol. All percentage are by weight. Calculate (a) the mass flow rate of distillate and bottom product and (b) the percent loss of methyl alcohol.

Basis :- 10000 Kg/h of 20% methanol feed solution to column.



Let x and y be the mass flow rate of distillate/product and waste solution (bottom product) respectively.

Overall Material Balance :⇒

Feed = Distillate + Bottom

$10{,}000 = x + y \quad , \quad x = 10{,}000 - y \quad — (1)$

Material balance of Methonal :-

$$10{,}000 \times 0.2 = 0.98x + 0.01y$$

$$2000 = 0.98x + 0.01y$$

$$2000 = 0.98(10{,}000 - y) + 0.01y$$

$$2000 = 9800 - 0.98y + 0.01y$$

$$-0.97y = 2000 - 9800$$

$$\boxed{y = 8041.237 \text{ kg/h}}$$

From (1).

$$x = 10{,}000 - 8041.237$$

Mass flow rate of distillate = 1959 kg/h

Mass flow rate of the waste solution = 8041 kg/h

Methanol in the waste solution = 0.01×8041

$= 80.41$ kg/h

Methanol in the feed = $0.2 \times 10{,}000$

$= 2000$ kg/h

Formula:

$$\boxed{\%\text{ loss of Methanol} = \frac{\text{Methanol in waste solution}}{\text{Methanol in feed solution}} \times 100}$$

$$= \frac{80.41}{2000} \times 100$$

$$= 4.02 \quad \text{Ans.}$$

Ex (3.12) :⇒ A Feed to a continuous fractioning column analyses by weight 28 percent benzene and 72 percent toluene. The analysis of the distillate shows 52 weight percent benzene and 5 weight percent benzene was found in the bottom product. Calculate the amount of distillate and bottom product per 1000 kg of feed per hour. Also calculate the percent recovery of benzene.

Solution Basis. 1000 kg/h of feed to column.

Let x and y be the kg/h of distillate and bottom product respectively:

Overall Material Balance.

$x + y = 1000$, $x = 1000 - y$.

Material Balance of Benzene:-

Benzene in feed = Benzene in distillate + Benzene in bottom product.

$0.28 \times 1000 = 0.52x + 0.05y$

$280 = 0.52(1000 - y) + 0.05y$

$280 = 520 - 0.52y + 0.05y$

$280 = 250 - 0.47y$

$280 - 250 = \cancel{0.47y}\ 0.47y$

5000 kg/h → Distillation → 95% Benzine 5 toluine Top. (x)

→ bottom 92 Toluine, 8% Benzine

y

x is distillate and y is the bottom product.

Benzine –

$$x + y = 5000 \quad \text{—— (i)}$$

$$0.50 \times 5000 = 0.95 \times x + 0.08 \times y \quad \text{—— (ii)}$$

$$25\,0000 = 0.95 \times x + 0.08y$$

$$\therefore y = \frac{2500}{0.08} - \frac{0.95}{0.08}x$$

$$y = 31250 - 11.875x \quad \text{—— (iii)}$$

समी० (3) का मान समी० (1) में रखने पर -

$$x + 31250 - 11.875x = 5000$$

$$x + 11.815x = 26250$$

$$10.875x = 26250$$

$$x = \frac{26250}{10.875}$$

$$x = 2413.793 \text{ kg/h}$$

$$y = 5000 - 2413.79$$

$$\boxed{y = 2586.21 \text{ kg/h}}$$

(i) Percentage recovery of benzine.

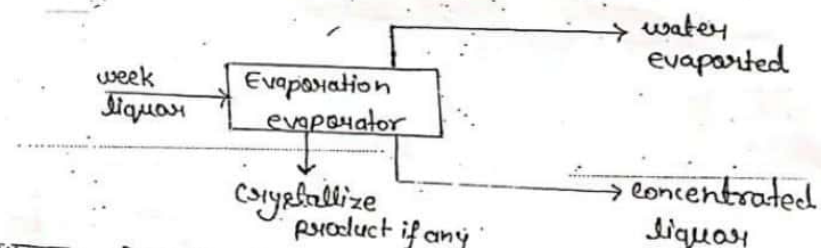
$$= \frac{\text{benzine in waste solution}}{\text{benzine in feed solution}} \times 100$$

Evaporation :→ (वाष्पीकरण)

Evaporation एक प्रकार का unit operation है जिसका प्रयोग chemical Industry मे किया जाता है। Chemical Industry मे week liquor के solution से water को Evaporat करके तथा अगर कोई crystallize product है तो उसे remove करके concentated liquor as a product.

अथवा

This operation used in the chemical industry for the concentration of a week liquor to product a thick liquor by evaporating a portion of the solvent (generally water) by means of condensing steam. It may be carried out in a single or a multiple effect evaporation system.



समान्यत: तीन प्रकार के Evaporator Industry मे use किये जा सकते है -

1. Single effect Evaporator.
2. Open pan Evaporator.
3. Multi effect Evaporator.

Overall Material balance :-

weak liquor = water evaporated + crystallized product + Thick liquor.

crystallized product is nil :-

weak liquor = water evaporated + Thick liquor.

Material balance of solid (solute) :-

Solid (solute) in weak liquor = Solids (solute) in thick liquor

Material balance of water :-

water in weak liquor = water evaporated + water in thick liquor.

The above material balance equation may be written in terms of quantity in kg or flow rate in kg/h.

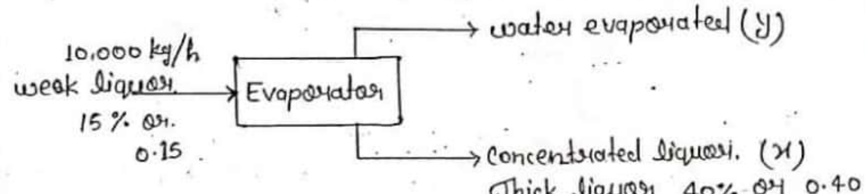
3.

Ques :⇒ A single effect evaporator is fed with 10000 kg/h of weak liquor containing 15% caustic by weight and is concentrated to get thick liquor containing 40% by weight caustic (NaOH). Calculate.

(a). kg/h of water evaporated.

(b). kg/h of thick liquor obtained.

Solve Basis :- 10,000 kg/h of weak liquor.



Let x be the kg/h thick liquor obtained and y be the kg/h water evaporated.

Overall Material balance -

(kg/h) weak liquor = water evaporated + Thick liquor (kg/h)

$$10{,}000 = y + x \quad \text{--- (1).}$$

Material balance of NaOH :-

NaOH in the weak liquor = NaOH in thick liquor

NaOH in the input stream = NaOH in the output stream

$$10{,}000 \times 0.15 = 0.40x$$

$$x = \frac{1500}{0.40}$$

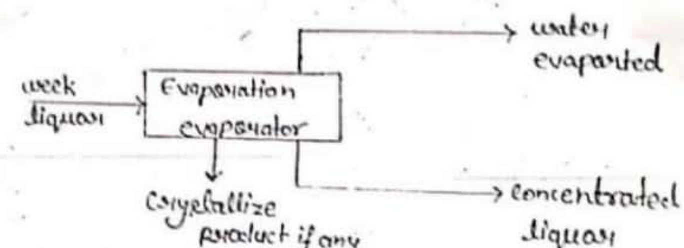
(वाष्पीकरण)

Evaporation :→

Evaporation एक प्रकार का unit operation है जिसका प्रयोग chemical Industry मे किया जाता है। Chemical Industry मे week liquor के solution से water को Evaporate करके तथा अगर कोई crystalize product है तो उसे remove करके concentated liquor as a product.

अथवा

This operation used in the chemical industry for the concentration of a week liquor to product a thick liquor by evaporating a portion of the solvent (generally water) by means of condensing steam. It may be carried out in a single or a multiple effect evaporation system.



समान्यत: तीन प्रकार के Evaporator Industry मे use किये जा सकते हैं -

1. Single effect Evaporator.
2. Open, pan Evaporator.
3. Multi effect Evaporator.

Overall Material balance :-

weak liquor = water evaporated + crystallized product + Thick liquor.

If crystallized product is nil :-

weak liquor = water evaporated + Thick liquor.

Material balance of solid (Solute) :-

Solid (Solute) in weak liquor = Solids (Solute) in thick liquor

Material balance of water :-

water in weak liquor = water evaporated + water in thick liquor.

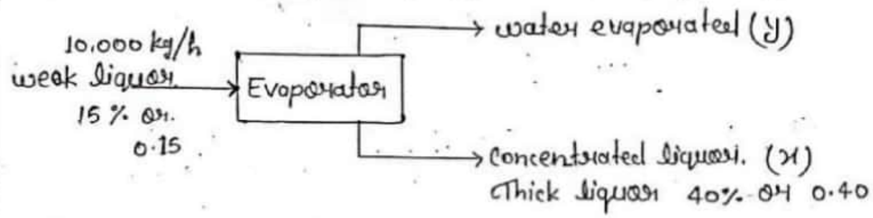
The above material balance equation may be written in terms of quantity in kg or flow rate in kg/h.

Ques ⇒ A single effect evaporator is fed with 10000 kg/h of weak liquor containing 15% caustic by weight and is concentrated to get thick liquor containing 40% by weight caustic (NaOH). Calculate.

(a). kg/h of water evaporated.

(b). kg/h of thick liquor obtained.

Solve Basis :- 10,000 kg/h of weak liquor.



Let x be the kg/h thick liquor obtained and y be the kg/h water evaporated.

Overall Material balance -

(kg/h) weak liquor = water evaporated + Thick liquor (kg/h)

$$10{,}000 = y + x \quad \text{—} \quad (1).$$

Material balance of NaOH :-

NaOH in the weak liquor = NaOH in thick liquor.

NaOH in the input stream = NaOH in the output stream

$$10{,}000 \times 0.15 = 0.40x$$

$$x = \frac{1500}{0.40}$$

we have $x+y = 10{,}000$

$3750 + y = 10{,}000$

$y = 10{,}000 - 3750$

$\boxed{y = 6250 \text{ kg/h}}$

water evaporater = 6250 kg/h

and Thick liquor obtained = 3750 kg/h Ans

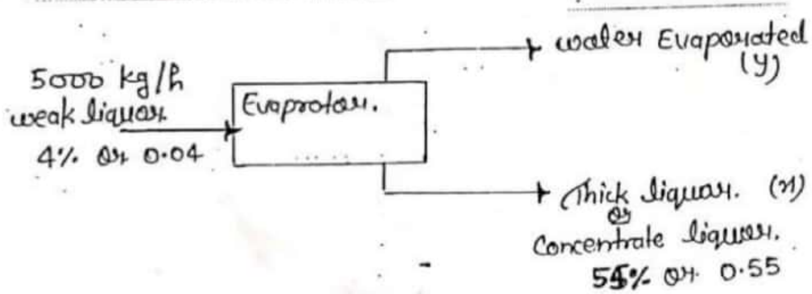
ercise :-

uestion ① :⇒ Single effect evaporator concentrating a weak liquor containing 4% solid to 55% solid (by weight) is fed with 5000 kg/h of weak liquor. Calculate.

). water evaporated per hour.

). Flow rate of thick liquor.

Basis :⇒ 5000 kg/h of weak liquor.



Let x be the kg/h thick liquor obtained and y be the kg/h water evaporator.

Overall Material balance -

week liquor kg/h = kg/h thick liquor + kg/h water evaporator.

$5000 = x + y$

Material balance of

Solid in weak liquor = Solid in thick liquor.

Solid in input stream = Solid in output stream.

$5000 \times 0.04 = 0.55x$

$x = \frac{200}{0.55}$

$\boxed{x = 363.636}$ kg/h

we have -

$x + y = 5000$

$363.636 + y = 5000$

$y = 5000 - 363.636$

$\boxed{y = 4636.364 \text{ kg/h}}$

(a). water evaporater = 4636.364 kg/h Answer

(b). Flow rate of thick liquor = 363.636 kg/h Answer

Exp. No. 3.3 :⇒ An evaporator is fed with 15000 kg/h of a solution containing 10% NaCl, 15% NaOH, and rest water. In the operation water is evaporated and NaCl is precipitated as crystals. The thick liquor leaving evaporator contains 45% NaOH, 2% NaCl and rest water. Calculate.

①. kg/h water evaporated. ⓑ kg/h salt precipitated ⓒ kg/h th liquor.

Basis ⇒ 15000 kg/h of weak solution fed to the evaporator

15000 kg/h Feed solution (10% NaCl, 15% NaOH) → Evaporator

Evaporator → water evaporator (x)

Evaporator → Thick liquor, 45% NaOH, 2% NaCl (y)

Evaporator → NaCl precipitated (z)

Let x, y, and z be the kg/h of water evaporated, thick liquor and NaCl precipitated.

Overall Material Balance :-

Feed solution (kg/h) = water evaporator (kg/h) + Thick liquor (kg/h) + NaCl precipitated (kg/h)

$$15000 = x + y + z$$

Material Balance of NaOH :-

NaOH in feed solution = NaOH in Thick liquor.

$$15000 \times 0.15 = 0.45y$$

$$\boxed{y = 5000 \text{ kg/h}}$$

Material Balance of NaCl. :-

NaCl in feed solution = NaCl in precipitated + NaCl in thick l.

$$15000 \times 0.1 = 0.02 \times 5000 + z$$

$$z = \frac{1500 - 100}{}$$

$$\Rightarrow \boxed{z = 1400} \text{ kg/h}$$

We have

$$x + y + z = 15000$$

$$x + 5000 + 1400 = 15000$$

$$x = 15000 - 5000 - 1400$$

Or ⇒ $\boxed{x = 8600 \text{ kg/h}}$

Check :⇒

Material Balance of water :-

water in feed solution = water evaporated + water in thick liquor.

$$0.75 \times 15000 = 8600 + 0.53 \times 5000$$

$$11250 = 8600 + 2650$$

$$11250 = 11250$$

As L.H.S = R.H.S calculation done are correct.

water evaporator = 8600 kg/h

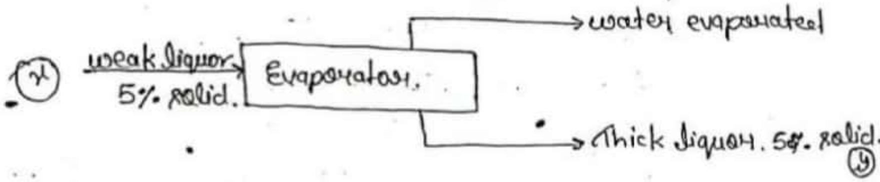
Thick liquor obtained = 5000 kg/h

NaCl precipited as crystals = 1400 kg/h Answer

Exp. No. 3.4 An evaporator system concentrating a week liquor from 5% to 50% solid handles 100 kg of solid per hour. If the same system is to concentrate a weak liquor from 4% to 35%. Find the capacity of the system in terms of solid that can be handled per hour assuming water evaporation capacity to be same in both the cases.

Solve

Case-I : Basis :- 100 kg/h of solid handling capacity of the evaporator.



Let x be the kg/h of weak liquor then we have.

$$0.05\,x = 100$$

$$x = \frac{100}{0.05}$$

$$x = 2000 \text{ kg/h}$$

Let y be the kg/h of thick liquor then we have.

$$0.5y = 100$$

$$y = 200 \text{ kg/h}$$

Material Balance :-

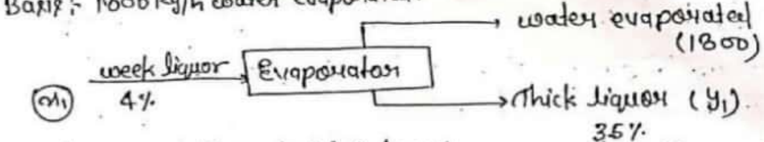
Kg/h weak liquor = kg/h thick liquor + kg/h water evaporator.

$$2000 = 200 + \text{kg/h water evaporator.}$$

$$\boxed{\text{water evaporated} = 1800 \text{ kg/h}}$$

water evaporation capacity in case - II i.e in process of concentration of solution from 5% solid to 35% solid is same as case-I ie 1800 kg/h

Basis :- 1800 kg/h water evaporated.



Then, Overall Material Balance :-

$$x_1 = y_1 + 1800$$

Material Balance :-

$$0.04\,x_1 = y_1 \times 0.35$$

$$x_1 = \frac{0.35}{0.04}\,y_1$$

$$x_1 = 8.75\,y_1$$

put the value of x_1 from equation (2) in equation (1) and solve for y_1

$$8.75\,y_1 = y_1 + 1800$$

$$8.75\,y_1 - y_1 = 1800$$

$$\boxed{y_1 = 232.26 \text{ kg/h}}$$

$$x_1 = 232.26 + 1800$$

$$\boxed{X_1 = 2032.26 \text{ kg/h}}$$

we have :

solid in weak liquor = 2032.26×0.04

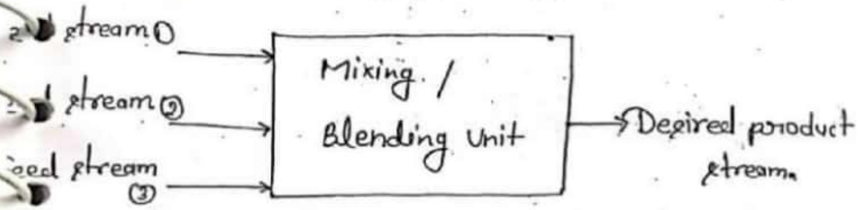
= 81.3 kg/h

Solid in weak liquor in case II = 81.3 kg/h **A**

Mixing / Blending :⇒

Mixing chemical Industry में carried out करने वाली बहुत Important operation है जिसमे weak व concentrated stream. (liquid - liquid, liquid - solid) etc को Mixing के द्वारा किसी Agitator vessel में Mix करके desired quantity का product प्राप्त किया जाता है।

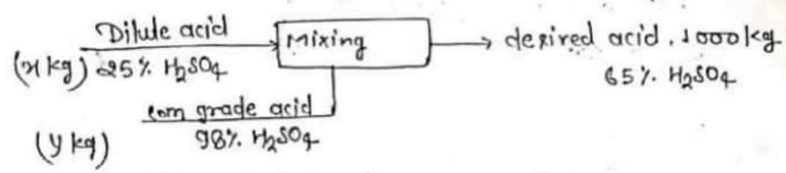
Let as consider,
Product stream को Blending / mixing द्वारा stream ① ② & ③ से प्राप्त किया जाता है।



Over all Material Balance :—

Feed stream ① + Feed stream ② + Feed stream ③ = Desired product stream

A + B + C = Desired product stream.



Overall Material balance on system.

$$x + y = 1000 \quad \text{— ①}$$

applying the material balance of H_2SO_4

$$0.25x + 0.98y = 0.65 \times 1000$$

$$0.25x + 0.98y = 650 \quad \text{— ②}$$

$$0.98y = 650 - 0.25x$$

$$y = \frac{650 - 0.25x}{0.98}$$

$$y = 663.26 - 0.255x \quad \text{— ③}$$

y का मान समी० ① मे रखने पर -

$$x + (663.23 - 0.225x) = 1000$$

$$x + 663.23 - 0.225x = 1000$$

$$0.775x = 336.77$$

$$\boxed{x = 434 \text{ kg}}$$

$x + y = 1000$

$434 + y = 1000$

$y = 1000 - 434$

$\boxed{y = 566\ kg}$

dilut acid required = 434 kg.

commer ~~acid~~ grade acid required = 566 kg.

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Material Balance with Chemical Reaction (4)

– जब किसी Raw Material से Desire product बनाया जाता है तो उसके Manufacturing के Material मे Physical और chemical दोनों के changes को consider किया जाता है। process के Material Balance मे जहाँ पर chemical Reaction invalv होता है। तो वह chemical Reactor मे Design के लिए बहुत ही Important होता है।

Material Balance with chemical Reaction unit process के अन्तर्गत आता है जिसमे हमको chemical व Physical दोनों प्रकार के changes को consider करके problems को solve होता है।

chemical Reaction से invalve process मे varius component का total mass जो Reactor मे enter करते हैं वे Reactor को छोड़ने वाले total mass के equal होते हैं but. component के Mole का योग जो Reactor को छोड़ने वाले Moles के equal नही होता है। तो इस case मे Material Balance करने के लिए Moles unit मे basis of Calculation का use करते हैं।

Stoichiometry :⇒

Stoichiometry chemistry का एक section है जो किसी chemical Reaction मे Desired quantitative dada determine करने के लिए Reactants (अभिकारक) और product (उत्पाद) के बीच Relationship को व्यक्त करता है।

Stoichiometery Equation :⇒

किसी chemical Reaction का stoichiometery equation एक statement है जो किसी Reaction मे भाग लेने वाले Reactant व product के Mole को Indicate करते है।

Exp:- $CO + 2H_2 \longrightarrow CH_3OH$

इस Reaction मे carbon Monooxide (CO) का 1 Mole H_2 के दो Mole से React करके Methye Alchohale (CH_3OH) के 1 Mole का निर्माण करता है।

Stoichiometery cofficient :⇒

Stoichiometery cofficient एक Number है जो किसी chemical Reaction मे invalve प्रत्येक component को Introdus करता है। Ex:- $CO + 2H_2 \longrightarrow CH_3OH$

इस chemical Reaction मे CO का stoichiometery cofficien 1, H_2 का 2 व CH_3OH का 1 है।

Stoichiometery Ratio :⇒

किसी Balonce chemical Reaction मे दो Mole के stoichiometery coefficient के अनुपात को stoichiometery Ratio कहते है।

$$CO + 2H_2 \longrightarrow CH_3OH$$

दिये गये equation मे CO व H_2 का Ration = $\frac{1}{2}$

Limiting Reactant and Component
सीमान्त अभिकारक

Limiting Reactant जो smaller ~~tacometry~~ stoichiometric मे उपलब्ध होता है अर्थात वह Reactant जो किसी other Reactant के साथ combine और React होने के लिए अधिक मात्रा मे नही present है तो इस प्रकार के Reactant को हम limiting Reactant कहते है।

Limiting Ractant किसी chemical Raction मे वह Reactant है जिसके consum हो जाने पर chemical Reaction रुक जाती है।

वह Reactant जो completely used up या Reacted है उसे limiting Reactant कहते है क्योकि जो भी product बनना है उसमे use होने वाले Reactant की अपना एक limitation है।

Exp:
$$C_2H_4 + \frac{1}{2}O_2 \longrightarrow C_2H_4O$$

Ethylene oxide के production मे जो Athylene के oxida-
...

वह हमेशा excess quantity मे होता है तथा Athylene limited quantity ~~मे होता है। इसमें हम Reactant~~ Athylene को limiting Reactant कहते है।

37

Excess Reactant :⇒

किसी chemical Reaction मे जो वह Reactant जो ~~Reactant~~ Rxn के रुक जाने पर भी बचे रहते है उसे Excess Reactant कहते है।

In other word
ऐसे Reactant जो limiting Reactant के साथ React करने के लिए excess मे होते है उसे Excess Reactant कहते है।

$$C_2H_4 + \frac{1}{2}O_2 \longrightarrow C_2H_4O$$

Athylene oxide के production मे Athylene के oxidation के द्वारा ऑक्सीजन जो Reactor मे fed हो रहा है हमेशा Axcess मे होता है।

Percent Excess :⇒

Axcess Reactant जो सामान्यत: Reaction मे involve है उसे Percent excess के रूप मे Expsace (व्यक्त) किया जाता है।

Let us consider a reaction -

$$A + B \longrightarrow C$$

where in B is the excess reactant —

$$\text{Percent Excess of } B = \left[\frac{\text{Moles of B supplied or fed} - \text{Mole of B theoretically required}}{\text{Moles of B theoretically required}}\right] \times 100$$

Reactor में feed किये गये excess Reactant की quantity limiting Reactant पर Based होती है।

1- imp
Conversion :⇒ Conversion हमेशा limiting reactant पर based होता है और यह किसी भी chemical reaction में degree of completion के बारे में information देता है।

2) Conversion कुछ reactant का fraction होता है जो product convert होते हैं।

Let's consider a chemical reaction

$$A + B \longrightarrow C$$

जहाँ A is the limiting reactant and B is the excess reactant then -

3) किसी chemical reaction में limiting reactant का वह amount (Mole/Mass) जो react होता है। और जो amount reactor में feed किया जाता है। इसके अनुपात को conversion या fraction conversion कहते हैं।

किसी limiting reactant का Percentage conversion वह है जब A के reacted amount को reactor में feed किये गये A के amount के साथ Percent के रूप में व्यक्त किया

$$\text{Conversion या Fractional con.} = \frac{\text{Mole of A reacted}}{\text{Mole of fed into the reactor}}$$

$$\%\ \text{conversion} = \frac{\text{Mole of A reacted}}{\text{Mole of A fed into the reactor}} \times 100$$

imp 2010
Degree of completion :⇒ किसी chemical reaction का degree of completion उस reaction की limiting reactant का product में convert होने की जानकारी देता है अर्थात degree of completion यह बताता है। किसी reaction में limiting reactant का कितना amount product में convert हो रहा है।

imp 2010
Yield and selectivity :⇒ सारी chemical process industry में केवल एक ही objective होता है वह होता है। Produce a desired product.

जैसे कि हम जानते हैं। raw material को product बनने के लिए कई सारी series व Parallel reaction (side-reaction) से गुजरना पड़ता है। और इन side reaction's की वजह से underside product बन जाते हैं। जो process की economic पर reverse effect रखते हैं। तो In such case इन side reaction को depress रखने के लिए हम field में selective catalyst का use करते हैं।

i- Yield and selectivity को multiple reaction के case में use किया जाता है।

Let's consider-

$A + B \longrightarrow C$

$C + B \longrightarrow D$

In the above reaction C is the desired product and the D is undesired product. A is the limiting reactant and B is the across reaction is yield of the desired product (C) is given by.

$$\text{yield of } C = \frac{\text{Moles of A reacted to produce C}}{\text{Mole of A total reacted}} \times 100$$

So. किसी desired product का yeild limiting reatant की वह quantity है जो इसे produce करने के लिए limiting reactant के totally reacted quantity को percent मे व्यक्त करता है।

It means, किसी reaction मे A के reacted amount C को produce करने के लिए और reactant A के totally reacted amount के अनुपात को yield कहते है।

Selectivity of C related to D :⇒ किसी chemical reaction मे produce desired product के moles तथा produce undesired product के moles के अनुपात को selectivity कहते है। for the chemical parallel reaction.

$A \rightarrow C$ and $A \rightarrow D$

selectively is defined as.

$$\text{selectivity of C relative to D} = \frac{\text{Moles of C (desired product) Formed}}{\text{Moles of D (undesired product) Formed.}}$$

दूसरे शब्दो मे, किसी reaction मे limiting reactant के desired product को produce करने व limiting reatant के undesired product को produce करने के अनुपात को selectivity कहते है। अगर yeild 100% हो, तो selectivity 1 होगी।

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= II year

Govt. Polytechnic Sutawali

Amaroha

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Ex :⇒ The carbon monoxide is reacted with hydrogen to produce methanol. Calculate from the reaction.

(a). The stoichiometric ratio of H_2 to CO.

(b): kmol of CH_3OH produced per kmol CO reacted.

(c) :⇒ The weight ratio of CO to H_2 if both are fed to reactor in stoichiometric proportion.

(d):- The quantity of CO required to produce 1000 kg of CH_3OH.

Solve :- Reaction $CO + 2H_2 \longrightarrow CH_3OH$

Stoichiometric coefficient of CO = 1

Stoichiometric coefficient of H_2 = 2

∴ Stoichiometric ratio of H_2 to CO $= \frac{2}{1} = 2$ Ans

1 kmol CO ≡ 1 kmol CH_3OH

CO reacted to produce 1 kmol $CH_3OH = \frac{1}{1} \times 1 = 1$ kmol.

= 1 kmol Ans

CO fed to the reactor = 1 kmol.

∴ CO fed to the reactor = 1 × 28 kg.

∴ H_2 fed to the reactor = 1 kmol = 2×2 kg.

= 4 kg.

∴ weight ratio of CO to H_2 fed $= \frac{28}{4} = 7$ Ans

1 kmol CO ≡ 1 kmol CH_3OH

28 kg CO ≡ 1 × 32 kg CH_3OH

Ex 4.2: Ammonia is produced by the following reaction.

$N_2 + 3H_2 \longrightarrow 2NH_3$

calculate.

(a). The molal flow rate of hydrogen corresponding to nitrogen feed rate of 25 kmol/h if they are fed in the stoichimetric proportion.

(b): The kg of ammonia produced per hour if percent conversion is 25 and Nitrogen feed rate is 25 kmol/h.

Solve Basis- 25 kmol/h of N_2 fed to reactor.

Reaction :- $N_2 + 3H_2 \longrightarrow 2NH_3$

Stoichometric proportion of N_2 to H_2 from the reation.

i.e. $1/3 = N_2/H_2$

1 kmol N_2 ≡ 3 kmol H_2

Mol Flowrate $H_2 = 3 \times N_2$

$= 3 \times 25$

∴ Mol Flowrate H_2 = 75 kmol/h Ans

$$\% \text{ Conversion} = \frac{\text{Moles } N_2 \text{ reacted}}{\text{kmol } N_2 \text{ fed per hour}} \times 100$$

$$\text{Moles } N_2 \text{ reacted} = \text{kmol } N_2 \text{ fed per hour} \times \frac{\% \text{ Conversion}}{100}$$

$$= 25 \text{ kmol/h} \times \frac{25}{100}$$

$$= 6.25 \text{ kmol/h}$$

From the reaction -

1 kmol N_2 ≡ 2 kmol NH_3

NH_3 produce per hour to $N_2 = 2 \times 6.25$

= 12.50 kmol/h

Amount of NH_3 produced = 12.50 × Molecular weight of NH_3

= 12.50 × 17

= 212.5 kg/h **Ans**

Ex (4.9) :⇒ In manufacture of sulphur trioxide, feed to a reactor consists of 50 kmol SO_2 and 150 kmol air. Calculate the % excess air is used.

Basis : 50 kmol of SO_2 feed to a reactor.

Reaction : $SO_2 + \frac{1}{2}O_2 \longrightarrow SO_3$

$$\%\ \text{excess} = \frac{O_2 \text{ in supplied air} - O_2 \text{ theoretically required}}{O_2 \text{ theoretically required}}$$

air used = 150 kmol.

Air contains 21 mole % O_2.

O_2 in the supplied air = 150 (0.21) = 150 kmol

= 31.5 kmol.

1 kmol $SO_2 \equiv$ 0.5 kmol O_2

The stoichiometric proportion of SO_2 to O_2 = 1/0.5

Theoretical requirement of O_2 = 0.5 × SO_2

= 0.5 × 50

= 25 kmol.

$$\%\ \text{excess } O_2 \text{ used} = \frac{31.5 - 25}{25} \times 100$$

= 26% **Ans**

Ex (4.10) :⇒ A combustion reactor is fed with 50 kmol/h of butane and 2100 kmol/h of air calculate the % excess air used.

Solve

Basis : 50 kmol/h of butane.

Reaction : $C_4H_4 + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$

$$\%\ \text{excess} = \frac{O_2 \text{ in supplied air} - O_2 \text{ theoretically required}}{O_2 \text{ theoretically required}} \times 100$$

air flow rate = 2100 kmol/h

Air contains 21 mole % O_2

O_2 in the supplied air = 2100 (0.21)

= 441 kmol/h

$\frac{13}{2}$ kmol $O_2 \equiv$ 1 kmol C_4H_4

The stoichiometric proportion of C_4H_4 to O_2 = $\frac{1}{13/2} = \frac{1}{6.5}$

Theoretical requirement of O_2 = $\frac{13}{2} \times C_4H_4$

= 6.5 × 50 kmol/h

= 325 kmol/h

$$\%\ \text{excess } O_2 \text{ used} = \frac{441 - 325}{325} = \frac{116}{325}$$

= 0.3569 × 100

= 35.69 %

= 35.7 % **Ans**

Humidity :

एक Kg dry Air में जितना Kg water (moisture) vapour Contained होता है वही उस air की Humidity कहलाता है

Humidity air में मौजूद water vapour की मात्रा को बतलाता है।

इसे H से denote करते है।

$$H = \frac{\text{Kg of water vapour}}{\text{Kg of dry Air}}$$

Generally water vapour का molecular weight 18 तथा Air का molecular wt 29 लिया जाता है।

Humidification

2010

Humidity :→ (आद्रता)

air मे water vapour की मात्रा को — Humidity कहते है। water vapour water का gases state होता है। Humidity air मे मौजूद water vapour की quantity को indicate करता है।

Humidification :→ Humidification एक operation है जिसमे gas stream मे vapour के Amount को increase किया जाता है। Humidifier Humidification के process पर कार्य करता है और इसका work dry gas या gas stream मे water vapour contain की मात्रा को increase करता है।

Dehumidification :⇒ Dehumidification भी एक प्रकार का operation है जिसमे gas stream मे water vapour ~~contain की~~ amount ~~मात्रा को~~ decrease किया जाता है। Dehumidifier Dehumidification पर कार्य करने वाला equipment है जो किसी gas stream मे water vapour की मात्रा को कम करता है।

⇒ इस operation मे हम liquid को gas phase मे Transfer करते है। जिससे gas को liquid के ऊपर से pass कराया जाता है। जिससे gas phase मे vapour के contain increase हो जाते है।

⇒ किसी दीये गये Tempr व pressure पर एक gas Phase को liquid के contact मे लाया जाता है। जो कि उनमे insoluble होता है। तो liquid के Molecules evaprate होना प्रारम्भ कर देते है।

⇒ Liquid का amount gas phase मे इस प्रकार होता है कि evaporation द्वारा liquid से gas phase मे Material का Transfer, gas phase से liquid मे होने वाले Material के Transfer change नहीं होता है।

Humidity के measure करने ~~के लिए बहुत से तरीके है।~~

1). **Absolute humidity** :⇒

एक ~~kg dry gas में उपस्थित~~

It is defined as the weight of vapour, present in a unit weight of dry gas.

$$H = \frac{\text{Kg Vapour}}{\text{kg dry gas.}}$$

किसी air water vapour mixture के लिए H की unit kg water vapour / kg. dry होती है।

Molar Humidity :⇒ It is defined as the ratio of moles of vapour to the moles of dry gas.

It is denoted by H_m

$$H_m\,(S_m) = \frac{\text{KMol vapour}}{\text{KMol dry gas.}}$$

for air - water system, vapour gas mixture.

$$\boxed{H = H_m\left(\frac{M_A}{M_B}\right)}$$

where:-

M_A = Molecular weight of water = 18

M_B = Molecular weight of air = 29

$$H = H_m\left(\frac{18}{29}\right) = 0.6207\, H_m$$

In vapour - gas mixture at total pressure of P. If P_A is the partial pressure of vapour and P_B in the partial pressure of gas. 43

$$H_m = \frac{n_A}{n_B} = \frac{P_A}{P_B} \qquad \because P = P_A + P_B$$

$$\boxed{H_m = \frac{P_A}{P - P_A}} \qquad \because P_B = P - P_A$$

where- P_A = partial pressure of water vapour, KPa.

P = Total pressure of the system.

V.V. Imp. Exm 2011, 2010, 13

Relative humidity / percentage relative humidity :⇒ **(relative Saturation)** :⇒

It is defined as the ratio of the partial pressure of condensable vapour in the gas phase to the vapour pressure of liquid at D.B. (Dry Bulb Tempr)

उपाया

~~Relative humidity of~~ ~~a water vapour in gas (phase) to vapour pressure of a pure liquid~~

Relative humidity of a water vapour gas mixer is defin as the Ratio of Partial pressure of the water vapo in gas phase to Vapour pressure of a pure liqui at a dry bulb tempr. —

$$\boxed{\% RH (R_s) = \frac{P_A}{P_S} \times 100}$$

where,

P_A = partial pressure of vapour in gas phase

P_S = Vapour pressure of pure liquid at DBT

For air - Water system (P_S) = V.P. of water at DBT

Humid Heat :→

Humid Heat is define as the heat capacity of one kg of dry gas and water vapour contained in it.

It is denoted by "C_s"

$$\boxed{C_s = 1.006 + 1.84\,H}\ \text{kJ}/(\text{kg dry air} \cdot \text{K})$$

Exp:- 7.13 :- The dry bulb Temperature and dew point of ambient air were found to be 302 K (29°C) and 291K 289K (18°C) respectively. Barometer read 100 kPa.

calculate :

1. The absolute molal humidity.
2. The absolute humidity.
3. The % RH.
4. The % saturation.
5. The humid heat and
6. The humid volume.

Sol:- (i) partial pressure of water at 289 K = 1.818 kPa. = P_A

(ii) Vapour pressure of water at 302 K = 4.243 kPa.

(1).

$$H_m = \frac{P_A}{P - P_A}$$

$$H_m = \frac{1.818}{100 - 1.818}$$

$$\boxed{H_m = 0.0185\ \frac{\text{kmol water vapour}}{\text{kmol dry air}}}\ \text{Ans}$$

(2). The absolute humidity.

$$H = H_m \left(\frac{M_A}{M_B}\right) \qquad \because M_A = 18,\ M_B = 29$$

$$H = H_m \left(\frac{18}{29}\right)$$

$$H = H_m \times 0.6207$$

$$H = 0.0185 \times 0.6207$$

$$\boxed{H = 0.01159\ \frac{\text{kg water vapour}}{\text{kg dry}}}\ \text{A}$$

(3). The % RH.

$$\% RH = \frac{P_A}{P_S} \times 100$$

$$= \frac{1.818}{4.243} \times 100$$

$$= 0.42658 \times 100$$

$$= 42.658.\ \text{Ans}$$

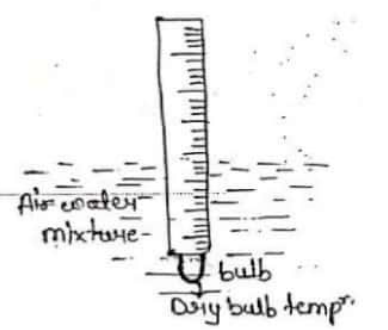
(4). The % saturation :-

The Humid heat,

$$C_s = 1.006 + 1.84H$$
$$= 1.006 + 1.84 \times 0.01159$$
$$= 1.0273$$
$$\boxed{C_s = 1.02\ kJ/(kg\ dry\ air.K)}$$

2011, 10

DBT (Dry Bulb Temp) :⇒ किसी भी गैस (gas) और vapour के mixture (Air-water vapour mixture) का वह temp^r जो साधारण रूप से इसके अन्दर thermometer का bulb कुछ देर तक डुबाये रहने पर प्राप्त होता है। इसे हम इस Mixture का DBT कहते हैं।



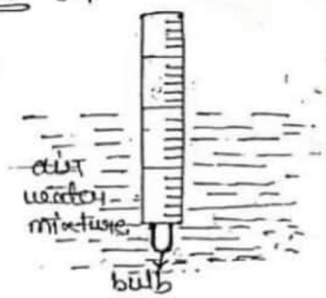
जब हम Dry bulb thermometer को simply तरीके से air और water vapour के mixture मे डालते हैं। तथा हिलाते-डुलाते हैं। और फिर जो भी temp^r प्राप्त होता है। इसे Dry Bulb Temp^r (DBT) कहते हैं।

⇒ Dry bulb temp^r हमेशा wet bulb temp^r से high होता है। परन्तु saturation condition मे DBT, WBT के equal होता है। था हो जाता है।

45

2011, 10

Wet bulb temperature :⇒



Adiabatic condition मे अगर किसी liquid (vapour) की अल्प मात्रा को अधिक मात्रा मे प्रवाहित होने वाली unsaturated air या gas मे evaporate होने के लिए खुला छोड़ दिया जाये तो धीरे-धीरे उस liquid का temp^r कम हो जाता है। और एक ऐसी स्थिति आती है। जब liquid का temp^r कम नही होता है। (अर्थात steady state) उस स्थिति मे measure किये गये temp^r wet bulb temperature (WBT) कहते हैं।

Unsaturated condition में $DBT > WBT$

Saturated condition में $DBT = WBT$

Dew point :⇒ constant Humidity पर वह temp^r जिस पर कोई भी air-water vapour का Mixture saturated होकर condense होने लगता है। Dew point कहलाता है।

⇒ इसमे partial pressure को fixed रखते हैं। तथा temp^r को कम (used) करते हैं। जिससे vapour pressure कम होकर partial pressure के equal हो जाता है। और air-vapour water का mixture saturate हो जाता है। $\boxed{\bar{P}_A = P_A}$

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Humid Volume :⇒

जिस temp व pressure पर gas या air है, उसी tempr व pressure पर unit mass of dry air तथा इसमे present water vapour के द्वारा जितना volume occupied होता है। वही उसका humid volume कहलाता है। इसे (V_H) से denote करते हैं।

Kmole dry air $= \frac{1}{29}$

Kmole water vapour $= \frac{H}{18}$

total mol $= \left(\frac{1}{29} + \frac{H}{18}\right)$

∵ 1 kmol NTP पर Volume $= 22.4\,l$.

∴ $\left(\frac{1}{29} + \frac{H}{18}\right)$ kmol NTP पर Volume $= \left(\frac{1}{29} + \frac{H}{18}\right) 22.4$

we know that.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$P_1 = 1\,atm = 101.325\,kpa$.

$V_1 = 22.4\left(\frac{1}{29} + \frac{H}{18}\right)$ $V_2 = V_H$

$T_1 = 273\,K$ $T_2 = T$

$P_2 = 101.325$

$$V_H = \frac{101.325 \times 22.4\,(1/29 + H/18) \times T}{273 \times 101.325}$$

$$\boxed{V_H = \frac{22.4\,T}{273}\left(\frac{1}{29} + \frac{H}{18}\right)}$$

Unit process :⇒

Qn. वह process जिसमे materials मे phisical changes के साथ-साथ chemical changes मे occurs (होना) होते है इस प्रकार के process को unit process कहते हैं।

Unit process के दौरान कई तरह के chemical reaction होती है जो निम्न है –

Exp:-
① Oxidation
② Hydrogenation
③ Neutrilization
④ ~~Alkalization~~ Clorination ~~clor~~ Halogenation

Oxidation :⇒

Oxidation एक chemical reaction है जिसमे oxigen के molecules एक different type के substance से क्रिया करके एक नया substance बनाते हैं।

Exp:-

$$CH_3CHO + \frac{1}{2}O_2 \longrightarrow \underset{\text{acetic acid}}{CH_3COOH}$$

Hydrogenation :⇒

Hydrogenation किसी substance का एक chemical reaction है जिसमे Hydrogen किसी catalist के उपस्थिति मे किसी substance से क्रिया करके उसे एक नये product मे convert करता है।

$$CO_2 + 3H_2 \longrightarrow CH_3OH + H_2O$$

Clorination :⇒ (क्लोरीनीकरण) या (हैलोजनीकरण)

Hylogenation :⇒ Clorination भी chemical reaction का एक part है जिसमे clorin compound ~~किसी~~ सूर्य की रोशनी की उपस्थिति मे किसी organic compound के साथ क्रिया करके नया substance बनाता है।

Exp:-

$C_6H_6 + Cl_2 \xrightarrow{\text{inpresence of sunlight}} C_6H_5Cl + HCl$

mono chloro benzene.

$C_6H_5Cl + Cl_2 \longrightarrow C_6H_4Cl_2 + HCl$

dichloro benzene

Nutralization :⇒ Nutralization एक प्रकार का chemical ~~reatic~~ reaction है जिसने acid base के साथ क्रिया करके salt formation करता है और water as a by product बनाता है।

Exp ⇒

$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

sodium acitate.

47

Ques:- Calculate the following chemical reaction -

$C_2H_4 + 2Cl_2 \longrightarrow C_2HCl_3 + H_2 + HCl.$

(a):- By the stoichiometric of Cl_2 to C_2H_4.

(2):- if 4 kmol Cl_2 are used per kimol C_2H_4. find the percent of ~~Cl_2~~ axess of Cl_2

(3): The amount of HCl producted from 50 kg of C_2H_4 assuming reaction goes to completion.

Solve Reaction. $C_2H_4 + 2Cl_2 \longrightarrow C_2HCl_3 + H_2 + HCl.$

stoichiometric coefficient of $C_2H_4 = 1$

stoichiometric coefficient of $Cl_2 = 2$

(a). stoichiometric ratio of Cl_2 to $C_2H_4 = \frac{2}{1} = 2$

$$\% \text{ excess} = \frac{\text{Mole of } Cl_2 \text{ supplied} - \text{Moles of } Cl_2 \text{ theoretically supplied}}{\text{Moles of } Cl_2 \text{ theeoretically supplied}} \times 100$$

$1 \text{ kMol } C_2H_4 \equiv 4 \text{ kmol } Cl_2$

~~C_2H_4 reacted to produce 1 kmol Cl_2 = $\frac{4}{1}$ = 4 kmol.~~

(b) $\% \text{ excess} = \frac{4-2}{2} \times 100 = 1 \times 100$

$= 100\%$ Ans -

(c):

RECYCLE OPERATIONS

Recycling किसी भी chemical Industry में further (आगे) processing के लिए process Unit को छोड़ने वाले stream के एक portion को पुनः intrention पर लौट कर जाने को कहा जाता है और वह product stream फिर से fresh stream के साथ process Unit में inter करता है।

Recycling Operation Commonly Unit operation and Unit process मे निम्नलिखित objective को प्राप्त करने के लिए Use किया जाता है –

1. Recycling Operation को valuable reactants के maximum के Utilization के लिए use किया जाता है।
2. Recycling operation को equipment व operation के performance को Improvement करने के लिए Use किया जाता है।
3. इसे system को better operating condition provied कराने के लिए use किया जाता है।

   As:- Pressure, Tempr. Concentration.

4. इसके द्वारा जो Heat exit steam के साथ loss हो जाते है। उसको फिर से Utilis करने के लिए use किया जाता है। product की selectivity को Improve करने के लिए भी Recycling Operation किया जाता है।
5. product के quality को Enrichment product की purity. आदि के लिए Recycle का use किया जाता है।

E.g :→

(i). Distillation operation मे distillate का कुछ part purity बढ़ जाती है।

(ii). chemical reaction मे Regeneration के बाद spent (खर्च) या exit catalyst को Reactor मे reuse के लिए वापस भेज दिया जाता है।

(iii). मेथेनॉल के Manufacturing मे separation के बाद product stream से वह gas stream जो reactor को छोड़ते है। उन्हे फिर से Recycle करके उनका Utilization किया जाता है।

(iv). Drying Operation मे Hot air वह Major portion है जो Dryer को छोड़ता है उसे conserve Heat के लिए पुनः Recirculate कर लिया जाता है। जो Heat exit air मे loss हो रहा है। उसके Utilization के लिए।

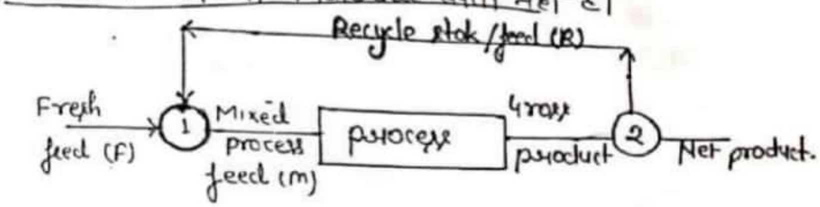
(v). अमोनिया, मेथेनॉल, एथेनॉल के Manufacturing में complete Conversion को achieving करने के लिए, yield production को Minimum करने के लिए व High rate पर reaction को effect करने के लिए Recycle operation का use किया जाता है।

2010

Recycle Stream :→

किसी भी chemical process Industry मे Recycle stream एक process stream है। जिसमे जो Material process Unit को छोड़ रहा है। उसका कुछ portion उसी unit के entrance पर वापस लौट जाता है।

Recycle Operation steady state condition के अन्तर्गत carry किया जाता है। जिसमे process के अन्दर या Recycle stream मे कोई भी Material बचता नही है।



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Purging Operation :⟹

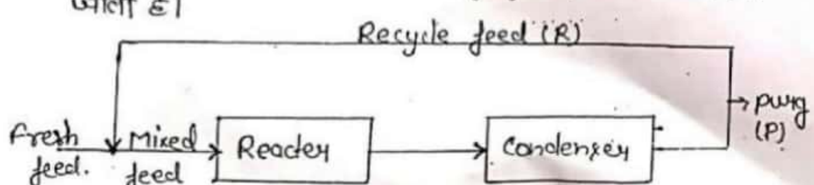
इस operation मे Recycle Operation मे Recycle stream का एक fraction (part) stream मे मौजुद Unwanted gases के concentration को एक desired limit तक रोकने के लिए bled-off (निकालना) किया जाता है।

जब कभी भी unwantage gases और inert fresh stream के present हो, तो inert recycle fluid stream के साथ accumulates हो जाते है। और यदि यह inert tolerable limit से exceeds (बढ़) कर जाता है। तो वह reaction मे conversion को बुरी तरह affect करता है। तो इसको ध्यान मे रखते हुये reactor मे inert से concentration को specific limit तक control किया जाता है।

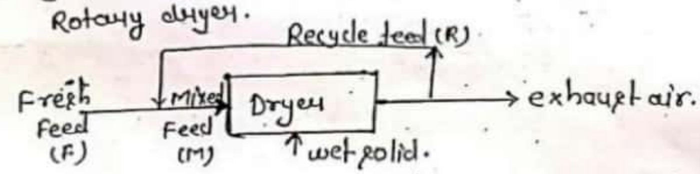
purging operation chemical process Industry मे inert व unwanted gases को remove करने के लिए recycle loop मे convert किया जाने वाला बहुत ही common practical है

For steady operation के लिए inert in fresh feed other wise, inert product के साथ accumulate होगा और conversion perfect करेगा।

E.g :- (I). अमोनिया के synthesis मे या Manufacture मे recycle loop मे CH_4 बनने को purging द्वारा control किया जाता है।



E.g (II). Recycle of air in drying of solid in operation of Rotary dryer.



Purg Stream :⟹ ये Recycle stream का fraction है जो Recycle loop मे inert को accumulate होने से रोकने के लिए continuously bled-off (remove) होता है।

ऊपर - Exp: (I), (II). है।

Imp

Recycle Ratio :⟹

Recycle Ration is define as the ration of the quantity of recycle feed (R) to the quantity of fresh feed (F).

$$\boxed{\text{Recycle Ratio} = \frac{R}{F} \frac{(\text{recycle feed of quantity})}{(\text{fresh feed of quantity})}}$$

Combine feed Ratio :⟹

Combine feed ratio is define as the ratio of the quantity of Mixed feed (M) to the quantity of fresh feed. (F)

$$\boxed{\text{Combine feed Ratio} = \frac{M}{F} \frac{(\text{qantity of Mixed feed})}{(\text{qantity of fresh feed})}}$$

Purge Ratio :→

purge Ratio is defined as the ratio of quantity of purge stream (P) to the quantity of recycle feed (R).

$$\boxed{\text{purg Ratio} = \frac{P}{R}\ \frac{(\text{qantity of purge stream})}{(\text{quantity of recycle feed})}}$$

Tie substance :-

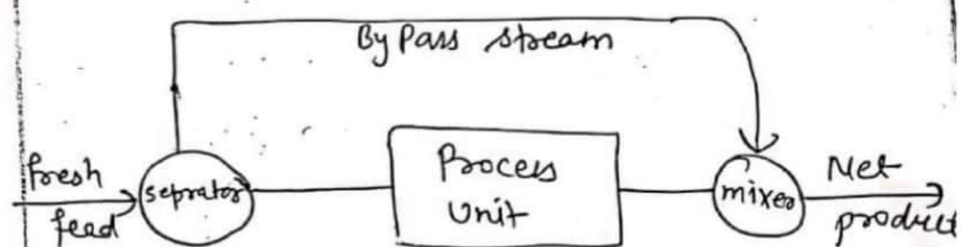
A component that goes directly from an input stream to an output stream without any chemical change is called tie substance.

It is not ultering the rate of reaction.

It helps to measure the flow of process stream.

By-Pass stream.

By-Pass stream is a stream that skips one or more stage of the process and goes directly to another down stream stage.



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1-02-16

51

Energy Blance

Introduction :⇒

Energy किसी भी object की property है जो किसी दुसरे object को transfer हो सकती है या different type

परन्तु न तो create किया जा सकता है और न ही d.

In simple word the ability of the system to perform work called energy.

Energy का कोई एक simple comprehensive (विस्तृत) deffination देना बहुत ही मुश्किल है क्योंकि इसके बहुत से from होता है।

(1): Energy का वह from जो किसी system से related होता है वह है potential energy, kinetic energy, pressure energy, internal energy, magnetic energy, etc.

(2): Energy का वह from जब वह किसी process से assosiated होता है तो इसमे इसकी processing के कारण होने वाली energy पुर्णत Heat and work है।

Heat :⇒ Heat एक प्रकार की energy है। जो किसी Hot source और cold reciver के बिच मे Transfer होती है। Heat energy का ही एक from है जो Temperature different के कारण एक body से दुसरे body मे

Work :→ In Mechanics किसी force द्वारा work done वह है जो force and force द्वारा Applied direction मे Move की distance के गुणनफल को कहते है। work को 'W' से denoted करते है। इसका M

$$W = F \cdot d.$$

Work भी energy का एक form है -
System and surrounding के बीच जो भी Heat transfer होती है वह Heat and work के कारण होती है। system मे जो भी Heat add की जाती है वह positive होती है। work done भी positive लिया जाता है।

Calori :⇒ 1 gram water का Tempr 1°C बढ़ाने के लिए जितनी quantity of Heat की आवश्यकता होती है उसे calori कहते है।

$$1\ \text{Calori} = 4.18\ \text{Joule}$$

Sensible Heat :- Sensible Heat किसी substance का वह Heat है जो उस substance का Tempr बढ़ाने के लिए उसे transfer की जाती है।

Heat Capacity :- 1kg substance का Tempr 1°C से बढ़ाने के लिए जितने Heat की मात्रा की आवश्यकता होती है उसे Heat capacity कहते है। Heat capacity को generally unit mass या unit

Heat Capacity :⇒ 1kg substance का Tempr 1°C से बढ़ाने के लिए जितने Heat की मात्रा की आवश्यकता होती है। इसे Heat capacity कहते है। Heat capacity को generally unit mass या unit mole basis पर expressed किया जाता है। जब यह Mole basis पर व्यक्त किया जाता है। तो इसे Molal/molar Heat capacity कहते है। इसे, It is denoted by "C". It has the unit of KJ/(Kmol.K). or KJ/Kg°C

$$\boxed{C = \frac{dQ}{dT}}$$

Heat capacity is of two types.

(i). **Heat capacity at constant Volume :→** यदि किसी substance को constant Volume पर Non-flow condition पर Heat दिया जाता है, तो वह Heat उस substance के internal energy को increase करता है।

$$C_v = \frac{dQ}{dT} \quad \text{but for constant Volume.}$$

$$dQ = dU$$

$$dU = dQ = C_v \cdot dT \quad \text{———— (1).}$$

(ii). **Heat capacity at a constant pressure :-** यदि हम किसी substance को Heat add करते है, तो constant pressure और flow condition मे $C_p = \frac{dQ}{dT}$ लेकिन flow condition मे substance के Heat मे change -

$$C_p = \frac{dQ}{dT} \Rightarrow dQ = C_p \cdot dT$$

$$\boxed{dQ = dU + P \cdot dV}$$

Relation between C_p and C_v for an Ideal Gas ⇒

Ideal Gas. $PV = nRT$

for, n=1 mole.

$$PV = RT$$

Constant pressure $dQ = C_p dT$ —— (I)

$$dQ = dU + PdV \text{ —— (II)}$$

Equ^n (I) = (II).

Diff. w.r.to T $C_p dT = dU + PdV$ Keeping P cons.

$$C_p = \left(\frac{\partial U}{\partial T}\right)_P + P\left(\frac{\partial V}{\partial T}\right)_P \text{ —— (III)}$$

But at constant Volume.-

$$C_v = \left(\frac{dU}{dT}\right)_V$$

For an ideal gas, the internal energy is independent of volume or pressure.

$$C_v = \left(\frac{\partial U}{\partial T}\right)_V = \left(\frac{\partial U}{\partial T}\right)_P$$

समी० (III) से -

$$C_p = C_v + P\left(\frac{\partial V}{\partial T}\right)_P \text{ —— (IV)}$$

चूंकि $PV = RT$

Partial differentiation of the above equation with respect to T at constant P yields.

$$P\left(\frac{\partial V}{\partial T}\right) = R \text{ —— (V)}$$

समी० (IV) में $P\left(\frac{\partial V}{\partial T}\right)_P = R$ रखने पर -

$$\Rightarrow \boxed{C_p = C_v + R}$$ Hence proved

Internal Energy :⇒

किसी substance में internal energy, energy की वह Total quantity है। जो substance के component, Molecular, atom के relative position या movement के कारण उसमे present करती या होती है internal energy Molecular के rotational Motion द्वारा include होती है जिसमे Molecular के atom उस Molecular के अन्दर rotate करने के लिए free होती है।

⇒ Internal energy Molecular के atom के बीच vibration की energy और atom मे electron के motion द्वारा include होती है।

⇒ Total internal entergy का Kinetic portion substance के Temperature and उसके molecular structure द्वारा determine किया है। Internal energy का remainder part जो कि potential energy है वो उसमे atom and electron के बीच लगने वाले repulsive or attractive force के कारण होता है।

Empirical Equation for heat capacity :⇒

जैसा की हम जानते हैं heat capacity tempr का function होता है। जो frequently (शीघ्रता पूर्वक) Tempr range के बढ़ने के साथ polynomial way में express (व्यक्त) किया जा सकता है किसी भी ideal gas के लिए C_p is given by.

$$C_p = a + bT + cT^2 + dT^3$$

यहाँ पर a, b, c constant हैं और Tempr T है।

We know that :-

- $$dQ = C_p\, dT$$

$$\int dQ = \int_{T_1}^{T_2} (a + bT + cT^2 + dT^3)\, dT$$

- For 'n' Moles :-

$$\Rightarrow \quad Q = n\int_{T_1}^{T_2} (a + bT + cT^2 + dT^3)\, dT$$

$$\Rightarrow \quad \boxed{Q = n\left[a(T_2 - T_1) + \frac{b}{2}(T_2^2 - T_1^2) + \frac{c}{3}(T_2^3 - T_1^3) + \frac{d}{4}(T_2^4 - T_1^4)\right] \ldots} \quad (1)$$

n Mole heat capacity :- जब C_{pi} data दो दिया हो तब -

Formula :-

$$\boxed{Q = n\left[C^{\circ}_{pm_2}(T_2 - T_0) - C^{\circ}_{pm_1}(T_1 - T_0)\right]}$$

Mean Molal Heat Capacity of Gases :⇒

किसी भी gas के Heating व cooling के दौरान Heat के change को equa^n (1) द्वारा calculate करना एक lengthy procedure है इस procedure को avoid करने के लिए Mean Molal Heat capacity का data है।

माना किसी Base system में Tempr T_0 तथा final Tempr T है तो T and T_0 के बीच Heat change के लिए Mean molal Heat capacity को निम्नलिखित equa^n द्वारा दिया जा सकता है।

$$C^{\circ}_{pm} = \frac{\int_{T_0}^{T} C^{\circ}_p\, dT}{(T - T_0)}$$

if - $$C^{\circ}_p = a + bT + cT^2 + dT^3$$

$$C^{\circ}_{pm} = \frac{a(T - T_0) + b/2\,(T^2 - T_0^2) + \frac{c}{3}(T^3 - T_0^3) + \frac{d}{4}(T^4 - T_0^4)}{T - T_0}$$

$$\Rightarrow \quad C^{\circ}_{pm} = \frac{a(T - T_0)}{T - T_0} + \frac{b}{2}\frac{(T^2 - T_0^2)}{T - T_0} + \frac{c}{3}\frac{(T^3 - T_0^3)}{T - T_0} + \frac{d}{4}\frac{(T^4 - T_0^4)}{T - T_0}$$

$$\Rightarrow \quad \boxed{C^{\circ}_{pm} = a + \frac{b}{2}(T + T_0) + \frac{c}{3}(T^2 + TT_0 + T_0^2) + \frac{d}{4}(T - T_0)(T^2 + T_0^2)}$$

Heat capacity of Gaseous Mixtures :⇒

किसी know composition वाले gase mixture के Heating व cooling के case में Heat change के calculation को mixture की Heat capacity को calculate करके निकाला जाता है।

$$C^{\circ}_{pMix} = \sum_{j=0}^{n} x_i C^{\circ}_{pi}$$

x_1 = Mole fraction है gas mixture के component का।

C°_{pi} = Heat capacity

यदि system की Heat chang को calculate करना है। तो system को change करेंगे फिर Heat को use कर सकते हैं।

$$\boxed{Q = n \int_{T_1}^{T_2} C_{p\,mix}(T)\, dT}$$

Energy Balance :→

Energy conservation का principle जिसे हम Thermodynamic first law के अनुसार energy को न तो create किया जा सकता है और न ही distroyd किसी भी system में energy का जो भी Total amount enter कर रहा है वह system को छोड़ने वाले तथा system के अन्दर होने वाले acumulation के योग के अवश्य equal होना चाहिए।

इस principle के Mathmatical and Numerical expression को ही energy Balance कहते हैं।

⇒ Energy Balance का primary importance process designing व operation में होता है।

⇒ Energy Balance किसी भी system में होने वाले flow process तथा Non flow process के बीच अन्तर करने के लिए भी usefull है।

Flow process :→

वह process जिसमें material के stream continuously system में enter करते हैं और system को leave करते हैं ...

Non Flow process :→

यह ~~...~~ Batch type intermittent ...

इस process में किसी system के operation के दौरान Material के stream continuous system में न तो enter करते हैं और न ही system में ~~...~~ leave (छोड़ना) करते हैं।

Energy Balance closed system :→

कोई भी system energy balance open तब कहा जाता है जब mass system boundry को cross कर जाता है जब mass energy Balance द्वारा cover किये गये Time में system boundry को cross न करे तो वह closed system है।

$$\begin{bmatrix}\text{Final system} \\ \text{energy}\end{bmatrix} - \begin{bmatrix}\text{initial system}\end{bmatrix} = \begin{bmatrix}\text{accumulation}\end{bmatrix}$$

$$[U_2 + E_{k_2} + E_{P_2}] - [U_1 + E_{k_1} + E_{P_1}] = Q + W \quad —(\text{I})$$

$$(U_2 - U_1) + (E_{k_2} - E_{k_1}) + (E_{P_2} - E_{P_1}) = Q + W$$

$$\Delta U + \Delta E_K + \Delta E_P = Q + W \quad —(\text{II})$$

Energy Balance for Open System :⇒

Input energy सभी potential energy kinetic energy तथा external energy का योग है। और यह जो Heat supply की गयी है। plus किये गये कार्य का योग होती है।

$$Q + W + \Sigma E_1 = \Sigma E_2 \quad —(\text{iii})$$

$$Q + W_s + W_f + \Sigma E_1 = \Sigma E_2 \quad —(\text{iv}) \qquad \because W = W_s + W_f$$

यदि v पर Unit mas Volumetric flow rate हो, और P Pressure हो

$$W_f = \Sigma P_1V_1 + \Sigma P_2V_2 \quad \text{—— (V)}$$

but,

$$E_1 = E_{K_1} + E_{P_1} + U_1$$

$$E_2 = E_{K_2} + E_{P_2} + U_2$$

$$\Rightarrow \quad Q + W_S + \Sigma P_1V_1 - \Sigma P_2V_2 = \Sigma(U_2 + E_{K_2} + E_{P_2}) - \Sigma(U_1 + E_{K_1} + E_{P_1})$$

$$\Sigma(U_2 + P_2V_2) - \Sigma(U_1 + P_1V_1) + \Sigma(E_{K_2} - E_{K_1}) + \Sigma(E_{P_2} - E_{P_1}) = Q + W_S \quad \text{—— (VI)}$$

Enthalpy के equa^n से

$$H = U + PV$$

$$\Sigma H_2 - \Sigma H_1 + \Sigma(E_{K_2} - E_{K_1}) + \Sigma(E_{P_2} - E_{P_1}) = Q + W_S$$

In industrial chemical process, the kinetic energy, potential energy and work term are negligible.

$$\Sigma H_2 - \Sigma H_1 = Q$$

For the mass m or mass flow rate $\dot{m}$.

$$\boxed{Q = \Sigma \dot{m}H_2 - \Sigma \dot{m}H_1}$$

$$\boxed{Q = \Sigma mH_2 - \Sigma mH_1}$$

Enthalpy changes Accompanying chemical Reaction :⇒

जब कभी भी chemical reaction होता है, तो उसमे या तो Heat का absorbtion होता है या तो evolution (फैलाव) होता है। Heat का evolution और absorbtion किसी भी chemical process industry के economics मे बेहद ही important roll play करता है।

जब कभी भी enthalpy change किसी reaction से associated (जुड़ा) होता है। और enthalpy change possitive होता है तो वह यह denote करती है कि reaction मे energy का as a Heat की तरह absorbtion करेगा। और यदि enthalpy change Negative है, तो यह denote करता है। तो system मे energy as a Heat remove हो रही है।

V.V.imp

Heat of Reaction (ΔH_R) :⇒

किसी भी certain Temp^r and pressure पर reactant को stoichiometry ratio मे दिया ~~जाय~~ जाए और Reaction 100% complete हो, तो इस Reaction के दौरान जितनी heat निकलती है या दी जाती है। वह Heat ही उस Reation की heat of Reaction कहलाती है

Example :-

$$\underset{\text{बुझा हुआ चूना}}{Ca(OH)_2} + MgCO_3 \longrightarrow Mg(OH)_2 + CaCO_3 \pm \Delta H$$

$Ca(OH)_2$ व $MgCO_3$ को stoichiometry ratio मे लेकर Re कराने पर $CaCO_3$ व $Mg(OH)_2$ बनता है। इस Rax^n मे अगर ΔH Heat निकल रही है। या बाहर से देनी पड़ रही है तो $Ca(OH)_2$ व $MgCO_3$ का ΔH ही Heat of Reation कहलाता है।

Heat of Reaction किसी भी chemical reaction के कारण Heat of reaction Enthalpy change का result है यहाँ पर-

(1) Reactant जो भी system मे feed किये जा रहे हैं। वो reaction को पुरा complete कर देते हैं।

(2) यह तभी सम्भव है जब reactant जिस temp^r व pressure पर feed किये जा रहे हो, product भी हमे उसी condition पर प्राप्त हो।

2011

Standard Heat of Reaction :⇒

1 atmospheric pressure तथा 25°c temp^r पर Reactant को stoichiometry ratio मे दिया जाए और Reaction 100% complete हो तो इस Reaction के द्वारा जितनी Heat देने की आवश्यकता होती है या जितनी Heat निकलती है वही इस reaction की standered Heat of Reaction कहलाती है।

इसे ΔH°_R से denote करते हैं।

Unit :- KJ/mol या J/mol

Standard Heat of reaction किसी chemical reaction के साथ associated एक enthalpy change है। जब temp^r 25°c (298.15K) तथा pressure 0.1 Mpa पर उस reaction के reactant and product अपने standerd state मे होते हैं

- यदि Heat of reaction positive (+ve) है अर्थात Heat absorb हो रही है। तो उसे endothermic reaction कहते हैं तो यदि Heat of reaction Negative है। अर्थात Heat ... exothermic reaction कहते हैं Heat of reaction की value substance के state (gas, liquid, solid) के reactant and product पर depend करती है।

$$CO(g) + 2H_2(g) \longrightarrow CH_3(OH)(l) \; --- \; \Delta H_R$$

V.V.imp 2011, 10, 13

Heat of Formation (ΔH_f) :→

किसी constant temp^r व pressure पर किसी Reactant के द्वारा 1 mole product बनाने के लिए जितनी Heat की आवश्यकता होती है: या बनाने पर जितनी Heat निकलती है वही Heat की Formation कहलाती है। इसे ΔH_f से प्रदर्शित करते हैं।

$$2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \longrightarrow C_2H_5OH(l) \; ---- \; \Delta H = \Delta H_f$$

V.V.imp 2013

Heat of Combustion (ΔH_c) :⇒

निश्चित temp^r पर किसी compound के 1 mole को oxygen Molecular के साथ Reaction कराने पर जो Heat produce (enthalpy मे change) होता है। उसे Heat of combustion कहते हैं।

Exp:- $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + H_2O(l) \; --- \; \Delta H(\Delta H_c)$

Standared Heat of Combustion (ΔH°_c) :⇒

1 atmospheric pressure व 25°c temp^r पर किसी compound के 1 mole को oxygen Molecular के साथ Reaction कराने पर जो enthalpy मे change आता है। वही उस compound का standared Heat of combustion कहलाती है। It is denoted by $\Delta H^\circ c$

Standard heat of combustion :→

Hess law of constant heat summation :→

Hess के अनुसार

निश्चित temp^r पर pressure पर कई chemical reaction सीधे one step मे करायी जाएं या एक से अधिक intermediate step मे हैं, तो इस Reaction मे absorbe व generate heat की net quantity same रहती है।

$$\begin{tikzcd} A \arrow[rr, "\Delta H"] \arrow[d, "\Delta H_1"'] & & B \\ C \arrow[r, "\Delta H_2"'] & D \arrow[r, "\Delta H_3"'] & E \arrow[u, "\Delta H_4"'] \end{tikzcd}$$

path ① $A \rightarrow B$

path ② $A \rightarrow C$

$C \rightarrow D$

$D \rightarrow E$

$E \rightarrow B$

$$\boxed{\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4}$$

अथवा :-

Hess law के अनुसार किसी भी एक particular chemical reaction मे enthalpy change होती है। चाहे reaction एक step या कई step मे भी हो रही हो।

Total enthalpy change reactant व product के temp^r and pressure and उसके state पर निर्भर करती है।

Enthalpy change number of intermediat reaction पर independent होती है।

Hess's law का use करके हम series मे अगर कई reaction हो रहे हैं, तो किसी Heat compound of formation को Calculate कर सकते हैं।

Exp:→

$\Delta H = 94.3$ kcal/mol

path 1 → $C(s) + O_2(g) \longrightarrow CO_2(g)$ $-\Delta H$

path 2 → $C(s) + \frac{1}{2}O_2(g) \longrightarrow CO(g)$ $-\Delta H = -26.41$ kcal/mol.

$2CO(g) + \frac{1}{2}O_2(g) \longrightarrow CO_2(g)$ $-\Delta H = -67.62$ kcal/mol.

Standard heat of reaction from heat of formation :→

$$aA + bB \longrightarrow cC + dD$$

Standard heat of reaction is the difference between the algebraic sum of heat of formation of products and that of reactants.

$$\Delta H^\circ_R = \Sigma \Delta H^\circ_f(\text{product}) - \Sigma \Delta H^\circ_f(\text{reactant})$$

Consider a reaction :→

$$aA + bB \longrightarrow cC + dD$$

where, a, b, c, d, are stoichiometric coefficients.

A, B, C, D → standard heat of formation of components.

$$\Delta H^\circ_R = (d\,\Delta H^\circ_{fD} + c\Delta_{fC}) - (a\,\Delta H^\circ_{fA} + b\,\Delta H^\circ_{fB})$$

Standard Heat of Reaction from Heats of Combustion :→

It is the difference of the algebraic sum of the heat of combustion of reactant's and that of product.

$$\Delta H^\circ_R = \Delta H^\circ_C(\text{Reactant}) - \Delta H^\circ_C(\text{product})$$

if reaction:

$$aA + bB \longrightarrow cC + dD$$

Phase change operation :⇒

Phase change जैसे :- fusion, vaporization and condensation enthalpy में large change से accompanied (जुड़े) होते हैं।

" जब किसी constant temp^r व pressure पर किसी unit amount of matter का phase change होता हैं। और उससे जो भी enthalpy change associated होती है। तो इसे latent Heat of phase change कहते हैं।"

> जब भी कोई matter किसी एक phase से दूसरे phase में change होती है, तो या latent heat absorb होती है या reject होती है।

- for example :→ ice 0°c पर melt होता है। और इसे अगर Heat supply की जाए तो वह water में melt होता है। और इस तरह water 100°c पर vapour produce करता है। अगर इसे लगातार heat supply की जाय तो।

1):⇒ Latent heat of Vaporization :⇒

Constant temp^r व pressure पर liquid के unit amount को vapour होने के लिए जितनी heat की requirement या आवश्यकता होती है उसे हम Latent heat of vapourisation कहते हैं।

पर 1kg solid को liquid होने के लिए जितनी heat की आवश्यकता होती है। इसे ही latent heat of fusion कहते हैं।

3):⇒ Latent heat of sublimation :⇒

Constant temp^r व pressure पर unit amount of solid को vapourize होने के लिए जितने heat की आवश्यकता होती है उसे ही latent heat of sublimation कहते हैं।

Energy Balance During phase change Operation :⇒

माना vapour इसके saturation temp^r (T_s) and pressure (P) पर और Heat process stream को दिया जा रहा है, तो -

Heat remove from vapour = heat gained by process stream

$$\boxed{\dot{m}_v \lambda_v = \dot{m}_p C_{p_p} (T_2 - T_1)}$$

where :-

$\dot{m}_v$ = Vapour flow rate, kg/h.

λ_v = latent heat of condensation of vapour.

$\dot{m}_p$ = mass flow rate of process stream.

C_{p_p} = Specific heat of process stream.

T_2 and T_1 = final and initial temp^r of process stre

Combustion

It is a process of burning of fuel in the presence of oxygen in which Carbon, Hydrogen and Sulphur take place. By oxygen and Carbon reacts with oxygen to form CO, CO_2 parallely Hydro-gen gives water molecules and Sulphur gives SO_2.

Chapter → 8

COMBUSTION

chemical process industry मे जो भी fuel furnace में burnt होते हैं, वे solid liquid या gases state मे होते हैं।

⇒ furnace एक enclosed vessell (shape) मे है जिसमे fuel के chemical oxidation से heat produce की जाती है। समान्यत: use होने वाले fuels निम्न हैं –

① ⇒ Solid fuels :→ समान्यत: कोल (coal) होते हैं जो कि carbon, hydrogen व non-combustible ash, water and sulphur, coke आदि का mixture होता है।

② :⇒ Gases fuels :⇒ समान्यत: Natural gases जो usually 80 to 95% methane and ethane, propane व small quantities में others gases का mixture होता है।

③ :⇒ Liquid fuels :⇒ वह fuels जो सामान्यत: crude oil के distillation द्वारा उत्पन्न hydrocarbon के mixture होते हैं।

Combustion :⇒ fuel का oxygen के साथ rapid reaction ही combustion कहा जाता है।

⇒ combustion operation मे fuel के carbon Hydrogen व sulfer का union oxygen के साथ react करते हैं।

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⇒ जब कोई fuel burn होता है। तो fuel मे present carbon CO_2 या CO तथा hydrogen H_2O व sulphur, SO_2 बनाने के लिए react करता है।

⇒ combustion को complete combustion तब कहते है जब इसके products CO_2, H_2O, व SO_2 हों।

⇒ वह combustion reaction जिसमे CO form होता है उसे partial या incomplete combustion कहते है।

Example :-

$C + O_2 \longrightarrow CO_2$ ⇒ Complete combustion of carbon.

$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$ ⇒ Complete combustion of propane.

$C_3H_8 + \frac{7}{2}O_2 \longrightarrow 3CO + 4H_2O$ ⇒ partial combustion.

Importance or Significance :⇒

Combustion process के दौरान बहुत अधिक मात्रा में heat released होती है। जिसका use steam produce करने, electricity produce करने के लिए turbines को drive करने, heat की thermal energy को supply करने के लिए use किया जा सकता है।

> Economic reasons मे most combustion operation मे air oxygen का source होती है।

⇒ Product gases (CO_2, CO, H_2O, O_2, SO_2, SO_3) जो combustion chamber को छोडती है उन्हे stack gases या fuel gases कहते है।

Calorific Values of fuel :⇒ Unit mass of fuel को pure oxygen के साथ completly burnt करने पर जो भी total heat produce होती है। उसे वह fuel की calorific value कहलाती है।

Calorific value को हम fuel की heating value भी कहते है।

⇒ जब एक fuel burnt होता है, तो fuel में उपलब्ध हाइड्रोजन oxygen के साथ react करता है और water बनाता है। जब water fuel gas मे present रहता है as vapour तो vaporization की latent heat loss होती है। (heat associated with water vapour). जिससे heat की quantity किसी useful purpose के लिए avilable नहीं होती है।

⇒ Fuels की calorific value दो प्रकार की होती है —

(1): Gross calorific value / High calorific value / High heating value (HHV)

(2): Net calorific value (NCV) / Low calorific value (LCV) / Low heating value (LHV).

2011,10,13

(1):- Gross Calorific Value (GCV) :⇒ Fuel के unit mass को complitly combustion कराने पर उत्पन्न water vapour को condence करने पर मुक्त हुयी latent heat की value को भी

fuel के calorific value में add कर देते है जिससे fuel को calorific value (High) बढ़ जाती है जिसे HCV (High Calorific Value) कहते है।

⇒ G.CV की total heat की मात्रा को हम use नही कर पाते है

$$G.C.V = N.C.V + m\lambda$$

$$\boxed{G.C.V = N.C.V + \frac{(\text{wt\% hydrogen})(9)(\lambda)}{100}\ \text{KJ/Kg}}$$

where, m = mass of H_2O

λ = latent heat of water.

2011,10,13

3) ⇒ **Net Calorific Value (NCV)** :⇒ fuel के unit mass को complete burn करने पर उत्पन्न water vapour को बाहर निकालने के बाद जो heat बचती है उसे ही उस fuel की NCV कहते है।

⇒ NCV fuel की एक calorific value है जहाँ combustion product में water as vapour state present रहता है।

NCV का totally use हो जाता है।

$$NCV = GCV - m\lambda$$

$$\boxed{NCV = GCV - \frac{(\text{wt\% of } H_2) \times 9 \times (\lambda)}{100}}\ \text{KJ/Kg.}$$

Analysis of Coal :⇒ Coal को analyse करने के दो Method होते है –

(1):- Ultimate analysis.

(2):- Proximate analysis

(1) **Ultimate analysis** :⇒ Coal के ultimate analysis में coal के carbon (C), Hydrogen (H), sulfur (S), nitrogen (N) व oxygen (O) को determine किया जाता है।

⇒ यह coal के combustion के लिए air की quantity तथा combustion gases के volume व composition को भी determine करने मे useful है।

⇒ इसके द्वारा दी गयी information flame temperature के calculation व flue duct design में require होती है।

Theoretical oxygen :⇒ Fuel में complete combustion के लिए required oxygen की मात्रा को उस fuel का Theoretical oxygen कहते है।

Theoretical air :- Air की व quantity जिसमे theoretical oxy[gen] contain हो उसे theoratical air कहते है।

$$\boxed{21\ \text{Kmol } O_2 \equiv 100\ \text{kmol air}}$$

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Excess air :⇒ It is the amount ~~by which the air fed~~ to the combustion chamber exceed the theoretical air

$$\boxed{\%\ \text{excess air} = \frac{\text{actual air supply} - \text{theoretical air requirement}}{\text{Theoretical air requirement}} \times 100}$$

2): **Proximate analysis** :⇒ Coal को proximate analysis मे moisture%, volatile matter, ash %, fixed carbon by weight % को determine किया जाता है।

⇒ Fixed carbon व volatile combustion matter amount coal के heating value में directly contribution करते है।

Fixed carbon :⇒ यह solid fuel है जो volatile matter का distillation होने के बाद furnace मे शेष बचता है।

⇒ इसमे mostly carbon होता है लेकिन कुछ amount में hydrogen, Oxygen व sulfer भी होता है।

Volatile matter :⇒ Volatile matters CH_4, hydrocarban, CO व incombustible gases जैसे CO_2 व N_2 जो coal मे पायी जाती है वह है।

range - 20 to 35%.

Ash content :⇒ Ash coal मे वह impurity है जो burn नही होती है इसकी Rang 5% to 40% होती है।

Moisture content :- range 0.5 to 10%

Sulphur content :- range 0.5 to 0.8%

2010, 11, 13, 15, 18, 19

Endothermic Reaction :⇒ Endothermic Reaction वह chemical reaction है जिसमे reaction के दौरान system अपने sourrounding से energy को Heat के form मे absorb करता है जिसे Endothermic reaction कहते है।

Endothermic reaction मे enthalpy change (ΔH) positive होता है।

Exp :⇒ photosynthesis endothermic chemical का example है। जिसमे plant CO_2 तथा H_2O को ग्लुकोज व oxygen मे convert करने के लिए sunlight से energy को absorve करता है।

$$\text{Sunlight} + 6CO_2(g) + 6H_2O(l) \longrightarrow \underset{(\text{ग्लुकोज})}{C_6H_{12}O_6(aq)} + 6O_2(g)$$

Example :- Melting of Ice cubic.

2011, 13

Exothermic Reaction :⇒ ऊष्माक्षेपी

Exothermic Reaction वह chemical reaction है जिसमे reaction के दौरान energy Heat के form मे sourrounding मे relase (मुक्त) होती है उसे Exothermic reaction कहते है।

इस reaction के दौरान उत्पन्न होने वाली Heat से sourrounding या system का Tempr increase हो जाता है।

Exp :⇒ 1): Cumbustion reactions of fuel.

2): Nutrlization reactions.

3): Corrosion reaction such as oxidation of m

$$4Fe + 3O_2 \longrightarrow 2Fe_2O_3 + \text{energy}$$

6

Exp:- Convert a Volumetric flow rate of $2\ m^3/sec$ to l/s.

$= 2\ m^3/sec$

$= 2\ \frac{(1000)\ l}{sec}$ $\qquad 1m^3 = 1000\ l$

$= 2000\ l/sec$ Ans

Q:- Convert $127\ lb/ft^3$ to g/cm^3 $\qquad 1kg = 1000g$

$= 127\ lb/ft^3$

$= 127 \times \frac{453.6g}{(30.48)^3\ cm^3}$ $\qquad 1lb = 0.4536\ kg$

$1lb = 0.4536\ kg$

$= 127 \times \frac{453.6g}{(30.48)^3\ cm^3}$ $\qquad 1lb = 453.6\ g$

$= 453.6g$

$= 2.0343\ g/cm^3$ $\qquad 1ft = 30.48\ cm$

$= 2.034\ g/cm^3$ Ans

Q:- Convert 1400 mm Hg to atm

1400 mmHg

$= 1400 \times \frac{1}{760}$ atm $\qquad 1atm = 760\ mmHg$

$= 1.842$ atm Ans $\qquad 1mmHg = \frac{1}{760}$ atm

Q:- Convert 1000 dyne to Newton. $\qquad 1N = 10^5$ dyn

$= 1000$ dyne $\qquad 1 dyn = \frac{1}{10^5} N$

$= 1000 \times \frac{1}{10^5}$ Newton

$= 0.01$ Newton Ans

$= \frac{4.18\ k\ Joule}{kg\ ^\circ c}$

$1\ cal = 4.18\ Joule$

$1\ Kcal = 418\ kg\ Joule.$

$= 4.18\ \frac{k\ Joule}{kg\ ^\circ c}$ Ans

Exp: In a multiple effect evaporator system, the second effect is maintained under vaccume of 475 torr (mmHg). Find the absolute pressure in kpa.

Sol.

Absolute pressure = atmospheric pressure − Vaccume.

$= 760 - 475$

$= 285$ torr (mmHg)

Absolute pressure $= 285$ (mmHg)

$= 285 \left(\frac{101.325}{760}\right) \cdot \left(\frac{kpa}{mmHg}\right)$

$= 38$ kpa

Exp: convert a pressure of 2 atm to mmHg.

Sol. 2 atm pressure.

$1\ atm = 760\ mmHg.$

$2\ atm = 760\ mmHg.$

$= 2\ atm$

$= 2 \times 760\ mmHg$

$= 1520\ mm\ Hg$. Ans

Ques: $\frac{kg\ f}{c\ m^2} \longrightarrow \frac{kN}{m^2}$

$1\ kgf = 9.807\ N$

$= 9.807 \times 10^{-3}\ kN$

$1\ cm = \frac{1}{100}\ m.$

$1\ N = \frac{kg\ m}{sec^2}$

Solve.

$\frac{kg \cdot 9.807\ m/sec^2}{(1/100)^2\ m^2}$

$\frac{9.807\ N}{100^{-2}\ m^2}$

$\frac{\frac{9.807}{10^{-3}}\ kN}{(1/100)^2\ m^2}$

$= \frac{9.807 \times 10^4}{10^{-3}}\ \frac{kN}{m^2}$

$= 9.807 \times 10^{4+3}\ kN/m^2$

$= 9807\ kN/m^2$ Ans

Ques: poise $\longrightarrow$ kg / m sec

$= g/cm\ sec$

$= \frac{10^{-3}\ kg}{10^{-2} m\ sec}$

$= 0.1\ kg/m\ sec$

Ques: ft lbf/sec $\longrightarrow$ W

$1\ ft\ lbf/sec = \frac{1 \times ft \times 32.17 \times lb}{sec}$

$= \frac{1 \times 0.3048\ m^2 \times 32.17 \times 0.4530\ kg \times 0}{sec}$

$= 1.35\ kg\ m^2/sec^3$

$= 1.35\ Nm/sec$

$= 1.35\ W$ Ans

332 m/sec —— km/hr

Solve

$$= \frac{\frac{332}{1000}\ km}{1/3600\ hr}$$

$1m = \frac{1}{1000} km$

$1hr = 3600 sec$

$= 1193.2\ km/hr$ Ans

Ques → $13.6\ g/cm^3 \longrightarrow kg/m^3$

Solve

$$= \frac{\frac{13.6}{1000}\ kg}{1/100^3\ m^3}$$

$= 13600\ kg/m^3$ Ans

Ques → $760\ mm\,Hg \longrightarrow kN/m^2$

$1atm = 760\ mmHg$

$1atm = 101.325\ kN/m^2$

Solve

$760\ mmHg = 101.325\ kN/m^2$ Ans

Ques :- $kcal/m^2 sec \longrightarrow w/m^2$

$w = \frac{Joule}{sec}$

$1 calori = 4.18\ Joule$

$1k calori = 4.18 \times 10^{-3}\ kJoule$

$$= \frac{4.18 \times 10^{-3}\ kJoule}{m^2 \cdot sec}$$

$$= 4.18 \times 10^{-3}\ \frac{kJoule}{m^2 sec}$$

$$= 4.18 \times 10^{-3}\ \frac{w}{m^2}$$ Ans

(4) → $200\ mm\,Hg \longrightarrow ATM \cdot PSI$

PSI = Pound per square inch

Solve

$200 \times 1.3157\ atm$

$0.2631\ atm$

$1atm = 760\ mmHg$

$1mmHg = \frac{1}{760}\ atm$

$1mmHg = 1.3157\ atm$

$1atm = 14.7\ lb/inch^2$

$0.2631\ atm = 14.7\ lb/inch^2$

(5) → $lb/ft^3 \longrightarrow kg/m^3$

Solve

$$\frac{0.4536\ kg}{(0.3648)^3 m^3}$$

$1lb = 0.4536\ kg.$

$1ft = 36.48\ cm$

$= 0.3648\ m$

$= 9.3434\ kg/m^3$ Ans

(7) – $127\ lb/ft^3 \longrightarrow g/cm^3$

Solve

$$= \frac{127 \times 45.36\ g}{(36.48)^3\ cm^3}$$

$$= \frac{127 \times 45.36}{48547.23}\ g/cm^3$$

$= 0.118\ g/cm^3$ Ans

(8) → $1kgf \longrightarrow lbf/sec^2$

Solve

$1kg \times 9.807\ m/sec^2$

$1lb = 0.4536\ kg.$

$1kg = \frac{1}{0.4536}\ lb$

$1ft = 0.3648\ m$

$1m = \frac{1}{0.3648}\ ft$

$$= \frac{lb}{0.4536} \times \frac{9.807}{0.3648}\ ft/sec^2$$

$= 54.81247\ lb\,ft/sec^2$ Ans

V.Imp

This Equation is attamp in board examination :—

Ques ①. $\dfrac{16.2\ BTU}{hr.ft\ ^\circ F} \longrightarrow \dfrac{g\ cal}{sec\ c.m\ ^\circ F}$

Solve

$= \dfrac{16.2 \times 252\ g\ cal}{3600 \times 30.48 \times [illegible]\ ^\circ F\ sec.c.m}$

$= \dfrac{4082.4}{109728.0} \dfrac{g\ cal}{sec.c.m\ ^\circ F}$

$= 0.0372 \dfrac{g\ cal}{sec.c.m.\ ^\circ F}$ Ans

1 BTU = 252 g cal
1 hr = 3600 sec
1 foot = 30.48 c.m
$1^\circ C = 1.8^\circ F$
$1^\circ F = \frac{1}{1.8}\ ^\circ C$
$1^\circ F = 0.555\ ^\circ C$.

Ques ② $\dfrac{3.96\ BTU}{ft^2 .\ ^\circ F .\ hr} \longrightarrow \dfrac{K\ cal}{m^2\ ^\circ C.hr}$

Solve

$= \dfrac{3.96 \times 0.252\ K\ cal}{(0.3048)^2 m^2\ 0.555\ ^\circ C.hr.}$

$= \dfrac{0.99792\ K\ cal}{0.05156\ m^2\ ^\circ C\ hr}$

$= 19.3545 \dfrac{K\ cal}{m^2\ ^\circ C\ hr}$ Ans

1 BTU = 252 g cal
= 0.252 K cal.
1 ft = 30.48 c.m
= 0.3048 m
$1^\circ F = \frac{1}{1.8}\ ^\circ C$
$1^\circ F = 0.555\ ^\circ C$

Ques ③ $\dfrac{BTU}{hr\ ^\circ F\ ft} \longrightarrow \dfrac{K\ cal}{hr\ ^\circ C\ m}$

$= \dfrac{0.252\ K\ cal}{hr \times 0.555\ ^\circ C \times 30.48\ c.m}$

$= \dfrac{0.252\ K\ cal}{0.555 \times 0.3048\ hr\ ^\circ C\ m} = 1.48967 \dfrac{K\ cal}{hr\ ^\circ C\ m}$ Ans

Force = m.a = Newton = kgm/sec^2

work = Force x ~~Displment~~

= F x M = Newto · Meter

= Joule.

$\boxed{\text{work} = \text{Joule}}$

Pressure = Newton/m^2 = Pascal (Pa)

power = Joule/sec = Newton.meter/second

= Joule/sec = watt

= 1.8°F

foot = 12" (inch) = 30.48 cm = 0.3048m

= 453.6 gram = 0.4536 kg.

= 4.18 Joule.

g calori = 4.180 Joule.

= 252 calori = 252 g°c

= 0.252 kg calori

HU = 453.6 calori = 453.6 g°c

= 0.4536 kg calori.

H.P = 746 w

Kilo = 10^3
milli = 10^{-3}
micro = 10^{-6}
Nano = 10^{-9}
Tera = 10^{12}
giga = 10^9
mega = 10^6

(C.G.S) → 1 Dyne = gm.cm/sec^2

(M.K.S) → 1 Newton = kg m/sec^2

$\boxed{1m = 100\ c.m}$

$\boxed{1kg = 1000\ g}$

1वाट = Joule/sec

HP = 746 w

शक्ति = कार्य/समय

$= \frac{F.d}{t} = \frac{m\text{-}a \times d}{sec}$

$= \frac{\text{kg} \cdot \text{m/sec}^2 \times m}{sec}$

$= \frac{\text{kg m}^2}{\text{sec}^3} = \text{Nm/sec}$

1000 dyne $= 1000 \times 10^{-3} \times 10^{-2} \frac{\text{kg m}}{\text{sec}^2}$

$= 10^{3-3}\, 10^{-2} \frac{\text{kg m}}{\text{sec}^2}$

1000 dyne $= 10^{-2}$ kg m/sec^2

$\frac{10^3}{10^{-2}}$ dyne = Newton

Bihar Graduate assistant teacher

Post 211. Hindi 26, english 33, Math 33. Science 19, History 22. Geografy 15, Sanskrit 17, economics 26, physical education 20, Bed (55%) average 21 - 37, (F-40) pay scale 5300 - 34800
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Age → 18 - 40
qualification → 10th/12th/ Graduation