PRAYAS

FOR JEE 2023

MOLE CONCEPT

Lec-1

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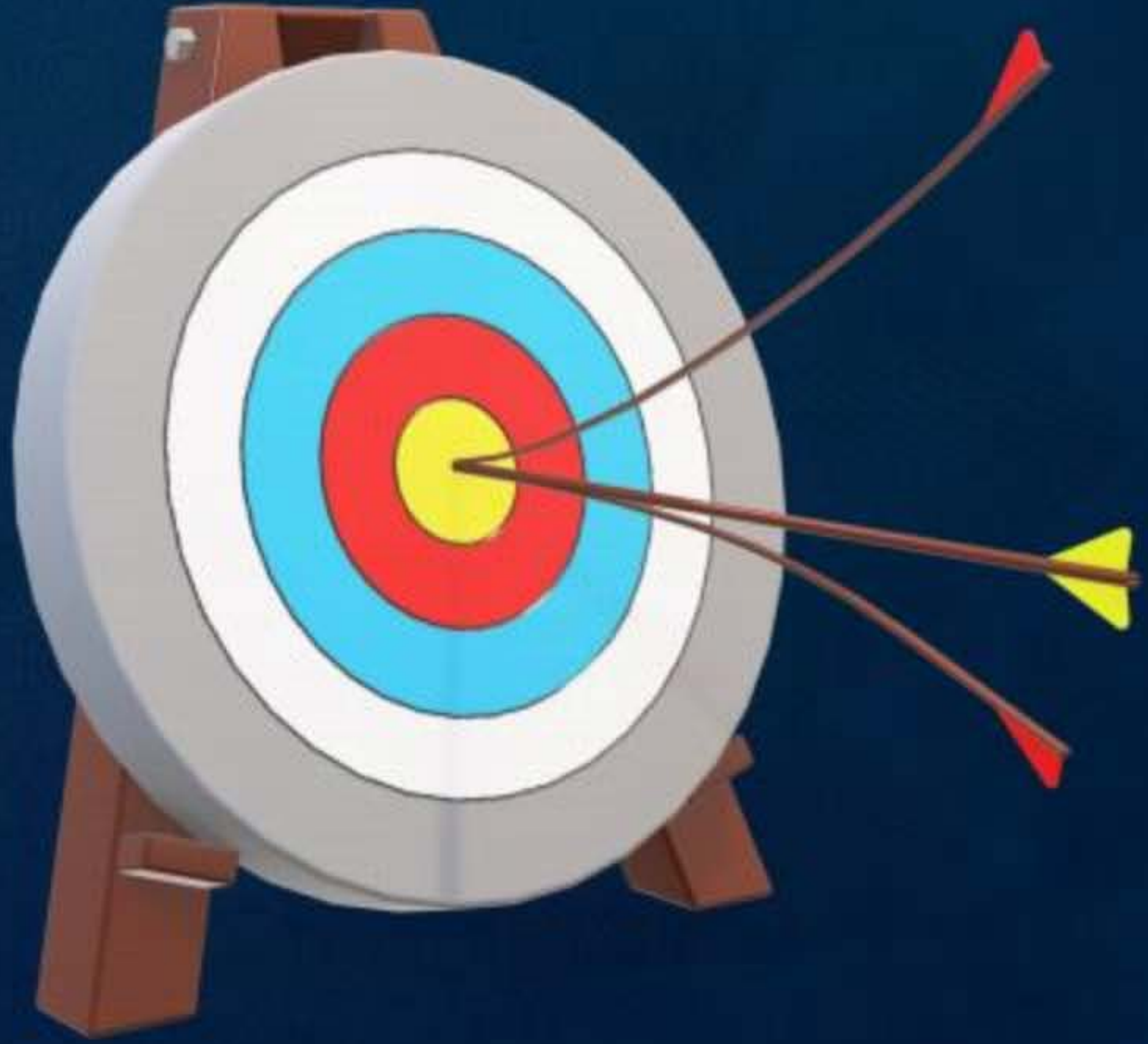
TOPICS TO BE COVERED

1. Classification of Matter
2. Atomic Mass Unit
3. Moles
4. Gram Atomic Mass
5. Gram Molecular Mass
5. No. of moles calculation



Classification of matter

Universe ⇒ Matter + Energy

<u>Matter</u>- Any thing that has mass & space.

H_2O, Air, Chair, Table etc

	Mass	space
Matter ⇒	✓	✓

Classification of matter

Matter

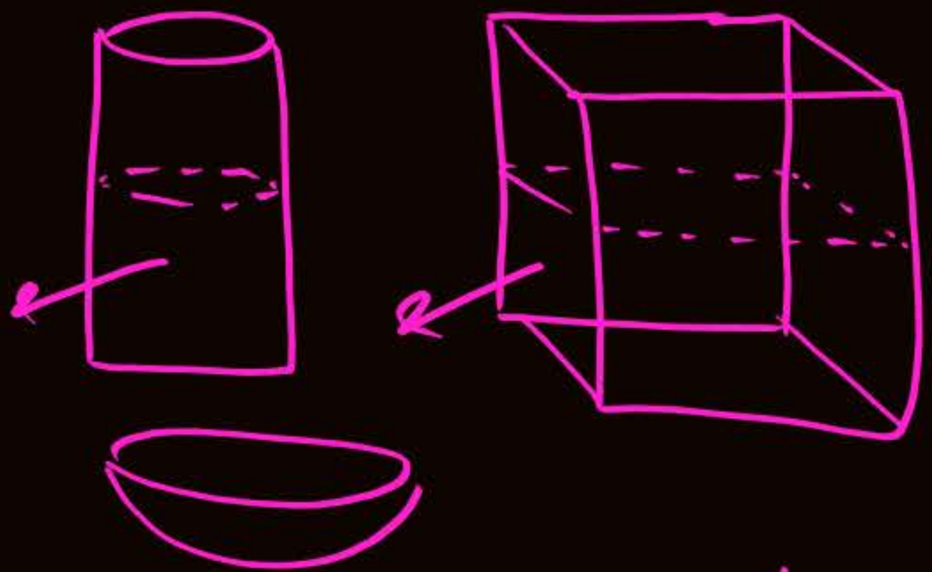
- Physical Classification — outside story
  - ① Solid (S✓ V✓)
  - ② Liquid (S✗ V✓)
  - ③ Gas
  - Classical states of matter
- Chemical classification — Inside story
  - ① Pure substance — only one type of units
    - ① Elements — only one types of atoms — H_2, O_2, Fe, Ag
      - Metal
      - Non metal
      - Metalloid
    - ② Compounds — more than one type of atoms ⇒ $H_2O, NH_3, CO_2, H_2SO_4$
      - Organic — C_xH_y
      - Inorganic
  - ② Mixture (more than one type of units)
    - Air ⇒ O_2, N_2, CO_2, H_2O
    - Homogeneous — Conc. - uniform — Salt + H_2O
    - Heterogeneous — Conc - Non uniform — H_2O + Sand

IPD liquid > Solid

FOA liquid < Solid

KE liquid > Solid

1 lit H_2O



Volume, shape fix ✗

FOA - liquid > Gas

KE ⇒ liquid < Gas

$$\text{Solid} \underset{LT}{\overset{HT}{\rightleftharpoons}} \text{liquid} \underset{LT}{\overset{HT}{\rightleftharpoons}} \text{Gas}$$

Plasma / BEC → low energy

High Energy

IPD ⇒ Gas > liquid

Atom

→ Smallest unit of any elements than can not have independent existance but takes part in chemical reaction.

	CR	IE
Atom-	✓	×

H- atom

O- atom

N- atom

Cl- atom

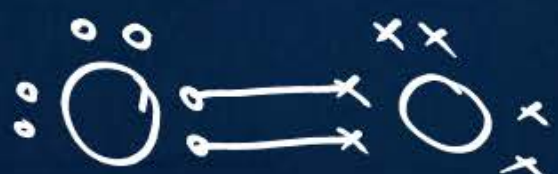
Fe- atom

Molecules

⇒ Smallest unit of any substance, that can have indipendent existance but can not take part in chemical reaction.

	CR	IE
Molecule ⟹	×	✓
	✓	✓

H—H



$H_2 + O_2 \Rightarrow$ mixture

$CH_4 \Rightarrow$

$H_2 \Rightarrow$ molecule

$O_2 \Rightarrow$ molecule

$N_2 \Rightarrow$

$Cl_2 \Rightarrow$

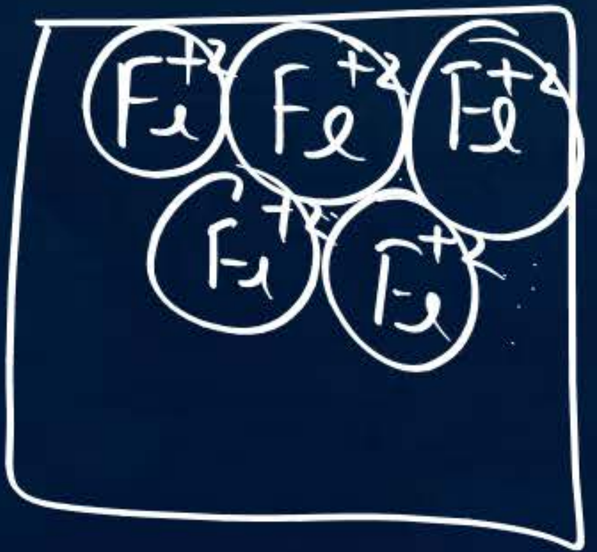
$H_2O \Rightarrow$

$NH_3 \Rightarrow$

$CO_2 \Rightarrow$

	CR	IE
Atom	✓	×
Molecule	×	✓
He, Ne, Ar → Atoms	×	✓

→ Single atomic molecule



Atomicity -

no. of atoms required to form one molecule.

He, Ne, Ar ⇒ Atomicity = 1

O_2, H_2, Cl_2, N_2 ⇒ Atomicity = 2

NH_3, H_2O, CO_2, CH_4 ⇒ Polyatomic molecule

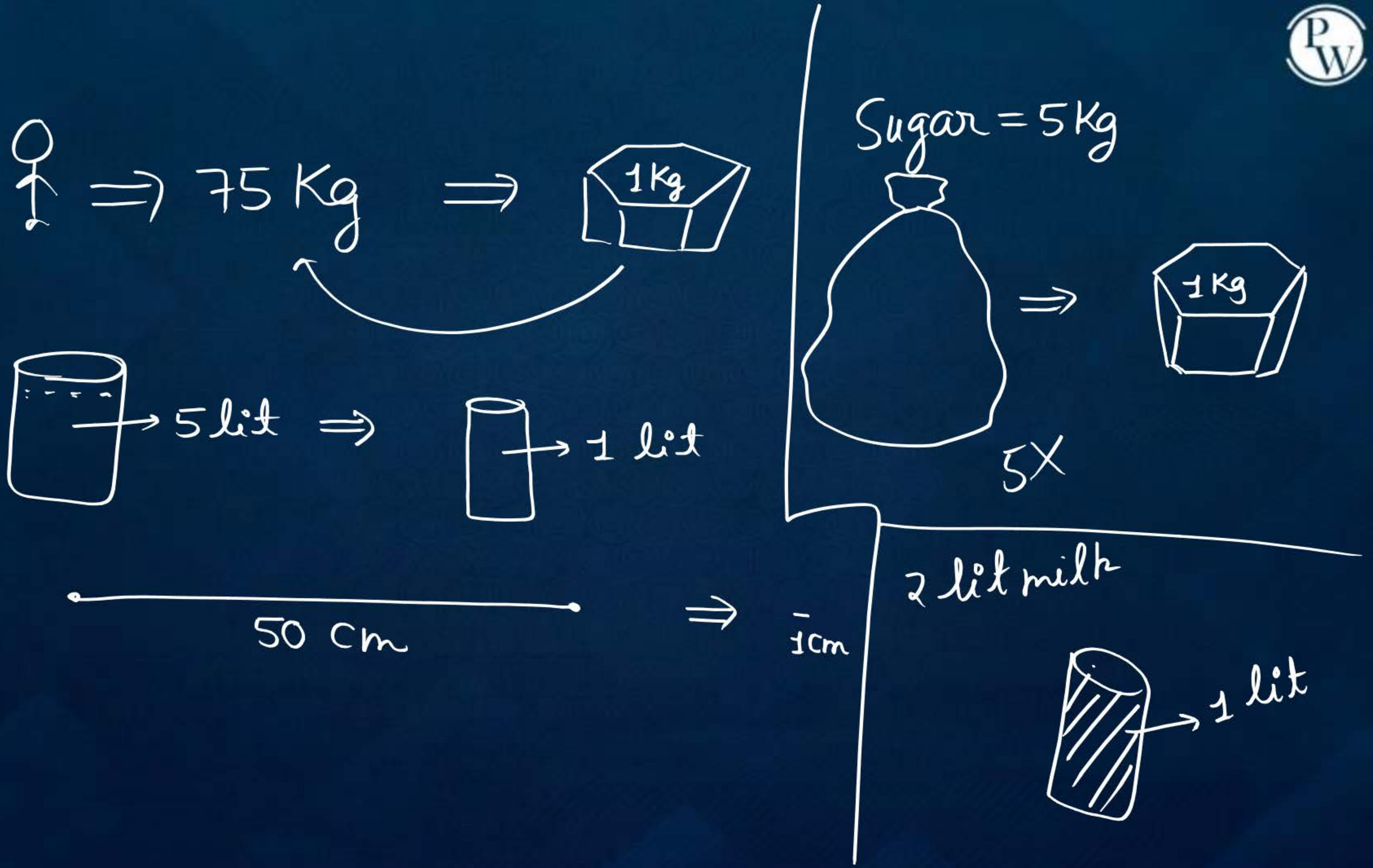
Atomic Mass Unit (amu)

unified mass (u) / Avogram

One atomic mass unit is equal to 1/12th mass of 1 atom of C-12 isotope. It is used to calculate mass of small particles like atoms, Molecules, Ions.

$$1\ amu = \frac{\text{mass of one atom of C-12 isotope}}{12} = \frac{1.99 \times 10^{-23}\ gm}{12}$$

$$\boxed{1\ amu = 1.6626 \times 10^{-24}\ gm}$$



⇒ 75 Kg ⇒
1Kg
5 lit ⇒
1 lit
50 cm
⇒
1cm
Sugar = 5 Kg
⇒
1 Kg
5X
2 lit milk
1 lit

$\boxed{Na = 23\ amu}$ $\Rightarrow$ 1 atom of sodium is 23 times heavier than <u>1 amu</u>.

$\Rightarrow$ 1 atom of Sodium is 23 times heavier than <u>$\frac{1}{12}$th</u>

<u>mass of one atom of C-12 isotope.</u>

S = 32 amu $\Rightarrow$

Atomic Mass

$H_2O = 18$ amu $\Rightarrow$ 1 molecule of H_2O is 18 times heavier than $\frac{1}{12}$th mass of one atom of C-12 isotope.

$H_2S = 34$ amu >

Molecular Mass

1. The modern atomic mass unit is based on the mass of C^{12} isotope (Adv-1980)

(A) H

(B) O

~~(C)~~ C^{12}

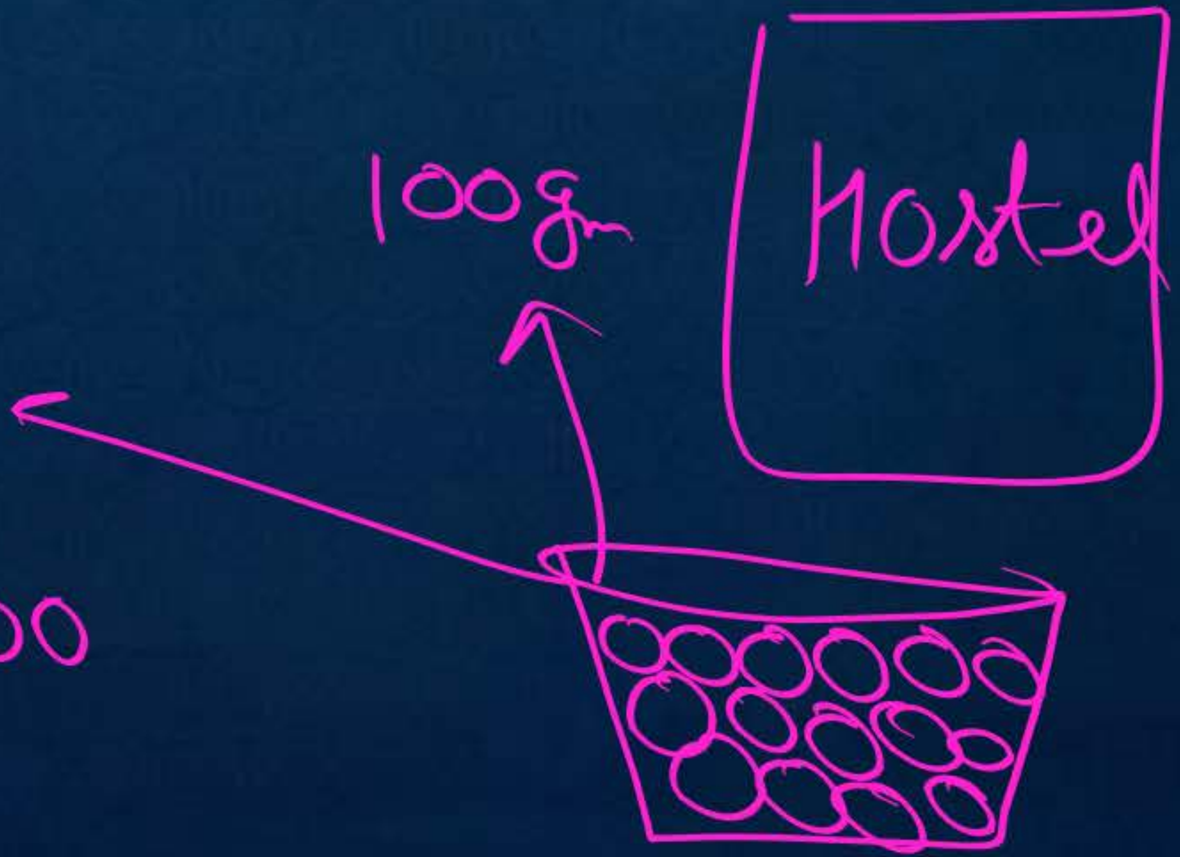
(D) C^{14}

Moles → unit of Substances

Quantity of particles which is equal to the no. of atoms present in 12 g of sample of C-12 isotope. ⇒ 1 mole

10 Kg

100gm



Rank-1

$$\frac{10,0\cancel{00}}{1\cancel{00}} = 100$$

12- gm of C-12 isotope (1 mol) $=$ $\dfrac{12 \text{ gm of C-12 isotope}}{\text{mass of one atom of C-12}}$ $=$ no. of atoms

1 atom

Avagardo's No.

$$1 \text{ mole} = \frac{12 \text{ gm}}{1.99 \times 10^{-23} \text{ gm}} = \underline{6.022 \times 10^{23}}$$

$\boxed{1 \text{ mole} = 6.022 \times 10^{23}}$ units

N_A

- Atoms
- molecules
- Ions

N_A

1 mole of H_2O ⇒ 6.022×10^{23} molecules of H_2O

2 mole of Na-atoms ⇒ $2 \times 6.022 \times 10^{23}$ atoms of Na

$2N_A$

4 moles of SO_4^{--} = $4 \times 6.022 \times 10^{23}$ ions of Sulphate

$4N_A$

Darzan ⇒ 12

1 mole = 6.022×10^{23} units

Gram Atomic Mass (GAM)

Gram atoms

Mass of one mole of atoms in gram unit.

$1\,amu = 1.6626 \times 10^{-24}\,gm$

$$Na = \underbrace{23\,amu \times 6.022 \times 10^{23}}_{amu} \times 1.6626 \times 10^{-24}\ gm/amu$$

$$\boxed{Na\ (1\ mole) = 23\ gm}$$

$H = 1\,amu$ $\quad O = 16\,amu$

$H = 1\,gm$ $\quad O = 16\,gm$

GAM

GAM $\hookrightarrow$ Atoms

$$S = \frac{\underline{32\,amu} \times 6.022 \times 10^{23}}{1\,mole\ in\ amu} \times 1.6626 \times 10^{-24}\ gm/amu$$

$$\boxed{S = 32\ gm}$$

GMM $\hookrightarrow$ molecules

Gram Molecular Mass (GMM)

Gram - molecules

Mass of one mole of molecules in gram unit.

$H_2O \Rightarrow 18\ amu \times 6.022 \times 10^{23} \times 1.6626 \times 10^{-24}\ gm/amu$

$\boxed{H_2O = 18\ gm}$

$NH_3 \Rightarrow 17\ amu \times 6.022 \times 10^{23} \times 1.6626 \times 10^{-24}\ gm/amu$

$= 17\ gm$

$H_2O \Rightarrow 1 \text{ mole} = 18 \text{ gm}$

$\rightarrow$ 90 gm $\Longrightarrow \because 18 \text{ gm } H_2O = 1 \text{ mole}$

$\therefore 1 \text{ gm} = \frac{1}{18} \text{ mole}$

$\therefore 90 \text{ gm} = \frac{90}{18} = 5 \text{ moles of } H_2O$

$$\boxed{\text{no. of moles} = \frac{\text{Given mass}}{\text{GMM}}}$$

1 mole H_2O = 18 am

1 mole = 6.022×10^{23}

36 gm $H_2O \Rightarrow$ molecules = ?

36 gm = $\underline{\underline{2 \text{ moles}}}$

= $2 \times 6.022 \times 10^{23}$ molecules of H_2O

$H_2 \Rightarrow$ 6.022×10^{24} molecules

no. of moles = $\dfrac{\text{no. of Particles}}{N_A}$ = $\dfrac{6.022 \times 10^{24}}{6.022 \times 10^{23}} = 10$

Molar Mass

GAM or GMM ⇒ 1mole

Mass of one mole of any substance. Substance may be the atoms, molecules, ions or mixture.

Molar mass ⇒ mass of 1 mole
- → atoms ✓
- → molecules ✓
- → Ions ✓
- → mixture ✓

1mole Air

O_2, N_2 ⇒ 28.8 gm ⇒ malar mass of Air

oxygen

Mixture

Average malar Mass

Average Molar Mass $\Longrightarrow$ mixture (more than one types of unit)

Concept of average molar mass is used to calculate the mass of one mole of mixture or naturally occurring isotopes (average atomic mass).

$$\text{AAM} / \text{AMM} = \frac{\left(\text{Mass of 1st Isotope} \times \text{\% of 1st Isotope}\right) + \left(\text{mass of 2nd isotopes} \times \text{\% of 2nd Isotope}\right) + \ldots}{100}$$

$$\text{Average molar mass} = \frac{\left(\text{Molar mass of 1st} \times \%\text{ of 1st}\right) + \left(\text{Molar mass 2nd} \times \%\text{ of 2nd}\right) + \ldots}{100}$$

2. The average molar mass of chlorine is 35.5 g mol^{-1}. The ratio of ^{35}Cl to ^{37}Cl in naturally occurring chlorine is close to

(a) 4 :1 (b) 3 : 1 (c) 2 : 1 (d) 1 : 1

2019
2020

(September)

$$AMM = 35.5 = \frac{(M_A \cdot \%A) + (M_B \cdot \%B)}{100}$$

$\cancel{M_A x_A + M_B x_B}$

$\%A = x$ $\%B = 100 - x$

$$35.5 = \frac{(35x) + (37(100-x))}{100}$$

3. **Give that the abundances of isotopes $_{54}Fe$, $_{56}Fe$ and $_{57}Fe$ are 5%, 90% and 5%, respectively, the atomic mass of Fe is** **(2009)**

(A) 55.85 (B) 55.95

(C) 55.75 (D) 56.05

$$AAM = \frac{(54 \times 5) + (56 \times 90) + (57 \times 5)}{100}$$

Boron has two isotopes ^{10}B and ^{11}B whose relative abundances are 20% and 80% respectively. Atomic weight of boron is

a) 10 b) 11 c) 10.5 d) 10.8

PYQ

H.W.

The mass numbers of 2 isotopes are 20 & 21. If the average atomic mass of element is 20.2. then percentage composition of isotope mass number 20 is…

H.W.

a) 90 b) 80 c) 20 d) 40

Calculate $\boxed{\text{average molar mass}}$ of air, which mainly consist 20% oxygen and 80% Nitrogen.

mixture

a) 32 b) 28 c) 31.5 ~~d)~~ 28.8

$$AMM = \frac{(32 \times 20) + (28 \times 80)}{100}$$

$$= (32 \times 0.2) + (28 \times 0.8)$$

$$\boxed{AMM \text{ of air} = 28.8 \text{ gm}}$$

Vapor Density & Molar Mass

$$\boxed{\text{Molar Mass} = VD \times 2}$$

O_2 gas $\Rightarrow$ molar Mass $= 32$ gm

$V.D. \times 2 = M$

$$\boxed{VD = \frac{32}{2} = 16 \text{ gm}}$$

$\underline{VD = 8}$

$MM = 8 \times 2$
$= 16$ gm

(A) SO_2 (B) O_2
(C) CH_4 (D) H_2

Molar volume

⇒ only valid for gases

The volume occupied by one mole of any gas at STP (NTP) is known as Molar Volume. Its value is 22.4 lit or 22,400ml. .

The volume occupied by 44g of CO_2 (1 mole) at STP = 22.4 lit

44g → 1 mole

STP or NTP – Standard Temperature & Pressure, → 0°C, 1 atm
Or Normal Temperature & Pressure

Temperature – 0°C or 273 K

Pressure – 1 atm or 76cm of Hg or 760 mm of Hg

1 mole gas @ STP (0, 1 atm) = 22.4 lit (MV)

No. of moles

$$\text{No. of moles} = \frac{\text{Given mass}}{\text{Molar Mass}}$$

$$= \frac{\text{Given Particles}}{N_A}$$

$$= \frac{\text{Given volume of gas}}{\text{molar volume of gas (22.4 lit @ STP)}}$$

34 gm NH_3

$n^0 = 14\ N_A$

$p^+ = 20\ N_A$

$\underline{20 N_A}$ Total e^-

volume @STP $= 44.8$ lit

H-atoms $= 6\ N_A$

N-atoms $= 2\ N_A$

Total atoms $= 8\ N_A$ atom

No. of moles $= 2$ moles

molecules $\Rightarrow \underline{2\ N_A}$

64 gm

CH_4

18 gm

H_2O

4. Which has maximum number of atoms? (2003)

(A) 24 g of C(12)

(B) 56 g of Fe(56)

(C) 27 g of Al(27)

(D) 108 g of Ag(108)

5. The largest number of molecules is in **(1979)**

(A) 36 g of water

(B) 28 g of CO

(C) 46 g of ethyl alcohol

(D) 54 g of nitrogen pentaoxide (N_2O_5)

6. **A gaseous mixture contains oxygen and nitrogen in the ratio of 1:4 by weight. Therefore, the ratio of their number of molecules is (1979)**

(A) 1 : 4
(B) 1 : 8
(C) 7 : 32
(D) 3 : 16

Fill in the Blanks:

7. The weight of 1×10^{22} molecules of $CuSO_4.5H_2O$ is ________ (1991)

8. The total number of electrons present in 18 mL of water is ___ (1980)

9. The total number of electrons in one molecule of carbon dioxide is
[1979, 1M]

(A) 22
(B) 44
(C) 66
(D) 88

10. How many moles of electron weight 1 kg? [2002, 3 M]

(A) 6.023×10^{23}

(B) $\frac{1}{9.108} \times 1031$

(C) $\frac{6.023}{9.108} \times 1054$

(D) $\frac{1}{9.108 \times 6.023} \times 108$

11. How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms?

(a) 0.02

(b) 3.125×10^{-2}

(c) 1.25×10^{-2}

(d) 2.5×10^{-2}

(2006)

90 Th THORIUM | 7 N NITROGEN | 19 K POTASSIUM

39 Y YTTRIUM | 8 O OXYGEN | 92 U URANIUM