SOME IMPORTANT DEFINITIONS

Actual atomic mass ÷ Mass of 1 atom of element in grams.

***

Ex. mass of 1 S atom = $32 \cdot \left(\frac{1}{N_A}\right)$ g/atom

$= 32 \times 1.66 \times 10^{-24}$ g/atom

- Molar mass / Gram Atomic mass ÷ mass of 1 mole (6.022×10^{23}) atoms in grams.

Ex. Molar mass of oxygen atom = 16 g/mole

SOME IMPORTANT DEFINITIONS

ATOMIC MASS

- **Relative atomic mass** → mass of an atom Relative to C-12.

O = 16 amu

- **Actual Atomic mass** ÷ **mass of an atom**

1 gram

6.02×10^{23}

O = $16 \times 1.66 \times 10^{-24}$ g/atom

- **Molar Mass / Gram atomic mass** = mass of 1 mole (6.022×10^{23} oxygen atom)

$O = 16 \times 1.66 \times 10^{-24} \times 6.022 \times 10^{23} = 16$ g/mol.

(amu, N_A)

SOME IMPORTANT DEFINITIONS

$$1\,amu = \frac{1}{N_A}$$

SOME IMPORTANT DEFINITIONS

MOLECULAR MASS

$1\ amu = \frac{1}{12}$ mass of atom of C-12 $= \frac{1}{N_A} = 1.66 \times 10^{-24}\ g$

- **Relative molecular mass** :- The mass of 1 molecule. w.r.t C-12 atom unit.

  Ex. $CO_2 \Rightarrow 1 \times 12\ amu + 2 \times 16\ amu$

  $= 44\ amu$.

- **Actul Molecular mass** : the mass of 1 molecule in grams

  Ex. = CO_2 = $\Rightarrow \frac{44}{6 \times 10^{23}} = 7.2 \times 10^{-23}\ g/molecule$

SOME IMPORTANT DEFINITIONS

- Molar mass / Gram molecular mass
  - The mass of 1 mole molecule (6.022×10^{23}) in gram.

Ex. Molar mass of CO_2 = 44 g/mol.

✓ Examples : Find Relative molecular mass and mass of 1 molecule in grams and molar mass of following.

1) H_2S

RMM = 2x1amu + 1x32amu = 34amu

1 molecule of H_2S = $\frac{34}{6 \times 10^{23}}$ = 5.66×10^{-23} g

molar mass = 34 g/mol.

SOME IMPORTANT DEFINITIONS

(ii) SO_2

- RMM = $1 \times 32\text{amu} + 2 \times 16\text{amu}$
  $= 64\text{amu}$.

- Mass of 1 molecule of SO_2

  $= \frac{64}{6 \times 10^{23}} = 10.6 \times 10^{-23}$ g/molecule

- Molar mass = 64 g/mol.

SOME IMPORTANT DEFINITIONS

Ex. The molecular mass of H_2O is

(a) 18 amu (b) 2.99×10^{-23} g/molecule (c) 18 g/mol

✓(d) All of these.

HW $ZnSO_4$, HIO_4, $C_6H_{12}O_6$, AgI, $AgCl$, $AgBr$, HNO_3, H_2SO_4, H_3PO_4, $C_{12}H_{22}O_{11}$, $CaCO_3$, $MgCO_3$, NaCl, KCl, $KClO_3$, Urea (NH_2CONH_2).

Relative Atomic Mass (RAM)

Actual weight of 1 atom of Hydrogen = 1.67×10^{-24} g

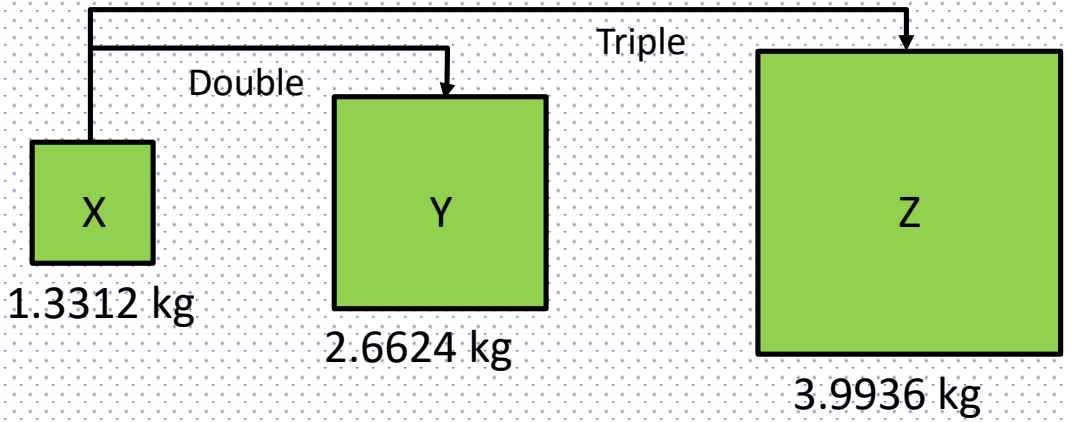
Actual weight of 1 atom of C-12 Isotope = 19.9×10^{-24} g

Actual weight of 1 atom of O-16 Isotope = 26.6×10^{-24} g

Relative Atomic Mass (RAM)

RAM w.r.t. Hydrogen atom

$$\text{RAM of an atom} = \frac{\text{Actual weight of 1 atom of element}}{\text{Actual weight of 1 atom of Hydrogen}}$$



Weight of Y = 2 × (weight of X)

Weight of Z = 3 × (weight of X)

Relative Atomic Mass (RAM)

Examples

$$\text{RAM of C-12 isotope} = \frac{\text{Actual weight of 1atom of C}-12 \text{ isotope}}{\text{Actual weight of 1 atom of Hydrogen}}$$

$$= \frac{19.9 \times 10^{-24}\,\text{g}}{1.67 \times 10^{-24}\,\text{g}} = 12$$

$$\text{RAM of O-16 isotope} = \frac{\text{Actual weight of 1atom of O}-16 \text{ isotope}}{\text{Actual weight of 1 atom of Hydrogen}}$$

$$= \frac{26.6 \times 10^{-24}\,\text{g}}{1.67 \times 10^{-24}\,\text{g}} = 16$$

Relative Atomic Mass (RAM)

RAM w.r.t. O-16 Isotope

$$\text{RAM of an element} = \frac{\text{Actual weight of 1atom of element}}{\frac{1}{16} \times \text{Actual weight of 1 atom of O}-16 \text{ Isotope}}$$

RAM w.r.t. C-12 Isotope

$$\text{RAM of an element} = \frac{\text{Actual weight of 1atom of element}}{\frac{1}{12} \times \text{Actual weight of 1 atom of C}-12 \text{ Isotope}}$$

C-12 Isotope $\rightarrow$ 98.75% Abundance

C-13 Isotope $\rightarrow$ 0.75% Abundance

C-14 Isotope $\rightarrow$ 0.50% Abundance

Relative Molecular Mass (RMM)

$$\text{RMM of molecule} = \frac{\text{Actual weight of 1molecule}}{\frac{1}{12} \times \text{Actual weight of 1 atom of C}-12 \text{ Isotope}}$$

Unit of RAM & RMM "a.m.u." (Atomic Mass Unit)

OR

'u' (Unified mass)

EXAMPLES

Actual mass of O-16 isotope atom = $16 \times 1.67 \times 10^{-24}$ g

RAM of O = 16 a.m.u.

RAM of N = 14 a.m.u.

RAM of S = 32 a.m.u.

RAM of CH_4 = 16 a.m.u.

RAM of O_2 = 32 a.m.u.

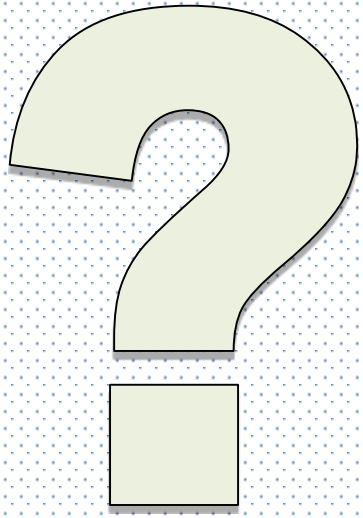
RAM of H_2SO_4 = 98 a.m.u.

RAM of CO_2 = 44 a.m.u.

1 a.m.u. = 1.67×10^{-24} g

ILLUSTRATIONS

Question : What is relative mass and actual mass of 1 P atom ?

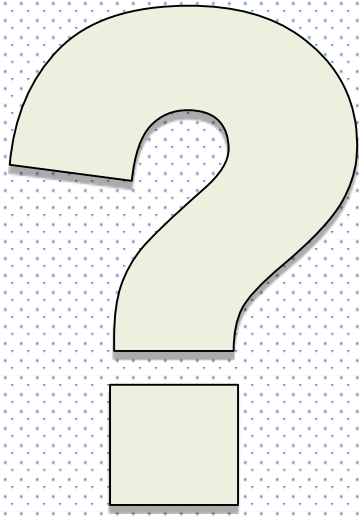


RAM = 31 amu

$$\text{Actual mass} = \frac{31}{6 \times 10^{23}} = 5.1 \times 10^{-23}\ \text{g/atom}$$

ILLUSTRATIONS

Question : What is relative mass and actual mass of 1 P atom ?



Solution : In P atom

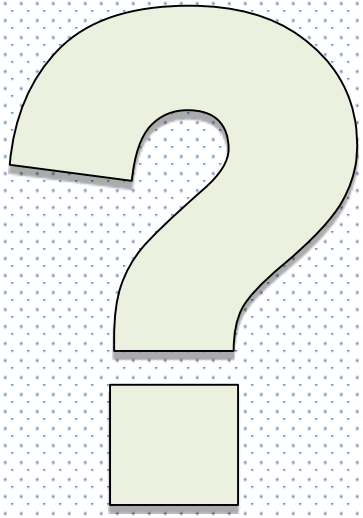
Relative atomic mass = 31 a.m.u.

Actual mass = $31 \times 1.67 \times 10^{-24}$ g

$= 5.17 \times 10^{-23}$ g

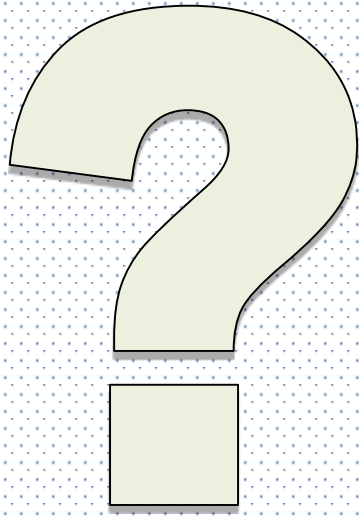
ILLUSTRATIONS

Question : What is relative mass and actual mass of 1 $Ca(OH)_2$ molecule?



ILLUSTRATIONS

Question : What is relative mass and actual mass of 1 $Ca(OH)_2$ molecule?



Solution : In $Ca(OH)_2$

Relative molecular mass = 40 + 2 (16 + 1)

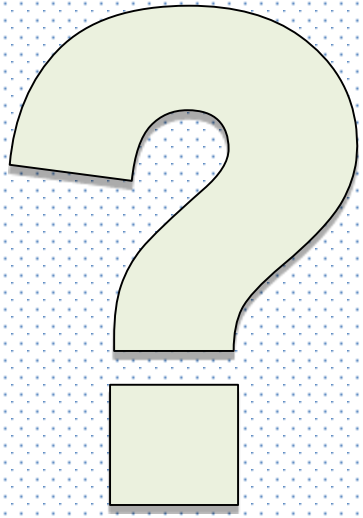
= 74 a.m.u.

Actual Mass = $74 \times 1.67 \times 10^{-24}$ g

= 1.23×10^{-22} g

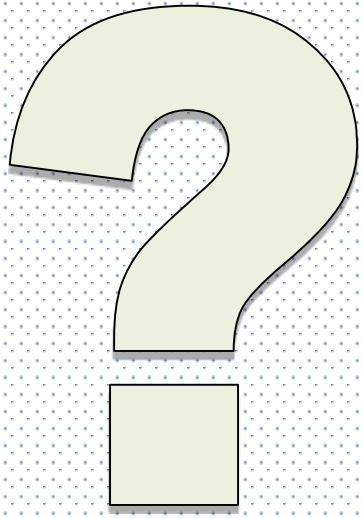
ILLUSTRATIONS

Question : Calculate number of atoms in 108 a.m.u. of Aluminium?



ILLUSTRATIONS

Question : Calculate number of atoms in 108 a.m.u. of Aluminium?



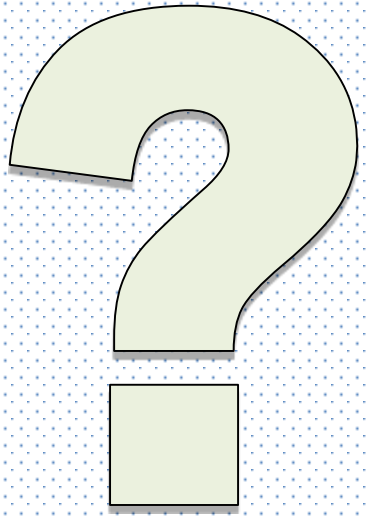
Solution : RAM of Al atom = 27 a.m.u.

$$\text{No. of Al atoms in 108 a.m.u.} = \frac{108}{27}$$

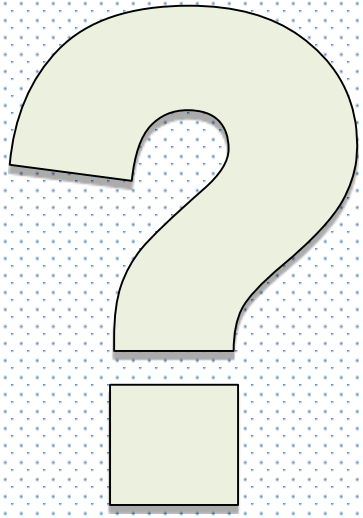
$$= 4$$

ILLUSTRATIONS

Question : Calculate the number of molecules and number of atoms in 34 a.m.u. of NH_3 ?



ILLUSTRATIONS



Question : Calculate the number of molecules and number of atoms in 34 a.m.u. of NH_3 ?

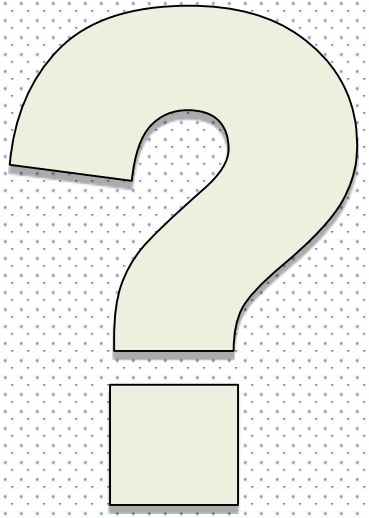
Solution : Relative molecular mass of NH_3 = 17 a.m.u.

No. of NH_3 molecules in 34 a.m.u. of NH_3 = $\frac{34}{17}$

= 2

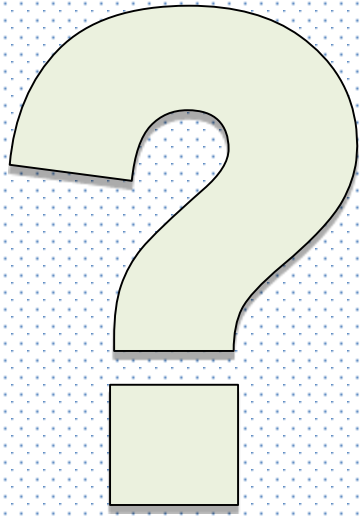
ILLUSTRATIONS

Question : Calculate the relative mass and actual mass of 1 molecule of $C_6H_{12}O_6$ (Glucose) ?



ILLUSTRATIONS

Question : Calculate the relative mass and actual mass of 1 molecule of $C_6H_{12}O_6$ (Glucose) ?



Solution : Relative molecular mass $= 6(12) + 12(1) + 6(16)$

$= 72 + 12 + 96$

$= 180$ a.m.u.

Actual mass $= 180 \times 1.67 \times 10^{-24}$ g

$= 3 \times 10^{-22}$ g

AVOGADRO NUMBER (N_A)

Avogadro Number (N_A) = 6.02×10^{23} entities / atoms / molecules / ions / e^- / p / n.

RAM of O-16 isotope = 16 a.m.u.

Actual mass of 1 atom of O-16 isotope = $16 \times 1.67 \times 10^{-24}$ g

Actual mass of 6.02×10^{23} atoms of O-16 isotope

$= 16 \times 1.67 \times 10^{-24} \times 6.02 \times 10^{23}$ g

Actual mass of N_A atoms of O-16 isotope = 16 g

Actual mass of 1 mole of atoms of O-16 isotope = 16 g

$1 \text{ a.m.u.} \times N_A = 1\text{g}$ ← Magical calculation

$$N_A = \frac{1}{\text{a.m.u.}}$$

AVOGADRO NUMBER (N_A)

- If in RAM or RMM, **'amu'** is replaced by **'gm'**, it becomes mass of 1 mole.

Example :

RAM of N = 14 a.m.u.

Actual weight of 1 mole of N = 14 a.m.u. × N_A = 14 g

SOME IMPORTANT DEFINITIONS

Ex: The mass of 3.2×10^5 atoms of an element is 8×10^{-18} gram find its. ($N_A = 6 \times 10^{23}$)

(i) RAM — 15 amu

(ii) Actual Atomic mass — 2.5×10^{-23} g/atom

(iii) Molar mass. — 15 g/mol.

3.2×10^5 atom ——— 8×10^{-18} g

1 atom ——— $\frac{8 \times 10^{-18}}{3.2 \times 10^5} = 2.5 \times 10^{-23}$

Molar mass $= 2.5 \times 10^{-23} \times 6 \times 10^{23} = 15$ g/mol

SOME IMPORTANT DEFINITIONS

Ex. The word "CHEMISTRY" is written by graphite (C) pencil. it has weight 3×10^{-10} gm find No of Carbon atom in this word. 1.5×10^{13} atoms.

✓ Mass of 1 atom C-12 $= \frac{12}{6 \times 10^{23}}$ g/atom

$= 2 \times 10^{-23}$ g/atom

✓ 2×10^{-23} g ——— 1 atom

3×10^{-10} g ——— ?

$= \frac{3 \times 10^{-10}}{2 \times 10^{23}} = \underline{1.5 \times 10^{13}}$

SOME IMPORTANT DEFINITIONS

Ex. 19.7 Kg Gold (Au) recoverd from a smuglar how many atoms of gold are recovered from smuglar (Atomic mass of Au = 197)

→ Mass of 1 atom of Au = $\frac{197}{6\times10^{23}}$ g

$\frac{197}{6\times10^{23}}$ g ——— 1 atom

19700 g ——— ? 100

$= \frac{19700 \times 6\times10^{23}}{197} = 6\times10^{25}$ atoms.

SOME IMPORTANT DEFINITIONS

Ex. Mass of 1 Br_2 molecule is 2.65×10^{-22} g/molecule find mass of 1 million Br atom.

(10^6)

2 atom ——— 2.65×10^{-22} g

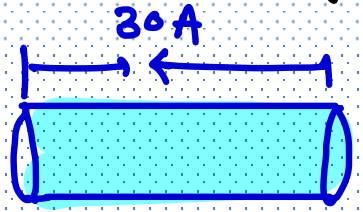
10^6 atom ——— ?

$$= \frac{2.65 \times 10^{-22} \times 10^6}{2}$$

$$= 1.325 \times 10^{-16} \text{ g}$$

SOME IMPORTANT DEFINITIONS

Ex. A cylendrical virus of length 30 A° and 7 A° diameter have density 5 g/cm³ what will be molar mass of virus.



1A → cm

$= \frac{10^{-10}}{10^{-2}} = 10^{-8}$ cm

$V = \pi r^2 h$

$= 3.14 \times \left(\frac{7}{2} \times 10^{-8}\right)^2 \cdot (30 \times 10^{-8})$

$V = \frac{22}{7} \times 3.5 \times 3.5 \times 10^{-16} \times 30 \times 10^{-8}$

$= 1153.95 \times 10^{-24}$ cm³/virus

mass of 1 virus $= 1153.95 \times 10^{-24}$ cm³ $\times 5$ g/virus

$= 1153.95 \times 10^{-24} \times 5$ g/virus

molar mass $= 1153.95 \times 10^{-24} \times 5 \times 6 \times 10^{23} = 3461.8$ g/mol

SOME IMPORTANT DEFINITIONS

- Molar mass means mass of 1 mole 6.02×10^{23}.

Ex. Find the no of CO_2 molecules in 66 gram sample of CO_2.

Mass of 1 molecule of $CO_2 = \frac{44}{N_A}$ g/mol.

$\frac{44}{N_A}$ g ——— 1 molecule

66 g ——— ?

$= \frac{66}{44} \times N_A = 1.5 N_A$

SOME IMPORTANT DEFINITIONS

Ex. How many atoms of S collectively weigh 16 kg.

Soln mass of 1 S atom = $\frac{32}{N_A}$ g/atom

$\frac{32}{N_A}$ g ——— 1 atom

16000 g ⟶ ?

$= \frac{16000 \times 1 \times N_A}{32}$

$= 500 N_A$ atoms

SOME IMPORTANT DEFINITIONS

Ex. If we change amu from C-12 to C-14 calculate relative atomic of Ca in new amu system.

: Assume mass of 1 atom C-12 = mass of 1 atom C-14

$$1\ amu = \frac{1}{12} \text{ mass of 1 atom C-12}$$

$$1(amu)' = \frac{1}{14} \text{ mass of 1 atom C-14}$$

$$\frac{1\ amu}{1(amu)'} = \frac{14}{12} = 7/6$$

$$1\ amu = (7/6)\cdot amu'$$

∴ Atom Mass of Ca

$= 40\ amu$

$= 40 \times 7/6\ amu'$

$= 46.67\ (amu)'$

SOME IMPORTANT DEFINITIONS

Ex: If we change amu from C-12 to N-15 find Relative atomic mass of S in new system

given mass 1 atom N-15 $= 3/2$ mass of 1 atom C-12

(y) (x)

$$1\,amu = \frac{1}{12} \times (x)$$

$$1(amu)' = \frac{1}{15} \times (y)$$

$$\frac{1\,amu}{1\,amu'} = \frac{15}{12}\left(\frac{x}{y}\right) = \frac{15 \times 2}{12 \times 3} = \left(\frac{30}{36}\right)$$

$$1\,amu = \left(\frac{30}{36}\right) amu'$$

Relative Atomic mass $= 32\,amu = \frac{8}{32} \times \frac{10}{\frac{30}{36}} \times 3 = \frac{80}{3} = 26.67\,amu'$

SOME IMPORTANT DEFINITIONS

Ex. A mixture of 2×10^{21} molecules of P and 3×10^{21} molecules of Q has weight 0.6 gram If molecular mass of P = 45, then molecular of Q will be ?.

$$\left(\frac{45}{N_A}\right)\times 2\times10^{21} + \left(\frac{M}{N_A}\right)\times 3\times10^{21} = 0.6$$

$$\frac{45\times 2\times10^{21}}{6\times10^{23}} + \frac{M\times 3\times10^{21}}{6\times10^{23}} = 0.6$$

$$M = 90 \text{ amu}$$