Number of moles = $\frac{\text{Mass}}{\text{Avogadro number}}$

$$n = \frac{N}{N_0}$$

or $m = n \times M$ and $N = n \times N_0$

Let us apply these formulae to solve numerical problems.

Important Note

The numerical problems can be solved directly by using the above formulae. Alternatively, these can be solved by using the main relations and applying unitary method. Most of the numerical problems in the chapter are solved by this method because it is easy and no cramming of the formulae is needed.

A. Calcutation of Moles of a substance (element or compound)

We have learnt that

1 Mole of an element = Gram atomic mass

1 Mole of a compound = Gram molecular mass or Molar mass

Moles can be calculated from mass by using these relations.

Solved Examples

❑ **Example 20. An ornament of silver contains 20 g of silver. Calculate the moles of silver present (atomic mass of silver = 108 u)**

Solution : We know that

1 mole of silver atoms = Gram atomic mass of silver

= 108g

Now, 108g of silver = 1 mole of silver

$$20\text{g of silver} = \frac{1}{108} \times 20 = \mathbf{0.185\ mole}$$

Note: The above problem can also be solved by applying the relation:

$$\text{Moles of atoms, } n = \frac{\text{Mass of element in grams}}{\text{Gram atomic mass}}$$

$$\therefore n = \mathbf{0.185\ mole}$$

❑ **Example 21. How many moles of CO_2 are present in 51.2 g of it ?**

(atomic masses, C = 12 u, O = 16 u)

Solution : Molecular mass of $CO_2 = 12 + 2 + 16 = 44$ u

We know that,

1 mol of CO_2 = Gram molecular mass of CO_2

= 44g

Now, 44g of CO_2 = 1 mole of CO_2

$$51.2\text{g of } CO_2 = \frac{1}{44} \times 51.2$$

$$= \mathbf{1.16\ mole}$$

❑ **Example 22. Calculate the number of moles of 52 g of He. (atomic mass of He = 4 u)**

Solution : We know that

1 mole of He = Gram atomic mass of He

= 4g

Now, 4 g of He = 1 mole of He

$$52\text{ g of He} = \frac{1}{4} \times 52$$

$$= \mathbf{13\ mole}$$

❑ **Example 23. Calculate the mass of**

(*i*) 0.5 moles of N_2 gas

(*ii*) 0.5 moles of N atoms

Solution : (*i*) **0.5 moles of N_2 gas**

Molecular mass of $N_2 = 2 \times 14 = 28$u

1 mole of N_2 = Gram molecular mass of N_2

= 28g

Now, 1 mole of N_2 = 28g

0.5 mole of $N_2 = 28 \times 0.5 = \mathbf{14g}$

(*ii*) **0.5 mole of N atoms**

1 mole of N atoms = Gram atomic mass of N

= 14g

Now, 1 mole of N atoms = 14g

0.5 mole of N atoms $= 14 \times 0.5 = \mathbf{7g}$

❑ **Example 24. What is the mass in grams of 3 moles of zinc (Zn) ?**
(atomic mass of Zn = 65.4)

Solution : Atomic mass of zinc = 65.4 u

We know that

1 mole of zinc = Gram atomic mass of zinc
= 65.4g

Now, 1 mole of zinc = 65.4g

3 moles of zinc = 65.4 × 3 = **196.2g**

❑ **Example 25. What is the mass of 2.5 moles of methane (CH_4) ? (atomic mass of C = 12, H = 1)**

Solution : Molecular mass of CH_4 = 12 + 4 × 1 = 16 u

We know that,

1 mole of CH_4 = Gram molecular mass of CH_4
= 16g

Now, 1 mole of CH_4 = 16g

2.5 moles of CH_4 = 16 × 2.5 = **40g**

❑ **Example 26. Convert into moles :**
(a) 90 g of water
(b) 12 g of oxygen
(c) 22 g of carbon dioxide.

Solution :

(a) Molecular mass H_2O = 2 × 1 + 16 = 18 u

We know that,

1 mole water (H_2O) = 18g of water

Now, 18g of water = 1 mole

$$90\text{g of water} = \frac{1}{18} \times 90 = 5 \text{ mole}$$

(b) Molecular mass of oxygen = 2 × 16 = 32 u

We know that,

1 mole of oxygen = 32g of oxygen

Now, 32g oxygen = 1 mole

$$12\text{ g of oxygen} = \frac{1}{32} \times 12 = \mathbf{0.375\ mole}$$

(c) Molecular mass of CO_2 = 12 + 2 × 16 = 44 u

We know that,

1 mole of CO_2 = 44g

Now, 44g of CO_2 = 1 mole

$$22\text{g of } CO_2 = \frac{1}{44} \times 22 = \mathbf{0.5\ mole}$$

B. Calculation of number of atoms or molecules from moles of substance.

We have learnt that

1 mole of a substance = 6.022×10^{23} particles (atoms, molecules or ions)

e.g., 1 mole of an element = 6.022×10^{23} atoms

1 mole of a compound = 6.022×10^{23} molecules.

Solved Examples

❑ **Example 27. Calculate the number of calcium atoms in 2.5 mole of calcium.**

Solution : 1 mole = 6.022×10^{23} particles

Now,

1 mole of calcium atoms = 6.022×10^{23} atoms

2.5 moles of calcium atoms = $6.022 \times 10^{23} \times 2.5$
= $\mathbf{15.055 \times 10^{23}}$ **atoms**

❑ **Example 28. Calculate the number of water molecules and number of oxygen and hydrogen atoms in a drop of water containing 0.03 mole of water.**

Solution : 1 mole of water = 6.022×10^{23} molecules of water

0.03 mole of water = $6.022 \times 10^{23} \times 0.03$
= 1.81×10^{21} molecules of water

$\therefore$ Molecules of water = 1.81×10^{21}

Now 1 molecule of water contains two atoms of H and one atom of O

$\therefore$ Atoms of O = $1.81 \times 10^{21} \times 1 = 1.81 \times 10^{21}$

Atoms of H = $1.81 \times 10^{21} \times 2 = 3.62 \times 10^{21}$.

❑ **Example 29. Calculate the number of sulphur (S) atoms in one mole of S_8.**

Solution : 1 mole of S_8 = 6.022×10^{23} S_8 molecules

No. of atoms in one S_8 molecule = 8

No. of atoms in 6.022×10^{23} S_8 molecules =
$8 \times 6.022 \times 10^{23}$ = $\mathbf{4.818 \times 10^{24}}$

C. Calculation of number of atoms or molecules from mass of substance.

These types of calculations can be done by combining earlier types A and B.

❑ **Example 30. Calculate the number of moles of 12.046×10^{23} number of He atoms.**

Solution :

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

$$1 \text{ mole of He atoms} = 6.022 \times 10^{23} \text{ He atoms}$$

Now, 6.022×10^{23} He atoms $= 1$ mole

$$12.046 \times 10^{23} \text{ He atoms} = \frac{1}{6.022 \times 10^{23}} \times 12.046 \times 10^{23}$$

$$= \mathbf{2 \text{ mole}}$$

Alternatively,

$$\text{No. of moles} = \frac{\text{Given number of particles}}{\text{Avogadro number}}$$

$$n = \frac{N}{N_0}, \; N = 12.046 \times 10^{23}, \; N_0 = 6.022 \times 10^{23}$$

$$\therefore \quad n = \frac{12.046 \times 10^{23}}{6.022 \times 10^{23}} = \mathbf{2 \text{ mole}}$$

❑ **Example 31. Calculate the number of atoms in 0.1 mole of carbon atoms.**

Solution : We know that,

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

$$1 \text{ mole of C atoms} = 6.022 \times 10^{23} \text{ C atoms}$$

$$0.1 \text{ mole of C atoms} = 6.022 \times 10^{23} \times 0.1$$

$$= \mathbf{6.022 \times 10^{22} \text{ atoms}}$$

❑ **Example 32. Calculate the number of particles in each of the following:**

(a) 46 g of Na atoms (at mass of Na = 23 u)

(b) 8 g of O_2 molecules (at. mass of O = 16 u)

Solution :

(a) We know that,

$$1 \text{ mole of Na} = \text{Gram atomic mass} = 23\text{g}$$

$$= 6.022 \times 10^{23} \text{ particles (or Na atoms)}$$

Now, $23\text{g of Na} = 6.022 \times 10^{23}$ particles

$$46\text{g of Na} = \frac{6.022 \times 10^{23}}{23} \times 46$$

$$= 1.2044 \times 10^{24} \text{ atoms (or particles)}$$

This numerical problem can also be solved in two steps as:

(i) First calculate the number of moles from the mass and then

(ii) Calculate the number of Na atoms in the given mass as:

(i) $1 \text{ mole of Na} = \text{Gram atomic mass} = 23\text{g}$

Now, $23\text{g of Na} = 1 \text{ mole of Na}$

$$46\text{g of Na} = \frac{1}{23} \times 6 = 2 \text{ mole}$$

(ii) Now, $1 \text{ mole of Na} = 6.022 \times 10^{23}$ Na atoms

$2 \text{ mole of Na} = 6.022 \times 10^{23} \times 2$

$$= 1.2044 \times 10^{24} \text{ atoms}$$

(b) Atomic mass of oxygen $= 16$ u

Molecular mass of $O_2 = 16 \times 2 = 32$ u

$1 \text{ mole of } O_2 = \text{Gram molecular mass of } O_2 = 32\text{g}$

$= 6.022 \times 10^{23}$ molecules (particles)

Now, $32g \text{ of } O_2 = 6.022 \times 10^{23} \text{ molecules}$

$$8g \text{ of } O_2 = \frac{6.022 \times 10^{23}}{32} \times 8$$

$$= \mathbf{1.5055 \times 10^{23} \text{ molecules}}$$

Example 33. Calculate the mass of

(i) 3.011×10^{23} atoms of N

(ii) 1.807×10^{24} molecules of N_2.

Solution : (i) Atomic mass of N = 14u

We know that,

$$1 \text{ mole of N} = \text{Gram atomic mass of N} = 14g$$
$$= 6.022 \times 10^{23} \text{ N atoms}$$

Now, 6.022×10^{23} N atoms have mass = 14g

$$3.011 \times 10^{23} \text{ N atoms have mass} = \frac{14}{6.022 \times 10^{23}} \times 3.011 \times 10^{23}$$
$$= 7g$$

(ii) Molecular mass of $N_2 = 14 \times 2 = 28$ u

We know that

$$1 \text{ mole of } N_2 = \text{Gram molecular mass of } N_2 = 28g$$
$$= 6.022 \times 10^{23} \text{ molecules of } N_2$$

Now, 6.022×10^{23} molecules of $N_2 = 28g$

$$1.807 \times 10^{24} \text{ molecules of } N_2 = \frac{28}{6.022 \times 10^{23}} \times 1.807 \times 10^{24} = \mathbf{84g}$$

SOME ADDITIONAL NUMERICAL PROBLEMS (MISCELLANEOUS)

Example 34. Convert into moles

(i) 12 g of oxygen gas

(ii) 20 g of water

(iii) 22 g of carbon dioxide.

Solution : (i) Molecular mass of O_2 gas = $16 \times 2 = 32$ u

We know that,

$$1 \text{ mole of } O_2 \text{ gas} = \text{Gram molecular mass of } O_2$$
$$= 32g$$

Now, $32g \text{ of } O_2 \text{ gas} = 1 \text{ mole}$

$$12g \text{ of } O_2 \text{ gas} = \frac{1}{32} \times 12 = \mathbf{0.375 \text{ mole}}$$

(ii) Molecular mass of water $= 2 \times 1 + 16 = 18$u

We know that

$$1 \text{ mole of water} = \text{Gram molecular mass of } H_2O$$
$$= 18g$$

Now, $18g \text{ of water} = 1 \text{ mole}$

$$20g \text{ of water} = \frac{1}{18} \times 20 = \mathbf{1.11 \text{ mole}}$$

(iii) Molecular mass of $CO_2 = 12 + 2 \times 16 = 44$ u

We know that

$$1 \text{ mole of } CO_2 = \text{Gram molecular mass of } CO_2$$
$$= 44g$$

Now, $44g \text{ of } CO_2 = 1 \text{ mole}$

$$22g \text{ of } CO_2 = \frac{1}{44} \times 22 = \mathbf{0.5 \text{ mole}}$$

Example 35. What is the mass of

(i) 0.5 mole of water molecules

(ii) 0.2 mole of oxygen atoms.