

## Atomic & molecular weights, mole concept and

### Equivalent Weights

1. The smallest particle of an element that takes part in a chemical reaction is an atom.
2. The smallest particle of a substance that can exist in the free State is a molecule.
3. Atomic weight or atomic mass of an element is a relative mass and is expressed in Atomic mass units or atomic weight units (a.m.u. or u).
4. The latest standard for determining Atomic masses is  ${}_{6}\text{C}^{12}$  which is assigned a mass of 12 a.m.u. So, one a.m.u. is  $1/12$  part of the mass of  ${}_{6}\text{C}^{12}$  atom.
5. One a.m.u. is also known as one Dalton or one Aston or Avogram.

$$1 \text{ a.m.u.} = 1.66 \times 10^{-24} \text{ gm}$$

6. Atomic mass of an element is the average of the isotopic masses (in a.m.u) of the Isotopes present in it.

**E.g.** Natural Neon consists of two Isotopes with Isotopic masses 20 and 22 in the percentage abundance of 90: 10.

$$\text{Hence the Atomic mass of Neon} = (90 \times 20 + 10 \times 22) / 100 = 20.2$$

7. Molecular weight (or) Molecular mass is also a relative mass expressed in a.m.u..
8. The numerical value of the molecular mass expressed in grams is called a gram - molecular weight or a gram molecule or a gram mole or a molar mass or a mole of that substance.

**E.g.:** 1 mole of oxygen is 32g of oxygen.

$$1 \text{ mole of Nitrogen is } 28\text{g of Nitrogen.}$$

9. Number of moles (n) = mass of the substance/molar mass.

10. One mole of any substance (or one mole of a mixture of substances) contains the same number of molecules namely  $6.023 \times 10^{23}$  molecules. This number is known as Avogadro number (N).
11. One mole of any gas or Vapour (or a mixture of gases) at STP occupies a volume of 22.4 litres. This is known as Gram Molar Volume (G.M.V.)
12. One mole = Numerical value of the molecular weight of the substance expressed in grams.  
= mass of  $6.023 \times 10^{23}$  molecules of the substance  
= mass of 22.4 lit of gas (or) vapour at STP  
\*No. of molecules in 1cc of a gas at S.T.P =  $2.67 \times 10^{19}$ .
13. The numerical value of the atomic weight of an element expressed in grams is known as a gram atomic weight (GAW) or a gram atom of that element.  
E.g.: One gram atom of carbon = 12 grams of carbon
14. One gram atom of any element contains  $6.023 \times 10^{23}$  atoms of the element.
15. Number of gram - atoms (n) = Mass of element / gram atomic weight.
16. One gram -atom = Numerical value of the atomic weight of the element expressed in grams = Mass of  $6.023 \times 10^{23}$  atoms of the element.
17. Mass of one atom =  $GAW / 6.023 \times 10^{23}$ .
18. The numerical value of the formula weight of an ion expressed in grams is called one gram ion.  
One gram - ion or a mole of ions contains  $6.023 \times 10^{23}$  ions.
19. A mole of molecules means  $6.023 \times 10^{23}$  molecules, a mole of atoms means  $6.023 \times 10^{23}$  atoms and a mole of ions means  $6.023 \times 10^{23}$  ions.
20. Vapour density of a gas or vapour =  $\frac{\text{Density of the gas}}{\text{Density of Hydrogen}}$

21. The ratio of densities, the ratio of vapour densities and the ratio of molecular weights of two gases are equal.

$$\frac{d_A}{d_B} = \frac{D_A}{D_B} = \frac{M_A}{M_B}$$

22. Molecular weight = density of the gas at STP in g/L  $\times$  22.4

23. Vapour density of a gas = density of the gas at STP  $\times$  11.2

24. Molecular weight = 2  $\times$  vapour density.

25. Equivalent weight of an element = Atomic weight/valency.

Element	Atomic Mass	Valency	Equivalent Weight
Hydrogen	1	1	1
Sodium	23	1	23
Magnesium	24	2	12
Aluminium	27	3	9
Carbon	12	4	3
Zinc	65.4	2	32.7
Silver	108	1	108
Oxygen	16	2	8
Chlorine	35.5	1	35.5
Nitrogen	14	3	4.67
Phosphorus	31	3	10.33
Potassium	39.1	1	39.1
Sulphur	32	2	16
Bromine	80	1	80

26. In a balanced chemical equation, always two substances are in 1:1 ratio of their equivalents.

27. The equivalent weight of a substance need not necessarily be a fixed value.

28. Equivalent weight of an acid =  $\frac{\text{Formula weight}}{\text{Basicity}}$

**Equivalent weights of some acids**

Acid	Formula	Formula Weight	Basicity	Equivalent Weight
Hydrochloric acid	HCl	36.5	1	36.5
Sulphuric acid	H <sub>2</sub> SO <sub>4</sub>	98	2	49
Nitric acid	HNO <sub>3</sub>	63	1	63
Acetic acid	CH <sub>3</sub> COOH	60	1	60
Oxalic acid	H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> .2H <sub>2</sub> O	126	2	63
Phosphoric acid	H <sub>3</sub> PO <sub>4</sub>	98	3	32.67
Phosphorous acid	H <sub>3</sub> PO <sub>3</sub>	82	2	41
Hypo phosphorus acid	H <sub>3</sub> PO <sub>2</sub>	66	1	66
Perchloric acid	HClO <sub>4</sub>	100.5	1	100.5

29. Equivalent weight of base =  $\frac{\text{Formula weight of base}}{\text{Acidity of base}}$

**Equivalent weights of some bases**

Base	Formula	Formula Weight	Acidity	Equivalent Weight
Sodium hydroxide	NaOH	40	1	40
Potassium hydroxide	KOH	56	1	56
Calcium hydroxide	Ca (OH) <sub>2</sub>	74	2	37
Aluminium hydroxide	Al (OH) <sub>3</sub>	78	3	26
Ferrous hydroxide	Fe (OH) <sub>2</sub>	90	2	45
Ferric hydroxide	Fe (OH) <sub>3</sub>	107	3	35.67
Ammonium hydroxide	NH <sub>4</sub> OH	35	1	35
Chromic hydroxide	Cr (OH) <sub>3</sub>	103	3	34.33

30. Equivalent weight of salt

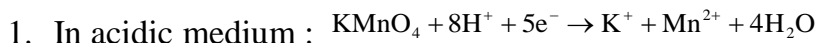
$$E_{\text{salt}} = \frac{\text{Formula weight of the salt}}{\text{Total charge of the cation or anion of the salt}}$$

$$E_{\text{Al}_2(\text{SO}_4)_3} = \frac{F}{6} = \frac{342}{6} = 57$$

31. Equivalent weight of Ion =  $\frac{\text{Formula weight}}{\text{Charge / Valency}}$ ,  $E_{\text{Fe}^{+2}} = \frac{56}{2} = 28$

32. Equivalent weight of oxidising agent =  $\frac{\text{Formula weight of oxidant}}{\text{Electrons gained by one molecule of oxidant}}$

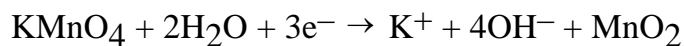
E.g.: KMnO<sub>4</sub> acts as oxidant in acidic, basic and also in neutral medium.



One molecule of KMnO<sub>4</sub> gains five electrons. Hence, the equivalent weight of KMnO<sub>4</sub>

$$= \frac{\text{Mol.wt.of KMnO}_4}{5} = \frac{158.04}{5} = 31.608$$

2. In neutral as well as weakly basic medium:



One molecule of  $\text{KMnO}_4$  gains three electrons.

Hence the equivalent weight of

$$\text{KMnO}_4 = \frac{\text{Mol.wt.of KMnO}_4}{3} = \frac{158.04}{3} = 52.68$$

3. In strongly alkaline medium:  $\text{MnO}_4^- + \text{e}^- \rightarrow \text{MnO}_4^{2-}$

$$\text{Then the equivalent weight of KMnO}_4 = \left\{ \frac{\text{Mol.wt.of KMnO}_4}{1} \right\} = 158.04$$

33. Equivalent weight of reducing agent

$$E_{\text{reductant}} = \frac{\text{Formula weight of reductant}}{\text{Electrons lost by one molecule of reductant}}$$

Mohr's salt is ferrous ammonium sulphate



Formula weight = 392



The equivalent weight of Mohr's salt is  $392/1 = 392$