THE MOLE

VISUAL CHEM CARDS

Nigel Freestone

The Mole

6.02×10^{23}

Avogardo's Number (N_A)

602,214,090,000,000,000,000,000

1 mole = 6.02×10^{23}

1 mole of an element = Relative Atomic Mass (A_r) in g

1 mole of a compound = Relative Formula Mass (M_r) in g

1 mole of a gas occupies a volume of 22,400 cm^3 at STP

Essential Mole Equations

$$n = \frac{m}{M_r}$$

$$N = n \ x \ N_A$$

$$m = n \ x \ M_r$$

$$v = n \ x \ V_m$$

$$M_r = m \ x \frac{V_m}{v}$$

n = number of moles (mol.)

N = number of particles i.e. atoms/molecules/ions etc.

m = mass (g)

M_r = molar mass (g/mol)

N_A = 6.02 x 10^{23}

v = volume (cm^3)

V_m = molar volume

Mole Calculating Framework

Mole Calculating Framework – use to solve all mole-based problems

$$cAX_3 + dZ_2 \longrightarrow eAZ + fZX_2$$

Balanced Equation	cAX_3	+	dZ_2	$\longrightarrow$	eAZ	+	fZX_2
A_r or M_r	$M_r[AX_3]$		$M_r[Z_2]$		$M_r[AZ]$		$M_r[ZX_2]$
Reaction Coefficients	c		d		e		f
Mass Balance*	c x $M_r[AX_3]$		d x $M_r[Z_2]$		e x $M_r[AZ]$		f x $M_r[ZX_2]$
No. of Moles	= Mass of $AX_3/M_r[AX_3]$		= Mass of $Z_2/M_r[Z_2]$		= Mass of $AZ/M_r[AZ]$		= Mass of $ZX_2/M_r[ZX_2]$
No. of Moles (gases only)	= Vol. $(AX_3)/V_m$		= Vol. $(Z_2)/V_m$		= Vol. $(AZ)/V_m$		= Vol. $(ZX_2)/V_m$
Mass (g)	= No. of moles AX_3 x $M_r[AX_3]$		= No. of moles Z_2 x $M_r[Z_2]$		= No. of moles AZ x $M_r[AZ]$		= No. of moles ZX_2 x $M_r[ZX_2]$
Volume (cm^3) (solutions only)	= No. of moles AX_3 x V_m		= No. of moles Z_2 x V_m		= No. of moles AZ x V_m		= No. of moles ZX_2 x V_m

Mass Balance: $(c \times M_r[AX_3]) + (d \times M_r[Z_2]) = (e \times M_r[AZ]) + (f \times M_r[ZX_2])$

All the items in red are known or can be readily obtained from the balanced equation and relative atomic masses. In calculations additional information will be provided from which all the remaining values can be determined, using the equations provided in the boxes.

Concentration

Solution: A homogeneous mixture of substances.

Solvent: The substance in a solution present in the greatest amount.

Solute: the substance in a solution present in the least amount.

Solubility: the property of a solid, liquid or gaseous chemical substance called **solute** to dissolve in a solid, liquid or gaseous **solvent**.

Concentration refers to the amount of a substance per defined space.

Another definition is that **concentration** is the ratio of solute in a solution to either solvent or total solution.

Concentration can be expressed in several ways:

Type of solution (solute-solvent)	Units	Equation
solid-liquid	**Molarity** (M or mol/L or mol dm^{-3})	Number of moles of solute per litre of solvent*
solid-liquid	**Mass per volume** (g/L or g dm^{-3})	Number of g per litre of solvent
solid-solid	**Percent by Mass** (% m/m) **	Mass of solute/ Mass of solution x 100
liquid-liquid	**Percent by volume** (% v/v)	Volume of solute / Volume of Solution x 100
solid-liquid	**Percent by mass/volume** (% m/v)	Mass of Solute/ Volume of Solution x 100
All solutions	**Parts per million** (ppm; mg /L; mg/kg)	Mass of solute/ Mass of Solution x 10^6

Molarity

Molarity (M) is the concentration of a solution expressed as the number of moles of solute present in a litre of solution.

A 1M solution contains a molar mass (M_r) of solute in 1 litre (L) of solvent.

The following units of concentration are all the same:

M = mol L^{-1} = mol/L = mol dm^{-3} = mol/dm^3

Useful Equations

$$c = \frac{n}{v}$$

$$n = c \times v$$

$$v = \frac{n}{c}$$

c = concentration (mol dm^{-3}, mol/l)

n = number of moles (mol.)

v = volume (dm^3 or litre)

Note: dm^3 = litre = 1000cm^3

Molarity

Concentration can also be expressed as stated above in terms of mass (g) per unit of volume (L), i.e. gL^{-1} (g/L) or g dm^{-3} (g/dm^3).

Units:

V = Volume (L)

If the amount of solute is measured in moles, then concentration unit is M

If amount of solute is measured in g then concentration unit is g/L (g L^{-1}) or g dm^{-3}

For example: glucose, $C_6H_{12}O_6$ has a molar mass (M_r) of 180 g mol^{-1}. A solution of 180 g of glucose dissolved in a total volume of 1 litre therefore, has a concentration of 1.0 M or 180g/L. A 0.1M solution of glucose therefore contains 18.0g (0.1 x M_r) of dissolved glucose in 1 L of solution. Similarly, 1.8 g of glucose in $100cm^3$ is equivalent to 18 g in 1000 cm^3 (1 L), giving a concentration of 0.1 M or 18 g/L.

To convert from M to g/L multiply by M_r

To convert g/L to M divide by M_r

Volumetric Analysis Calculating Framework

Volumetric (Titrimetric) Analysis Calculating Framework

..........to solve all volumetric analysis problems.

$$uA_{(aq)} + wB_{(aq)} \longrightarrow yC_{(aq)} + zD_{(aq)}$$

A: Unknown concentration (analyte)

B: Standard solution (**titrant**) – known concentration and volume

Balanced Equation	**uA**	**+**	**wB**	$\longrightarrow$	**yC**	**+**	**zD**
Reaction Coefficients	u		w		y		z
Concentration (M)	Concentration of A (c_A)		Concentration of B (c_B)				
Volume (cm^3)	Volume of A (V_A)		Volume of B (V_B)				
No. of Moles (n)	$n_A = V_A \times c_A$		$n_B = V_B \times c_B$				

At the end point:

number of moles of B (n_B) $= V_B \times c_B$

number of moles of A (n_A) $= (u/w) \times n_B$
$= (u/w) \times V_B \times c_B$

concentration of A (analyte) $= n_A/V_B$
$= (u/w) \times V_B/V_A \times c_B$

Concentration (M) of A = $(u/w) \times V_B/V_A \times c_B$