RMIT UNIVERSITY

CHEM 3.2 CHEMICAL BONDING 2

Oxidation States, Solubility Rule

Oxidation Numbers (ON) also called Oxidation States (OS)

Definition:

Oxidation Is the Loss of electrons, Reduction Is the Gain of electrons by a species, "OILRIG"

Eg, **in Na^+ $C\ell^-$** Na^o [Ne]$3s^1$ loses one electron to form Na^+ [Ne]$3s^o$, so it has been oxidised, whilst $C\ell^o$ [$1s^22s^22p^5$] gains one electron to form $C\ell^-$ [$1s^22s^22p^6$]=[Ne], so it has been reduced, and the two ions have the stable 's^2p^6' electron configuration.

Na^+ is said to have an OS (ON) of +1, while $C\ell^-$ has an OS (ON) of -1.

Eg

-2

+1 H x • O • x H +1

-1

: F • x H +1

EN(O) = 3.44 > EN(H) = 2.2

So O takes share of electrons

So **ON(O) = -2** & **ON(H) = +1**

EN(F) = 3.98 > EN(H) = 2.2

So F takes share of electrons

So **ON(F) = -1** & **ON(H) = +1**

To calculate oxidation numbers(ON)

Rule for $A_aB_b{}^n$; a.ON(A) + b.ON(B) = n

Usually take **ON(O) as -2** **ON(H) = +1**

OCl^- hypochlorite anion Electronegativities : O, 3.44 ; Cl, 3.16, so take ON(O) as -2

ON(O) + ON(Cl) = -1 so, -2 + ON(Cl) = -1, Hence, ON(Cl) = +1

SO_2 sulphur dioxide Electronegativities : O, 3.44 ; S, 2.58, so take ON(O) as -2

2.ON(O) + ON(S) = 0 so, 2.(-2) + ON(S) = 0 , Hence, ON(S) = +4

(Elec. Config. S = [Ne]$3s^23p^43d^0$ so S^{4+} = [Ne])

SO_3 sulphur trioxide Electronegativities : O, 3.44 ; S, 2.58, so take ON(O) as -2

3.ON(O) + ON(S) = 0 so, 3.(-2) + ON(S) = 0 , Hence, ON(S) = +6

(Elec. Config. S = [Ne]$3s^23p^43d^0$ so S^{6+} =[Ne])

Oxidation Numbers:

Iron(III) chloride, **$FeCl_3$** Electronegativities : Cl, 3.16 ; Fe, 1.83, so take ON(Cl) as -1

$2.Fe + 3.Cl_2 \longrightarrow$ **$2FeCl_3$** ($2.Fe^{3+}$ $6.Cl^-$)

Iron(III) oxide, **Fe_2O_3** Electronegativities : O, 3.44 ; Fe, 1.83, so take ON(O) as -2

$4.Fe + 3.O_2 \longrightarrow$ 2. **Fe_2O_3** ($4.Fe^{3+}$. $6.O^{2-}$)

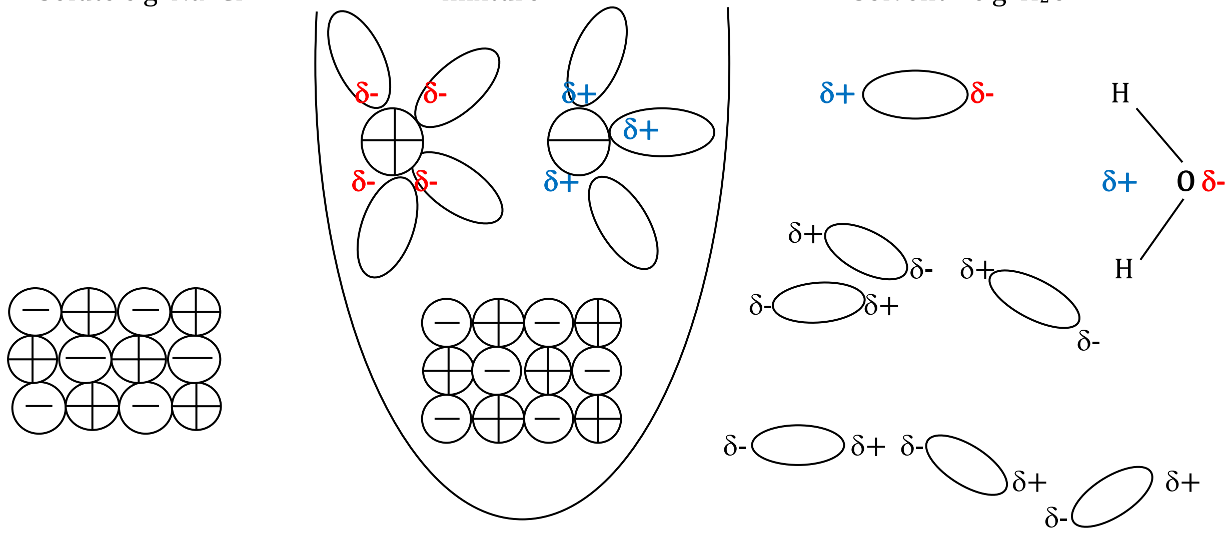
Magnesium(II) oxide, **MgO** Electronegativities : O, 3.44 ; Mg, 1.31, so take ON(O) as -2

$2.Mg + O_2 \longrightarrow$ 2.**MgO** (Mg^{2+} O^{2-})

SOLUBILITY is an important topic in chemistry because many chemical reactions occur in aqueous fluids. In general, solubility depends on whether the **solute** (usually a **solid**) is ionic or molecular, and whether the **solvent liquid** contains polar or non-polar molecules.

Ionic Solutes in polar solvents

Solute e.g. Na^+Cl^- mixture Solvent e.g. H_2O



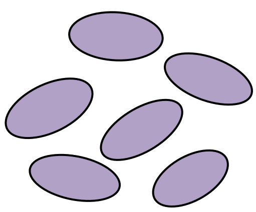
Forces between ions:
Ionic (electrostatic)

Forces between solvent molecules:
dipole – dipole (electrostatic)

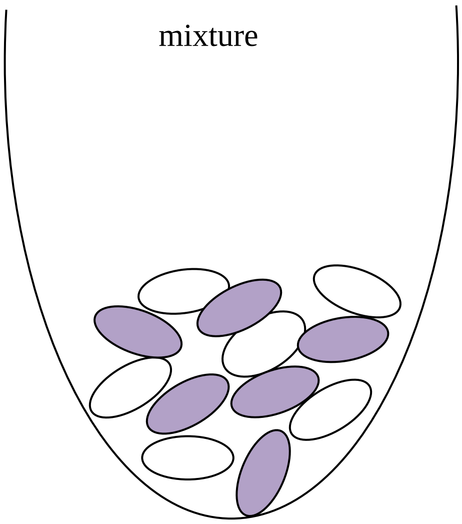
So, the nature of the forces between solute and solvent are comparable.
Hence, the strong electrostatic forces between ions in the crystal lattice can be matched by the ion-dipole electrostatic interaction between ions and the polar solvent molecules. Thus, we can expect **ionic (polar) solutes** to be **soluble** in **polar solvents**.

Molecular solutes in non-polar solvents

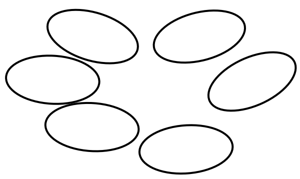
Solute, eg. I_2



Forces between solute molecules:
van der Waals



Solvent, eg. C_8H_{18} (octane)



Forces between solvent molecules:
van der Waals

The forces between the solute and solvent molecules are comparable, hence we can expect solubility. In this case both the solute and the solvent are molecular, so when solute contacts solvent the molecules freely intermingle. **Molecular compounds** eg. iodine are therefore generally **soluble** in **non-polar liquids**, eg. Hydrocarbons such as octane.

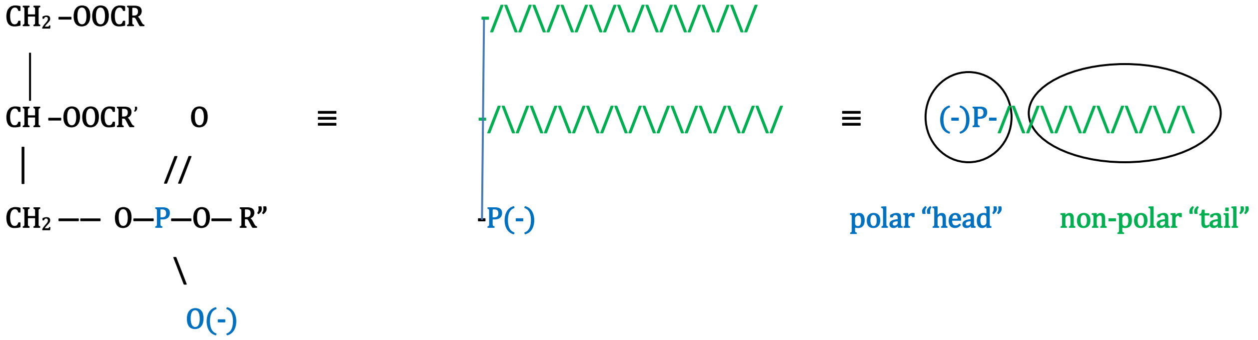
Solubility Rule "Like Dissolves Like"
Polar solutes dissolve in polar solvents   Non-Polar solutes dissolve in non-polar solvents

Compare the WATER SOLUBILITY of **HEXANE & GLUCOSE**   **Water is a polar liquid**

Hexane = C_6H_{14} = **$H_3C-(CH_2)_4-CH_3$**   Glucose = $C_6H_{12}O_6$ = **$HO-H_2C-(CH-OH)_4-CHO$**

Non-polar, so insoluble in water   **Polar due to many –OH groups, so Soluble in water**

What about the following **amphi-philic** PHOSPHO-GLYCERIDE molecule containing both **hydro-philic** (water-loving) and **hydro-phobic** (water-hating) regions ?

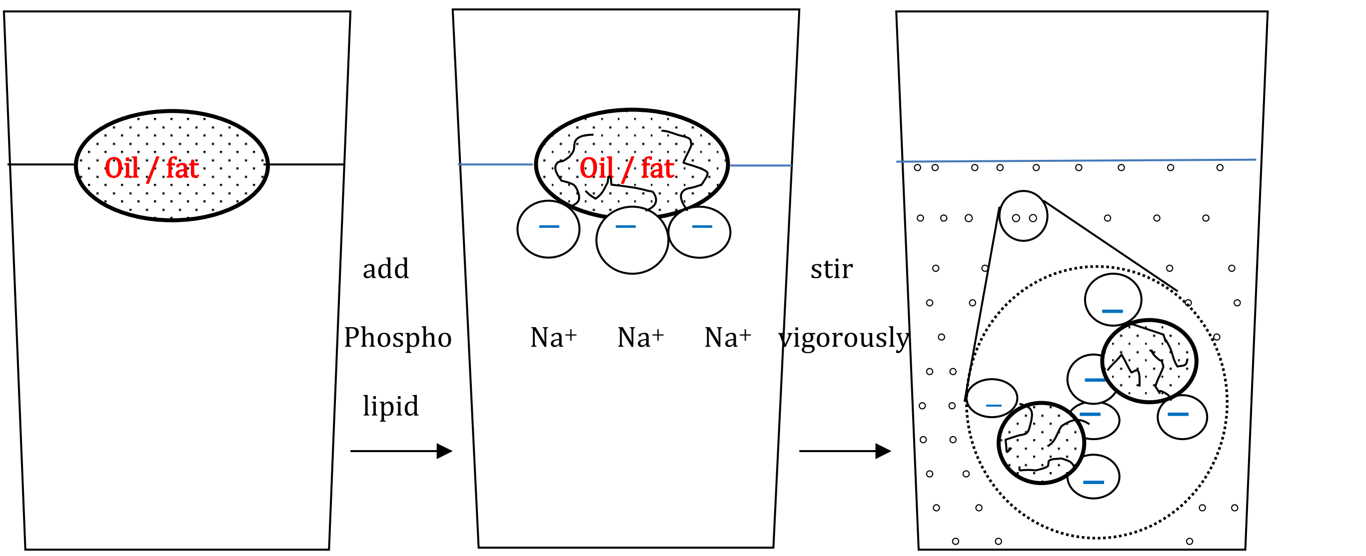


Phospho-glyceride; when R" = —O-CH_2CH_2-N$(CH_3)_3^+$ (= choline) the **phospholipid** is **lecithin** (composes about 10-15% of egg yolk).
Being amphiphilic it is used as an **emulsifying agent** in foodstuffs such as mayonnaise.

Phospho-lipids (P/L), amphiphiles, in aqueous media

Polar 'head' ⟶ (-)P-/\/\/\/\/\/\/\ ⟵ Non-polar 'Tail'
Hydrophilic **("Water loving")** Na^+ hydrophobic **("Water hating")**

Schematic representation of EMULSION formation



Non-polar oil/fat globule floats on surface of polar water.

Non-polar tails of P/L dissolve in non-polar oil/fat globule, polar heads dissolve in polar aqueous phase.

Emulsion of oil/fat droplets in water is stabilised by like-charge repulsion--so droplets do not coalesce upon colliding.