Concept of Solid Solution

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A solid solution is formed, as the solute atoms are added to the parent materials, the crystal structure is maintained and no new structures are formed.

This is analogous to liquid solution of two liquids, for example the solution of water and alcohol, while the solution becomes homogeneous throughout. In solid the solution is formed when impurities are added or remain into parent solid and are dispersed in a homogeneous manner.

Solute- The impurity atoms that create the solution with host atoms without forming a new crystal structure.

Solid Solution Example→ Steel (Carbon in Iron), Bronze, Cu-Ni, Gold-Ni

Liquid Solution Example→ Salt in Water

Gaseous solution Example→ Air

Two types of solutions exist-

1. **Substitution**al – When impurity atoms substitute host or parent atoms.
2. **Interstitia**l- When impurity atoms take interstitial places of parent crystal structure.

How to determine whether there will be a solution or separate phase-

Determined by **Hume-Rothery Rules**. It has 4 levels such as-

1. Atomic size factor- Solute atoms should have radius no larger than 15% of the radius of solvent atoms.
   % difference=$((r_{solute}-r_{solvent})/r_{solvent})x100\% \leq 15\%$
2. Crystal Structure- For a metal solid solubility, crystal structures of both atom types must be the same.
3. Electronegativity Factor- Higher the difference in electronegativity, higher the chance of formation an intermetallic compound instead of a substitutional solid solution.
4. Valences-Two elements should have same valence.

   For example, Copper and Nickel are 0.128 and 0.125 nm. Both have FCC crystal and electronegativity 1.9 and 1.8, Finally most common valences are +1 for copper and +2 for Nickel. Therefore, Copper and nickel will form a solid solution.

Write a small summary on the solid solution Hume-Ruthery Rule.

Would you predict Al or Ag to dissolve in Zn?

Would you predict Zn or Al to dissolve in Cu?

Look the Table below-

Element	*Atomic Radius (nm)*	*Crystal Structure*	*Electro-nega-tivity*	*Valence*
Cu	**0.1278**	**FCC**	**1.9**	**+2**
C	0.071			
H	0.046			
O	0.060			
Ag	**0.1445**	**FCC**	**1.9**	**+1**
Al	**0.1431**	**FCC**	**1.5**	**+3**
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Ni	0.1246	FCC	1.8	+2
Pd	0.1376	FCC	2.2	+2
Zn	**0.1332**	**HCP**	**1.6**	**+2**