HUME-ROTHERY RULES

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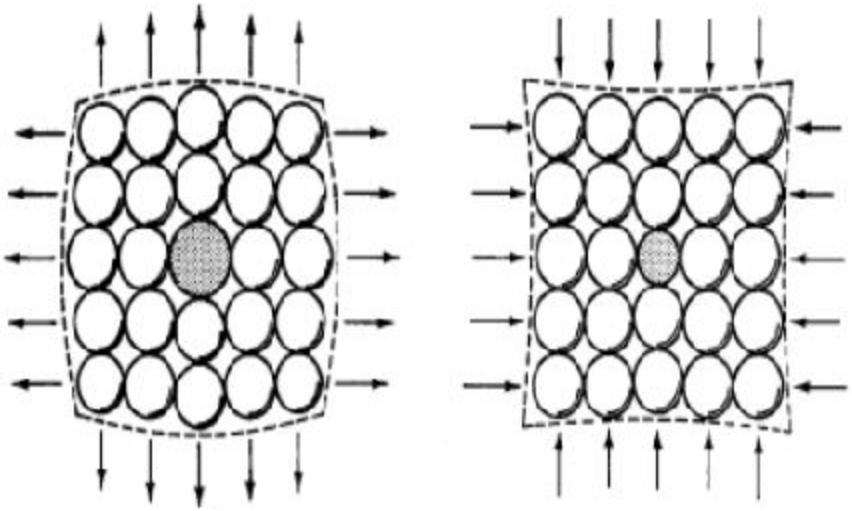
Hume-Rothery rules

- Hume-Rothery (1899-1968) was a metallurgist who studied the alloying of metals. His research was conducted at Oxford University where in 1958, he was appointed to the first chair in metallurgy.
- The **Hume-Rothery rules** are a set of basic rules describing the conditions under which an element could dissolve in a metal, forming a solid solution. There are two sets of rules, one which refers to substitutional solid solutions, and another which refers to interstitial solid solutions



Substitutional Solid Solution Rule

1. The atomic radii of the solute and solvent atoms must differ by no more than 15%:
2. The crystal structures of solute and solvent must match.

3. Maximum solubility occurs when the solvent and solute have the same valency. Metals with lower valency will tend to dissolve metals with higher valency.

4. The solute and solvent should have similar electronegativity. If the electronegativity difference is too great, the metals will tend to form intermetallic compounds instead of solid solutions.

Interstitial Solid Solution Rules

1. Solute atoms must be smaller than the pores in the solvent
   lattice.

2. The solute and solvent should have similar electronegativity.

- In contrast to intermetallic and compounds, solid solution in general are

- Easier to separate,
- Melt over a rang in temperature,
- have properties that are influenced by those of solvent and solute,
- Usually show a wide range of composition so that they are not expressed by a chemical formula

Hume-Rothery Rule 1:Atomic Size Factor (the 15%) Rule.

- Extensive substitutional solid solution occurs only if the relative difference between the atomic diameters (radii) of the two species is less than 15%. If the difference > 15%, the solubility is limited. Comparing the atomic radii of solids that form solid solutions, the empirical rule given by Hume-Rothery is given as:

$$Mismatch = \left(\frac{r_{solute} - r_{solvent}}{r_{solvent}} \right) \times 100 \leq 15\%$$

- **HUME-ROTHERY RULE 2:CRYSTAL STRUCTURE RULE .**
- For appreciable solid solubility, the crystal structures of the two elements must be identical.
- **HUME-ROTHERY RULE 3: VALENCY RULE .**
- A metal will dissolve a metal of higher valency to a greater extent than one of lower valency. The solute and solvent atoms should typically have the same valence in order to achieve maximum solubility.
- **HUME-ROTHERY RULE 4: THE ELECTRO NEGATIVITY RULE .**
- Electro negativity difference close to 0 gives maximum solubility. The more electropositive one element and the more electronegative the other, the greater is the likelihood that they will form an
- intermetallic compound instead of a substitution solid solution. The solute and the solvent should lie relatively close in the electrochemical series.

Thermal Equilibrium Diagrams

- Definition:- A diagram which shows variations of phases of a metal or ally with respect to changes in temperature is called as phase equilibrium diagram.
- A system is at equilibrium if its free energy is at a minimum, given a specified combination of temperature, pressure and composition.
- The (macroscopic) characteristics of the system do not change with time — the system is stable.

Phase Equilibrium: Solubility Limit

- Solution – solid, liquid, or gas solutions, single phase
- Mixture – more than one phase
- Solubility Limit:

Maximum concentration for which only a single phase solution exists.

Thank You