Hard and Soft Acids and Bases (HSAB)

Pearson's HSAB Concept

"Hard acids prefer hard bases and soft acid prefers to soft bases."

Hard Acid: **Alkali, Alkaline earth and lighter transition metals are called hard acids. They are small, compact, less polarizable with high electronegativity e.g. H^+, Na^+, Li^+, Mg^{++}**

Soft Acid: **Heavier metal ions such as Ag+, Cu+ are called Soft acids. They are large in size and more polarizable with low electronegativity e.g. Ag^+, Cu^+**

Hard Base: **Ligands which preferably from stable complexes with hard acids are known as hard bases. They are small size, and less polarizability. e.g. H_2O, NH_3**

Soft Base: **Ligands which preferably from stable complexes with Soft acids are known as Soft bases. They are large size, and more polarizability. e.g. H^-, I^-, CN^-**

Applications of HSAB Principle

1. It explains the stability of AgI_2^- because of soft-soft interaction and AgF_2^- is unstable due to soft-hard interaction.

$$\underset{\text{Hard-Soft}}{LiI} + \underset{\text{Hard- Soft}}{CsF} \rightarrow \underset{\text{Hard-Hard}}{LiF} + \underset{\text{Soft-Soft}}{CsI}$$

2. Catalytic reactions can be explained on the bases of HSAB Principle.
3. Hard solvent is dissolve into hard solute.
4. Rates of chemical reactions in electrophilic as well as nucleophillic substitution reaction based on HSAB Principle.
5. Soft ligands have tendency to combine with center having soft ligands while hard ligands have tendency to combine with center having hard ligands. This is called symbiosis.
6. Non-aqueous solvents are used to dissolve non-polar compounds and carry out reaction in non-aqueous medium.
7. The strength of halo acids is based on HSAB Principle. HF is weak acid and HI is strong acid.
8. In Complexes hard and soft ligands forms their groups.
9. In Minerals cations reacts with anions based on HSAB Principle eg. $^{MgCO}{}_3$

Limitations of HSAB Principle

1. It is not quantitative scale of measurement.
2. This phenomenon is applicable only known reaction.
3. Hard-soft factors are independent of the acidic or basic character of the compounds.
4. This theory is unable to determine the relative strength of acid and base.
5. Some reaction cases hard –soft interaction occurs.