

# Study Notes on Soft Acid and Base Concept



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## Soft Acid and Base concept

### Hard-soft acid-base concept

According to the HSAB principle, soft base tends to combine with soft acid while hard base combines with hard acid. Let us discuss each term one by one:

Soft base: Large ionic radius, highly polarizable, intermediate electronegativity, low energy HOMOs. Ex-RNC, CO, RSH, H<sup>-</sup>

Soft acid: Large ionic radius, low positive charge, low energy LUMOs. Ex- Ag<sup>+</sup>, Cs<sup>+</sup>, Pd<sup>2+</sup>

Hard acid: Small ionic radius, high positive charge, high energy LUMOs. Ex-K<sup>+</sup>, H<sup>+</sup>, Al<sup>3+</sup>.

Hard base: Small ionic radius, high electronegativity, weakly polarizable, high energy HOMOs. Ex- H<sub>2</sub>O, R<sub>2</sub>O, NH<sub>3</sub>.

**Borderline acid and base:** They have intermediate properties between hard acid/base and soft acid/base. Ex- Aniline, N<sub>2</sub>, pyridine

### Some important points regarding the stability of compound formed:

1. Higher the electronegativity difference between hard acid and hard base, stronger will be ionic interactions.
2. Due to almost the same electronegativity of soft acid and soft base, they have covalent interactions.
3. When hard acid and soft base or vice-versa combines, the interaction between them is polar covalent which makes them reactive.

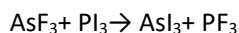
### Applications of HSAB:

1. **Hydrogen Bonding:** H-bonding is possible when H is attached to highly electronegative elements such as N, O or F. In cases of NH<sub>3</sub>, H<sub>2</sub>O or HF, H-bonding is possible.
2. **Linkage of ambidentate ligand to metal atom:** Ambidentate ligand can use its different elements to bind with metal. Example- SCN<sup>-</sup>. It can bind with metal both as M-NCS or M-SCN. Now which atom will combine depend on the nature of the acid or base.

**Symbiotic effect:** The hard-soft nature of metal ion can be changed by the presence of other groups.

**3. Predict the direction of inorganic reactions:** Let us understand this concept by taking 1 example:

Consider the reaction between AsF<sub>3</sub> and PI<sub>3</sub>:



This reaction will go in the right direction as  $\text{As}^{3+}$  is softer and  $\text{P}^{3+}$  and  $\text{I}^-$  is softer than  $\text{F}^-$ .

- 4. Solubility in water:** The polar compound will be soluble in water while non-polar will be insoluble. Now, when soft acid combines with a soft base, the compound formed has covalent nature due to which it will be less soluble in water.
- 5. Precipitation reaction:** Soft and borderline acids can be precipitated in the form of sulfides from their aqueous solution.

**Limitations of the HSAB principle:**

According to Fajan's rule, salts of Be are covalent in nature but according to the HSAB principle, Be compounds show ionic nature. This is not true.



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