**TDC Part III**

**Paper VI**

**Inorganic Chemistry**



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**TOPIC:- PEARSON’S HSAB CONCEPT: ACID BASE STRENGTH AND HARDNESS AND SOFTNESS**

**PEARSON’S HSAB CONCEPT: ACID BASE STRENGTH AND HARDNESS AND SOFTNESS**

According to the Pearson HSAB concept, hard acid- hard base combination & soft acid-soft base combination give rise to the more stable compound or complexes in comparision to the hard acid–soft base & soft acid-hard base combination compound.

Hard acid + hard base more stable compound / complexes Soft acid + soft base more stable compound / complexes or

Hard acid + soft base

Soft acid + hard base

**Explanation:**

Due to the very low polariziability of hard acid and hard base their combination are ionic in nature while due to the very high polarize ability of soft acid and soft base their combinations are covalent in nature. Both these combinations of ionic and covalent nature have more stable combination due to which HSAB principle states the hard– hard and soft-soft combinations as a stable combination.

Less stable complexes

**Applications of HSAB principle**

**occurrence of metal ions on the earth**

Lighter metal ions like Li+, Na+, Mg+2 , Ca+2 etc. exist in the form of there chlorides, carbonates, sulphates, phosphates (O-2, CO3-2 , SO4-2, PO4-3) on the earth crust but cannot exist in the form of their sulphides ( S-2) while on the other hand heavier metal ions like Ag +, Hg +, Cu+ etc. exist in the form of their sulphides on the earth crust and cannot exist in the form of CO3-2, O-2 , SO4-2 etc.

**Explanation :-**

Lighter metal ions like Li+, Na+, K+, Mg+2 , Al+ 3, etc. form the stable hard – hard combination with the O-2 , CO3-2, SO4-2, PO4-3 on the earth crust due to which they exist ions in the form of there oxides, carbonate, sulphates and phosphates while these lighter metal ion forms the less stable unstable hard soft combination with the sulphide ion due to which they connot exist in the form of there sulphides on the earth crust. Heavier metal like Ag+, Hg+, Cu+ etc. form the stable soft –soft combination with the S-2 ion due to which they can exist in the form of their sulphides on the earth crust while on the other hand, the heavier metal ions like Ag+, Hg+, Cu+ etc. form the unstable or less stable soft-hard combination with the O-2, CO3-2, SO4-2, PO4-3 etc. due to which they cannot exist in the form of there oxides, carbonates, sulphates and phosphates on the earth crust.

**Stability of the compound/complexes**

With the help of HSAB principle, we can compare the stability of various compounds or complexes.

1. AgI2- is more stable than the AgF2-

**Explanation:**

AgI2- containing soft- soft combination due to which accoding to the HSAB principle, AgI2- well be more stable while AgF2- containing soft –hard combination, will be less stable or sometime cannot exist.

AgI2- AgF2-





AgI2- I - Ag+ F-

(Soft acid) (Soft base) (Soft acid) (Hard base)



S-S Combination S-H Combination

(More stable) (Less stable)

1. [Co(F)6]-3 is being more stable then [Co(I)6]-3 ion.

**Explanation:**

[Co(F)6]-3 ion containing hard-hard (H-H) combination is more stable while on the other hand, [Co(I)6]-3 ion having hard-soft (H-S) combination, will be less stable.

[Co(I)6]-3 [Co(F)6]-3

 



Co+3 I- Co+3 F-

(Hard acid) (Soft base) (Hard Acid) (Soft Base) H-S combination H-H combination

(Less stable) (More stable)

**Stability of the complexes containing different ligand**

According to the Pearson principle, a complex containing more than one type of the ligands (hard or soft), then the complex will be more stable.

(**iii)**[Co (N)5(F)]-3  ion is less stable than [Co(CN)5(I)]-3 ion

**Explanation:**

[Co(N)5(F)]-3 ion containing soft CN- & Hard F- ligands will be less stable while on the other hand [Co(N)5(I)]-3 ion containing both the soft ligands (CN- and I- ) will be more stable.

**Occurrence of the chemical reaction**

With the help of HSAB principle we can give the idea about the occurrence of the chemical reaction. According to HSAB principle, if the reactants present in the chemical reaction have less stable H-S & S-H combinations, then they will have the tendency to react with each other to generate the more stable H-H & S-S combinations i.e. in such condition chemical reaction will be possible. If the reactants have more stable H-H & S-S combinations, then they will not have the tendency to convert into the less stable H-S & S-H combinations by the reaction i.e. in such condition reaction will not be possible.

Li + CsF LiF + CsI

(H-S) (S-H) (H-H) (S-S)

In the above reaction, both the reactants have less stable H-S & S-H combinations and the products have the more stable H-H & S-S combination so acc to HSAB principle the above Reaction will be possible.

BeF2 + HgI2 BeI2 + HgF2

(H-H) (S-S) (H-S) (S-H)

In the above reaction, both the reactants have more stable (H-H, S-S) combinations and products haveless stable H-S and S-H combinations. Hence, according to HSAB principle, this reaction will not be possible.

### Nature of the doner site in the ambident ligand

With the help of HSAB principle, we can also give an idea about the actual doner site of an ambident ligand.

Ni(CO)4



Ni CO

(S. A.) : C O:

(S. B.) (H. B.)

When the C atom of the CO behave as a doner site, then there occur the formation of more stable S-S combination with the central metal atom (Ni) while when the O atom of CO behaves as a doner site, then there occur the formation a less stable S-H combination with the central metal atom (Ni). Therefore, the actual doner site of CO will be carbon.

**Solubility of the compounds**

According to the HSAB concept, those compounds which have more stable H-H & S- S combinations, exhibit less solubility in the aqueous medium in compare to the compounds which have less stable H-S & S-H combinations.

**Explanation:**

Hg(OH)2 exhibits more solubility in the aqueous medium due to less stable H-S combination, while HgS exhibits less solubility in aqueous medium due to the more stable S-S combination.

Hg S Hg (OH)2

Hg+2 S-2 Hg+2 OH-

(SA) (SB) (SA) (HB)

## Limitation of HSAB principle

According to HSAB concept, chemical reactions have a tendency to occur in such direction which can generate the more stable H-H & S-S combination. But sometimes the chemical reactions can also occur in such direction which can generate the less stable S-H & H-S combination and this can not be explained by HSAB concept of Pearson.