# 7.3: Unit 7 Practice Problems

## Exercise 1

Decide if the following species are acids or bases according to Lewis theory. Order them with respect to their hardness and polarizability.

$Ti^{3+}$, $Ti^{4+}$, $Zr^{3+}$, $Hf^{3+}$

**Answer**

Hardness: $Ti^{4+}>Ti^{3+}>Zr^{3+}>Hf^{3+}$

Polarizability: $Hf^{3+}>Zr^{3+}>Ti^{3+}>Ti^{4+}$

## Exercise 2

Decide if the following species are acids or bases according to Lewis theory. Order them with respect to their hardness and polarizability.

$NH_3$, $PH_3$, $AsH_3$, $SbH_3$.

**Answer**

Bases.

Hardness: $NH_3>PH_3>AsH_3>SbH_3$

Polarizability: $SbH_3>AsH_3>PH_3>NH_3$

## Exercise 3

CsI is much less soluble in water than CsF. Why?

**Answer**

Cs-F hard-hard interactions are stronger than Cs-I hard-soft interactions. Nonetheless, CsI is less soluble because of the small solvation enthalpy for $I^-$ (weak hard-soft interaction between water and $I^-$).

## Exercise 4

Order the following species with regard to their expected solubility in water: ZnS, CdS, HgS.

**Answer**

ZnS> CdS>HgS

## Exercise 5

$AlF_3$ is insoluble in liquid HF but dissolves when NaF is present. When $BF_3$ is added to the solution, $AlF_3$ precipitates. Explain.

**Answer**

Hard-Hard interactions between H and F in H-F stronger than Hard-Hard interactions between $Al^{3+}$ and $F^-$. Consequence: no reaction occurs (no formation of $AlF_4^-$).

Hard-Hard interactions between $Al^{3+}$ and $F^-$ are stronger than hard-hard interactions between $Na^+$ and $F^-$. Consequence: $AlF_3$ dissolves to form $AlF_4^-$.

$AlF_3$ precipitates upon addition of $BF_3$ because Al-F hard-hard interactions are weaker than B-F hard-hard interactions ($B^{3+}$ is harder than $Al^{3+}$). $AlF_4^-$ (aq) + $BF_3$ (aq) --> $BF_4^-$ (aq) + $AlF_3$(s).

### Exercise 6

Why were most of the metals used in early prehistory soft metals (in HSAB terminology)?

**Answer**

Because oxygen is the most abundant element in the earth crust. Thus most hard metals have formed oxides with oxygen. Soft metals do not easily combine with oxygen to form oxides. Therefore, they can be found more often in elemental form in nature. Because of that they have been used more often.

### Exercise 7

Which of the following ions is the softest according to HSAB theory:

a) oxide ($O^{2-}$)

b) peroxide ($O_2^{2-}$)

c) ozonide ($O_3^{-}$)

**Answer**

c) ozonide ($O_3^{-}$)

### Exercise 8

The oxidation of barium with oxygen gas yields barium peroxide while the oxidation of strontium with oxygen gas yields strontium oxide. Explain this from the standpoint of the HSAB theory.

**Answer**

Barium is softer, so it has a greater tendency to combine with the peroxide ion which is relatively soft compared to the oxide ion.

### Exercise 9

A molecule with an electron pair in an antibonding HOMO will most likely undergo a reaction in which

a) this molecule will get oxidized

b) this molecule will be reduced

c) this molecule will act as a donor in a Lewis acid base reaction.

d) this molecule will act as an acceptor in a Lewis acid base reaction.

**Answer**

a) this molecule will get oxidized

### Exercise 10

When a dative bond is polarized toward the acceptor this indicates that

a) the HOMO energy of the donor is higher than the LUMO energy of the acceptor.

b) the HOMO energy of the donor is lower than the LUMO energy of the acceptor.

c) the HOMO energy of the donor is equal to the LUMO energy of the acceptor.

**Answer**

a) the HOMO energy of the donor is higher than the LUMO energy of the acceptor.