HW 11
CHEM 362

Due: December 3, 2019

1. What is the difference between a hydrate and a clathrate?

A hydrate is a compound containing discrete water molecules bound to some other molecule via hydrogen bonding and/or cation-oxygen bonds. A clathrate is a cage-like compound in which other molecules or atoms can be trapped

2. a) When an H bond is symbolized as X—H ---Y, what do the solid and dashed lines mean? Which distance is shorter?

The solid line indicates the shorter (and stronger) polar covalent bond and the dashed line indicates the longer (weaker) hydrogen bond.

b) Which H bond would you expect to be stronger and why?

S—H---O or O—H---S

In the case of O-H-----S, the O-H bond is very polar given a significant partial positive charge to the H atom allowing it to H-bond to the electron rich S atom. S-H bonds are much less polar meaning that the O atom, while electron rich, would not be able to form a very strong hydrogen bond due to the low partial positive charge on the H atom.

3. Give the product(s) for the following reactions

a. $N_2 + 3\ H_2 \xrightarrow[\text{pressure}]{\text{Fe catalyst}}$ **$2NH_3$**

b. $Cu_2S + 2\ O_2 \rightarrow$ **$2CuO + SO_2$**

c. $C_4H_9Li + CH_3I \rightarrow$ **$C_5H_{12} + LiI$**

d. $KCl + Na \rightarrow$ **$NaCl + K$**

e. $6Li + N_2 \rightarrow$ **$2Li_3N$**

f. $Be(s) + H_2O \rightarrow$ **no reaction**

g. $CO_2(aq) + OH^-(aq) \rightarrow$ **HCO_3^-**

h. $NH_3(g) + 2O_2(g) \rightarrow$ **$HNO_3 + H_2O$**

4. Water has several interesting properties that are needed for life as we know it. Three of these were discussed in class. List them and *briefly* mention why each is needed for life.

Very high boiling point – if not for this, water would be a gas at room temperature (life on earth would be impossible, our bodies need *liquid* water, nature needs liquid water to penetrate the soil, we need oceans etc.,

Very low density of the solid form (ice) – if not the case there would be no aquatic life as lakes would freeze from the bottom up as instead of freezing from the top down.

Hydrogen bonding – this forms the "glue" that holds proteins and DNA together, without it we would quite literally "fall apart

5. Rank the following ions in terms of their hydration enthalpy, and explain *why*

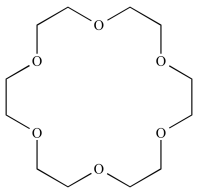
Li^+ Rb^+ Cs^+ K^+ Na^+

Li>Na>K>Rb>Cs
This is due to relative charge densities. Lithium has the greatest charge density of the series.

6. Why are Na^+ and K^+ important physiologically?

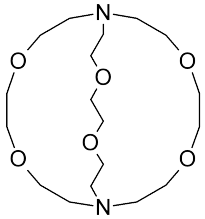
7. Draw the structure of
i) a crown ether

Example: 18-Crown-6



ii) a cryptate.

Example: 2.2.2-cryptand



Be sure to give the correct name for the structures you drew

8. Do the alkaline earth cations form many complexes? Which cations tend to do so and what are the best ligands (complexing agents)?

The alkaline earth cations do not form many complexes with the exception of "Be^{2+}". Be^{2+} is capable of complexing with Lewis bases to form linear and tetrahedral compounds. Be prefers to bind with oxygen donors more so than nitrogen donors.

9. Explain the roles of CO and CO_2 in the environment. Be as complete as possible in your response. (ie. How are they formed? What physiological and/or environmental effects do they have?)

CO is a poisonous gas often formed by incomplete combustion of hydrocarbons that acts in the body by bonding to the heme iron in hemoglobin more favorably than O_2. This action cuts off O_2 causing death. A source of CO in the environment is automobile exhaust.

CO_2 is formed by complete combustion of hydrocarbons. CO_2 is a critical part of the natural carbon cycle wherein plants and phytoplankton take up CO_2 and convert it to sugars by photosynthesis yielding oxygen as a byproduct. CO_2 is also a naturally occurring greenhouse gas and aids in maintaining the temperature on the Earth. Recently, the amount of CO_2 in the atmosphere has been increasing (mainly from the production of CO_2 by vehicles and industry) and is a cause of global warming. There is also some evidence that the increased CO_2 levels may help to increase plant growth.

10. Use MO theory to compare and contrast the bonding in CO, N_2, CN^- and NO^+. Why does N_2 form complexes with metals much less than CO? *(this is review but is being re-emphasized in this section)*

All these species have a bond order of three a similar ordering in the molecular orbitals ($1\sigma^2\ 2\sigma^2\ 1\pi^4\ 3\sigma^2$). The major difference between them is the relative positions of the molecular orbitals (in terms of energy). Both CO and N_2 have a MO arrangement of $1\sigma^2\ 2\sigma^2\ 1\pi^4\ 3\sigma^2$ but N_2 is less likely to bind to metal complexes because the lone pair that engages in σ bonding to the metal is lower in energy than that in CO.