

Chemistry 362 Mini-EXAM V
Chapters 8, 9, HSAB

Answer Key

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NAME: _____
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Total Points on Exam is 98 points
(as for the others, the total will be scaled to 50 points)

1. (15 pts)

In this section of course material, we covered the topic of how different elements are present in their natural state in different forms. Name an *element* in each of the following structural categories and give the formula:

- monoatomic elemental form
He, Ne, Ar, Kr, Xe or Rn
- diatomic elemental form
H₂, N₂, O₂, F₂, Cl₂, Br₂ or I₂
- polyatomic elemental form (discrete molecules with more than two atoms)
P₄, S₈, C₆₀, C₇₀ or B₁₂

2. (9 pts)

The first short period (Li→Ne) exhibits very different chemistry than the second short period (Na→Ar), and the rest of the periodic table. In the lectures, five reasons were given to explain this behavior. List *three* of these five reasons.

- The elements of the second short period do not form favorable $p\pi$ - $p\pi$ bonds.**
- The elements of the second short period form multiple bonds through $d\pi$ - $p\pi$ interactions.**
- The accessible 3d orbitals in the second short period elements allows them to form more than 4 bonds, breaking the octet rule.**
- The shapes of molecules formed by the second short period elements are very different from the first.**
- The properties of the cations and anions formed differ greatly between the two periods (i.e. B³⁺ versus Al³⁺).**

3. (10 pts)

Briefly describe the bonding in metals as discussed in lecture.

Elemental metal atoms covalently bind to all nearest neighbors (as many as 8 or 12 other atoms) resulting in extensive orbital overlap. This causes the M.O. diagram to become a series of continuous bands. The “HOMO” is the valence band (the band filled with electrons) and the “LUMO” is the conducting band (the empty band).

4. (15 pts)

The *Hard and Soft Acid and Base Principle* is a simple concept introduced by Ralph Pearson in 1965. Briefly describe the HSAB idea and describe the main characteristics of the four general types of acids and bases: Hard Acid, Soft Acid, Hard Base, Soft Base.

HSAB can be summarized as follows “Hard acids prefer to coordinate to hard bases and soft acids to soft bases”.

Hard acid – high positive charge, small size, not easily polarized

Soft acid – low positive charge, large size, easily oxidized, high polarizability

Hard base – low polarizability, high electronegativity, not easily oxidized

Soft base – high polarizability, diffuse donor orbital, low electronegativity, easily oxidized

5. (15 pts)

Using the concept of HSAB theory, predict which way, LEFT or RIGHT, that the following reactions will tend to proceed:

- a. $\text{CaS} + \text{H}_2\text{O} \leftrightarrow \text{CaO} + \text{H}_2\text{S}$ **Right**
- b. $\text{AlI}_3 + 3\text{NaF} \leftrightarrow \text{AlF}_3 + 3\text{NaI}$ **Right**
- c. $\text{Mg}(\text{OH})_2 + \text{Cu}(\text{SCN})_2 \leftrightarrow \text{Mg}(\text{SCN})_2 + \text{Cu}(\text{OH})_2$ **Left**
the S end of SCN is coordinated

6. (9 pts)

Write reasonable products for the following reactions:

- a. $\text{WO}_3 + 3\text{H}_2 \rightarrow \text{W}^0 + 3\text{H}_2\text{O}$
- b. $\text{H}_2 + \text{Li at } 700^\circ\text{C} \rightarrow 2\text{LiH}$
- c. $\text{NaH} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \frac{1}{2}\text{H}_2$

7. (10 pts)

What is hydrogen bonding and name three important reasons why life as we know it would not exist without it.

Hydrogen bonding refers to the formation of weak interactions between a covalently bound, polarized, hydrogen atom and a negatively charged or electron rich atom.

Hydrogen bonding is required for life to exist because it causes water to have a high boiling point, ice to have a low density and holds DNA and proteins together.

8. (10 pts)

What are the structures of graphite and diamond? (essentially I want you to tell me what is the hybridization of the C atom and what is the resulting extended structure- you can be very brief)

Graphite consists of sp^2 hybridized carbon atoms in a two dimensional sheet comprised of hexagons. Weak interactions allow the sheets to stack.

Diamond consist of sp^3 hybridized carbon atoms in a tetrahedral arrangement forming a three dimensional structure.

(5 pts)

9. What effect does the lanthanide contraction have on the transition elements?

The lanthanide contraction causes the second and third row transition elements to be essentially the same size.