Exam 3

# Part 1: Multiple Choice (2 points each)

## Directions: Please circle the *best* answer for each of the following questions.

1. Cations are \_\_\_\_\_\_\_\_\_\_\_\_\_ than their corresponding parent.
2. much smaller
3. much larger
4. the same size
5. not related in size to the atom from which they are formed.
6. none of the above
7. Which of the following is true of an endothermic reaction?
	* + 1. Strong bonds break and weak bonds form.
			2. Weak bonds break and strong bonds form.
			3. The bonds that break and those that form are approximately the same strength.
			4. Triple bonds are formed
			5. none of the above
8. How many of the following elements have 2 unpaired electrons in the ground state? C, O, Ti, Si
9. 0
10. 1
11. 2
12. 3
13. 4
14. The ground state electron configuration for Cr3+ is
15. [Ar] 4s2 3d1
16. [Ar] 3d3
17. [Ar]
18. [Ar] 4s2 3d6
19. [Ar] 4s1 3d2
20. \_\_\_\_\_\_ is the most polar bond.
21. C-O
22. C-N
23. C-C
24. F-F
25. C-F
26. Place the following in order of decreasing dipole moment:
27. cis-CHCl=CHCl;
28. II. trans-CHCl=CHCl;
29. III. cis-CHF=CHF
30. I = III > II
31. III > I > II
32. II > III > I
33. II > I > III
34. I > III > II
35. Out of C2Cl2, CO2, O3, H2O, there are \_\_\_\_\_ with sp hybridization on the central atom?
36. 4
37. 3
38. 2
39. 1
40. none of the above
41. A chemical equation may sometimes be balanced with fractional coefficients. This is not appropriate when utilizing what interpretation of the reaction?
	1. Macroscopic
	2. Molar
	3. Particulate
	4. Both macroscopic and molar
	5. Both molar and particulate
42. Which statement is true?
43. When two atomic orbitals come together to form two molecular orbitals, one molecular orbital will be lower in energy than the two separate atomic orbitals and one molecular orbital will be higher in energy than the separate atomic orbitals.
44. The total number of molecular orbitals formed doesn’t always equal the number of atomic orbital in the set.
45. A bond order of 0 represents a stable chemical bond.
46. Electrons placed in antibonding orbitals stabilize the ion/molecule.
47. all of the above
48. What is the most important part of laboratory safety?
49. Recognizing hazards
50. Assess the risk level
51. Minimizing risks
52. Preparing for emergencies
53. all of the above

# Part 2: Short Answer

## Directions: Answer each of the following questions. Be sure to use complete sentences where appropriate. For full credit be sure to show all of your work.

1. Use your knowledge of electron configurations to explain the following observations (8 points):
	1. Silver tends to form ions with a charge of +1, but the element to the right of silver in the periodic table tends to form ions with +2 charge.

Ag: [Kr] 5s1 4d10 Cd: [Kr] 5s2 4d10

Silver forms a +1 ion thorough the loss of a high-lying 5s electron and cadmium loses two 5s electrons to form a +2 cation.

* 1. The heavier group 13 elements (Ga, In, Tl) tend to form ions with charges of +1 or +3, but not +2.

Ga: [Ar] 4s2 3d10 4p1 In: [Kr] 5s2 4d10 5p1 Tl: [Xe] 6s2 4f14 5d10 6p1

The heavier group 13 elements may form +1 cations through the loss of the np electron and form +3 cations through the loss of np electrons and the two ns electrons.

* 1. The heavier elements of group 14 (Sn, Pb) and group 4 (Ti, Zr, Hf) tend to form ions with charges of +2 or +4.

Sn: [Kr] 5s2 4d10 5p2 Pb: [Xe] 6s2 4f14 5d10 6p2

Ti: [Ar] 4s2 3d2 Zr: [Kr] 5s2 4d2 Hf: [Xe] 6s2 4f14 5d2

The heavier group 14 elements may form +2 cations through the loss of two ns electrons and form +4 cations through the loss of both ns electrons and the two np electrons, whereas the group 4 elements may lose the two ns electrons to form +2 cations and may lose both the ns electrons and the two (n-1)d electrons to form +4 cations.

1. Does the number of valence electrons in a neutral atom ever equal the atomic number? If so, what are they (2 points)?

Yes, in hydrogen and helium.

1. What is meant when two or more orbitals are said to be degenerate (3 points)?

Degenerate orbitals have the same energy and are indistinguishable from each other.

1. How can we use electronegativity to predict whether a bond between two atoms is likely to be covalent or ionic (3 points)?

If there is an electronegativity difference of 2.0 or greater, the bond between the atoms is ionic. For electronegativity differences below 2.0, the bond is covalent.

1. Explain on the basis of atomic structure why trends in electronegativity are related to trends in atomic size (4 points).

The size of the atoms is the result of the nucleus pulling on the electrons. The higher the nuclear charge, the stronger the pull on the electrons within a given valence shell. This is why the size of the atoms generally decreases across a period. A small atom will form a shorter bond with another atom, and these electrons in the bond will “feel” a stronger pull from the nucleus of the small atom since the bonding electrons will be “closer” to the nucleus. This stronger pull results in a higher electronegativity for smaller atoms.

1. Pick the larger species from each of the following pairs (4 points):
	* + - 1. Se2- or Sr2+ b. Rh2+ or Rh c. N3- or N d. Ba or Ba2+

1. Effective nuclear charge (Zeff) is related to atomic number by a parameter called the shielding parameter (S) (5 points).
2. Calculate Zeff for the outermost s electrons of Ne and Ar given that S = 4.24 for Ne and 11.24 for Ar.

Zeff = Z – S

Zeff = 10 – 4.24 = 5.76 for Ne

Zeff = 18 – 11.24 = 6.76 for Ar

1. Explain why the shielding parameter is much greater for Ar than for Ne.

The outermost electron in argon is a 3p electron, which is mostly shielded by the electrons in the n = 2 level (10 electrons) and the n = 1 level (two electrons), whereas the outer most electron in Ne is a 2p electron, which is shielded by the electrons in the n = 1 level (two electrons).

1. Consider the electron configuration of a carbon atom. After sp3 hybridization, which of the following statements are true about the carbon atom (5 points)?

\_\_false\_\_\_no unpaired electrons

\_\_false\_\_\_hybrid orbitals of two distinctly different energies

\_\_true\_\_\_hybrid orbitals with energy between that of the 2s and 2p orbitals

\_\_true\_\_\_the ability to form four bonds

\_\_false\_\_\_three hybrid orbitals and an unhybridized p orbital

1. Synthesis of the first compound of argon was reported in 2000. HArF was made by reacting Ar with HF. Draw a Lewis structure for HArF, and determine the orbital geometry, molecular geometry, approximate bond angle(s), polarity, and hybridization (9 points).



Trigonal bipymidal, linear, 180°, polar molecule, sp3d

1. A molecular compound is composed of 60.4% Xe, 22.1% O, and 17.5% F by mass. If the molecular weight is 217.3 amu, what is the molecular formula? What is the Lewis structure? Predict the electron and molecular geometry using the VSPER model. Is this a polar or nonpolar molecule? Describe the bonding using valence bond theory (15 points).

Empirical formula XeO3F2

Empirical mass 217.29 g/mol

217.3 amu ≈ 217.29 g/mol

Molecular formula is also XeO3F2



Molecular and electron geometry is trigonal bipyamidal

sp3d hybrid

Xe-F bond is a sp3d-sp3 sigma bond

Xe-O bond is a sp3d-sp2 sigma bond

Xe=O bond is a 5d-2p pi bond

nonpolar molecule

O-Xe-O bond angle 120°

F-Xe-O bond angle 90°

|  |  |
| --- | --- |
| Bond | Energy (kJ/mol) |
| N-N | 163 |
| N=N | 418 |
| N≡N | 941 |
| H-H | 436 |
| N-H | 388 |

1. Nitrogen and hydrogen gases can react to form hydrazine, H2NNH2. Hydrazine is used as a foaming agent in the preparation of polymer forms as well as used in many rocket fuels. Hydrazine is produced according to the following equation (10 points):

N2(g) + 2 H2 (g) ⎯→ H2NNH2 (g)

From bond energies, calculate the standard enthalpy change for the reaction.



$$∆H\_{rxn}=\sum\_{}^{}bonds broken-\sum\_{}^{}bonds formed$$

$$∆H\_{rxn}=[\left(1 mol\right)(∆H\_{N≡N})+\left(2 mol\right)(∆H\_{H-H})]-[\left(4 mol\right)(∆H\_{N-H})+\left(2 mol\right)(∆H\_{N-N})] $$

$∆H\_{rxn}=\left[\left(1 mol\right)\left(941\frac{kJ}{mol}\right)+\left(2 mol\right)\left(436\frac{kJ}{mol}\right)\right]-\left[\left(4 mol\right)\left(388\frac{kJ}{mol}\right)+\left(1 mol\right)\left(163\frac{kJ}{mol}\right)\right] $

$$∆H\_{rxn}=941 kJ+872 kJ-1552 kJ-163 kJ=98 kJ $$

1. The odd-electron molecule ClO affects the atmospheric chemistry of chlorofluorocarbons as illustrated by the reaction (where the \* indicates an excited-state oxygen atom) (12 points):

CF2Cl2 (g) + O\* (g) → ClO (g) + CF2Cl (g)

* 1. Draw a molecular orbital diagram for ClO.



* 1. Is the odd electron in a bonding or antibonding orbital? \_\_\_\_antibonding orbital
	2. What is the bond order?

$$Bond order=\frac{bonding electrons-antibonding electrons}{2}=\frac{(8-5)}{2}=\frac{3}{2}=1.5$$

* 1. Is the molecule paramagnetic or diamagnetic? \_\_\_\_\_paramagnetic