+ Exam 3

# Part 1: Multiple Choice (2 points each)

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

1. Place the following elements in order of increasing atomic radius: P, Ba, Cl
2. Ba < P < Cl
3. P < Cl < Ba
4. Cl < P < Ba
5. Cl < Ba < P
6. none of the above
7. Which of the following processes are exothermic?
8. Cl2 (g) 🡪 2Cl- (g)
9. Br (g) + e- 🡪 Br- (g)
10. Li (s) 🡪 Li (g)
11. NaF (s) 🡪 Na+ (g) + F- (g)
12. none of the above
13. Identify the true statement(s) about noble gas trends.
14. The density of the noble gases increases down a column.
15. The atomic radius decreases down a column.
16. The ionization energy increases down a column.
	1. I
	2. II
	3. III
	4. I and III
	5. all of the above
17. Place the following in order of decreasing magnitude of lattice energy: K2O, Rb2S, Li2O
	1. Li2O > K2O > Rb2S
	2. Li­2O > Rb2S > K2O
	3. Rb2S > K2O > Li2O
	4. Rb2S > Li2O > K2O
	5. none of the above
18. Choose the bond below that is the strongest.
19. C-F
20. C=O
21. C-I
22. C≡N
23. all of the above
24. Which of the following is true about the nitrite ion?
25. contains one N-O single bond and one N=O double bond.
26. contains two N-O bonds that are equivalent to 1 ½ bonds.
27. contains two N=O double bonds.
28. contains two N-O single bonds.
29. none of the above
30. How many of the following molecules are polar?

XeO2 SiCl2Br2 C2Br2 SeCl6

1. 4
2. 3
3. 2
4. 1
5. none of the above
6. The electron geometry of a molecule containing a central atom with a sp3d2 hybridization is
7. octahedral
8. trigonal bipyramidal
9. tetrahedral
10. linear
11. none of the above
12. Which of the following statements are true?
13. The total number of molecular orbitals formed doesn’t always equal the number of atomic orbitals in the set.
14. A bond order of ½ represents a stable chemical bond.
15. Antibonding orbitals are filled with electrons first
16. none of the above
17. all of the above
18. What factors contribute to “messy labs” in academic environments?
	1. Many of the occupants are students with limited training in safety and cleanliness.
	2. Faculty mentors offer varying degrees of supervision in labs.
	3. “Productivity” can sometimes override “safety and cleanliness.”
	4. all of the above
	5. Academic labs are not messy.

# 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. 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. Both vanadium and its 3+ ion are paramagnetic (6 points).
2. Write the complete electron configuration of vanadium.

V: 1s22s22p63s23p64s23d3

1. Write the condensed electron configuration of the vanadium(III) ion.

V3+: [Ar] 4s03d2

1. Explain why vanadium and the vanadium(III) ion are paramagnetic.

Both vanadium and the vanadium(III) ion have unpaired electrons in their 3d subshell.

V: 3d ↑ ↑ ↑ \_\_ \_\_ V3+ ↑ ↑ \_\_ \_\_ \_\_

 4s ↑↓ \_\_

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+
2. 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. Below is a list of successive ionization energies in kJ/mol for a period 3 element. Identity the element and explain how you can to that conclusion (5 points).

IE1 = 1012; IE2 = 1900; IE3 = 2910; IE4 = 4960; IE5 = 6270; IE6 = 22,200

The large increase in ionization energy between IE5 and IE6 shows that there are five valence electrons in this element. The only period 3 element that contains five valence electrons is phosphorus.

1. Using Lewis structures and formal charge, which of the following ions is the most stable? Explain your choice (8 points).

OCN- ONC- NOC-



OCN- is the best structure. It contains the least amount of formal charge and it is able to put the negative charges on the more electronegative atoms.

1. Each of the following compounds has a nitrogen-nitrogen bond: nitrogen gas, dinitrogen tetrahydride, and dinitrogen difluoride. Match each compound with one of the following bond lengths: 110 pm, 122 pm, 145 pm. Describe the electronic and molecular geometry about one of the nitrogen atoms in each compound and show the bond angles. What hybrid orbitals are needed to describe the bonding in valence bond theory (9 points)?

|  |  |  |  |
| --- | --- | --- | --- |
| Formula | Nitrogen gas, N2 | Dinitrogen tetrahydrate, N2H4 | Dinitrogen difluoride, N2F2 |
| Lewis structure |  |
| Bond Length | 110 pm | 145 pm | 122 pm |
| Electronic geometry | Linear | Tetrahedral | Trigonal planar |
| Molecular geometry | Linear | Trigonal pyramidal | Bent |
| Bond angle | 180° | <109.5° | <120° |
| Hybridization | sp | sp3 | sp2 |

1. Determine the energy of formation of magnesium bromide. Given (8 points):

Mg (s) → Mg (g) +147.7 kJ/mol

Mg (g) → Mg+(g) + 1 e- +737.7 kJ/mol

Mg+(g) → Mg2+ (g) + 1 e- +1,450.7 kJ/mol

Br2 (g) → 2 Br (g) +193 kJ/mol

Br (g) + 1 e- → Br- (g) -325 kJ/mol

Mg2+ (g) + 2 Br- (g) → MgBr2 (s) -2,440 kJ/mol

Mg (s) → Mg (g) +147.7 kJ/mol

Mg (g) → Mg+(g) + 1 e- +737.7 kJ/mol

Mg+(g) → Mg2+ (g) + 1 e- +1,450.7 kJ/mol

Br2 (g) → 2 Br (g) +193 kJ/mol

**(**Br (g) + 1 e- → Br- (g) -325 kJ/mol**) x 2**

Mg2+ (g) + 2 Br- (g) → MgBr2 (s) -2,440 kJ/mol

Mg (s) + Br2 (g) 🡪 MgBr2 (s) -560.9 kJ/mol ≈ -561 kJ/mol

1. Use the bond energies provided to estimate ∆H°rxn for the reaction below (10 points).

2 Br2 (l) + C2H2 (g) 🡪 C2H2Br4 (l) ∆H°rxn = ?

Bond Bond Energy (kJ/mol)

Br-Br 193

C≡C 837

C-C 347

C-Br 276

C-H 414

∆H°rxn = ∑ bond broken - ∑ bonds formed

∆H°rxn = [(2 mol)(Br-Br) + ~~(2 mol)(C-H)~~ + (1 mol)(C≡C)] – [~~(2 mol)(C-H)~~ + (4 mol)(C-Br) + (1 mol)(C-C)]

∆H°rxn = [(2 mol)(193 kJ/mol) + (1 mol)(837 kJ/mol)] – [(4 mol)(276 kJ/mol) + (1mol)(347 kJ/mol)]

∆H°rxn = -228 kJ

1. Cyanogen is a gas which contains 46.2% C and 53.8% N by mass. At a temperature of 25 °C and a pressure of 750 mm Hg, 1.50 g of cyanogen occupies 0.714 L (15 points).

What is the molar mass of cyanogen?

$$MM=\frac{mRT}{PV}$$

$$MM=52.05868011\frac{g}{mol}≈52.1\frac{g}{mol}$$

What is the empirical formula of cyanogen?

$$46.2 g C×\frac{1 mol C}{12.011 g C}=3.846474065 mol C$$

$$53.8 g N×\frac{1 mol N}{14.007 g N}=3.840936675 mol N$$

$$C\_{\frac{3.846474065 mol}{3.840936675 mol}}N\_{\frac{3.840936675 mol}{3.840936675 mol}}=C\_{1.001441677}N\_{1}≈CN$$

What is the molecular formula of cyanogen?

$$ratio=\frac{molecular mass}{empirical mass}=\frac{52.1\frac{g}{mol}}{26.018\frac{g}{mol}}=2.002459835≈2$$

The molecular formula is C2N2.

Draw the best Lewis structure for cyanogen, and label the orbital geometry, molecular geometry, the bond angle of the central atom(s), and the hybridization.

Lewis structure: 

Orbital geometry of central atom(s) \_\_\_\_\_\_\_\_linear\_\_\_\_\_\_\_\_\_\_\_

Molecular geometry of central atom(s) \_\_\_\_\_\_\_linear\_\_\_\_\_\_\_\_

Bond angle \_\_\_\_\_\_\_180°\_\_\_\_\_\_\_

Hybridization of carbon atoms \_\_\_\_\_\_\_sp\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Use the molecular orbital diagram shown to answer the following questions about

F22-, F2, O22+, F22+, Ne22+ (5 points).



1. Which one is the most stable? \_\_\_\_\_O22+\_\_\_\_\_
2. Which one(s) has (have) a bond order of 1? \_\_\_\_\_F2, Ne22+\_\_\_\_\_
3. Which is paramagnetic? \_\_\_\_\_F22+\_\_\_\_\_
4. Which one is the least stable? \_\_\_\_\_F22-