CAPE BRETON UNIVERSITY

Chem 1104 – Final Exam
Date: June 18, 2018

Instructor: Calvin Howley
Time Period: 3 hour

Student: ________________________________

Student #: ________________________________

Instructions:

Please turn off all cell phones. Only scientific calculators are allowed in the exam room. Students found to be using any electronic organizer or other electronic device during the exam will be given a grade of zero and asked to leave the testing area.

Clear desk area of all personal items other than pen, approved calculator and photo id.

All answers are to be done on test paper. If more room is needed use the back side of the paper and indicate.

Read all questions carefully.

Answer all questions for full point value. Partial marks may be awarded for incomplete questions.

Make sure you have all data sheets and test pages.

Complete as many questions as soon as possible and then go back to incomplete questions.

Test papers not turned in to the instructor at the end of the test period will not be accepted.

Part I: Short Answer

Instructions: Circle the correct answer or fill your answer in the space provided.

1. Calculate the work, w, done on the surroundings when a gas expands from 15 L to 35 L against a constant external pressure of 1.5 atm.

a) -5.3 kJ b) -3.0 kJ c) +3.0 kJ d) +5.3 kJ

2. For a process that is carried out at constant pressure, absorbs 125 kJ of heat and does 15 kJ of work. Therefore,

a) $\Delta E = +110$ kJ and $\Delta H = +125$ kJ b) $\Delta E = +125$ kJ and $\Delta H = +110$ kJ

c) $\Delta E = +125$ kJ and $\Delta H = +140$ kJ d) $\Delta E = +140$ kJ and $\Delta H = +125$ kJ

3. For bromine, $\Delta H°_{vap} = 30.91$ kJ/mol and $\Delta S°_{vap} = 93.23$ J/K·mol at 25°C. What is the normal boiling point for bromine?

a) 25°C b) 58°C c) 124°C d) 332°C

4. What is the frequency of a helium-neon laser light with a wavelength of 632.8 nm?

a) $4.74 \times 10^{14}\ s^{-1}$ b) $4.74 \times 10^{5}\ s^{-1}$ c) $2.11 \times 10^{-15}\ s^{-1}$ d) $1.58 \times 10^{-15}\ s^{-1}$

5. The wave characteristics of a large, moving object, such as an automobile, are difficult to observe because the

a) energy is not quantized. b) energy is quantized, but difference in levels is small.

b) wavelength is very large. d) wavelength is very small.

6. Which of the following is **not** a valid set of quantum numbers?

a) $n = 2$, $l = 1$, $m_l = 0$, and $m_s = -1/2$ b) $n = 2$, $l = 1$, $m_l = -1$, and $m_s = -1/2$

c) $n = 3$, $l = 0$, $m_l = 0$, and $m_s = +1/2$ d) $n = 3$, $l = 2$, $m_l = 3$, and $m_s = +1/2$

7. What is the ground-state electron configuration of Co?

a) $[Ar]3d^9$ b) $[Ar]4s^1 3d^8$ c) $[Ar]4s^2 3d^7$ d) $[Ar]4s^2 4p^6 4d^1$

8. Of the following elements, which has the lowest electronegativity?

a) Mg b) Cl c) Ca d) Br

9. The paramagnetism of O_2 is explained by

a) valence bond theory b) molecular orbital(MO) theory

b) resonance c) valence shell electron pair repulsion(VSEPR) theory

10. In liquid methanol, CH_3OH, which intermolecular forces are present?

a) Dispersion, hydrogen bonding and dipole-dipole forces are present.

b) Only dipole-dipole, ion-dipole forces are present.

c) Only dispersion and dipole-dipole forces are present.

d) Only hydrogen bonding forces are present.

Part II: Long Answer
Instructions: Fill your answer in the space provided. Show all work for full point value.
A. Thermochemistry

1. Using the thermodynamic data below at T = 298 K, answer each of the following by doing a quantitative calculation of the appropriate thermodynamic function:
a) Does the reaction absorb or release heat at constant pressure?
b) Are the products more or less disordered than the reactants?
c) Is this a spontaneous reaction?

$$2B(s) + 6HCl(g) \rightarrow 2BCl_3(g) + 3H_2(g)$$

Compound	$\Delta H_f°$(kJ/mole)	$\Delta S°$(J/K×mole)
B(s)	0	5.9
BCl_3(g)	-403.8	290.1
H_2(g)	0	130.68
HCl(g)	-92.3	186.9

2. Using Hess's law and the thermochemical data below determine ΔH for the reaction below.

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$ ΔH = ?

Given:

1. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ ΔH = -99.22 kJ
2. $N_2(g) + O_2(g) \rightarrow 2NO(g)$ ΔH = +180.5 kJ
3. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ ΔH = -571.6 kJ

3.a) A 1.108 g sample of naphthalene, $C_{10}H_8$, is burned in a bomb calorimeter and the temperature increased from 20.10°C to 26.02°C. If the heat of combustion of naphthalene is -5153.5 kJ/mol $C_{10}H_8$, what is the heat capacity of the calorimeter?

b) When a 1.351 g sample of thymol, $C_{10}H_{14}O(s)$(a preservative and mold and mildew inhibitor), is burned in the same calorimeter from part a), the temperature increased from 20.50°C to 27.24°C. Calculate the heat of combustion of thymol, in kJ/mol $C_{10}H_{14}O$?

B. Quantum Model of Atom/Periodic Properties of Elements

4.a) Calculate the wavelength, in nanometers(nm), of the electromagnetic radiation emitted or absorbed by the hydrogen atom when its electron drops from the n = 5 energy level to the n = 1 energy level.

b) Did the hydrogen atom absorb or emit the electromagnetic radiation in the transition described in part a.

c) If a hydrogen atom emits electromagnetic radiation with a wavelength of 1095 nm, calculate the value of the energy level(n) the electron ended up in if it is originally located in the n = 6 level.

5.a) What is the trend in atomic size found in the periodic table? Briefly explain this trend.
b) What is meant by ionization energy? State the periodic trend in ionization energy.
c) Silicon(Si) has an electron affinity of -134 kJ/mol. The electron affinity of phosphorous(P) is -72 kJ/mol. Give a plausible reason for this difference.

C. Bonding

6. Draw Lewis Structures, including formal charges, for the following molecules and ions and use VSEPR theory to determine the geometry of the following molecules and ions.

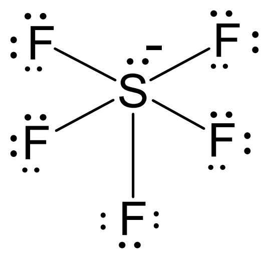
a) HCN

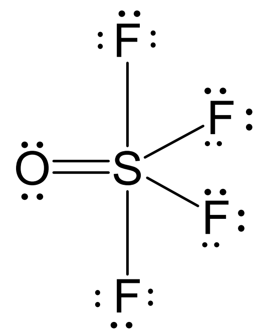
b) PCl_2Br

c) $COBr_2$

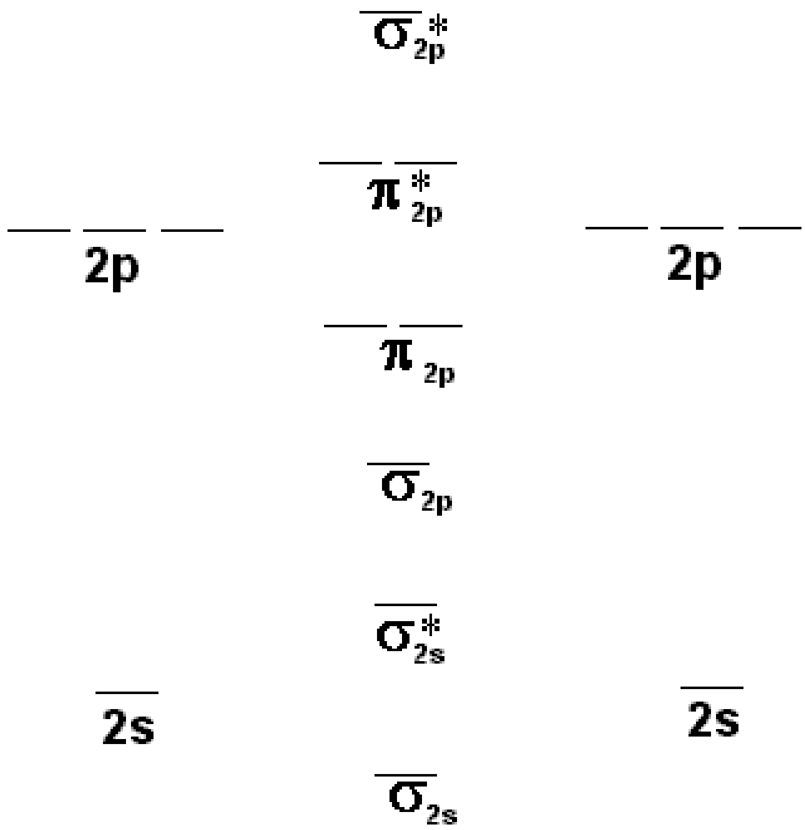
d) C_2^{2-}

7. In both the ion SF_5^- and the molecule OSF_4, a sulfur atom is bonded to five other atoms. Determine the hybridization scheme of the central S atom in each case.

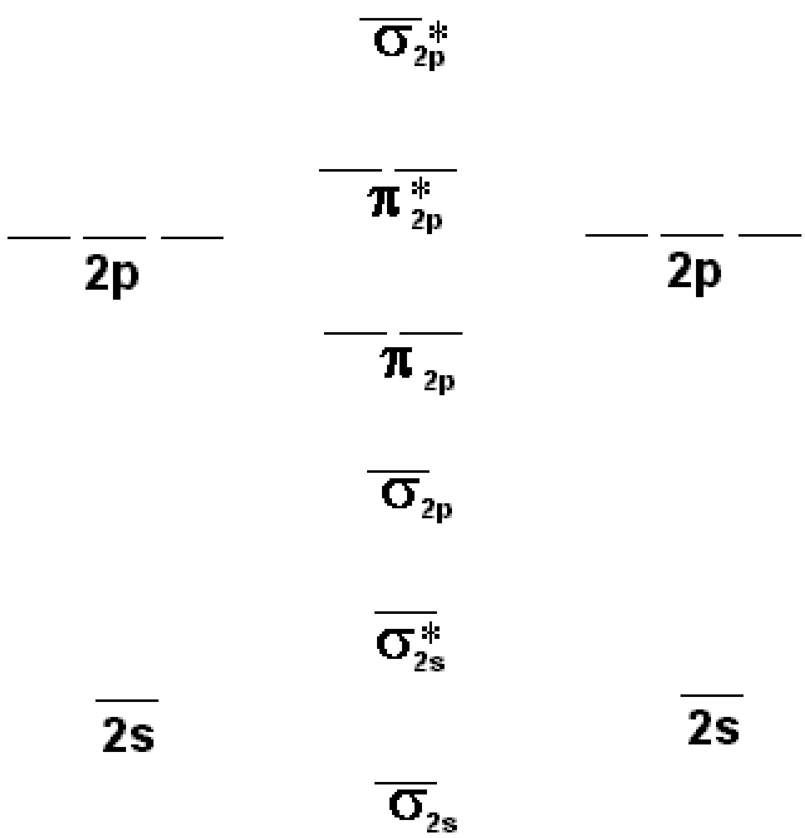




8. Complete the MO diagrams for F_2^+ and F_2^- , determine the bond order for each.



F_2^+



F_2^-

D. Intermolecular Forces

9. State and fully describe the three types of intermolecular attraction forces discussed in class.

10. The compounds H_2, Br_2, and I_2 are all examples of homonuclear diatomic molecules. Hydrogen(H_2) is a gas, bromine(Br_2) is a liquid, and iodine(I_2) is a solid at room temperature. Explain the differences in physical state.

Grade Sheet

The points awarded for this exam are outlined below. Please review. If there are any questions or possible corrections please consult the instructor.

Question	Points Awarded
Part I	
1-10	
Part II	
A	
1-3	
B	
4-5	
C	
6-8	
D	
9-10	
Total	

Comments:

Some Useful Data or Not!

Constants:

1 mole = 6.022×10^{23} elementary particles
$N_a = 6.0223 \times 10^{23}$
1000 g = 1 kg
1 g = 1000 mg = 0.001 kg
1 lb = 453.6 g
1 pg = 1×10^{-12} g
1 µg = 1×10^{-6} g
1 km = 1000 m
1 cm = 0.01 m
1 nm = 1×10^{-9} m
1 pm = 1×10^{-12} m
1 µm = 1×10^{-6} m
1 L = 1000 mL

R = 0.0821 L·atm/K·mole
R = 8.314 J/K·mole
R = 8.314 kg·m^2/s^2·K·mole
1 atm = 101.325 kPa
1 kJ =1000 J
1 kcal = 4.184 kJ
1 cal = 4.184 J
1 L·atm = 101.3 J
$R_H = 2.179 \times 10^{-18}$ J
h = 6.626×10^{-34} kg·m^2·s^{-1} = 6.626×10^{-34} J·s
c = 3.00×10^8 m/s
1 Hz = 1 s^{-1}
1 D = 3.33×10^{-30} C·m
Unit charge = 1.60×10^{-19} C

Equations:

T°C = (5°C/9°F)×(T°F - 32°F)   **T(K) = T(°C) + 273.15°C**

1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d

$\Delta G = \Delta H - T\Delta S$ $\Delta E = q + w$ $\Delta G° = -RT\ln K$

$\Delta G° = \Delta H° - T\Delta S°$ $\Delta H = q_p$ $\Delta E = q_v$ $\Delta G = \Delta G° + RT\ln Q$

$\Delta G = \Delta H - T\Delta S$ $\Delta E = q + w$ $\Delta G° = -RT\ln K$

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$w = -P\Delta V$ C = mass×sp_heat $-q_{rxn} = q_{cal}$

$\Delta H = \Delta E + \Delta nRT$ $q = C\Delta t$ $q_{cal} = C_{cal}\Delta t$

$$\Delta S = \frac{\Delta H}{T} \qquad \lambda = \frac{c}{\nu} \qquad E = h\nu$$

$$E = \frac{hc}{\lambda} \qquad \Delta E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) \qquad m \cdot \Delta x \cdot \Delta v \geq \frac{h}{4\pi}$$

$$\lambda = \frac{h}{mu}$$

VSEPR Theory: Geometry

Total Number of Electron Pairs	Number of Lone Pairs	Geometry
2	0	Linear
3	0	Trigonal Planar
3	1	Bent
4	0	Tetrahedral
4	1	Trigonal pyramidal
4	2	Bent
5	0	Trigonal bipyramidal
5	1	See-saw
5	2	T-shaped
5	3	Linear
6	0	Octahedral
6	1	Square pyramidal
6	2	Square planar

<u>SCRAP PAPER(</u>Do not pass in!!)

Answer Set For Chem 1104-Final Exam:

Part I
1.c)

2.a)

3.b)

4.a)

5.d)

6.d)

7.c)

8.c)

9.b)

10.a)

Part II
1.a) ΔH° = -253.8 kJ, release heat; b) ΔS° = -161 J/K×mole, less disordered; c) -205.8 kJ, spontaneous

2. -1156 kJ

3.a) 7.52 kJ/°C; b) -5640 kJ/mole

4.a) -95.1 nm; b) emit; c) $n_f = 3$

5.a) Atomic size increases going down a group in the periodic table and decreases left to right across a period in the periodic table.

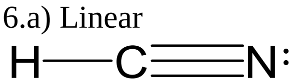
Atomic size increases down a group because as you go down a group you are adding electrons to a new n level and thus are further away from the nucleus.

Atomic size decreases left to right across a period because while you are adding electrons, they are added to the same n level. Thus the increasing positive nuclear charge can pull the electrons closer and atomic size decreases in magnitude.

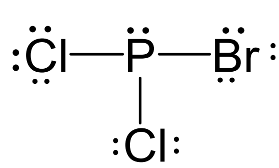
b) Trend in ionization energy is opposite of the trend in size.

c) The electron affinity is less positive for phosphorous(less energetically favourable) because adding an electron involves pairing up an electron while adding an electron to Si does not. Adding an electron to P produces a pair in one 3p orbital, and these electrons repel one another.

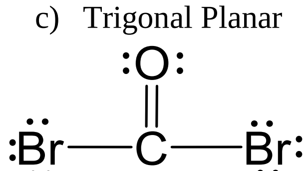
6.a) Linear



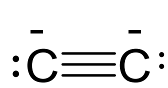
b) Trigonal pyramidal



c) Trigonal Planar



d) Linear



Not possible.

7. SF_5^-: sp^3d; OSF_4: sp^3d

8. F_2^+: BO = 1.5; F_2^-: BO = 0.5

9. Dispersion forces are intermolecular attraction forces due to the formation of temporary and instantaneous dipole-moments. These temporary and instantaneous dipole-moments are due to the random motion of the electrons. Dipole-dipole forces are intermolecular attraction forces due to the presence of permanent dipole-moments in the molecules. Hydrogen bonding a form of dipole-dipole forces where there is a hydrogen atom directly bonded to N, O, or F.

10. All are nonpolar molecules. Contain only dispersion forces. Dispersion forces increase with increasing number of electrons. Increasing attraction forces requires more energy to separate the molecules and thus has a larger melting point. Iodine has more electrons than bromine, while hydrogen has the least number of electrons. Thus iodine has the largest melting point and hydrogen has the lowest.