average: 71%

CHEMISTRY 1127 **EXAM III** **December 3, 2010**

NAME (PRINT) _____ SECTION KEY

SIGNATURE _____ TA _____

PLEASE READ THE FOLLOWING INSTRUCTIONS

Do NOT begin the exam until asked to do so.

There are 9 numbered pages, a useful information page and a periodic table in this exam. Check to see that they are all here before you begin the exam. Return all these papers when you are finished. Write your name on every page. Use a **pen** with blue or black ink for the entire exam.

Exams done in pencil, erasable ink, or where white-out, liquid paper, etc. have been used are *ineligible for regrades.*

Be sure to follow the directions in answering all questions. Write your final answers in the blanks provided. In working problems and the BONUS, you must **SHOW ALL WORK**. No credit will be given unless all work is clearly shown and the method of solution is logically correct. Use correct units and significant figures.

Do not write below this line

Page	Total	Grader
1	_____ / 24	
2	_____ / 21	
3	_____ / 21	
4	_____ / 16	
5	_____ / 22	
6	_____ / 20	
7	_____ / 16	
8	_____ / 10	
9 (Bonus)	_____ / 15	

Total Grade _____ **/150 Checked by** _____

CHEMISTRY 1127, EXAM III NAME KEY
December 3, 2010

1. **(41 points)**

A. (8 points) Answer the following True-False questions, please write the entire word True or False as your answer.

2 pts each

True **1.** The quantum number $\ell = 1$ corresponds to a *p*-type sublevel.

True **2.** No two electrons in the same atom can have the same four quantum numbers.

True **3.** Atomic radius decreases across (from left to right) a period.

False **4.** Electronegativity is the measure of how difficult it is to remove an electron from a gaseous atom.

B. (6 points) Consider an electron transition from energy level **n** = 4 to **n** = 2 in a hydrogen atom. What is the energy of one photon given off during this transition?

6 pts

$E = 2.180 \times 10^{-18} J \left(\frac{1}{2^2} - \frac{1}{4^2}\right)$

1 mist. 3

2 mist. 0

$4.088 \times 10^{-19} J$

C. (10 points) A green laser pointer used in the class has a frequency of $5.64 \times 10^{14}\ s^{-1}$.

1. What is the wavelength of the light?

4 pts

$\lambda = \frac{2.998 \times 10^{8}\ m/s}{5.64 \times 10^{14}\ s^{-1}} = 5.31 \times 10^{-7} m$ 2 pts

$5.31 \times 10^{-7} m \times \frac{1 \times 10^{9} nm}{1 m}$ 2 pts

531 nm

2. If 36 kJ of energy is given off when pointing at an exciting chemical equation on the projector screen, how many photons were emitted?

6 pts

$E = 5.64 \times 10^{14}\ s^{-1} \times 6.626 \times 10^{-34}\ J \cdot s = 3.74 \times 10^{-19} \frac{J}{photon}$

$36 kJ \times \frac{1000 J}{1 kJ} \times \frac{1 photon}{3.74 \times 10^{-19} J}$

1 mist. 3

2 mist. 0

9.63×10^{22} photons

24

CHEMISTRY 1127, EXAM III **NAME** KEY
December 3, 2010

D. (21 points) Answer the following questions in the space provided.

1. Classify the following as ground state, excited state or impossible.

a. $1s^2 2s^2 2p^5 3d^1$ excited

b. $1s^2 2s^2 2p^7 3s^1$ impossible

2. How many electrons in an atom can have the following quantum number designation

a. $n = 3, m_\ell = 0$ 6

b. $n = 5, \ell = 3, m_\ell = +2$ 2

$n=3 \quad \ell = 0, 1, 2$
$\ell = 0 \quad m_\ell = 0$
$\ell = 1 \quad m_\ell = \mp 1, 0$
$\ell = 2 \quad m_\ell = \mp 2, \mp 1, 0$

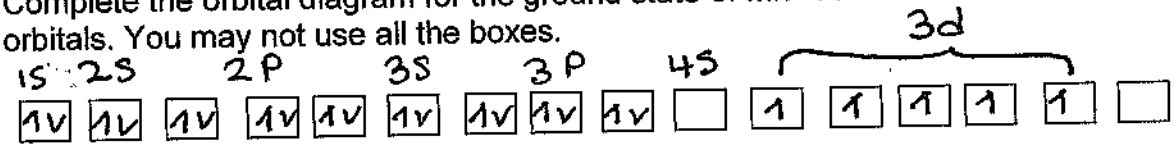
3 pts each All or nothing

3. Answer the following questions about the Mn^{2+} cation.

a. Write the **abbreviated** ground state **electron configuration** for Mn^{2+}.

[Ar] $3d^5$

b. Complete the orbital diagram for the ground state of Mn^{2+}. Be sure to label the orbitals. You may not use all the boxes.



c. Is the ground state of the Mn^{2+} ion paramagnetic or diamagnetic?

paramagnetic

21

CHEMISTRY 1127, EXAM III **NAME** KEY
December 3, 2010

II. (37 points)

A. (6 points) In each of the following questions, Print in capital letters (i.e. A, B, C, D, E) on the blanks at the left of the numbered question the letter of the best answer. Circled letters will not be considered.

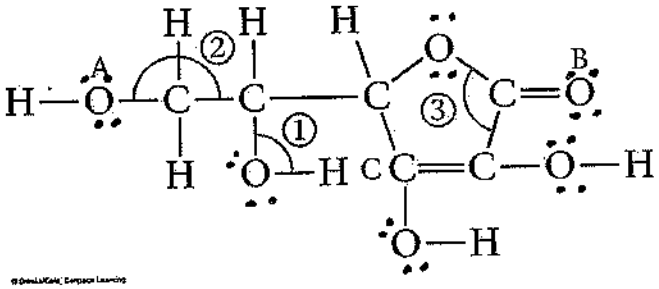
A 1. What is(are) the bond angle(s) in SF_6?
A. 90°, 180° **B.** 109.5° **C.** 120° **D.** 90° and 120° **E.** 180°

A 2. How many possible resonance structures exist for sulfur trioxide?
A. 3 **B.** 4 **C.** 5 **D.** 6 **E.** 8

2 pts each

B 3. Write the Lewis dot structure for BF_3. Which of the following statements best describes this structure?
A. It obeys the octet rule on all atoms.
B. It has less than an octet on at least one atom.
C. It has a lone pair of electrons on the boron atom.
D. It has less than an octet of electrons on all atoms.
E. It exceeds the octet rule.

B. (15 points) Consider the following molecule shown by its ***incomplete*** Lewis structure:



1. 2 How many pi bonds are in the structure?

2. 12 How many lone pairs of electrons are needed to complete the Lewis structure?

2 pts each except last

3. sp^3 What is the hybridization of oxygen atom marked as **A** in the molecule?

4. sp^2 What is the hybridization of carbon atom marked as **C** in the molecule?

5. 20 How many sigma bonds are in the molecule?

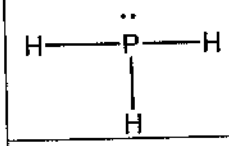
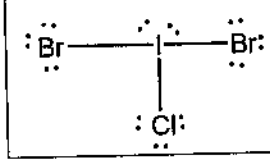
6. tetrahedral What is the molecular geometry around carbon atom marked as **2** in the structure?

7. What are the approximate values of the angles marked as **1**, **2** and **3**?

109.5° 109.5° 120° (1 pt each)

21

C. (16 points) Complete the following table about the following two molecules with complete Lewis structures (the structures given do not reflect the actual geometry):

	Electron pair geometry around the central atom	Molecular geometry around the central atom	Hybridization around the central atom	Is the molecule polar? **(Yes** or **No)**
	tetrahedral AX_3E	trigonal pyramid	sp^3	Yes
	trigonal bipyramidal AX_3E_2	T-shaped	sp^3d	Yes

2 pts each
All or nothing

16

CHEMISTRY 1127, EXAM III **NAME** KEY
December 3, 2010

III. (46 points)

A. (12 points) Answer the questions below, using **LT** (for *is less than*), **GT** (for *is greater than*), **EQ** (for *is equal to*), or **MI** (for *more information required*) in the blanks provided. Consider the reaction

$3\ A_2(\ell) + XY_3(s) \rightarrow X(s) + 3A_2Y(s)$ $\Delta H^\circ = 150$ kJ

where A_2 and X are elements in their most stable states under standard conditions. For this reaction:

3 pts each

GT **1.** The enthalpy of products ___ the enthalpy of reactants.

MI **2.** ΔH_f° for A_2 (s) ___ 0.

GT **3.** If this reaction is run such that the heat absorbed arises from 1000 g of water, the change in temperature of the water ___ 0.0359 °C (to 3 significant figures). $1000 \times 4.18 \times \Delta t = 150000$ $\Delta t = 35.9^\circ C$

EQ **4.** ΔH° for the reaction

$1/3X\ (s) + A_2Y\ (s) \rightarrow A_2\ (\ell) + 1/3\ XY_3\ (s)$ ___ -50 kJ.

B. (10 points) Brass has a density of 8.25 g/cm^3 and a specific heat of 0.362 J/g·°C. A cube of brass 22.00 mm on an edge is heated in a Bunsen burner flame to a temperature of 95°C. It is then immersed into 20.00 mL (d = 1.00 g/mL) of water at 22.0°C in an insulated container. Assuming no heat loss, what is the final temperature of the water?

$$q_{brass} = 87.8g \times 0.362 \frac{J}{g \cdot °C} (t_2 - 95°C)$$

$$q_{water} = 20.0g \times 4.18 \frac{J}{g \cdot °C} (t_2 - 22.0°C)$$

10 pts

$$q_{water} = -q_{brass}$$

$$20.0g \times 4.18 \frac{J}{g \cdot °C} \times (t_2 - 22.0°C) = 87.8g \times 0.362 \frac{J}{g \cdot °C} (95 - t_2)$$

$$2.63\ (t_2 - 22°C) = (95 - t_2)$$

$$t_2 = 42.1°C$$

1 mist. 7
2 mist. 4
3 mist. 0

42°C

22

CHEMISTRY 1127, EXAM III **NAME** KEY
December 3, 2010

C. (8 points) When propane gas is burned in air, the following reaction takes place:

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$ $\Delta H° = -2219.9$ kJ

How many grams of C_3H_8 (MM = 44.1 g/mol) must react with an excess of oxygen to liberate 57.2 kilojoules of heat?

$$-57.2\ kJ \times \frac{1\ mol\ C_3H_8}{-2219.9\ kJ} \times \frac{44.1\ g}{1\ mol\ C_3H_8}$$

8 pts

1 mist. 4 pts
2 mist. 0

1.14 g

D. (12 points) The following thermochemical equations are provided for use in solving this problem.

$C_2H_2(g) + \frac{5}{2}O_2(g) \rightarrow 2\ CO_2(g) + H_2O(\ell)$ $\Delta H = -1299.6$ kJ

2 × $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -393.5$ kJ

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(\ell)$ $\Delta H = -285.9$ kJ

Using the guidelines below, calculate the enthalpy change for the reaction given in the last row of the table below.

1. Complete the table below, showing the three reactions that must be added together to give the reaction shown at the bottom of the table.
2. Also show the enthalpy change for each of the reactions you provide below in the column to the right of the equations.
3. Report the enthalpy change for the reaction given in the last row of the table below.

Chemical reactions to be added together to give the formation reaction shown in the bottom row of this table:	ΔH
$2\ CO_2(g) + H_2O(\ell) \rightarrow C_2H_2(g) + \frac{5}{2}O_2$ (2 pts)	1299.6 (2 pts)
$2C(s) + 2O_2(g) \rightarrow 2CO_2(g)$ (2 pts)	2 × (−393.5) (2 pts)
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(\ell)$ (1 pt)	−285.9 (1 pt)
$2\ C(s) + H_2(g) \rightarrow C_2H_2(g)$	ΔH = 226.7 (2 pts)

20

CHEMISTRY 1127, EXAM III **NAME** KEY
December 3, 2010

IV. (26 points)

A. (8 points) Suppose you want a titration of 0.70 g $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ (MM = 392.19 g/mol) to require 25.00 mL $KMnO_4$ to reach an end point. What molar concentration of $KMnO_4$ (MM=158 g/mol) solution should be prepared?

$$8H^+(aq) + MnO_4^-(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O$$

$$0.70g \times \frac{1mol}{392.19g} \times \frac{1mol\ MnO_4^-}{5mol\ Fe^{2+}} = 3.6\times10^{-4}\ mol$$

(2pts for n_{Fe}, 2pts for 1/5)

(4pts)

$$M = \frac{3.6\times10^{-4}}{0.02500} = 0.0143\ M$$

OR $\frac{n_{MnO_4^-}}{0.02500}$

} 4 pts All or nothing

0.0143M

B. (8 points) When 35.0 mL of 1.43 M NaOH at 22.0°C is neutralized by 35.0 mL of HCl also at 22.0°C in a coffee cup calorimeter, the temperature of the final solution rises to 31.29°C. Calculate q for the neutralization of one mole of NaOH. Assume that the volumes are additive and the density of the solutions is 1.00 g/mL. (specific heat of solution is 4.18J/°C)

$$q_{H_2O} = (35.0 + 35.0) \times 4.18 \times (31.29 - 22.0)$$

$$= 2.72\times10^3\ J$$ (2pts)

$$q_{rxn} = -2.72\times10^3 J$$

(4pts)

$$n_{NaOH} = 35.0\ mL \times \frac{1.43mol}{1000mL} = 0.05005\ mol = 0.0500mol$$

(2pts)

$$q_{neut} = \frac{-2.72\times10^3}{0.0500} = -54345 = -5.43\times10^4\ J/mol$$

(4pts)

-54.3 kJ/mol

missing (-) 7 in front of 9 .2 pts

16

C. (10 points) A student evaporates 5.00 g of an unknown pure liquid in a nearly-closed flask of a known volume using the procedure used in the lab in this course. He condenses the liquid and then determines the mass of the condensed liquid. From the following data answer the questions below.

Mass of flask and cap	65.559
Mass of flask, cap and condensed liquid	66.083 g
Barometric pressure	752 mm Hg
Temperature of hot water bath	98.1°C
Volume of the flask	278 mL

1. What is the mass of the condensed liquid?

66.083 - 65.559

2pts

All or nothing

0.524g

2. How many moles of gas are in the flask at 98.1°C and 752 mm Hg?

$\frac{752}{760} \times 0.278 = n \times 0.0821 \times 371.1\ K$

4pts

1 mist. 2
2 mist. 0

0.00903 mol 9.03×10^{-3} mol

3. What is the molar mass of the liquid?

$\frac{0.524}{9.03 \times 10^{-3}}$ OR $\frac{\text{answer in \#1}}{\text{answer in \# 2}}$

4pts

All or nothing

58.0 g/mol

10

CHEMISTRY 1127, EXAM III **NAME** KEY
December 3, 2010

BONUS (15 points) ALL or NOTHING

The bonus should be done only after you have completed the main part of this exam and checked your work for errors. The time allotted for this exam does not include time for the bonus. (SHOW ALL WORK! Lucky guesses will not be considered. The method of solution must be reasonable and must get all answers correct for any credit)

A sample of sucrose, $C_{12}H_{22}O_{11}$, is contaminated by sodium chloride. When contaminated sample is burned in a bomb calorimeter, sodium chloride does not burn. What is the percentage of sucrose in the sample if a temperature increase of 1.73°C is observed when 3.000 g of the sample is burned in the calorimeter? Sucrose gives off 5.64 x 10^3kJ/mol when burned. The heat capacity of the calorimeter is 22.4 kJ/°C.

$$q_{cal} = 22.4 \frac{kJ}{°C} \times 1.73°C = 38.8\ kJ$$

$$q_{rxn} = -38.8\ kJ$$

$$\#\text{ of moles of } C_{12}H_{22}O_{11} = -38.8\ kJ \times \frac{1\ mol}{-5.64 \times 10^3\ kJ}$$

$$= 6.87 \times 10^{-3}\ mol$$

$$\text{mass of } C_{12}H_{22}O_{11} = 6.87 \times 10^{-3}\ mol \times \frac{342.3\ g}{1\ mol}$$

$$= 2.35\ g$$

$$\% \text{ sucrose} = \frac{2.35}{3.00} \times 100 =$$

78.3 %

15