CHEM 105 – Dr. Lammi Name: ________________________

EXAM II – Oct. 7, 2019

Please show all work and/or reasoning in the space provided or on the attached scratch page. Partial credit for incorrect answers may only be awarded if work/reasoning is shown. Remember to report the final results of your calculations with the appropriate significant figures. A Periodic Table and a page of helpful information are provided for your use. GOOD LUCK!!

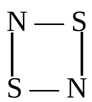
1. (9 pts) Please provide the correct formula or name for each of the following compounds.

   a. diantimony pentaselenide

   b. potassium dichromate

   c. N_2S_2

2. (14 pts) N_2S_2, named in Question 1(c) above, contains alternating N and S atoms connected in a 4-membered ring:



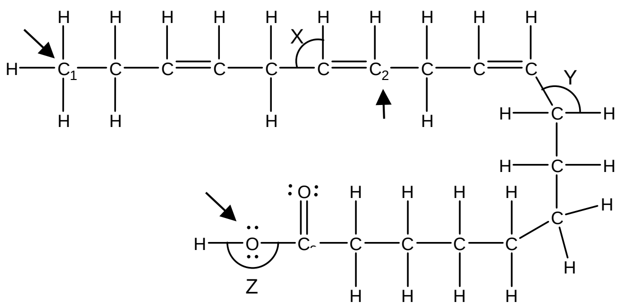
   a. Draw the best Lewis structure(s) that <u>**obey the octet rule**</u>. Include equivalent resonance structures if appropriate.

   b. Based on your structure(s), how do expect the **N-S bond lengths** to compare? <u>**Circle**</u> one answer below.
      i. All four bonds are the same length
      ii. One bond is shorter than the other three
      iii. One bond is longer than the other three
      iv. Two bonds are shorter and two bonds are longer

   c. This compound is not very stable: it is shock-sensitive and decomposes explosively above 30 °C. What <u>**evidence**</u> can you give based on your structure(s) in part (a) to help **explain its instability**?

3. (5 pts) Which of the following are **true** about hybridization? **Circle** all that apply.
   a. It involves mixing valence orbitals on a central atom
   b. Resulting hybrid orbitals can correctly explain known bond angles for all molecules
   c. There is no proof that hybridization occurs
   d. Atoms must mix all of their valence orbitals together to form hybrids

4. (27 pts) α-Linolenic acid, ALA, is one of the omega-3 fatty acids found to benefit heart health. Its chemical formula is $C_{18}H_{30}O_2$, and it has the **Lewis structure** shown below.



a. Please estimate the **bond angles** X, Y, and Z.

X: ______ **Y: ______** **Z: ______**

b. Please specify the **type of hybrid orbitals** used by each of the three numbered C atoms (see arrows).

C_1: ______ **C_2: ______** **$O_{\text{Angle Z}}$: ______**

c. Please specify the **numbers of sigma (σ) and pi (π) bonds** in the molecule.

σ bonds: ______ **π bonds: ______**

d. A teaspoon of flax seeds (which many people add to their breakfast cereal) contains 783 mg of ALA ($C_{18}H_{30}O_2$). **How many molecules of ALA** are present?

e. The calorie content of a food item – which is a measure of the energy stored in its chemical bonds – may be determined from the amount of energy given off when it is combusted. Please **write and balance** the chemical equation for the **complete combustion of ALA** ($C_{18}H_{30}O_2$).

(Lots of extra space here!!)

5. (12 pts) Hydrogen peroxide (H_2O_2) is often sold by chemical suppliers as a concentrated solution that is 30.0 % H_2O_2 by mass: this means that it contains 30.0 grams of H_2O_2 per 100.0 grams of water.

   a. Suppose that 30.0 g of H_2O_2 is combined with enough water to reach a total solution volume of 103.5 mL. What is the **molar concentration** of hydrogen peroxide in this solution?

   b. Suppose that you wish to dilute 50.0 mL of the solution prepared in (a) to a final concentration of 0.425 M (a concentration similar to what is sold in the drugstore). **To what final volume must you dilute it** in order to reach this concentration? [**Note:** If you did not obtain an answer for (a), you may use 1.00 M.]

6. (20 pts) Uranium must be refined and enriched in ^{235}U before it can be used as a fuel in nuclear reactors. (We sometimes hear news reports about nations "enriching uranium" in efforts to produce nuclear weapons, too.) The first step in this process involves formation of UF_4, an **unbalanced** equation for which is shown below.

$$UO_2\ (g) \quad + \quad HF\ (aq) \quad \rightarrow \quad UF_4\ (g) \quad + \quad H_2O\ (l)$$

   a. Please provide the correct **name** for UO_2.

   b. Please **balance** the chemical equation above.

   c. What **mass of UF_4 in kilograms** can be produced from the reaction of 10.00 kg of UO_2 and 5.00 kg of HF?

Problem 6, continued

d. Suppose that a scientist performs this reaction in the lab, obtaining 5.47 kg of UF_4. What is his/her **percent yield**?

7. (18 pts) In this problem, you will describe bonding in bromate, BrO_3^-.

a. Please draw the best Lewis structure(s) that **obey the octet rule**. Include equivalent resonance structures, if necessary. **Indicate the formal charge on each atom.**

b. Next, **draw the best Lewis structure(s) that minimize formal charge**, including equivalent resonance structures, if appropriate.

c. Please **use either your answer for (a) OR (b)** to **name and sketch the molecular geometry** of this ion. Also, please **estimate the bond angles.**

d. Is BrO_3^- **polar or nonpolar**?

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If there is material to be graded here, make sure that it is clearly labeled and write your name on the page.

Useful Constants, Conversion Factors and Equations

Constants and conversion factors:

$h = 6.626 \times 10^{-34}$ J·s

$c = 2.9979 \times 10^{8}$ m/s

$1 \text{ J} = 1 \ \frac{kg * m^2}{s^2}$

$N_A = 6.022 \times 10^{23}$

Equations:

$$d = \frac{m}{V}$$

$$\nu = \frac{c}{\lambda}$$

$$E_{photon} = h\nu$$

$$E_K \text{ (ejected electron)} = E_{photon} - \phi$$

$$E_K = \frac{1}{2}mv^2$$

$$\Delta E = -2.18 \times 10^{-18} \text{ J}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$E_{photon} = |\Delta E|$$

$$\lambda_{matter} = \frac{h}{mv}$$

$$M_iV_i = M_fV_f$$

Main groups — Transition metals — Main groups

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794																	2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.81	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.998403	10 Ne 20.1797
11 Na 22.98977	12 Mg 24.305											13 Al 26.98154	14 Si 28.0855	15 P 30.97376	16 S 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.9055	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.41	49 In 114.82	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.9045	54 Xe 131.29
55 Cs 132.9054	56 Ba 137.33	57 *La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.9665	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.9804	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0254	89 †Ac 227.0278	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Uun	111 Uuu	112 Uub		114 Uuq		116 Uuh		

*Lanthanide series	58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.9254	66 Dy 162.50	67 Ho 164.9304	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.967
†Actinide series	90 Th 232.0381	91 Pa 231.0359	92 U 238.0289	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)