Lakehead
UNIVERSITY

DEPARTMENT OF CHEMISTRY
Final Examination
Chemistry 1110 (Modern Chemistry I)
17 December, 2012

Name: _____

Student ID Number:_____

Instructions:
1. There are **3 parts to this exam!** Make sure you do them all.
2. Part 1 (multiple choice) should be answered on this page (below). Part 2 is to be answered on the exam paper. Part 3 should be answered in the exam booklets provided.
3. Allowed external materials: calculator (any type), tables at end of exam
4. Print or write legibly!
4. The final 3 sheets of this exam paper are a periodic table, a formula sheet, and enthalpy tables. Feel free to remove them if desired.
5. There are 72 points on the exam. Time allowed = 180 minutes.
6. There are a total of 13 pages including this one.

PART 1.

One-point multiple choice. Choose one answer only. (1 point each, 10 total)

(1) Alexander Litvinenko, a Russian spy, was murdered by poisoning with $^{210}_{84}Po$. It has a half-life of 138 days and decays by α-emission. What is the daughter nucleus (product)? Hint, an α-particle is a ^{4}He nucleus.

(e) $^{206}_{82}Pb$

(2) The polonium that Litvinenko received was in the form polonium nitrate, which is $Po(NO_3)_4$. What is the electronic configuration of the polonium *cation* in this compound? Hint: nitrate is NO_3^-.

(e) $[Xe]5d^{10}\ 6s^2$

(3) Solid polonium metal is the only element on the periodic table that crystallizes as a simple cubic structure under standard conditions. The edge of the cube is 310. pm. What is the radius of a Po atom?

(b) 155 pm

(4) Below is a representation of two *p* orbitals approaching each other. What sort of interaction will result when these two orbitals are close?

(a) π (bonding)

(5) This is the straight-chain form of the sugar fructose. When it cyclizes, it will become,

(b) a 5-membered ring

(6) Electronegativity of an atom is,

(c) its strength in drawing bonding (covalent) electrons to itself

(7) An atom on the face of a unit cell is shared by how many unit cells in total?

(b) 2

(8) What is the H-C-H bond angle in methane (CH_4)?

(d) 109.5°

(9) Which one term best describes the structure of this polymer?

(a) it contains a single monomer type

(10) What reagent will give the following conversion?

(a) $LiAlH_4$

(11) How much energy is required to boil 10.0 g of liquid water to steam at 100.°C? The ΔH_{vap} of water is 40.7 kJ/mol.

(a) 22.6 kJ

(12) Red light has a wavelength of 725 nm. What is the energy of 1.00 mol of photons?

(a) 165 kJ/mol

(13) Choose the correct IUPAC name for this compound.

(a) ethyl 3-methylpentanoate

(14) Choose the correct IUPAC name for this compound.

(e) *trans*-2-heptenal

(15) 3-Hexene reacts with HBr in a 1:1 molar ratio. Which carbon(s) are chiral in the product molecule?

(a) carbon #3

(16) Ethanol can be burned as a motor fuel. The reaction is,

$$C_2H_5OH\ (l)\ +\ 3\ O_2\ (g)\ \rightarrow\ 3\ H_2O\ (l)\ +\ 2\ CO_2\ (g)$$

Using the attached standard enthalpies of formation, calculate the amount of heat released by this reaction.

d) -1367 kJ/mol

(17) The unit cell for sphalerite (ZnS) is shown. What is the **total number** of ions (cations & anions) in this unit cell? Hint: the S^{2-} anions are arranged in a face-centred cubic structure, and the Zn^{2+} cations are entirely in the unit cell.

(c) 8

(18) The Zn^{2+} cations in sphalerite, see #(17), are best descibed as being located in

(b) a tetrahedral hole

(19) How many *d* electrons are there in the compound $Co(NH_3)_3Cl_3$?

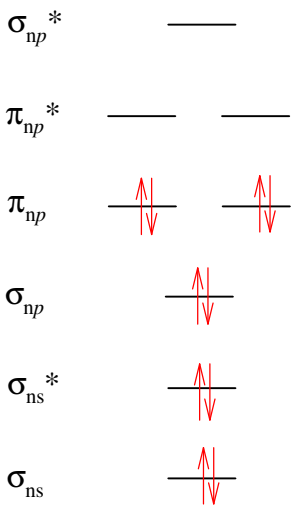
(c) 6

(20) This protein is *B. subtilis* SPP1, used for initiating DNA replication. Which of the following is true of this protein's structure?

(c) it has α-helices and tertiary structure

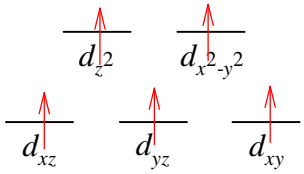
Part 2. ANSWER IN THE SPACE PROVIDED

Question 1 (3 points) A blank molecular orbital diagram is provided for a diatomic *p*-block molecule. **For the molecule N_2**, fill in the appropriate number of electrons on the diagram and give the bond order (number of bonds).



Bond Order = 3

Question 2 (2 points) Assume Mn^{2+} is in an octahedral complex with weak field ligands (for example, $Mn(H_2O)_6^{2+}$). Add electrons to the diagram to the right to represent the correct electron configuration for Mn^{2+} with weak-field ligands.



Question 3 *For 3 of the following 4*, predict the <u>organic</u> product of the following reactions. There is only one correct product in each case. (2 points each, 6 total)

(i) propanone (acetone)

(ii) 2,3-dibromobutane

(iii) ethylbenzene

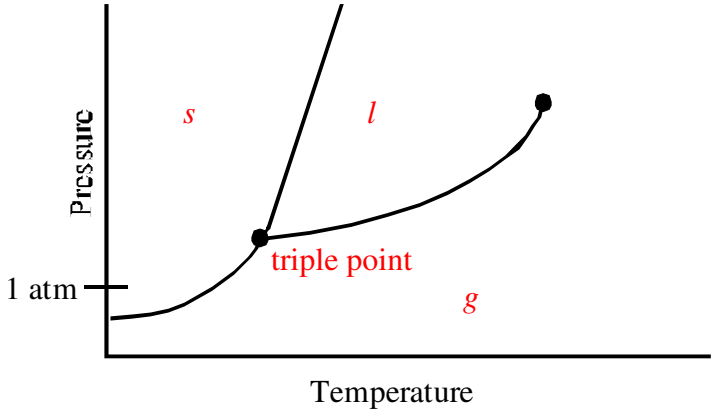
(iv) nitrobenzene

(You can either name or draw the structures for full marks)

Question 4 (4 points) Pictured are 4 amino acids with their 3-letter codes. Fill in the blanks with an appropriate amino acid. Each question may have more than one correct answer, but you may USE EACH AMINO ACID ONCE ONLY!

(a) is likely to reside in the interior of a protein leu or phe
(b) contains a non-polar R-group phe or leu
(c) contains a polar R-group asp or ser
(d) is likely to be found in a β-sheet ser or asp

Question 5 (4 points) For the following unlabelled phase diagram, answer the following



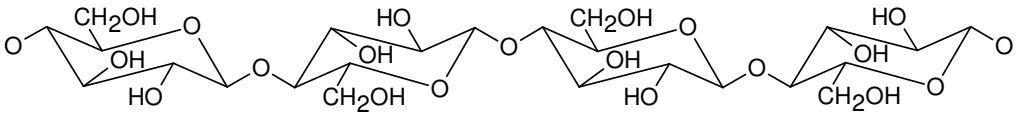
(i) label the regions of solid, liquid, and gas
(ii) label the triple point
(iii) 1.00 atm is labeled. What phase transition(s) could the material undergo at this pressure? sublimation

Question 6 (3 points) Shown below are three Boltzmann distributions, labeled X, Y, and Z.

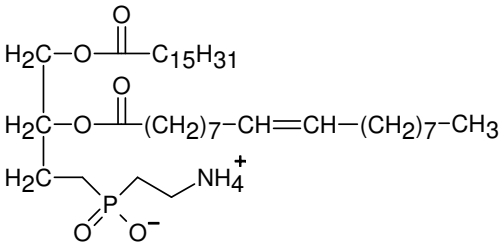
(i)	For X, Y, Z being the same molecule, which curve represents the highest temperature?	Z
(ii)	For X, Y, Z being different molecules at the same temperature, which of X, Y, or Z has the heaviest molar mass? (Note: the *x*-axis in this case would represent velocity instead of energy)	X
(iii)	The vertical line represents the boiling point temperature. Which of curves X, Y, and Z represents a molecule that is in the process of boiling (you may choose more than one curve, or with NONE if appropriate)	Z

Question 7 (6 points) Apply EACH LABEL ONCE to one of the following biomolecules (some labels may apply to more than one molecule and some molecules will have more than one label, but use each label only once; not all molecules need to be used).

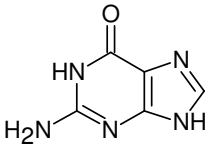
Labels:
- **A** a lipid
- **B** a steroid
- **C** a molecule that would appear in a mammalian cell wall membrane
- **X** cellulose
- **Y** a molecule with only sp^3 hybridized carbons
- **Z** a molecule containing a saturated fatty acid

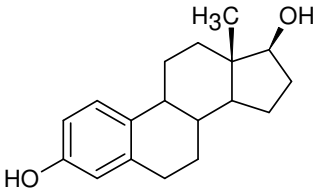


X, Y



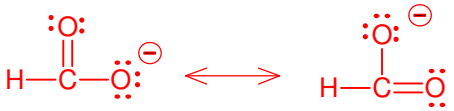
C, Z

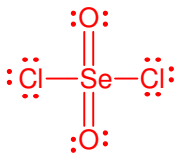




A, B

Question 8 *For 1 of the following 2*: (i) HCO_2^- (ii) SeO_2Cl_2
Draw a complete Lewis structure, including all lone pairs, resonance structures, and formal charges. (2 points)





Question 9 Short answer. *Answer 4 of the following 6.* (3 points each, 12 total)

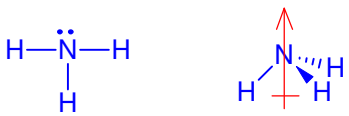
(a) Explain how CO poisoning works.

CO binds irreversibly to the iron centre in hemoglobin. Therefore, the position is blocked permanently and no oxygen can be transported.

(b) Explain how the genetic code stored in DNA is used to make a protein molecule.

DNA stores the information to make a protein, as 3-base codons. mRNA copies the relevant section of the DNA and moves from the nucleus to the robosome (transcription). There the codons are matched with anticodons on tRNA (each of which carries with it the correct amino acid) which are then assembled in the right order by the robosome (translation).

(c) For the ammonia (NH_3) molecule, draw the Lewis structure, give the three-dimensional shape, and show the direction of the dipole moment (or state that the molecule is non-polar).



(trigonal pyramidal)

(d) Explain the term "denature" (with respect to protein structure) and describe the two ways this might commonly be done.

Secondary and tertiary structure are held together by hydrogen bonds and London forces. Heat (or acid) can disrupt these intermolecular bonds, thus destroying the secondary and tertiary structures in the protein (but maintaining the primary structure). (You could also represent this with a picture like Fig 22.26 in your text)

(e) Hess's Law can be used to determine the enthalpies of reactions that might be unpleasant to actually perform, like the following synthesis of HCN:

$$CH_4\,(g) + NH_3\,(g) \rightarrow HCN\,(g) + 3\,H_2\,(g)$$

Calculate the enthalpy ($\Delta H°$) of this reaction.

$\frac{1}{2}$ [$2\,NH_3\,(g) \rightarrow N_2\,(g) + 3\,H_2\,(g)$] $\quad \Delta H° = -\frac{1}{2}(-91.8$ kJ/mol)

$CH_4\,(g) \rightarrow C$ (graphite) $+ 2\,H_2\,(g) \quad \Delta H° = -(-74.9$ kJ/mol)

$\frac{1}{2}$ [$H_2\,(g) + 2$ C (graphite) $+ N_2\,(g) \rightarrow 2\,HCN\,(g)$] $\quad \Delta H° = \frac{1}{2}(270.3$ kJ/mol)

$CH_4\,(g) + NH_3\,(g) \rightarrow HCN\,(g) + 3\,H_2\,(g) \quad \Delta H° = 256.0$ kJ/mol

(f) RNA is a short biochemical polymer. Describe the three parts that make up each monomer unit of RNA.

(1) a ribose sugar
(2) a phosphate unit
(3) an organic base containing complementary H-bonding sites (CAGU)