Lakehead
UNIVERSITY

DEPARTMENT OF CHEMISTRY
Exam
Chemistry 1110 (Modern Chemistry I)
xx December, xxxx

Name: _____

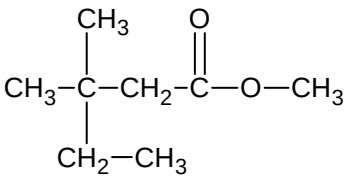
Student ID Number:_____

Instructions:

1. Not all questions are required (some have choices) - extra questions are not worth extra credit!
2. Part 1 (multiple choice) should be answered on this page (below). All other parts should be answered in the booklet provided unless otherwise stated in the question.
3. Allowed external materials: writing implements, 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 xxx points on the exam. Time allowed = 180 minutes.
6. There are a total of xxx pages including this one.

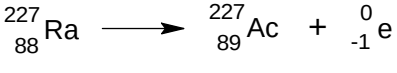
Part 1: Multiple Choice. Answer *all questions*. Worth 2 points each. There is no penalty for an incorrect answer.

1. What is the correct IUPAC name for the following species:



a) methyl 3,3-dimethylpentanoate
b) methyl 3-dimethyl-1-pentanoate
c) methyl 3-methyl-3-ethylbutanoate
d) methyl 2-methyl-2-ethyl-4-butanoate

2. For the following nuclear reaction, the decay constant, *k*, is 2.75 x 10^{-4} s^{-1}. What is the half-life?

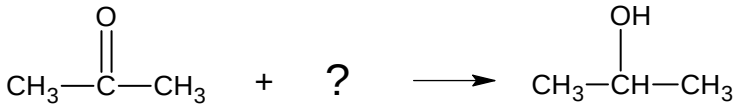


a) 2.75 x 10^{-4} s
b) 3.97 x 10^{-4} s
c) 2520 s
d) 3640 s

3. Which of the following is *not* a component of DNA?

a) an amino acid
b) a deoxyribose sugar
c) an organic base with nitrogen-containing rings
d) a phosphate group

4. Give the missing reagent in the following conversion:



a) H_2O
b) $LiAlH_4$
c) MnO_4^-
d) an oxidising agent
e) heat

5. Which of the following is the ground state electron configuration for germanium, Ge, by the Aufbau and Pauli Exclusion principles?

a) [Ar] $3d^8\ 4s^2\ 4p^4$
b) [Ar] $3d^{10}\ 4s^2\ 4p^2$
c) [Ar] $3d^6\ 4s^2\ 4p^6$
d) [Kr] $3d^{10}\ 4p^4$

6. What is the oxidation state of vanadium in $H_2V_2O_5$?

a) -2
b) 0
c) 2
d) 4
e) 8

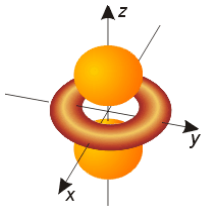
7. How much energy is required to change 10.0 g of liquid water at 100.°C to steam at 100.°C? The value of ΔH_{vap} for water is 40.7 kJ/mol

a) 0.0136 kJ
b) 0.246 kJ
c) 22.6 kJ
d) 40.7 kJ
e) 407 kJ

8. If 0.10 mol of H_2 effuses through a hole in a container in 4.6 s, how long will it take 0.10 mol of N_2 to effuse through the same hole?

a) 0.33 s
b) 1.2 s
c) 17 s
d) 64 s
e) 4.6 s

9. What is this orbital?



a) p_z
b) d_z2
c) d_{xz}
d) 3*s*

10. What is the %C (by mass) in CO_2?

a) 27.30
b) 33.33
c) 42.86
d) 57.14

11. Polonium crystals have a simple cubic unit cell. If the edge length of a unit cell is 310. pm, what is the radius a polonium atom?

a) 77.5 pm

b) 110. pm

c) 134 pm

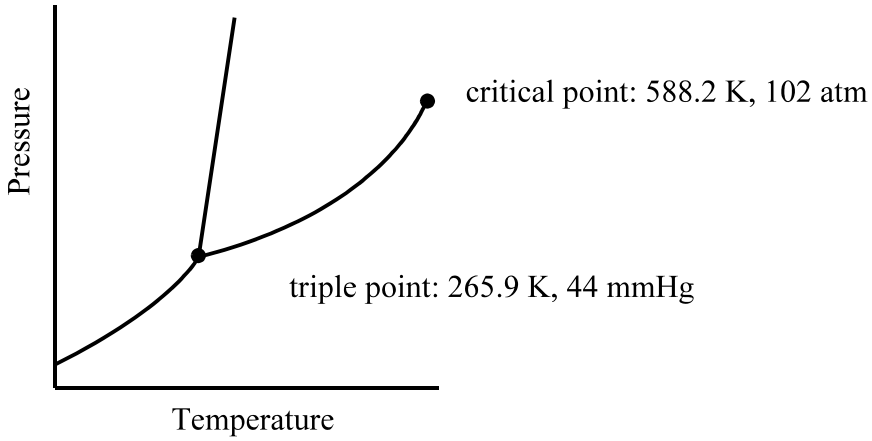
d) 155 pm

e) 310. pm

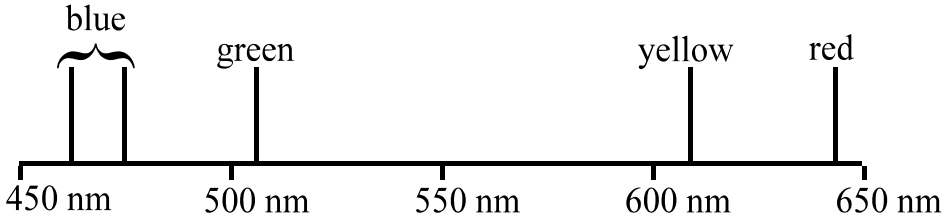
Part 2: Short Answer: Answer 4 of the following 6 (4 points each).

1. The phase diagram for bromine is given:

Explain the behaviour of bromine as you decrease the pressure (from 150 atm) at -200°C and at +200°C.



2. The emission spectrum of cadmium is shown. Why are only certain, narrow lines seen in this spectrum with nothing in between?



3. Explain why atomic radius decreases as you go left to right across the periodic table.

4. Using the Kinetic molecular theory, explain why pressure increases as volume decreases (at constant temperature).

5. Define allotrope and give examples of the allotropes of at least 1 element.

6. The density of iron is 7.87 g/cm^3 and the unit cell edge length of 286.6 pm. What type of unit cell does iron have?

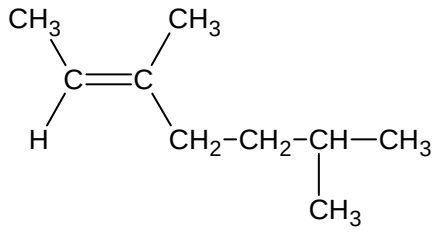
Part 3: Organic Chemistry. (12 points)

1. *Answer 3 of (a) to (d)* (6 points):

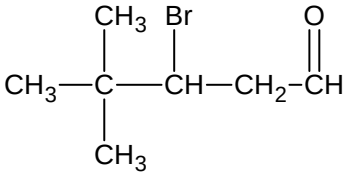
   a) Draw the structure for 1,2-dichloro-4-nitrobenzene.

   b) Draw the structure for 3-isopropyl-1,4-hexanediol.

   c) Name the following compound:



   d) Name the following compound:

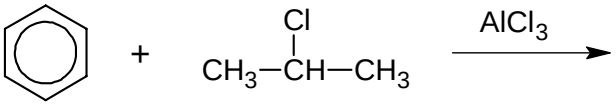


   (NOTE: on the actual exam, you will not get a question like (c) or (d) except as a multiple choice question; (a) and (b) are valid as written)

2. For 3 of the following reactions (a) to (d), give the organic product (the equation need not balance); [ox] is an oxidizing agent (*e.g.* $Na_2Cr_2O_7$).

   (a) $CH_3—CH{=}CH_2 + H_2O \xrightarrow{H_2SO_4}$

   (b) $CH_3—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_3 + [ox] \longrightarrow$

   (c) 

   (d) $CH_2{=}CH_2 + Br_2 \longrightarrow$

Part 4: Molecular Structures. (10 points)

1. For *2 of (a) to (c)*, give the Lewis structure and the three-dimensional geometry (linear, bent, trigonal planar, T-shaped, trigonal pyramidal, square planar, tetrahedral, see-saw, trigonal bipyramidal, square pyramidal, or octahedral). (6 points, 3 points each)

   (a) PF_5
   (b) IF_4^+
   (c) AlF_6^{3-}

2. For *1 of (a) or (b)*, give the Lewis structure, the three-dimensional geometry, and whether or not the molecule has a dipole moment (do not need to indicate direction). (4 points)

   (a) SiH_4
   (b) H_2S

Part 5: Inorganic/Nuclear. (7 points)

1. Answer *one of* (a) or (b) (3 points)

   (a) ^{241}Am is used in smoke detectors and decays by α-emission. Write a balanced nuclear equation for this process.

   (b) The decay constant for the decomposition of ^{212}Rn is 0.029 min^{-1}. How long will it take 90% of a sample to decay?

2. Answer *one of* (a) or (b) (4 points)

   (a) $CoCl_6^{4-}$ is a high spin octahedral complex. Show the *d*-orbital splitting in an octahedral complex, and say how many unpaired electrons the complex has.

   (b) Element 109, Meitnerium, is made in the following way

$$^{209}_{83}Bi + ^{58}_{26}Fe \longrightarrow ^{266}_{109}Mt + ^{1}_{0}n$$

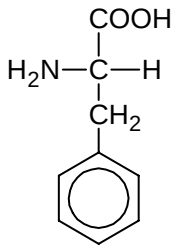
   Calculate the mass change for this reaction, then calculate the energy change, in kJ/mol. Atomic masses (in amu or g/mol) are: ^{209}Bi, 208.98037; ^{58}Fe, 57.933277; ^{266}Mt, 266.13764.

Part 6: Biochemistry. Answer *3 of the following 4* (4 points each). (12 points)

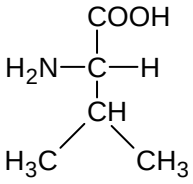
1. Explain the minimum requirements for DNA replication (*i.e.* how DNA makes copies of itself).

2. Explain the difference between primary, secondary, and tertiary structure in a protein.

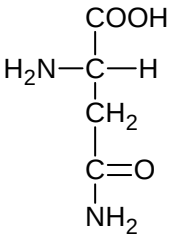
3. The structures of 4 amino acids are shown:



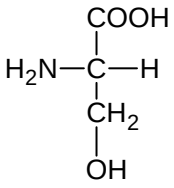
L-phenylalanine



L-valine



L-asparagine



L-serine

(a) Label each as having a hydrophobic or a hydrophilic side chain
(b) Which side chains are likely to be in the interior of the protein? Which on the outside? Explain briefly.

4. Describe the structure of a phospholipid and how/why a bilayer membrane is formed using this molecule.

Appendix 1: Formula Sheet

$\Delta H = q_p = \Delta E + P\Delta V$ $q = sm\Delta T = C_p \Delta T$ $\Delta U = q + w$	$\ln \frac{N_t}{N_0} = -kt$ $t_{\frac{1}{2}} = \frac{\ln 2}{k}$ $E = mc^2$ $c = \lambda\nu \ (= \lambda f)$
$PV = nRT$ $P_{total} = P_1 + P_2 + ...$ $\left(P + \frac{n^2 a}{V^2}\right) \cdot (V - nb) = nRT$ $\bar{u} = \sqrt{\frac{3RT}{M_m}}$ $\frac{\text{rate}_A}{\text{rate}_B} = \frac{\bar{u}_A}{\bar{u}_B} = \frac{\sqrt{M_{mB}}}{\sqrt{M_{mA}}}$	$E = h\nu \ (= hf)$ $\overline{E}_k = \frac{1}{2} m\bar{u}^2$ $\Delta E = -2.178 \times 10^{-18} \text{J} \left(\frac{1}{n^2_{final}} - \frac{1}{n^2_{initial}}\right)$ $\lambda = \frac{h}{mv}$

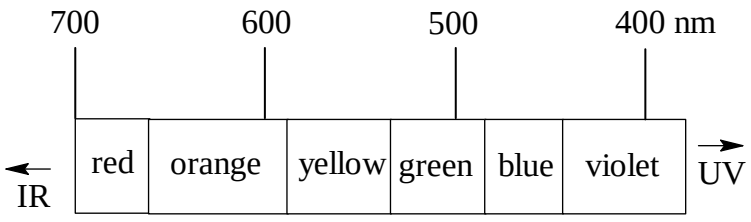
Constants:

h = 6.626 x 10^{-34} J s
c = 2.9979 x 10^8 m/s
joules = kg m^2 s^{-2}
0°C = 273.15 K
N_A = 6.022 x 10^{23} mol^{-1}

1 atm = 101.325 kPa = 760.00 Torr
mass of an electron: 0.000549 amu (g/mol)
mass of a proton: 1.00728 amu
mass of a neutron: 1.008665 amu
elementary charge (e) = 1.60218 x 10^{-19} C

R = 8.314 J mol^{-1} K^{-1} = 8.314 L Pa mol^{-1} K^{-1} = 0.08206 L atm mol^{-1} K^{-1}
STP = 1 atm, 0°C
standard conditions = 1 atm, 25°C, 1 M

kilo = 10^3 centi = 10^{-2} milli = 10^{-3} micro = 10^{-6} nano = 10^{-9} pico = 10^{-12}



For water: ΔH_{fusion} = 6.02 kJ/mol $\Delta H_{vaporization}$ = 40.7 kJ/mol
specific heat capacities (J/°C•g): s_{ice} = 2.03 s_{liquid} = 4.18

Attached at this point were:

Appendix 2: Some Thermodynamic Data ($\Delta H°$ values, bond enthalpies, etc.)

Appendix 3: Periodic Table