Lakehead
UNIVERSITY

3 October, 2012

DEPARTMENT OF CHEMISTRY
Midterm Examination
Chemistry 1110 (Modern Chemistry I)

Name: _____

Student ID Number:_____

Instructions:
1. **Put your name on this exam paper!!!** Questions are to be answered directly on these papers.
2. Allowed external materials: calculator (any type)
3. Print or write legibly!
4. periodic table is at the end; formula sheet is below.
5. There are xxx points on the exam. Time allowed = 55 minutes.
7. There are a total of xxx (multipart) questions and xxx pages including this one.

Formula Sheet:

gasses		general
$PV = nRT$	$V \propto \frac{1}{P}$	$E = h\nu$ (= hf)
$\frac{\text{rate}_A}{\text{rate}_B} = \frac{\bar{u}_A}{\bar{u}_B} = \frac{\sqrt{M_{mB}}}{\sqrt{M_{mA}}}$	$V \propto n$	$c = \lambda\nu$ (= λf)
	$V \propto T$	
	$P_{total} = P_1 + P_2 + ...$	$\bar{E}_k = \frac{1}{2} m \bar{u}^2$
$\left(P + \frac{n^2 a}{V^2}\right) \cdot (V - nb) = nRT$	$\bar{u} = \sqrt{\frac{3RT}{M_m}}$	

constants:
R = 0.08206 L atm/(mol K) = 8.315 kPa dm^3/(mol K) = 8.315 J/(mol K) = 62.36 Torr L/(mol K)
1.000 atm = 760. Torr = 101.3 kPa
N_A = 6.022 x 10^{23} mol^{-1}
c = 2.998 x 10^8 m/s
h = 6.626 x 10^{-34} J s
STP = 1.0000 atm pressure and 273.15 K

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

derived units:
N = kg m s^{-2}
J = kg m^2 s^{-2}

mL = cm^3
Pa = N m^{-1}

1. Multiple choice, select 1 answer only. 2 points each. (there is no penalty for a wrong guess)
SOLUTIONS ON PAGE 4

(i) What is its chemical formula of silver(III) carbonate?

(a) $AgCO_3$

(b) $Ag(CO_3)_3$

(c) Ag_2CO_3

(d) Ag_3CO_3

(e) $Ag_2(CO_3)_3$

(ii) What is the correct IUPAC name of Hg_2S?

(a) mercury(II) sulfide

(b) mercury (I) sulfide

(c) mercury sulfide

(d) mercury sulfate

(e) dimercury monosulfide

(iii) 12.0 moles of a gas (SO_2) under *non-ideal conditions* was measured to have a pressure of 1.00×10^2 atm in a 3.00 L container. What is the temperature? The van der Waals constants for SO_2 are $a = 6.865$ L^2atm/mol^2 and $b = 0.05679$ L/mol.

a) 296 K

b) 304 K

c) 494 K

d) 578 K

e) 767 K

(iv) The vapour pressure of a solvent is the amount of gaseous molecules over an open vessel of the solvent. A 50/50 mixture of benzene and toluene has 46.7 Torr of benzene and 13.5 Torr of toluene at STP. What is the pressure of air over this mixture?

a) 820.2 Torr

b) 739.2 Torr

c) 760.0 Torr

d) 726.8 Torr

e) 699.8 Torr

(v) Which of the following is the best conductor of electricity by ionic conduction through a solution (*i.e.* what gives the most ions)? Assume all solutions have the same molarity.

(a) a strong electrolyte

(b) a weak electrolye

(c) a strong acid

(d) a weak acid

(e) both (a) and (c)

(vi) Which one of the following is NOT true of an ideal gas?

(a) gas molecules are point masses (have 0 volume)

(b) gas molecules are non-interacting with each other

(c) gas molecules are in constant motion, with a distribution of speeds

(d) each individual gas molecule has a kinetic energy given by K.E. = $\frac{1}{2}mv^2$

(e) gas molecules are assumed to never hit the walls of their container

2. Answer the following questions. (5 points each, 10 points total)

(a) Explain the postulates of the Kinetic Molecular Theory (you'll need three of the four for full marks). Explain how these postulates lead logically to the idea of absolute zero temperature.

(b) HCN is made by an industrial process as follows:

$$2\ NH_3\ (g) + 3\ O_2\ (g) + 2\ CH_4\ (g) \rightarrow 2\ HCN\ (g) + 6\ H_2O\ (g)$$

The three gasses are sealed in a 200. L vessel and heated to 500. K. The partial pressure of the three gasses at 500. K are 10.0, 15.0, and 12.0 atm for NH_3, O_2, and CH_4, respectively. Calculate the maximum mass of HCN that can be produced under these conditions.

Multiple choice solutions: (e), (b), (c), (e), (e), (e)

Question 2(a) The four postulates are (these are not the same order as in your text!):

(i) gasses have point masses (0 volume)
(ii) gasses are non-interacting (do not have attractive or repulsive forces)
(iii) collision with the walls of the container gives rise to pressure
(iv) average kinetic energy represents the (Kelvin) temperature of the gas

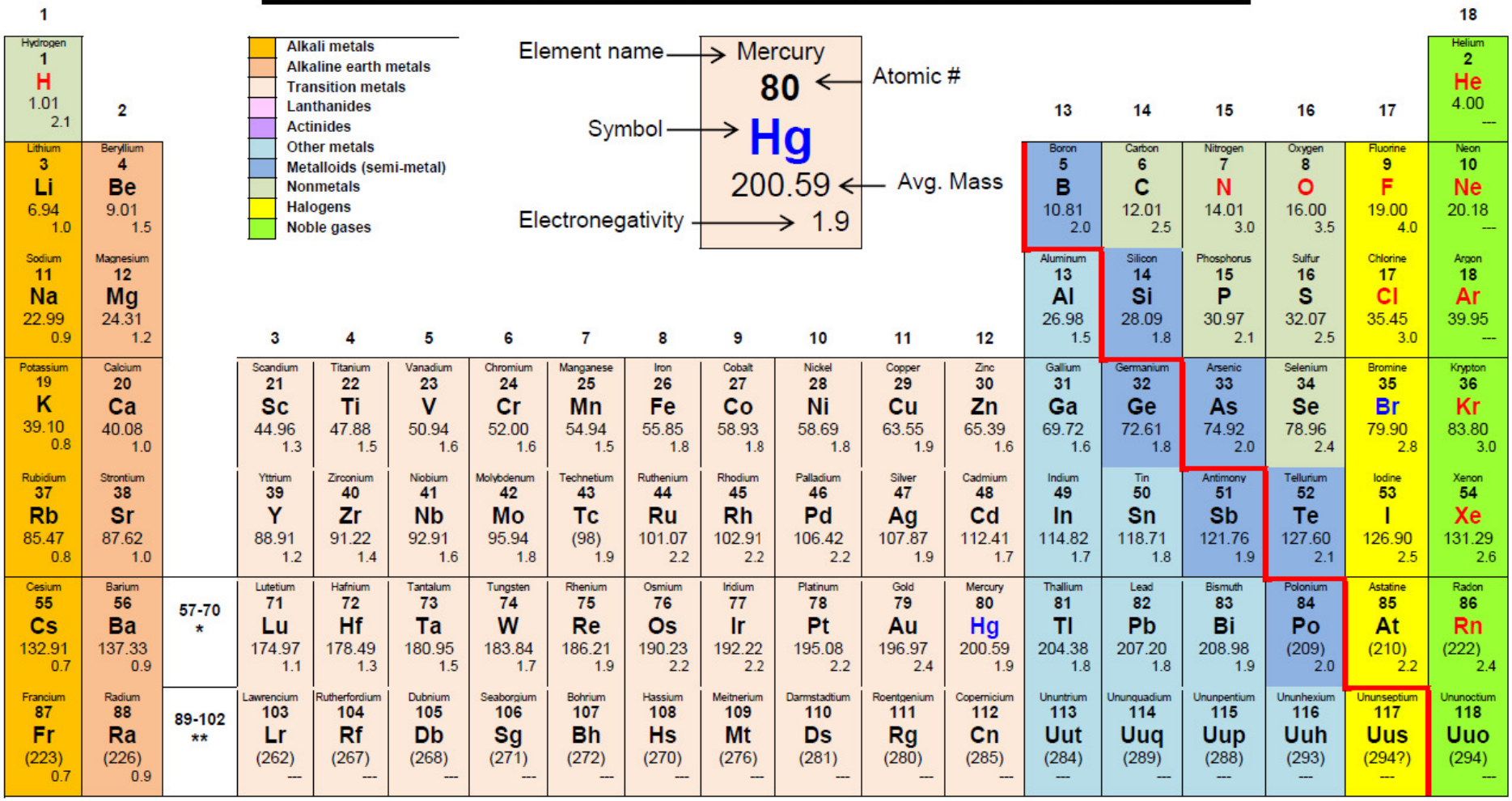
Depending on your postulates, you will have at least 1 that relate to 0K (points (ii) and (iii) do not). Thus you will need one of these for a complete answer:

(i) Because the molecules have 0 volume, there must be a point where the entire gas volume itself goes to 0 volume, this would be at abslute 0 (it's non-sensical to think of a negative volume!)
(iv) at some point the average energy will be at a minimum (it is non-sensical to think of negative internal energy, similar to negative volume), therefore the average at that point is the lowest limit of KE, therefore it would be called 0K.

Question 2(b) Avagadro's Law for an ideal gas states that $P \propto n$. Thus, moles of the gasses can be substituted by pressure of the gas.
PHCN produced from NH_3 is 2:2 molar ratio, therefore 10 atm HCN produced
Similarly, 12 atm HCN from 12 atm CH_4
And 15 atm * (2 mol HCN/3 mol O_2) = 10 atm HCN produced.
Thus, NH_3 and O_2 are both the limiting reagent (and CH_4 is in excess), and 10 atm of HCN is produced.

In a 200. L container, $n_{HCN} = PV/RT$ = (10.0)(200.)/(0.08206)(500.) = 48.7 mol HCN
mass = 48.7 mol * (27.03 g/mol) = 1320 g (or 1.32 kg)

The Periodic Table of the Elements (with Electronegativities)



1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 H 1.01 2.1																		Helium 2 He 4.00 ---
Lithium 3 Li 6.94 1.0	Beryllium 4 Be 9.01 1.5												Boron 5 B 10.81 2.0	Carbon 6 C 12.01 2.5	Nitrogen 7 N 14.01 3.0	Oxygen 8 O 16.00 3.5	Fluorine 9 F 19.00 4.0	Neon 10 Ne 20.18 ---
Sodium 11 Na 22.99 0.9	Magnesium 12 Mg 24.31 1.2												Aluminum 13 Al 26.98 1.5	Silicon 14 Si 28.09 1.8	Phosphorus 15 P 30.97 2.1	Sulfur 16 S 32.07 2.5	Chlorine 17 Cl 35.45 3.0	Argon 18 Ar 39.95 ---
Potassium 19 K 39.10 0.8	Calcium 20 Ca 40.08 1.0		Scandium 21 Sc 44.96 1.3	Titanium 22 Ti 47.88 1.5	Vanadium 23 V 50.94 1.6	Chromium 24 Cr 52.00 1.6	Manganese 25 Mn 54.94 1.5	Iron 26 Fe 55.85 1.8	Cobalt 27 Co 58.93 1.8	Nickel 28 Ni 58.69 1.8	Copper 29 Cu 63.55 1.9	Zinc 30 Zn 65.39 1.6	Gallium 31 Ga 69.72 1.6	Germanium 32 Ge 72.61 1.8	Arsenic 33 As 74.92 2.0	Selenium 34 Se 78.96 2.4	Bromine 35 Br 79.90 2.8	Krypton 36 Kr 83.80 3.0
Rubidium 37 Rb 85.47 0.8	Strontium 38 Sr 87.62 1.0		Yttrium 39 Y 88.91 1.2	Zirconium 40 Zr 91.22 1.4	Niobium 41 Nb 92.91 1.6	Molybdenum 42 Mo 95.94 1.8	Technetium 43 Tc (98) 1.9	Ruthenium 44 Ru 101.07 2.2	Rhodium 45 Rh 102.91 2.2	Palladium 46 Pd 106.42 2.2	Silver 47 Ag 107.87 1.9	Cadmium 48 Cd 112.41 1.7	Indium 49 In 114.82 1.7	Tin 50 Sn 118.71 1.8	Antimony 51 Sb 121.76 1.9	Tellurium 52 Te 127.60 2.1	Iodine 53 I 126.90 2.5	Xenon 54 Xe 131.29 2.6
Cesium 55 Cs 132.91 0.7	Barium 56 Ba 137.33 0.9	57-70 *	Lutetium 71 Lu 174.97 1.1	Hafnium 72 Hf 178.49 1.3	Tantalum 73 Ta 180.95 1.5	Tungsten 74 W 183.84 1.7	Rhenium 75 Re 186.21 1.9	Osmium 76 Os 190.23 2.2	Iridium 77 Ir 192.22 2.2	Platinum 78 Pt 195.08 2.2	Gold 79 Au 196.97 2.4	Mercury 80 Hg 200.59 1.9	Thallium 81 Tl 204.38 1.8	Lead 82 Pb 207.20 1.8	Bismuth 83 Bi 208.98 1.9	Polonium 84 Po (209) 2.0	Astatine 85 At (210) 2.2	Radon 86 Rn (222) 2.4
Francium 87 Fr (223) 0.7	Radium 88 Ra (226) 0.9	89-102 **	Lawrencium 103 Lr (262) ---	Rutherfordium 104 Rf (267) ---	Dubnium 105 Db (268) ---	Seaborgium 106 Sg (271) ---	Bohrium 107 Bh (272) ---	Hassium 108 Hs (270) ---	Meitnerium 109 Mt (276) ---	Darmstadtium 110 Ds (281) ---	Roentgenium 111 Rg (280) ---	Copernicium 112 Cn (285) ---	Ununtrium 113 Uut (284) ---	Ununquadium 114 Uuq (289) ---	Ununpentium 115 Uup (288) ---	Ununhexium 116 Uuh (293) ---	Ununseptium 117 Uus (294?) ---	Ununoctium 118 Uuo (294) ---

*lanthanides	Lanthanum 57 La 138.91 1.1	Cerium 58 Ce 140.12 1.1	Praseodymium 59 Pr 140.91 1.1	Neodymium 60 Nd 144.24 1.1	Promethium 61 Pm (145) 1.1	Samarium 62 Sm 150.36 1.2	Europium 63 Eu 151.97 1.1	Gadolinium 64 Gd 157.25 1.2	Terbium 65 Tb 158.93 1.1	Dysprosium 66 Dy 162.50 1.2	Holmium 67 Ho 164.93 1.2	Erbium 68 Er 167.26 1.2	Thulium 69 Tm 168.93 1.3	Ytterbium 70 Yb 173.04 1.1
**actinides	Actinium 89 Ac (227) 1.1	Thorium 90 Th 232.04 1.3	Protactinium 91 Pa 231.04 1.5	Uranium 92 U 238.03 1.4	Neptunium 93 Np (237) 1.4	Plutonium 94 Pu (244) 1.3	Americium 95 Am (243) 1.3	Curium 96 Cm (247) 1.3	Berkelium 97 Bk (247) 1.3	Californium 98 Cf (251) 1.3	Einsteinium 99 Es (252) 1.3	Fermium 100 Fm (257) 1.3	Mendelevium 101 Md (258) 1.3	Nobelium 102 No (259) 1.3