

Name (in ink) _____
Student Number (in ink) _____

Fall 2015 SC/CHEM 1000 A - Quiz #1

October 8, 2015

Calculators are permitted.

Answer all questions on this paper; **additional paper for rough work is not permitted. You may carry out your work in pencil if you wish, but please write your final answer in indelible (not erasable) ink.**

Assume all gases to be ideal unless otherwise noted

Time Allowed: 50 minutes

Total Marks = 30

1. (5 pts) Nitrous oxide, N_2O , is a gas commonly used in light general anaesthesia ... and to make whipped cream. But N_2O can also be used to supercharge a racing car engine. In this application the N_2O is used instead of air for the combustion of octane, C_8H_{18} , in accord with the chemical formula,



A race car has a cylinder volume of 825 mL, which fills with $N_2O(g)$ at 1.00 atm pressure and $185^\circ C$. What is the maximum number of grams of octane that can be completely combusted in the cylinder under these conditions?

$$m_{C_8H_{18}} = 0.100g$$

2. Carbon disulfide, CS_2 , is a volatile liquid that boils at 46.3°C . Calculate the pressure (in bar) of 0.283 mol of pure $\text{CS}_2(\text{g})$ at 140.0°C in a 1.20L flask by

(a) (2 pts) assuming CS_2 is an ideal gas

$$P = 8.10 \text{ bar}$$

(b) (4 pts) using the van der Waals equation (a table of van der Waals constants is included in this quiz)

$$P = 7.60 \text{ bar}$$

3. A tablespoon of water is placed in a 412 L evacuated flask, and allowed to completely evaporate at 57°C. The pressure of the H₂O(g) was then measured to be 40.8 torr. You can assume water vapor to be an ideal gas for this problem.

(a) (3 pts) What is the RMS average speed of a water molecule in the flask?

$$\bar{u}_{\text{rms}} = 676 \text{ m s}^{-1}$$

(b) (3 pts) How many grams of water was in the tablespoon?

$$m = 14.7 \text{ g}$$

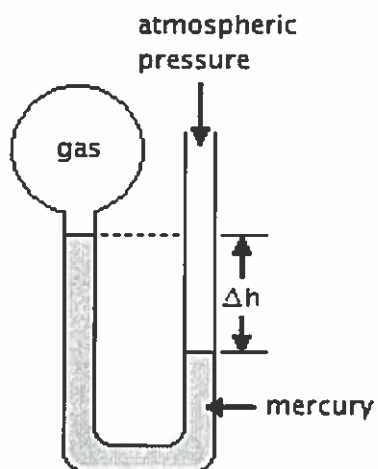
4. (4 pts) A equal molar mixture of $\text{H}_2(\text{g})$ and $\text{Ne}(\text{g})$ was placed in a 25.1 L balloon at 684 torr and 25°C . The balloon contains a tiny hole, through which the two gasses effuse. After two hours, it was found that 2.66×10^{-4} mol of H_2 effused through the hole. How many moles of Ne had also effused at that point?

$$n_{\text{Ne}} = 8.41 \times 10^{-5} \text{ mol}$$

5. (5 pts) It's your first day in your new position as forensic chemist working for a small town that has no analytical instrumentation. You were given a vial of a clear liquid and asked to identify it. All you have available in your lab is a thermometer and a vacuum line that can measure gas pressure. So you evaporate a few drops of the liquid into a vessel at 58.0°C , and measure the pressure to be 544.6 torr. Under these same conditions, you determined the density of the vapor to be $1.530 \times 10^{-3} \text{ g mL}^{-1}$. From these data, calculate the molar mass of the unknown liquid.

$$M = 58.02 \text{ g mol}^{-1}$$

6. In the manometer shown below, Δh was measured to be 137 mm. Ambient pressure in the laboratory was measured to be 764 torr.



(a) (2 pts) what is the pressure of the gas?

$$P = 627 \text{ torr}$$

(b) (2 pts) if the mercury in the manometer was replaced with water ($\rho = 1.00 \text{ g mL}^{-1}$), what would the new Δh be (in mm)?

$$1860 \text{ mm}$$

<input type="checkbox"/>	a (L ² bar/mol ²) <input type="checkbox"/>	b (L/mol) <input type="checkbox"/>
Acetic acid	17.82	0.1068
Acetic anhydride	20.16	0.1263
Acetone	14.09	0.0994
Acetonitrile	17.81	0.1168
Acetylene	4.448	0.05136
Ammonia	4.225	0.03707
Argon	1.363	0.03219
Benzene	18.24	0.1154
Bromobenzene	28.94	0.1539
Butane	14.66	0.1226
Carbon dioxide	3.640	0.04267
Carbon disulfide	11.77	0.07685

Equations

$$PV = nRT$$

$$\Delta U = q + w$$

$$H = U + PV$$

$$w = - \int PdV$$

$$U = \frac{3}{2}nRT$$

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

$$E = mc^2$$

$$E = hv$$

$$\bar{u}_m = \left(\frac{8RT}{\pi M} \right)^{1/2}$$

$$Z_w = \frac{N}{4V} \left(\frac{8RT}{\pi M} \right)^{1/2}$$

$$\bar{u}_{RMS} = \left(\frac{3RT}{M} \right)^{1/2}$$

$$E_n = - \frac{Z_{eff}^2 R_H}{n^2}$$

$$\ln \left(\frac{P_2}{P_1} \right) = \frac{\Delta H_v}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$q_A = G_A - N_A - \sum_B \frac{\chi_A}{\chi_A + \chi_B} N_{AB}$$

$$\bar{u}_{mp} = \left(\frac{2RT}{M} \right)^{1/2}$$

$$\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

$$4r_{BCC} = l\sqrt{3} \quad l_{FCC} = r\sqrt{8}$$

$$r_{cub} = 0.732R \quad r_{Td} = 0.225R$$

$$r_{trig} = 0.155R \quad r_{Oh} = 0.414R$$

$$\rho = \frac{NM}{VN_A}$$

$$\lambda = \frac{h}{mv}$$

Fundamental Constants

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$g = 9.807 \text{ m s}^{-2}$$

$$R_H = 2.179 \times 10^{-18} \text{ J}$$

$$c = 2.998 \times 10^8 \text{ m s}^{-1}$$

$$e^- = -1.602 \times 10^{-19} \text{ C}$$

$$h = 6.626 \times 10^{-34} \text{ J s}$$

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1} = 0.08315 \text{ L bar K}^{-1} \text{ mol}^{-1}$$

$$m_e = 9.109 \times 10^{-31} \text{ kg}$$

$$m_p = 1.673 \times 10^{-27} \text{ kg}$$

$$k = 1.381 \times 10^{-23} \text{ J K}^{-1}$$

Conversion Factors

$$1 \text{ atm} = 101.325 \text{ kPa (exact)}$$

$$1 \text{ atm} = 1.01325 \text{ bar (exact)}$$

$$1 \text{ kg} = 2.2046226 \text{ lbs}$$

Useful Data

$$S_{H_2O} = 4.184 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$$

$$S_{ice} = 2.01 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$$

$$\Delta H_v^0(\text{H}_2\text{O}) = 44.0 \text{ kJ mol}^{-1}$$

$$\Delta H_{fus}^0(\text{H}_2\text{O}) = 6.01 \text{ kJ mol}^{-1}$$

$$\rho_{Hg}(l) = 13.6 \text{ g cm}^{-3}$$

$$\rho_{H_2O}(l) = 1.00 \text{ g cm}^{-3}$$

hydrogen 1 H	lithium 3 Li	beryllium 4 Be																	helium 2 He		
1.0079	6.941	9.0122																	4.0026		
11	12	12																	10		
sodium	magnesium																		neon		
22.990	24.305																		20.180		
19	20	20																	18		
K	Ca	Ca																	Ar		
39.098	40.078	40.078																	39.948		
37	38	38																	36		
Rb	Sr	Sr																	Kr		
85.468	87.62	87.62																	83.80		
55	56	56																	54		
Cs	Ba	Ba																	Xe		
132.91	137.33	137.33																	131.29		
87	88	88																	86		
Fr	Ra	Ra																	Rn		
122.3	122.3	122.3																	122.3		
			scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc				boron	carbon	nitrogen	oxygen	fluorine	neon
44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.933	58.933	58.933	58.933	63.546	65.39	69.723	72.61	10.811	12.011	14.007	15.999	18.998	20.180	
39	40	41	42	43	44	45	46	47	48	49	50	51	52	13	14	15	16	17	18	18	
Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	Al	Si	P	S	Cl	Ar	Ar	
88.906	91.224	92.906	95.94	98.906	101.07	102.91	106.42	107.87	112.41	114.82	118.71	121.76	127.40	26.982	28.086	30.974	32.065	35.453	39.948	39.948	
71	72	73	74	75	76	77	78	79	80	81	82	83	84	13	14	15	16	17	18	18	
Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	Al	Si	P	S	Cl	Ar	Ar	
174.967	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.967	200.59	204.39	207.2	208.98	209	26.982	28.086	30.974	32.065	35.453	39.948	39.948	
103	104	105	106	107	108	109	110	111	112												
Lr	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub												
122.3	122.3	122.3	122.3	122.3	122.3	122.3	122.3	122.3	122.3												

lanthanum	cerium	praseodymium	neodymium	promethium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium
138.91	140.12	140.91	144.24	144.91	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
57	58	59	60	61	62	63	64	65	66	67	68	70
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Yb
actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	fermium	mendelevium	nobelium
227.03	232.04	231.04	238.03	237.04	244.04	243.06	247.07	247.07	251.08	257.10	258.10	259.10
89	90	91	92	93	94	95	96	97	98	99	100	102
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	No
122.3	232.04	231.04	238.03	237.04	244.04	243.06	247.07	247.07	251.08	257.10	258.10	259.10

* Lanthanide series

** Actinide series

Name (in ink) _____
Student Number (in ink) _____

Fall 2015 SC/CHEM 1000 A - Quiz #2

October 22, 2015

Calculators are permitted.

Answer all questions on this paper; **additional paper for rough work is not permitted. You may carry out your work in pencil if you wish, but please write your final answer in indelible (not erasable) ink.**

Assume all gases to be ideal unless otherwise noted

Time Allowed: 50 minutes

Total Marks = 30

1. (4 pts) The M16A4 rifle is a powerful assault rifle currently used by the United States and Canadian militaries, and was partly invented by (believe it or not) the Mattel toy company. An M16 bullet has a mass of 159 g. An M16A4 is fired into a tank of 100.0 L of pure water initially at temperature 23.72°C. The bullet streaks through the water and comes to a complete stop, converting all of its kinetic energy into heat that raises the temperature of the water to 23.89°C. What was the velocity of the bullet when fired from the gun? (recall that $E(\text{kinetic}) = mv^2/2$)

$$v = 950 \text{ m s}^{-1}$$

2. A cylinder with piston contains 4.00 L of helium gas at 1.00 atm and 48.3°C. The cylinder is placed in a thermostated water bath to keep the temperature constant. A weight is then placed on the piston, which compresses the gas to 2.00 atm (and reduces the volume to 2.00 L).

(a) (2 pts) how much work (in Joules) was done on the gas?

$$W = 405 \text{ J}$$

(b) (2 pts) what is the change in internal energy of the gas after it has been compressed?

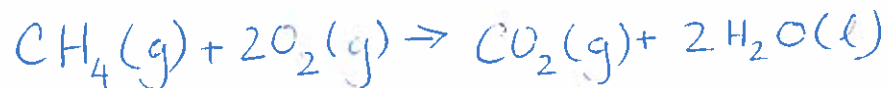
$$\Delta U = 0$$

3. (4 pts) A 159 g M16 bullet having a specific heat of $0.128 \text{ Jg}^{-1}\text{C}^{-1}$ is heated to a temperature of 99.2°C , then added to a cup containing 55.3 mL of water at 22.2°C . Assuming no heat is lost through the walls of the cup, calculate the final temperature of the water at thermal equilibrium.

$$T_f = 28.4^\circ\text{C}$$

4. Methane, CH₄, is a colorless, odorless gas, commonly known as "natural gas". Methane has recently been touted as a fuel that produces "less greenhouse emission" (meaning carbon dioxide) than other fossil fuels.

(a) (2 pts) write out the balanced chemical equation for the combustion of methane (with oxygen).



(b) (3 pts) using the thermochemical tables provided in this quiz, calculate the standard molar enthalpy of combustion of methane at 25°C.

$$\Delta H^\circ = -890.3 \text{ kJ mol}^{-1}$$

5. (1/2 pt each) Name the scientist (you can write only the last name if you wish) who

(a) won the Nobel Prize for explaining the photoelectric effect

ALBERT EINSTEIN

(b) derived an empirical formula for calculating the positions of the visible emissions of the hydrogen spectrum

JOHANN J. BALMER

(c) performed the famous experiment using gold foil, that demonstrated that the atom is mostly empty space

ERNEST RUTHERFORD

(d) explained black-body radiation by assuming the energy of light is proportional to its frequency, not amplitude

MAX PLANCK

(e) explained line emission spectra by assuming the "orbits" of electrons in an atom are quantized

NIELS BOHR

(f) correctly explained the structure of the hydrogen atom by using wave mechanics to describe the motions of electrons rather than circular orbits

ERWIN SCHRÖDINGER

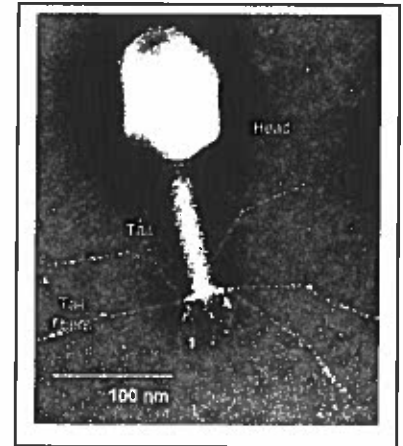
(g) formulated the "uncertainty principle"

WERNER HEISENBERG

(h) introduced the concept of particle-wave duality through the equation $\lambda = h/mv$

LOUIS DE BROGLIE

6. (3 pts) This is a picture of a bacteriophage, a virus that infects bacterial cells, taken in an electron microscope. The "head" of a typical bacteriophage is about 85 nm in diameter. Thus, in order to image a bacteriophage in an electron microscope, the de Broglie wavelength of the electron beam must be at most 85 nm. Calculate the minimum speed to which the electrons must be accelerated in the microscope to be able to image the bacteriophage head.



$$v \geq 8600 \text{ m s}^{-1}$$

7. A microwave oven works by the absorption of energy from microwave photons by water. A 150 watt microwave oven produces 150 J of microwave energy per second, carried by photons having a frequency of 2450 MHz.

(a) (3 pts) Assuming all of the microwave energy is absorbed by the water, how long (in seconds) will it take to heat a cup (250 g) of water from 25°C to its boiling point of 100°C?

520s

(b) (3 pts) How many photons does this microwave oven generate in 1.00 seconds?

$$N_{\text{PHOT}} = 9.2 \times 10^{25} \text{ PHOTONS}$$

A20 Appendix D Data Tables

Inorganic Substances			
	ΔH_f° , kJ mol ⁻¹	ΔG_f° , kJ mol ⁻¹	S° , J mol ⁻¹ K ⁻¹
Copper			
Cu(s)	-157.3	-129.7	42.63
Cu(OH) ₂ (s)	-449.8	—	—
CuSO ₄ · 5 H ₂ O(s)	-2280.	-1680.	300.4
Fluorine			
F(g)	78.99	61.91	158.8
F ⁻ (aq)	-332.6	-278.8	-13.8
F ₂ (g)	0	0	202.8
Helium			
He(g)	0	0	126.2
Hydrogen			
H(g)	218.0	203.2	114.7
H ⁺ (aq)	0	0	0
H ₂ (g)	0	0	130.7
HBr(g)	-36.40	-53.45	198.7
HCl(g)	-92.31	-95.30	186.9
HCl(aq)	-167.2	-131.2	56.5
HClO ₂ (aq)	-51.9	5.9	188.3
HCN(g)	135.1	121.7	201.8
HF(g)	-271.1	-273.2	173.8
HI(g)	26.48	1.70	206.6
HNO ₃ (l)	-174.1	-80.71	155.6
HNO ₃ (aq)	-207.4	-111.3	146.4
H ₂ O(g)	-241.8	-228.6	188.8
H ₂ O(l)	-285.8	-237.1	69.91
H ₂ O ₂ (g)	-136.3	-105.6	232.7
H ₂ O ₂ (l)	-187.8	-120.4	109.6
H ₂ S(g)	-20.63	-33.56	205.8
H ₂ SO ₄ (l)	-814.0	-690.0	156.9
H ₂ SO ₄ (aq)	-909.3	-744.5	20.1
Iodine			
I(g)	106.8	70.25	180.6
I ⁻ (aq)	-55.19	-51.57	111.3
I ₂ (g)	62.44	19.33	260.7
I ₂ (s)	0	0	116.1
IBr(g)	40.84	3.69	258.8
ICl(g)	17.78	-5.46	247.6
ICl(l)	-23.89	-13.58	135.1
Iron			
Fe(s)	0	0	27.28
Fe ²⁺ (aq)	-89.1	-78.90	-137.7
Fe ³⁺ (aq)	-48.5	-4.7	-315.9
FeCO ₃ (s)	-740.6	-666.7	92.9
FeCl ₃ (s)	-399.5	-334.0	-142.3
FeCl(s)	-272.0	—	—
Fe ₂ O ₃ (s)	-824.2	-742.2	87.40
Fe ₃ O ₄ (s)	-1118	-1015	146.4
Fe(OH) ₃ (s)	-823.0	-696.5	106.7
Lead			
Pb(s)	0	0	64.81
Pb ²⁺ (aq)	-1.7	-24.43	10.5
PbI ₂ (s)	-175.5	-173.6	171.9

Organic Substances				
	Name	ΔH_f° , kJ mol ⁻¹	ΔG_f° , kJ mol ⁻¹	S° , J mol ⁻¹ K ⁻¹
CH ₄ (g)	Methane(g)	-74.81	-50.72	186.3
C ₂ H ₂ (g)	Acetylene(g)	226.7	209.2	200.9
C ₂ H ₄ (g)	Ethylene(g)	52.26	68.15	219.6
C ₂ H ₆ (g)	Ethane(g)	-84.68	-32.82	229.6
C ₃ H ₈ (g)	Propane(g)	-103.8	-23.3	270.3
C ₄ H ₁₀ (g)	Butane(g)	-125.6	-17.1	310.2
C ₆ H ₆ (g)	Benzene(g)	82.6	129.8	269.3
C ₆ H ₆ (l)	Benzene(l)	49.0	124.5	173.4
C ₆ H ₁₂ (g)	Cyclohexane(g)	-123.4	32.0	298.4
C ₆ H ₁₂ (l)	Cyclohexane(l)	-156.4	26.9	204.4
C ₁₀ H ₈ (g)	Naphthalene(g)	150.6	224.2	333.2
C ₁₀ H ₈ (s)	Naphthalene(s)	77.9	201.7	167.5
CH ₂ O(g)	Formaldehyde(g)	-108.6	-102.5	218.8
CH ₃ CHO(g)	Acetaldehyde(g)	-166.2	-128.9	250.3
CH ₃ CHO(l)	Acetaldehyde(l)	-192.3	-128.1	160.2
CH ₃ OH(g)	Methanol(g)	-200.7	-162.0	239.8
CH ₃ OH(l)	Methanol(l)	-238.7	-166.3	126.8
CH ₃ CH ₂ OH(g)	Ethanol(g)	-235.1	-168.5	282.7
CH ₃ CH ₂ OH(l)	Ethanol(l)	-277.7	-174.8	160.7
C ₆ H ₅ OH(s)	Phenol(s)	-165.1	-50.4	144.0
(CH ₃) ₂ CO(g)	Acetone(g)	-216.6	-153.0	295.0
(CH ₃) ₂ CO(l)	Acetone(l)	-247.6	-155.6	200.5
CH ₃ COOH(g)	Acetic acid(g)	-432.3	-374.0	282.5
CH ₃ COOH(l)	Acetic acid(l)	-484.5	-389.9	159.8
CH ₃ COOH(aq)	Acetic acid(aq)	-485.8	-396.5	178.7
C ₆ H ₅ COOH(s)	Benzoic acid(s)	-385.2	-245.3	167.6
CH ₃ NH ₂ (g)	Methylamine(g)	-22.97	32.16	243.4
C ₆ H ₅ NH ₂ (g)	Aniline(g)	86.86	166.8	319.3
C ₆ H ₅ NH ₂ (l)	Aniline(l)	31.6	149.2	191.3

D-2 Thermodynamic Properties of Substances at 298.15 K

Inorganic Substances

	ΔH_f° , kJ mol ⁻¹	ΔG_f° , kJ mol ⁻¹	S° , J mol ⁻¹ K ⁻¹
Cadmium			
Cd(s)	0	0	51.76
Cd ²⁺ (aq)	-75.90	-77.61	-73.2
CdCl ₂ (s)	-391.5	-343.9	115.3
CdO(s)	-258.2	-228.4	54.8
Calcium			
Ca(s)	0	0	41.42
Ca ²⁺ (aq)	-542.8	-553.6	-53.1
CaCO ₃ (s)	-1207	-1129	92.9
CaCl ₂ (s)	-795.8	-748.1	104.6
CaF ₂ (s)	-1220.	-1167	68.87
CaH ₂ (s)	-186.2	-147.2	42
Ca(NO ₃) ₂ (s)	-938.4	-743.1	193.3
CaO(s)	-635.1	-604.0	39.75
Ca(OH) ₂ (s)	-986.1	-898.5	83.39
Ca ₃ (PO ₄) ₂ (s)	-4121	-3885	236.0
CaSO ₄ (s)	-1434	-1322	106.7
Carbon (See also the table of organic substances.)			
C(g)	716.7	671.3	158.0
C(diamond)	1.90	2.90	2.38
C(graphite)	0	0	5.74
CCl ₄ (g)	-102.9	-60.59	309.9
CCl ₄ (l)	-135.4	-65.21	216.4
C ₂ N ₂ (g)	309.0	297.4	241.9
CO(g)	-110.5	-137.2	197.7
CO ₂ (g)	-393.5	-394.4	213.7
CO ₃ ²⁻ (aq)	-677.1	-527.8	-56.9
C ₃ O ₂ (g)	-93.72	-109.8	276.5
C ₃ O ₂ (l)	-117.3	-105.0	181.1
COCl ₂ (g)	-218.8	-204.6	283.5
COS(g)	-142.1	-169.3	231.6
CS ₂ (l)	89.70	65.27	151.3
Chlorine			
Cl(g)	121.7	105.7	165.2
Cl ⁻ (aq)	-167.2	-131.2	56.5
Cl ₂ (g)	0	0	223.1
ClF ₃ (g)	-163.2	-123.0	281.6
ClO ₂ (g)	102.5	120.5	256.8
Cl ₂ O(g)	80.3	97.9	266.2
Chromium			
Cr(s)	0	0	23.77
[Cr(H ₂ O) ₆] ³⁺ (aq)	-1999	—	—
Cr ₂ O ₃ (s)	-1140.	-1058	81.2
CrO ₄ ²⁻ (aq)	-881.2	-727.8	50.21
Cr ₂ O ₇ ²⁻ (aq)	-1490.	-1301	261.9
Cobalt			
Co(s)	0	0	30.04
CoO(s)	-237.9	-214.2	52.97
Co(OH) ₂ (pink solid)	-539.7	-454.3	79
Copper			
Cu(s)	0	0	33.15
Cu ²⁺ (aq)	64.77	65.49	-99.6
CuCO ₃ ·Cu(OH) ₂ (s)	-1051	-893.6	186.2

Equations

$$PV = nRT$$

$$\Delta U = q + w$$

$$H = U + PV$$

$$w = - \int PdV$$

$$U = \frac{3}{2}nRT$$

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

$$E = mc^2$$

$$E = hv$$

$$\bar{u}_m = \left(\frac{8RT}{\pi M} \right)^{1/2}$$

$$Z_W = \frac{N}{4V} \left(\frac{8RT}{\pi M} \right)^{1/2}$$

$$\bar{u}_{RMS} = \left(\frac{3RT}{M} \right)^{1/2}$$

$$E_n = - \frac{Z_{eff}^2 R_H}{n^2}$$

$$\ln \left(\frac{P_2}{P_1} \right) = \frac{\Delta H_v}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$q_A = G_A - N_A - \sum_B \frac{\chi_A}{\chi_A + \chi_B} N_{AB}$$

$$\bar{u}_{mp} = \left(\frac{2RT}{M} \right)^{1/2}$$

$$\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

$$4r_{BCC} = l\sqrt{3} \quad l_{FCC} = r\sqrt{8}$$

$$r_{cub} = 0.732R \quad r_{Td} = 0.225R$$

$$r_{tri} = 0.155R \quad r_{Oh} = 0.414R$$

$$\rho = \frac{NM}{VN_A}$$

$$\lambda = \frac{h}{mv}$$

Fundamental Constants

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$g = 9.807 \text{ m s}^{-2}$$

$$R_H = 2.179 \times 10^{-18} \text{ J}$$

$$c = 2.998 \times 10^8 \text{ m s}^{-1}$$

$$e^- = -1.602 \times 10^{-19} \text{ C}$$

$$h = 6.626 \times 10^{-34} \text{ J s}$$

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1} = 0.08315 \text{ L bar K}^{-1} \text{ mol}^{-1}$$

$$m_e = 9.109 \times 10^{-31} \text{ kg}$$

$$m_p = 1.673 \times 10^{-27} \text{ kg}$$

$$k = 1.381 \times 10^{-23} \text{ J K}^{-1}$$

Conversion Factors

$$1 \text{ atm} = 101.325 \text{ kPa (exact)}$$

$$1 \text{ atm} = 1.01325 \text{ bar (exact)}$$

$$1 \text{ kg} = 2.2046226 \text{ lbs}$$

Useful Data

$$S_{H_2O} = 4.184 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$$

$$S_{ice} = 2.01 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$$

$$\Delta H_v^0(\text{H}_2\text{O}) = 44.0 \text{ kJ mol}^{-1}$$

$$\Delta H_{fus}^0(\text{H}_2\text{O}) = 6.01 \text{ kJ mol}^{-1}$$

$$\rho_{Hg}(l) = 13.6 \text{ g cm}^{-3}$$

$$\rho_{H_2O}(l) = 1.00 \text{ g cm}^{-3}$$

hydrogen 1 1.00794	helium 2 4.00260																						
lithium 3 6.941	beryllium 4 9.0122																						
sodium 11 22.98976928	lithium 3 6.941	beryllium 4 9.0122																					
potassium 19 39.0983	calcium 20 40.078	scandium 21 44.955912	titanium 22 47.867	vanadium 23 50.9415	chromium 24 51.9961	iron 26 55.845	nickel 28 58.6934	cobalt 27 58.9332	nickel 28 58.6934	copper 29 63.546	zinc 30 65.38	gallium 31 69.723	germanium 32 72.64	arsenic 33 74.9216	selenium 34 78.96	bromine 35 79.904	fluorine 9 18.9984032	oxygen 8 15.999	nitrogen 7 14.006434	carbon 6 12.011	boron 5 10.811	helium 2 4.00260	
rubidium 37 85.4678	strontium 38 87.62	yttrium 39 88.9062	zirconium 40 91.224	niobium 41 92.9064	molybdenum 42 95.94	technetium 43 [98]	rhodium 45 102.9055	rhodium 45 102.9055	silver 47 107.8682	cadmium 48 112.411	indium 49 114.818	tin 50 118.710	antimony 51 121.757	tellurium 52 127.60	iodine 53 126.905	astatine 85 [210]	nitrogen 7 14.006434	oxygen 8 15.999	fluorine 9 18.9984032	carbon 6 12.011	boron 5 10.811	beryllium 4 9.0122	lithium 3 6.941
cesium 55 132.90545196	barium 56 137.327	lutetium 71 174.967	hafnium 72 178.49	tantalum 73 180.948	tungsten 74 183.84	rhenium 75 186.207	iridium 77 223.029	iridium 77 223.029	gold 79 196.966569	mercury 80 200.59	thallium 81 204.384	lead 82 207.2	bismuth 83 208.9804	polonium 84 [209]	astatine 85 [210]	astatine 85 [210]	nitrogen 7 14.006434	oxygen 8 15.999	fluorine 9 18.9984032	carbon 6 12.011	boron 5 10.811	beryllium 4 9.0122	lithium 3 6.941
francium 87 [223]	radium 88 [226]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	actinium 89 [227]	nitrogen 7 14.006434	oxygen 8 15.999	fluorine 9 18.9984032	carbon 6 12.011	boron 5 10.811	beryllium 4 9.0122	lithium 3 6.941

lanthanum 57 138.90547	cerium 58 140.12	praseodymium 59 140.90768	neodymium 60 144.242	promethium 61 [147]	samarium 62 150.36	europium 63 151.964	gadolinium 64 157.25	terbium 65 158.92535	dysprosium 66 162.50	holmium 67 164.93033	erbium 68 167.259	thulium 69 168.934	ytterbium 70 173.045	lutetium 71 174.967
actinium 89 [227]	thorium 90 232.0377	protactinium 91 231.036888	uranium 92 238.02891	neptunium 93 [237]	plutonium 94 [244]	americium 95 [243]	curium 96 [247]	berkelium 97 [247]	californium 98 [251]	einsteinium 99 [252]	fermium 100 [257]	mendelevium 101 [258]	nobelium 102 [259]	lawrencium 103 [260]

* Lanthanide series

* * Actinide series

Name (in ink) _____
Student Number (in ink) _____

Fall 2015 SC/CHEM 1000 A - Quiz #3

November 26, 2015

Calculators are permitted.

Answer all questions on this paper; additional paper for rough work is not permitted. You may carry out your work in pencil if you wish, but please write your final answer in indelible (not erasable) ink.

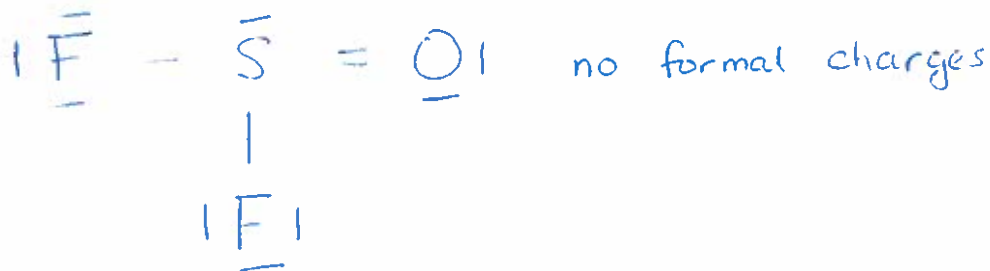
Assume all gases to be ideal unless otherwise noted

Time Allowed: 50 minutes

Total Marks = 30

1. Thionyl fluoride, F_2SO , is a colorless corrosive gas.

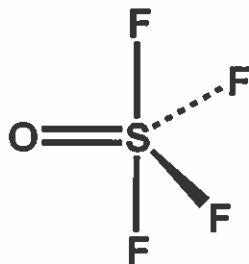
(a) (4 pts) Draw the best Lewis structure for F_2SO , indicating all formal charges, if any.



(b) (1 pt) What is the hybridization on the sulfur atom consistent with your Lewis structure?

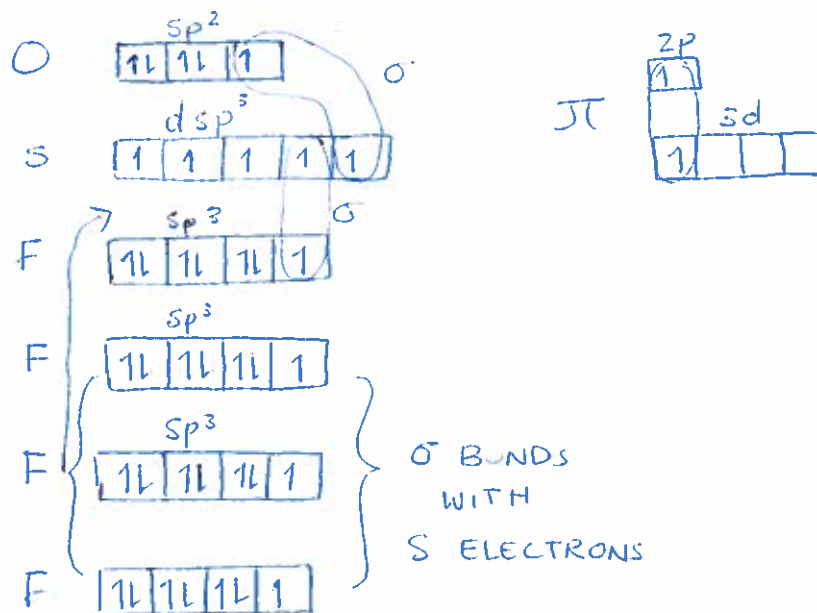
sp^3

2. Thionyl tetrafluoride, F_4SO , is another colorless corrosive gas that is quite useful in the preparation of fluorine containing organic compounds. The molecular structure of F_4SO is based on a trigonal bipyramid, as drawn below.



In the above structure, I omitted the lone pairs for clarity.

(a) (4 pts) Draw the full valence bond diagram (the little boxes with hybrid orbitals and electrons) for F_4SO . Make sure you (i) label the hybrids with the appropriate hybridizations, (ii) label any unhybridized atomic orbitals, and (iii) indicate which orbitals overlap to form σ and π bonds.

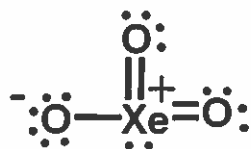


(b) (1 pt) Identify any hypervalent atoms in F_4SO , if any. S

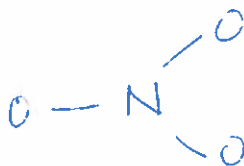
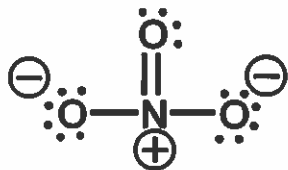
(c) (1 pt) Would you expect this molecule to have a dipole moment (yes or no)? YES

3. Use VSEPR theory to determine the shapes of each of the molecules in parts a-d (1 pt ea), draw here as Lewis structures. Draw each molecule using dotted and exploded lines to represent 3-dimensionality. Then answer questions e-h (1/2 pt ea). For molecules that have resonance structures, only one resonance structure is shown.

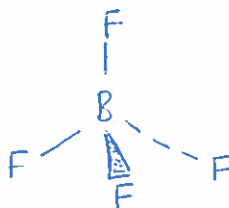
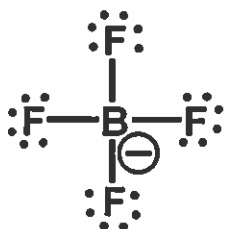
(a)



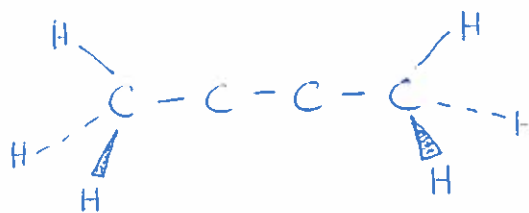
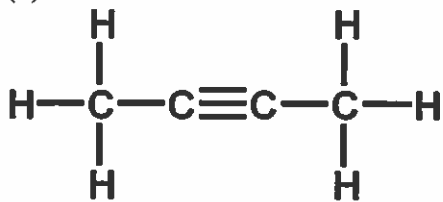
(b)



(c)



(d)



(e) What is the FBF bond angle in molecule (c)? 109.47°

(f) What is the CCC bond angle in molecule (d)? 180°

(g) What is the OXeO bond angle in molecule (a), to within $\pm 5^\circ$? 109°

(h) What is the ONO bond angle in molecule (b)? 120°

4. (1/2 pt ea) Determine whether each of the following sets of quantum numbers represents an allowed (A) or forbidden (F) state.

n	l	m	m_s	A or F?
2	1	1	+1/2	
3	3	2	+1/2	
3	0	0	0	
2	-1	0	-1/2	
3	2	-1	-1/2	
1	0	1	+1/2	

5. (1/2 pt ea) Determine whether each of the following electron configurations represents a ground state (G), excited state (E), or forbidden state (F) for an atom.

- (a) $[\text{Xe}]4f^4 5d^{10} 6s^2 6p^4$ G
- (b) $[\text{Ar}]2d^{10} 4s^2 4p^1$ F
- (c) $[\text{Ar}]3d^{10} 4s^1$ G
- (d) $[\text{Ne}]3s^1 3p^5$ E
- (e) $[\text{Kr}]4d^{12} 5s^2 5p^2$ F
- (f) $[\text{He}]2s^2 2p^3$ G

6. (1/2 pt ea) Write out (in *spdf* notation), the ground state electron configurations for the following ions. Please express the core electrons by their noble gas configuration (in brackets).

- (a) Fe^{3+} $[\text{Ar}] 3d^5$
- (b) Zn^{2+} $[\text{Ar}] 3d^{10}$
- (c) Pd^{2+} $[\text{Kr}] 4d^8$
- (d) C^{2-} $[\text{He}] 2s^2 2p^4$

7. (1/2 pt ea) Indicate whether each of the ions in question 6 is diamagnetic or paramagnetic.

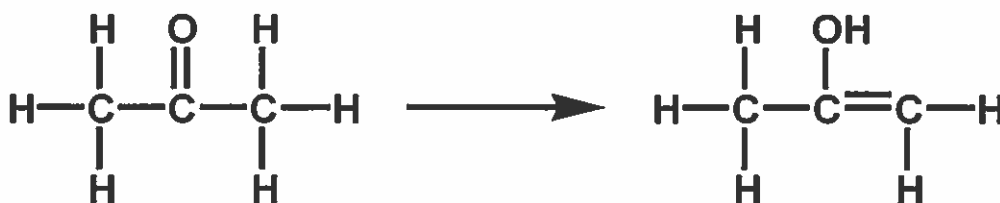
(a) Fe^{3+} P

(b) Zn^{2+} D

(c) Pd^{2+} P

(d) C^{2-} P

8. (3 pts) Using the table of bond dissociation energies provided in this quiz, estimate the energy per mole of the following isomerization (*hint: you really only need to consider bonds that are changing*).



<u>BREAK</u>		<u>MAKE</u>	
C=O	736	C-O	-360
C-C	347	C=C	-611
C-H	414	O-H	-464

+ 62 kJ mol⁻¹

Equations

$$PV = nRT$$

$$\Delta U = q + w$$

$$H = U + PV$$

$$w = - \int PdV$$

$$U = \frac{3}{2}nRT$$

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

$$E = mc^2$$

$$E = h\nu$$

$$\bar{u}_m = \left(\frac{8RT}{\pi M} \right)^{1/2}$$

$$Z_W = \frac{N}{4V} \left(\frac{8RT}{\pi M} \right)^{1/2}$$

$$\bar{u}_{RMS} = \left(\frac{3RT}{M} \right)^{1/2}$$

$$E_n = - \frac{Z_{eff}^2 R_H}{n^2}$$

$$\ln \left(\frac{P_2}{P_1} \right) = \frac{\Delta H_V}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$q_A = G_A - N_A - \sum_B \frac{\chi_A}{\chi_A + \chi_B} N_{AB}$$

$$\bar{u}_{mp} = \left(\frac{2RT}{M} \right)^{1/2}$$

$$\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

$$4r_{BCC} = l\sqrt{3} \quad l_{FCC} = r\sqrt{8}$$

$$r_{cub} = 0.732R \quad r_{Td} = 0.225R$$

$$r_{tri} = 0.155R \quad r_{Oh} = 0.414R$$

$$\rho = \frac{NM}{VN_A}$$

$$\lambda = \frac{h}{mv}$$

Fundamental Constants

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$g = 9.807 \text{ m s}^{-2}$$

$$R_H = 2.179 \times 10^{-18} \text{ J}$$

$$c = 2.998 \times 10^8 \text{ m s}^{-1}$$

$$e^- = -1.602 \times 10^{-19} \text{ C}$$

$$h = 6.626 \times 10^{-34} \text{ J s}$$

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1} = 0.08315 \text{ L bar K}^{-1} \text{ mol}^{-1}$$

$$m_e = 9.109 \times 10^{-31} \text{ kg}$$

$$m_p = 1.673 \times 10^{-27} \text{ kg}$$

$$k = 1.381 \times 10^{-23} \text{ J K}^{-1}$$

Conversion Factors

$$1 \text{ atm} = 101.325 \text{ kPa (exact)}$$

$$1 \text{ atm} = 1.01325 \text{ bar (exact)}$$

$$1 \text{ kg} = 2.2046226 \text{ lbs}$$

Useful Data

$$S_{H_2O} = 4.184 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$$

$$S_{ice} = 2.01 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$$

$$\Delta H_v^0(\text{H}_2\text{O}) = 44.0 \text{ kJ mol}^{-1}$$

$$\Delta H_{fus}^0(\text{H}_2\text{O}) = 6.01 \text{ kJ mol}^{-1}$$

$$\rho_{Hg}(l) = 13.6 \text{ g cm}^{-3}$$

$$\rho_{H_2O}(l) = 1.00 \text{ g cm}^{-3}$$

TABLE 10.3 Some Average Bond Energies^a

Bond	Bond Energy, kJ/mol	Bond	Bond Energy kJ/mol	Bond	Bond Energy kJ/mol
H—H	436	C—C	347	N—N	163
H—C	414	C=C	611	N=N	418
H—N	389	C≡C	837	N≡N	946
H—O	464	C—N	305	N—O	222
H—S	368	C=N	615	N=O	590
H—F	565	C≡N	891	O—O	142
H—Cl	431	C—O	360	O=O	498
H—Br	364	C=O	736 ^b	F—F	159
H—I	297	C—Cl	339	Cl—Cl	243
				Br—Br	193
				I—I	151

$$R = 8.315 \text{ JK}^{-1}\text{mol}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1} ; N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$1 \text{ atm} = 101,325 \text{ Pa} = 760 \text{ Torr (mm Hg)} ; 0^\circ\text{C} = 273.15 \text{ K} ; 1 \text{ m}^3 = 1000 \text{ L}$$

$$PV = nRT ; (P + an^2/V^2)(V - nb) = nRT ; \text{STP: } 0^\circ\text{C and } 1 \text{ bar} = 100,000 \text{ Pa}$$

$$u_{rms} = \sqrt{\frac{3RT}{M}} ; \bar{e}_k = \frac{1}{2}mu_{rms}^2 ; \text{effusion rates: } \frac{R_A}{R_B} = \sqrt{\frac{M_B}{M_A}}$$

Note: always write numerical answers with correct number of significant figures and write the final answer in non-erasable ink.

[marks]

1. Fill in the blanks with the appropriate missing numbers, symbols, or words.

[1] 1.1. In the kinetic molecular theory of gases, the average kinetic energy of molecules in a gas is proportional to the temperature of the gas in Kelvin.

[1] 1.2. In the van der Waals equation for a gas, V - mb is the volume available for motion of the gas molecules.

[1] 1.3. In a vacuum chamber, the pressure exerted at the base of a steel cylinder of height equal to 10 cm and diameter equal to 5 cm is P_1 . Under the same conditions, the pressure exerted at the base of a steel cylinder of height 20 cm and diameter 10 cm is 2 times P_1 .

[2] 1.4. Gases tend to behave like *ideal gases* at high temperatures and low pressures.

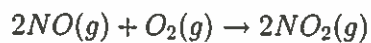
[2] 2. On October 1, at Pearson airport, the atmospheric pressure was 770.3 Torr, the temperature was 5°C , and the partial pressure of water vapor in the air was 4.6 Torr. What was the mole fraction of water vapor in air?

$$X_{\text{H}_2\text{O}} = 0.0060$$

[3] 3. A sample of nitrogen gas occupies 3.75 L at 25°C and 1.000 bar. Calculate its volume at -25°C and 1.420 bar.

$$V_2 = 2.20 \text{ L}$$

[4] 4. 3.00 mol of NO(g) and 2.00 mol of O₂(g) are introduced in a 50.0 L evacuated container at 21°C. They react like this:



The reaction goes to completion. What is the final total pressure, in Pascal, at 21°C?

$$P = 1.71 \times 10^5 \text{ Pa}$$

[5] 5. An equimolar mixture of methane (CH_4) and propane (C_3H_8) effuses out of a container through a tiny hole. If 5.0×10^2 mg of CH_4 effused out of the container in 1.00 hour, how many mg of C_3H_8 effused out in the same time?

The molar masses are 1.0079 g/mol for H and 12.011 g/mol for C, and 1000 mg = 1 g.

$$m_{\text{C}_3\text{H}_8} = 829 \text{ mg}$$

[5] 6. The molar concentration of a gas is defined as $c = n/V$, where n is the number of moles and V the volume in liters (L). The van der Waals parameters for chlorine gas, $\text{Cl}_2(\text{g})$, are $a = 6.49 \text{ atm L}^2 \text{ mol}^{-2}$ and $b = 0.056 \text{ L mol}^{-1}$. What is the temperature of $\text{Cl}_2(\text{g})$ if its pressure is 2.000 atm and its concentration is 0.0640 mol/L?

Hint: rewrite the van der Waals equation in terms of a, b, c, P, R , and T .

$$T = 384 \text{ K}$$

[3] 7.1 The molar mass of N is 14.01 g/mol. Calculate the root-mean-square speed of N_2 molecules at 300.0 K.

$$u_{rms} = 516.8 \text{ m/s}$$

[3] 7.2 Calculate, or estimate as best as you can, the most probable speed, u_m , of N_2 molecules at 100.0 K.

$$u_m = 244 \text{ m/s}$$

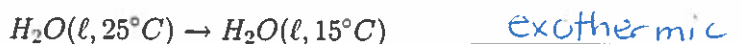
THE END

$R = 8.315 \text{ JK}^{-1}\text{mol}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$; $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
 $1 \text{ atm} = 101,325 \text{ Pa} = 1.01325 \text{ bar} = 760 \text{ Torr (mm Hg)}$; $0^\circ\text{C} = 273.15 \text{ K}$; $1 \text{ m}^3 = 1000 \text{ L}$
 $PV = nRT$; $\Delta U = q + w$; $H = U + PV$; $U = \frac{3}{2}nRT$ for a ideal gas
 $q = C\Delta T = C_{sp}m\Delta T = C_m n\Delta T$; $\Delta H_{rxn}^\circ = \sum_p \Delta H_f^\circ(p) - \sum_r \Delta H_f^\circ(r)$

Note: always write numerical answers with correct number of significant figures and write the final answer in non-erasable ink.

[marks]

[3] 1. Label each process "exothermic" or "endothermic".



[2] 2. What are the signs of q and w for water when we boil it? Circle the correct answer for each.

q is - 0 +

w is - 0 +

[4] 3. Fill in the blanks with the missing word(s).

3.1. A closed system can exchange only heat (or energy) with its surroundings.

3.2. In a bomb calorimeter, the work is zero during a chemical reaction.

3.3. Enthalpy is a state function but work (or heat) is not.

3.4. When a ideal gas expands against a pressure of 1 atm and there is no heat exchange, its temperature goes down.

[5] 4. We do 735 J of work on 2.00 mole of ideal gas by compressing it and observe that its temperature increases by 20.0°C. Calculate the heat in that process for the gas.

$$q = -236 \text{ J}$$

5. Molar masses (in g/mol) are 1.008 for H, 12.01 for C, and 16.00 for O. Combustion of an organic compound is the reaction of that compound with $O_2(g)$ to give $CO_2(g)$ and $H_2O(l)$. The heat of combustion of propane (C_3H_8) is 46.40 kJ/g at 25.0°C and 1 bar.

[2] 5.1. What is the enthalpy change for the combustion of 1.000 mole of propane at 25.0°C and 1 bar?

$$\Delta H = -2046 \text{ kJ}$$

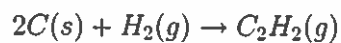
[5] 5.2. What is the energy change for the combustion of 1.000 mole of propane at 25.0°C and 1 bar?

$$\Delta U = -2039 \text{ kJ}$$

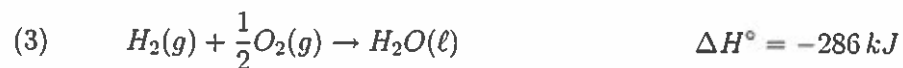
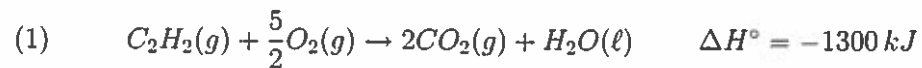
[5] 6. A 50.0 g sample of a metal at 145.0°C is added to 150.0 g of water at 15.0°C. The temperature of the water rises to 17.2°C. The specific heat capacity of water is 4.184 J g⁻¹ K⁻¹. Assume that all the heat lost by the metal is gained by the water and calculate the specific heat capacity of the metal.

$$c_{sp, m} = 0.22 \text{ J g}^{-1} \text{ K}^{-1}$$

[4] 7. Calculate ΔH° at 25.0°C for the reaction



given the following data at 25.0°C and 1 bar:



$$\Delta H^\circ_{rxn} = +226 \text{ kJ}$$

THE END

YORK UNIVERSITY

NAME: _____

F2015 CHEM1000 section B

STUDENT NO. _____

Quiz No. 3

November 24, 2015

50 minutes

30 Marks

$$R_H = 2.179 \times 10^{-18} \text{ J} \quad ; \quad h = 6.6261 \times 10^{-34} \text{ J s} \quad ; \quad c = 2.9979 \times 10^8 \text{ m/s}$$

$$E = h\nu = hc/\lambda \quad ; \quad E_n = \frac{-R_H Z^2}{n^2}$$

Note: always write numerical answers with correct number of significant figures and write the final answer in non-erasable ink.

[marks]

[5] 1. The ground-state electronic configuration of Mo ($Z = 42$) is $[\text{Kr}]4d^5 5s^1$.

1.1. Is the Mo atom diamagnetic or paramagnetic? *paramagnetic*

1.2. How many electrons are in orbitals with quantum number $n = 4$? *13*

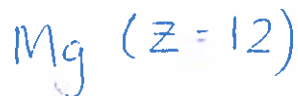
1.3. How many electrons are in orbitals with quantum number $\ell = 2$? *15*

1.4. How many electrons are in orbitals with quantum number $m_\ell = 0$? *18*

1.5. What is the ground-state electronic configuration of Mo^{2+} ? *$[\text{Kr}]4d^4$*



[2] 2. What metal atom "M" has an atomic number Z between 5 and 19 and forms a stable oxide with molecular formula "MO"?



[4] 3. A hydrogen-like atomic ion in a $n = 4$ excited state emits a photon of wavelength equal to 6.078 nm (6.078×10^{-9} m) as it returns to the ground state. What is the atomic number Z of this hydrogen-like atomic ion? Show your calculation.

$$Z = 4$$

4. Sodium (Na) is a group 1 element and neon (Ne) is a group 18 element. Fill in the gaps with numbers chosen among 1, 2, 13, 14, 15, 16, 17, and 18.

[1] 4.1. The smallest ionization energies are found among elements of group 1.

[1] 4.2. The atoms with the most negative electron affinities are found in group 17.

[1] 4.3. In a period where $Z > 2$, the atom with the smallest atomic radius is in group 17.

[1] 4.4. Most elements in groups 1, 2, and 13 are metals.

[4] 5. The ground-state electronic configuration of most atoms is obtained with the orbital filling order 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f. But there are exceptions such as Cu ($Z = 29$), Nb ($Z = 41$), and Mo ($Z = 42$). Give the name, *or* atomic symbol, *or* atomic number (Z), of four other elements that are exceptions to the orbital filling order rule.

1. Ag ($Z = 47$)

2. Cr ($Z = 24$)

Pa ($Z = 91$)

3. Au ($Z = 79$)

4. Pd ($Z = 46$)

U ($Z = 92$)

also Pt ($Z = 78$), Ru ($Z = 44$), Rh ($Z = 45$), Gd ($Z = 64$)

[3] 6. The first ionization energy of aluminum (Al, $Z = 13$) is 577.6 kJ/mol. Estimate as best as you can the effective nuclear charge Z_{eff} felt by an electron in the 3p atomic orbital of a ground state Al atom.

$$Z_{eff} \approx 1.99$$

[5] 7. $Z = 19$ for K and $Z = 53$ for I. Match each of the following diatomic molecules to one of the descriptions: HCl, I_2 , KCl, N_2 , O_2 .

covalent bond I_2

multiple covalent bond N_2

ionic bond KCl

paramagnetic molecule O_2

polar covalent bond HCl

[3] 8. Draw the best Lewis structure you can for the nitrite ion, NO_2^- , and show the formal atomic charges.



THE END

Name (in ink): _____

Student Number (in ink): _____

Fall 2015 SC/CHEM 1000 C - Quiz #1

October 6, 2015

Calculators are permitted. Answer all questions in the space provided on this paper; additional paper for rough work is not permitted.

All final answers must be written in non-erasable ink!

Important Note: The last page of this quiz is a reference page that may be removed if you wish. You will need information from this sheet to answer some of the questions.

Time Allowed: 50 minutes

Total Marks = 30

Marks

- 4 1. A 0.2258 g sample of a mixture of NaCl and NaClO₃ is decomposed by heating and produces 57.85 mL of O₂(g) measured at 23.0°C and 738 mmHg. The balanced equation of this decomposition process is



What is the mass percent of NaClO₃ in the original mixture?

$$\% \text{NaClO}_3 = 72.6\%$$

Marks

- 4 2. If the vapour pressure of mercury is 1.0×10^{-16} mmHg at -120°C , how many gaseous mercury molecules would there be per mL at this temperature?

~ 6 molecules

- 3 3. One mole of a gas in a volume of 0.13 L at 273K exerts a pressure of 200.0 atm. Under these conditions this gas is NOT behaving ideally. Describe whether this gas displays a positive or negative deviation from ideal behaviour and explain why you have made this conclusion. Also, what property of the gas leads to this deviation. (Your answer must be supported by a calculation.)

positive deviation

This deviation arises because the molecules occupy space. (ie. they have volume).

Marks

- 6 4. The vapour pressure of water at 80°C is 355 mmHg. A 100.0 mL vessel contained water-saturated oxygen at 80°C, the total gas pressure being 760 mmHg. The contents of the vessel were transferred completely by pumping into a 50.0 mL vessel at the same temperature. What were the partial pressures of oxygen and water vapour, and what was the total pressure, in the final equilibrated mixture? Neglect the volume of any water which might condense.

$$P_{\text{H}_2\text{O}} = 355 \text{ mmHg}$$

$$P_{\text{O}_2} = 810 \text{ mmHg}$$

$$P_{\text{TOTAL}} = 1165 \text{ mmHg}$$

- 5 5. At a fixed temperature and pressure, the density of gaseous methane, CH_4 , is 0.716 g/L.
a) What would the density of gaseous carbon monoxide, CO , be under these same conditions?

$$d_{\text{CO}} = 1.25 \text{ g/L}$$

- b) If these two gases were confined within a closed container, which one would tend to rise to the top? Why?

CH_4 would tend to rise in the container
because it is less dense than CO
(i.e. $M_{\text{CH}_4} < M_{\text{CO}}$)

Marks

- 8 6. A 1.50 m^3 cubical box containing helium at a pressure of $1.00 \times 10^{-10} \text{ atm}$ at 25°C is placed in an evacuated enclosure. An $8.00 \times 10^{-9} \text{ m}^2$ hole is made in the wall of the box and the diameter of a helium atom is $6.2 \times 10^{-11} \text{ m}$.

a) What is the effusion rate of the helium out of this hole?

$$\text{effusion rate} = 6.18 \times 10^9 \text{ molecules/s}$$

b) What is the mean free path for a helium atom under these conditions? Provide your answer in km.

$$\lambda = 24 \text{ km}$$

Reference Page for CHEM 1000C Quiz 1

Constants:

$R = 8.314472 \text{ JK}^{-1}\text{mol}^{-1} = 0.0820574 \text{ L atm K}^{-1} \text{ mol}^{-1}$
 $1.00 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 760 \text{ Torr (mm Hg)}$
 $N_A = 6.02214199 \times 10^{23} \text{ mol}^{-1}$ $1 \text{ mL} = 1 \text{ cm}^3$

$k = 1.38066 \times 10^{-23} \text{ J K}^{-1}$
 $g = 9.80665 \text{ m s}^{-2}$
 $0^\circ\text{C} = 273.15 \text{ K}$

density of water = $0.99707 \text{ g/mL @ } 25^\circ\text{C}$
 density of mercury = $13.5340 \text{ g/mL @ } 25^\circ\text{C}$

$\pi \approx 3.141593$
 $1 \text{ nm} = 10^{-9} \text{ m}$

Equations:

$$u_m = \sqrt{\frac{2RT}{M}} \quad u_{av} = \sqrt{\frac{8RT}{\pi M}} \quad u_{ms} = \sqrt{\frac{3RT}{M}} \quad Z = \frac{PV}{nRT}$$

$$Z_w = \frac{1}{4} \frac{N}{V} u_{av} \quad Z_A = \sqrt{2} \pi d^2 u_{av} \frac{N}{V}$$

$$Z_{AA} = \frac{1}{\sqrt{2}} \pi d^2 u_{av} \left(\frac{N}{V} \right)^2 \quad \lambda = \frac{1}{\sqrt{2} \pi d^2} \frac{V}{N}$$

$$\left(P + \frac{n^2 a}{V^2} \right) (V - nb) = nRT$$

Atomic Weights (g/mol):

H 1.00794 He 4.00260 C 12.0107 N 14.0067
 O 15.9994 Cl 35.453 Na 22.9898 Hg 200.59

Vapour Pressure (P) of Water at Various Temperatures:

T (°C)	P (mmHg)	T (°C)	P (mmHg)	T (°C)	P (mmHg)	T (°C)	P (mmHg)
13	11.23	19	16.48	25	23.76	31	33.7
14	11.99	20	17.54	26	25.21	32	35.66
15	12.79	21	18.65	27	26.74	33	37.73
16	13.63	22	19.83	28	28.35	34	39.9
17	14.53	23	21.07	29	30.04	35	42.18
18	15.48	24	22.38	30	31.82	36	44.56

Name: _____

Student Number: _____

Fall 2015 SC/CHEM 1000 C - Quiz #2

October 20, 2015

Calculators are permitted.

Answer all questions on this paper in the space provided; **additional paper for rough work is not permitted.**

All final answers must be written in ink!

Important Note: The last page of this quiz is a reference page that may be removed if you wish. You will need information from this sheet to answer some of the questions.

Time Allowed: 50 minutes

Total Marks = 30

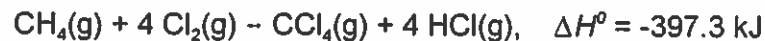
Marks

- 4 1. A 1.00 g sample of zinc sulfide (ZnS , $M = 97.47 \text{ g mol}^{-1}$) reacts completely with excess oxygen to produce zinc oxide (ZnO , $M = 81.41 \text{ g mol}^{-1}$) and sulfur dioxide (SO_2 , $M = 64.06 \text{ g mol}^{-1}$). The heat released is sufficient to raise the temperature of 100.0 g of water from 25.2°C to 42.8°C. What is the heat of combustion of zinc sulfide in kJ/mol?

$$\Delta H_{\text{combustion}} = -718 \text{ kJ/mol}$$

Marks

- 4 2. Determine the standard enthalpy of formation of $\text{CCl}_4(\text{g})$ at 298K.



$$\Delta H_f^\circ(\text{CCl}_4) = -102.9 \text{ kJ}$$

- 4 3. The production of a gaseous fuel mixture is described by the following equation:



Calculate the enthalpy change for this reaction given the following information:

(1)	$\text{C}(\text{graphite}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{CO}(\text{g})$	$\Delta H = -110.52 \text{ kJ}$
(2)	$\text{CO}(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	$\Delta H = -282.97 \text{ kJ}$
(3)	$\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$	$\Delta H = -285.83 \text{ kJ}$
(4)	$\text{C}(\text{graphite}) + 2 \text{H}_2(\text{g}) \rightarrow \text{CH}_4(\text{g})$	$\Delta H = -74.81 \text{ kJ}$

$$\Delta H_{\text{rxn}} = -747.5 \text{ kJ}$$

Marks

- 3 4. The specific heat of gold, Au, is $0.0310 \text{ cal g}^{-1} \text{ K}^{-1}$. What is the molar heat capacity of gold in $\text{J mol}^{-1} \text{ } ^\circ\text{C}^{-1}$?

$$\text{molar heat capacity} = 25.5 \text{ J mol}^{-1} \text{ } ^\circ\text{C}^{-1}$$

- 4 5. What wavelength of light is absorbed when an electron goes from $n = 3$ to $n = 7$ in a Bohr hydrogen atom? Your answer should be expressed in nm.

$$\lambda = 1005 \text{ nm}$$

- 4 6. Provide all possible values of n , l , m_l , and m_s for each of the following orbitals:

Orbital	n	l	m_l	m_s
3d	3	2	0, ± 1 , ± 2	$\pm 1/2$
4f	4	3	0, ± 1 , ± 2 , ± 3	$\pm 1/2$

Note: For example, you might wish to list in box for l something like 2, 3, 4 to indicate a range of numbers that are permitted.

Marks

- 3 7. Write the electron configuration for each of the following using the condensed spdf notation. (Note: an abbreviation for a noble gas core may be used)

Species	Electron configuration
P	$[\text{Ne}] 3s^2 3p^3$
Ga	$[\text{Ar}] 4s^2 3d^{10} 4p^1$
Ni^{2+}	$[\text{Ar}] 3d^8$

- 4 8. For each of the following, place your answer on the line provided.
(Note: Take care to consider charges on the various species given below.)

a) Which one of As^{3-} , Br, Sr^{2+} , or Cl has the largest radius?

Answer: As^{3-}

b) Which one of Si, Mg, Al or P has the smallest first ionization energy?

Answer: Al

c) Which one of Ti^{3+} , Co^{2+} , Cr^{2+} , or Ni has the greatest number of unpaired electrons?

Answer: Cr^{2+}

d) Which one of F^- , C, Al, or S^- is diamagnetic?

Answer: F^-

Reference Page for CHEM 1000C Quiz 2

Constants:

$a_0 = 53 \text{ pm}$ $1 \text{ nm} = 10^{-9} \text{ m}$ $1 \text{ mL} = 1 \text{ cm}^3$ $1 \text{ cal} = 4.184 \text{ J}$
 $R = 8.314472 \text{ JK}^{-1}\text{mol}^{-1} = 0.0820574 \text{ L atm K}^{-1} \text{ mol}^{-1}$ $k = 1.38066 \times 10^{-23} \text{ J K}^{-1}$
 $1.00 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 760 \text{ torr (mm Hg)}$ $0^\circ\text{C} = 273.15 \text{ K}$
 $N_A = 6.02214199 \times 10^{23} \text{ molecules mol}^{-1}$ $R_H = 2.179 \times 10^{-18} \text{ J}$
 $h = 6.62606876 \times 10^{-34} \text{ J s}$ $c = 2.99792458 \times 10^8 \text{ m s}^{-1}$

specific heat of water = $4.184 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$
 heat of vaporization of water = 2260 J g^{-1}

heat of fusion for water = 333 J g^{-1}
 density of water = 1.00 g mL^{-1}

Atomic Weights (g/mol):

H 1.008, C 12.011, N 14.007, O 15.999, Au 196.97

Some Standard Enthalpies of Formation at 298K:

Substance	ΔH_f° (kJ/mol)	Substance	ΔH_f° (kJ/mol)
C(graphite)	0	H ₂ O(g)	-241.8
CH ₄ (g)	-74.81	H ₂ O(l)	-285.8
CO ₂ (g)	-393.5	HCl(g)	-92.31
Cl ₂ (g)	0	O ₂ (g)	0

The periodic table

www.webelements.com

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 H 1.008	Helium 2 He 4.0026	Scandium 21 Sc	Titanium 22 Ti	Vanadium 23 V	Chromium 24 Cr	Manganese 25 Mn	Iron 26 Fe	Cobalt 27 Co	Nickel 28 Ni	Copper 29 Cu	Zinc 30 Zn	Gallium 31 Ga	Germanium 32 Ge	Arsenic 33 As	Selenium 34 Se	Bromine 35 Br	Krypton 36 Kr
Lithium 3 Li 6.94	Beryllium 4 Be 9.0122	Yttrium 39 Y	Zirconium 40 Zr	Niobium 41 Nb	Molybdenum 42 Mo	Technetium 43 Tc	Ruthenium 44 Ru	Rhodium 45 Rh	Palladium 46 Pd	Silver 47 Ag	Cadmium 48 Cd	Indium 49 In	Tin 50 Sn	Antimony 51 Sb	Tellurium 52 Te	Iodine 53 I	Xenon 54 Xe
Sodium 11 Na 22.990	Magnesium 12 Mg 24.305	Lanthanum 57 La	Barium 56 Ba	Radium 88 Ra	Francium 87 Fr	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides

Key:

Element Name
Atomic number
Symbol
Atomic weight (mean relative mass)

Lanthanum 57 La	Cerium 58 Ce	Praseodymium 59 Pr	Neodymium 60 Nd	Europium 63 Eu	Gadolinium 64 Gd	Terbium 65 Tb	Dysprosium 66 Dy	Ytterbium 70 Yb
Actinides	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides	Actinides

*lanthanoids
**actinoids

Symbols and names: the symbols and names of the elements, and their spellings are those recommended by the International Union of Pure and Applied Chemistry (IUPAC - <http://www.iupac.org>). Names have yet to be proposed for elements 113, 115, 117, and 118 and to those used here as IUPAC's temporary systematic names. In some countries, the spelling aluminium, calcium, and sulphur are usual.
Group labels: the numeric system (1-18) used here is the current IUPAC convention.
Atomic weights (mean relative masses): these are the IUPAC 2009 values and given to 5 significant figures. The last significant figure of each value is considered reliable to ±1 except where a larger uncertainty is given in parentheses. Representative values for those elements having an atomic weight interval are given (L, B, C, N, O, S, Cl, Tl). Elements for which the atomic weight is given within brackets have no stable nuclides and are represented by the element's longest lived isotope reported in the IUPAC 2009 values.
©2012 Dr Mark A Whiner (The-Elements Ltd and University of Sheffield). All rights reserved. For updates to this table see http://www.webelements.com/updates/Printable_Periodic_Table (Version date: 7 June 2012).

Name: _____

Student Number: _____

Fall 2015 SC/CHEM 1000 C - Quiz #3

November 24, 2015

Answer all questions on this paper in the space provided; **additional paper for rough work is not permitted. Cell phones must be turned off and placed out of reach, they may not be used as calculators.**

All final answers must be written in non-erasable ink!

Important Note: The last two pages of the quiz are reference pages that may be removed. You may need information from these sheets to answer some of the questions.

Time Allowed: 50 minutes

Total Marks = 30

Marks

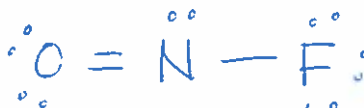
- 6 1. Provide the most stable Lewis Structure for each of the following.
- all lone pair electrons must be shown in these structures
 - expanded octets may be used when permissible
 - describe the shapes of each of these molecules
 - indicate whether each molecule is polar or non-polar

a) OSF_2 (S is central atom)



molecular shape trigonal pyramidal Is this molecule polar? YES

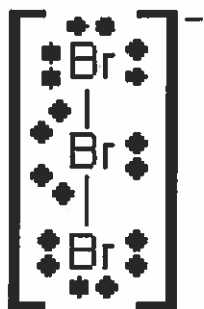
b) ONF (N is central atom)



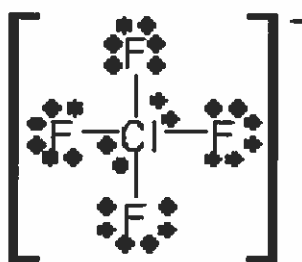
molecular shape Dent (or Angular) Is this molecule polar? YES

Marks

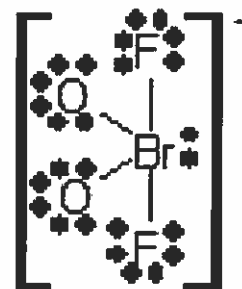
- 3 2. Provide the molecular geometry of each of the following on the line below each structure:



linear



square planar



see saw

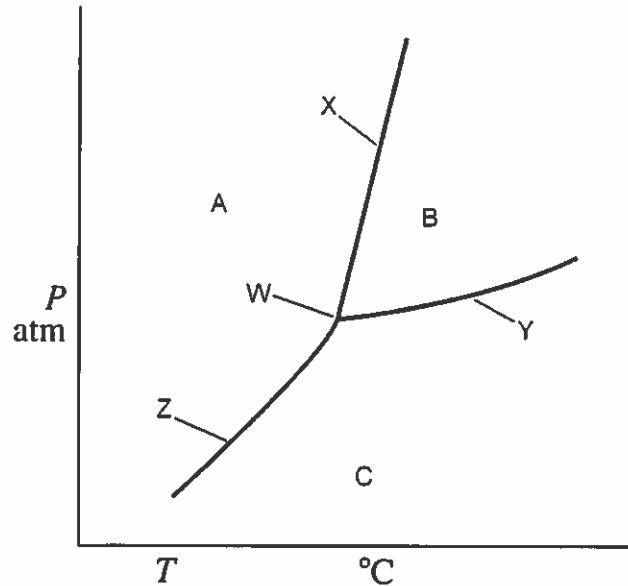
- 5 3. Identify the dominant intermolecular forces in each of the following substances when they are found as a pure liquid. You may choose from
- covalent bonding
 - dipole-dipole interactions
 - hydrogen bonding
 - ionic bonding, or
 - London forces

Note: Each of the options listed above may be used more than once if you wish.

Substance	Dominant Intermolecular Force
Ar	London forces
HCl	dipole-dipole interactions
HF	hydrogen bonding
CH ₄	London forces
CO	dipole-dipole interactions

Marks

5 4. Consider the phase diagram below:



a) What phase is specified by each of the following labels?

A solid

B liquid

C gas

b) What is the name of the point specified by W? triple point

c) Give the specific name for the curve indicated by each of the following labels.

X fusion

Y vapour pressure

Z sublimation

d) What is the specific name for the process going between the following phases?

B to A freezing

C to B condensation

A to C sublimation

Marks

- 5 5. The vapour pressure of ethyl acetate, $C_2H_5OCOCH_3$, is 305 torr at $51^\circ C$ and its heat of vapourization is 37.7 kJ/mol. What is the vapour pressure of ethyl acetate at $35^\circ C$?

$$P_2 = 148 \text{ torr}$$

Marks

- 6 6. Calcium has a face-centred cubic unit cell. The density of calcium is 1.54 g/cm^3 . Calculate the atomic radius of calcium. Give your answer in pm.

$$r = 197 \text{ pm}$$

Reference Page for CHEM 1000C Quiz 3

Constants:

$a_0 = 53 \text{ pm}$	$1 \text{ m} = 10^2 \text{ cm} = 10^{12} \text{ pm}$	$1 \text{ mL} = 1 \text{ cm}^3$	$1 \text{ cal} = 4.184 \text{ J}$
$R = 8.314472 \text{ JK}^{-1}\text{mol}^{-1} = 0.0820574 \text{ L atm K}^{-1} \text{ mol}^{-1}$		$k = 1.38066 \times 10^{-23} \text{ J K}^{-1}$	
$1.00 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 760 \text{ torr (mm Hg)}$		$0^\circ\text{C} = 273.15 \text{ K}$	
$N_A = 6.02214199 \times 10^{23} \text{ molecules mol}^{-1}$		$R_H = 2.179 \times 10^{-18} \text{ J}$	
$h = 6.62606876 \times 10^{-34} \text{ J s}$		$c = 2.99792458 \times 10^8 \text{ m s}^{-1}$	

specific heat of water = $4.184 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$
 heat of vaporization of water = 2260 J g^{-1}

heat of fusion for water = 333 J g^{-1}
 density of water = 1.00 g mL^{-1}

Electronegativities (Pauling Scale)

B 2.0 Br 2.8 C 2.5 Cl 3.0 H 2.1 I 2.5 N 3.0 O 3.5 F 4.0

Equations:

$$\ln\left(\frac{P_2}{P_1}\right) = -\frac{\Delta H}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right); \quad \ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\text{in bcc: } 4r = l\sqrt{3}$$

$$\text{in fcc: } 4r = l\sqrt{2}$$

The periodic table

www.webelements.com

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Hydrogen 1 H 1.008	Helium 2 He 4.0026	Scandium 21 Sc 44.956	Titanium 22 Ti 47.867	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.845	Cobalt 27 Co 58.933	Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.38	Aluminum 13 Al 26.982	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Helium 2 He 4.0026	
Lithium 3 Li 6.94	Beryllium 4 Be 9.0122	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.94	Technetium 43 Tc [97.9]	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 101.07	Palladium 46 Pd 106.42	Silver 47 Ag 107.87	Cadmium 48 Cd 112.41	Aluminum 13 Al 26.982	Carbon 6 C 12.011	Phosphorus 15 P 30.974	Sulfur 16 S 32.06	Chlorine 17 Cl 35.45	Neon 10 Ne 20.180	
Sodium 11 Na 22.990	Magnesium 12 Mg 24.305	Strontium 38 Sr 87.62	Rubidium 37 Rb 85.468	Cesium 55 Cs 132.91	Barium 56 Ba 137.33	Caesium 88 Ra [226.025]	Francium 87 Fr [223.021]	Radium 88 Ra [226.025]	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids
Potassium 19 K 39.098	Calcium 20 Ca 40.078	Barium 56 Ba 137.33	Rubidium 37 Rb 85.468	Cesium 55 Cs 132.91	Barium 56 Ba 137.33	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids	Actinoids

Key: Element Name
Atomic number
Symbol
Atomic weight (mean relative mass)

Lanthanum 57 La 138.91	Cerium 58 Ce 140.12	Praseodymium 59 Pr 140.91	Neodymium 60 Nd 144.24	Promethium 61 Pm [144.91]	Samarium 62 Sm 150.36	Europium 63 Eu 151.96	Gadolinium 64 Gd 157.25	Terbium 65 Tb 158.93	Dysprosium 66 Dy 162.50	Holmium 67 Ho 164.93	Erbium 68 Er 167.26	Thulium 69 Tm 168.93	Ytterbium 70 Yb 173.05	Lanthanoids	Actinoids
Actinium 89 Ac [227.03]	Thorium 90 Th 232.04	Protactinium 91 Pa 231.04	Uranium 92 U 238.03	Np 93 [237.05]	Pu 94 [244.06]	Am 95 [243.06]	Cm 96 [247.07]	Berkelium 97 Bk [247.07]	Californium 98 Cf [251.08]	Einsteinium 99 Es [252.08]	Fermium 100 Fm [257.10]	Mendelevium 101 Md [258.10]	No 102 [259.10]	Actinoids	Actinoids

*lanthanoids

**actinoids

Symbols and names: the symbols and names of the elements, and their spellings are those recommended by the International Union of Pure and Applied Chemistry (IUPAC). Names have yet to be proposed for elements 113, 115, 117, and 118 and so those used here are IUPAC's temporary systematic names. In some countries, the spellings aluminium, caesium, and sulphur are used. Group labels: the numeric system (1-18) used here is the current IUPAC convention. Atomic weights (mean relative masses): these are the IUPAC 2009 values and given to 5 significant figures. The last significant figure of each value is considered reliable to ±1 except where a larger uncertainty is given in parentheses. Recommended values for those elements having an atomic weight interval are given (H, Li, B, C, N, O, S, Cl, Ti). Elements for which the atomic weight is given within brackets have no reliable values and are represented by the element's longest lived isotope reported in the IUPAC 2009 values. ©2013 Dr Mark A. Winter, WebElements Ltd and University of Sheffield. All rights reserved. For updates to this table see http://www.webelements.com/instructions/Printable_Periodic_Table (Version date: 7 June 2013).

Last Name _____

Student Number _____

First Name _____

Quiz 1 – October 8 2015

Chemical Structure
Chemistry 1000 3.0 D
York University
Department of Chemistry

Notes and equations: All questions are to be answered. Non-programable calculators are allowed. Final answers must be in non-erasable ink for the quiz to be remarked. Total marks:30

$R = 8.3145 \text{ J K}^{-1} \text{ mol}^{-1} = 0.082057 \text{ L atm K}^{-1} \text{ mol}^{-1}$ $k = 1.38066 \times 10^{-23} \text{ J K}^{-1}$
Density of mercury = 13.6 g cm^{-3} $g = 9.807 \text{ m s}^{-2}$ $0 \text{ }^\circ\text{C} = 273.15 \text{ }^\circ\text{K}$ $1 \text{ m}^3 = 1000 \text{ L}$
 $N_A = 6.022 \times 10^{23} \text{ molecules mol}^{-1}$ $1 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 760 \text{ mm Hg} = 760 \text{ torr}$

$$F = mg \quad P = \rho gh \quad d = \frac{m}{V} \quad PV = nRT = NkT = \frac{m}{M}RT \quad E = \frac{3}{2}RT \quad E_{\text{kin}} = 1/2mu^2$$

$$\left(P + \frac{n^2a}{V^2}\right)(V - nb) = nRT \quad Z = \frac{PV}{nRT} = \frac{V}{V - nb} - \left(\frac{an}{RTV}\right) \quad P = \frac{1}{3} \frac{Nmu^2}{V} \quad Z_{\text{wall}} = \frac{1}{4} \frac{N}{V} u_{\text{av}}$$

$$Z_A = \sqrt{2} \pi d^2 u_{\text{av}} \frac{N}{V} \quad \lambda = \frac{u_{\text{av}}}{Z_A} \quad \text{Rate of effusion} = \frac{1}{4} \frac{N}{V} u_{\text{av}} A \quad Z_{AA} = \frac{1}{2} Z_A \frac{N}{V}$$

$$u_m = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2kT}{m}} \quad u_{\text{av}} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8kT}{\pi m}} \quad u_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3kT}{m}}$$

Marks

4

1. A 1.00 L mixture of helium, neon and 0.448 g of an unknown gas has a total pressure of 662 mm Hg at 25°C. If the partial pressure of helium is 342 mm Hg and the partial pressure of neon is 112 mm Hg, what is the molecular mass of the unknown gas present in the mixture?

$$M = 40.0 \text{ g/mol}$$

5 2. Circle true or false for the following statements.

a. If a sample of ideal gas in a sealed container of fixed volume is heated from 10 to 50°C the average molecular speed will increase.

TRUE

FALSE

b. If a sample of ideal gas in a sealed container of fixed volume is heated from 10 to 50°C the density of the gas will decrease.

TRUE

FALSE

c. If a sample of ideal gas in a sealed container of fixed volume is heated from 10 to 50°C the number of collisions with the wall per second will increase.

TRUE

FALSE

d. If a sample of ideal gas in a sealed container of fixed volume is heated from 10 to 50°C the pressure of the gas will remain constant.

TRUE

FALSE

e. If a sample of ideal gas in a sealed container of fixed volume is heated from 10 to 50°C the total kinetic energy will increase.

TRUE

FALSE

- 5 3. In order to determine the rate of photosynthesis, the oxygen gas emitted by an aquatic plant was collected over water at a temperature of 293.15 °K and a total pressure of 755.2 mm Hg. During a certain time period, a total of 1.02 L of gas was collected. How many grams of oxygen gas was formed? A table of vapour pressure is available at the end of the exam.

$$m = 1.32 \text{ g}$$

4. An open-end manometer containing silicon oil as the fluid is used to measure the pressure of gas in a bulb. The level of oil in the side attached to the bulb is 136 cm higher than that in the side open to the atmosphere. Atmospheric pressure is 92.4 kPa. What is the pressure of gas in the bulb (in mm Hg)? Assume that the density of silicon oil is 1.30 g mL^{-1} .

$$P_{\text{gas}} = 680 \text{ mm Hg}$$

- 7 5a. Electrical power plants use very high pressures of steam. A 2500 m^3 boiler contains $140 \times 10^3 \text{ kg}$ of steam at 540°C . What is the pressure of water vapour in this boiler assuming it is an ideal gas?

$$P = 207 \text{ atm}$$

- b. What is the pressure if it obeys the van der Waals equation with $a=5.464 \text{ atm L}^2 \text{ mol}^{-2}$ and $b=0.03049 \text{ L mol}^{-1}$?

$$P = 176 \text{ atm}$$

- 5 6. It is possible to cool a gas by using a laser to slow the motion of the molecules in the gas phase. The photons from the laser exert a pressure on the molecules in the gas phase which slows them. For sodium (Na) molecules in the gas phase it is possible to slow the molecules to a rms speed of 201 mm s^{-1} . What is the temperature of this laser-cooled gas?

$$T = 3.72 \times 10^{-5} \text{ K}$$

Vapour Pressure of Water versus Temperature			
Temperature (°C)	Pressure (mm Hg)	Temperature (°C)	Pressure (mm Hg)
0	4.58	55	118.2
5	6.54	60	149.6
10	9.21	65	187.5
15	12.79	70	233.7
20	17.55	75	289.1
25	23.78	80	355.1
30	31.86	85	433.6
35	42.23	90	525.8
40	55.40	95	633.9
45	71.97	100	760.0
50	92.60		

Periodic Table

1 H 1.00794																	2 He 4.00260										
3 Li 6.941	4 Be 9.01218															9 F 18.9984	10 Ne 20.1797										
11 Na 22.98976	12 Mg 24.3050															17 Cl 35.453	18 Ar 39.948										
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9380	26 Fe 55.845	27 Co 58.9332	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.64	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 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.9045	54 Xe 131.293										
55 Cs 132.9055	56 Ba 137.327	71 Lu 174.967	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.222	78 Pt 195.078	79 Au 196.9666	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.9804	84 Po [209]	85 At [209.99]	86 Rn [222.018]										
87 Fr [223.021]	88 Ra [226.075]	103 Lr [262.11]	104 Rf [261.10]	105 Db [262.10]	106 Sg [266.12]	107 Bh [264.12]	108 Hs [269.13]	109 Mt [268.10]	110 Ds [271.13]	111 Rg [272.15]	112 Cn [277]	113 Nh [284]	114 Fl [289]	115 Mc [288]	116 Lv [292]												
57 La [138.9055]	58 Ce [140.116]	59 Pr [140.9077]	60 Nd [144.24]	61 Pm [145]	62 Sm [150.36]	63 Eu [151.964]	64 Gd [157.25]	65 Tb [158.9253]	66 Dy [162.50]	67 Ho [164.9303]	68 Er [167.259]	69 Tm [168.9342]	70 Yb [173.04]	89 Ac [227.033]	90 Th [232.0381]	91 Pa [231.0360]	92 U [238.0289]	93 Np [237.048]	94 Pu [244.0642]	95 Am [243.061]	96 Cm [247.07]	97 Bk [247.07]	98 Cf [251.08]	99 Es [252.083]	100 Fm [257.10]	101 Md [258.10]	102 No [259.10]

Last Name _____

Student Number _____

First Name _____

Quiz 2 – October 22 2015

Chemical Structure
Chemistry 1000 3.0 D
York University
Department of Chemistry

Notes and equations: All questions are to be answered. Non-programable calculators are allowed. Final answers must be in non-erasable ink for the quiz to be remarked. Total marks:30

$R=8.3145 \text{ J K}^{-1} \text{ mol}^{-1}=0.082057 \text{ L atm K}^{-1} \text{ mol}^{-1}$ $k=1.38066 \times 10^{-23} \text{ J K}^{-1}$ $g = 9.807 \text{ m s}^{-2}$
 $N_A=6.022 \times 10^{23} \text{ molecules mol}^{-1}$ $0 \text{ }^\circ\text{C}=273.15 \text{ }^\circ\text{K}$ $1 \text{ atm}=1.013 \times 10^5 \text{ Pa}=760 \text{ mm Hg}=760 \text{ torr}$
 $1 \text{ cal} = 4.18 \text{ J}$ $C_s (\text{Aluminum}) = 0.897 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$ $C_s (\text{H}_2\text{O}) = 4.184 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$

$q = m C_s \Delta T$, $q = n C_p \Delta T$, $w = F d = -P \Delta V$, $\Delta H = \Delta U + \Delta PV$

Total marks: 30

Marks

- 4 1. How much work (in J) is required to expand the volume of a pump from 1.3 to 3.8 L against an external pressure of 836 mm Hg at a constant temperature of 20 °C?

$$W = -2.8 \times 10^2 \text{ J}$$

5 2. Circle the correct answer for the following statements or questions.

a. If a person pushes against an object that doesn't move, does that person do work?

YES

NO

b. If a 1 kg block of aluminum and 1 kg of water, both at room temperature, are placed in a refrigerator at 5°C. After 1 hour the temperature of each object is measured and one is colder than the other, which object is colder?

Water is colder

Aluminum is colder

c. In a closed system, energy and matter can not be exchanged with the surroundings.

TRUE

FALSE

d. In an open system, only energy can be exchanged with the surroundings.

TRUE

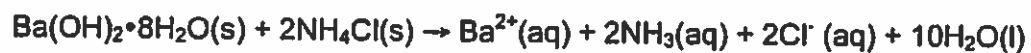
FALSE

e. When heat flows between a system and the surroundings heat is positive if heat is supplied to the system.

TRUE

FALSE

- 8 3. For the reaction below the two solids are mixed and the reaction takes place quickly between the solids.



- a. Using the table provided, what is the enthalpy of the reaction per mole of $\text{Ba(OH)}_2 \cdot 8\text{H}_2\text{O(s)}$?

$$\Delta H = 80.22 \text{ kJ/mol}$$

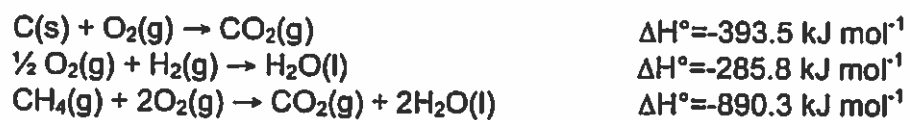
- b. If 250 g of $\text{Ba(OH)}_2 \cdot 8\text{H}_2\text{O(s)}$ was reacted with 85 g of $\text{NH}_4\text{Cl(s)}$ in an insulated cup initially at 50 °C, what is the the final temperature of the reaction products? Assume the specific heat of the reaction mixture is $4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$.

$$T_f = 4.6^\circ\text{C}$$

- 7 4 a. Write the balanced chemical reaction for the formation of methane, CH₄ (g).

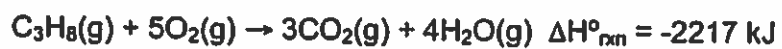


- b. Using the information below calculate the standard heat of formation for CH₄ (g).



$$\Delta H_{\text{rxn}} = -74.8 \text{ kJ/mol}$$

- 6 5. The propane fuel (C_3H_8) used as gas barbeque fuel burns according to the equation:



If a steak must absorb 1.60×10^3 kJ to be cooked "well done" but only half as much to be cooked to "medium" and if only 10.0% of the heat produced by the barbeque goes into cooking the meat, what mass of CO_2 is saved from emission into the atmosphere by cooking a steak to "medium" and not "well done"?

476 g

TABLE D-2 Thermodynamic Properties of Substances at 298.15 K^a
 Substances are at 1 bar pressure. For aqueous solutions, solutes are
 at unit activity (roughly 1 M). Data for ions in aqueous solution
 are relative to values of zero for ΔH_f° , ΔG_f° , and S° for H⁺.

Inorganic Substances

	ΔH_f° , kJ mol ⁻¹	ΔG_f° , kJ mol ⁻¹	S° , J mol ⁻¹ K ⁻¹
Barium			
Ba(s)	0	0	62.8
Ba ²⁺ (aq)	-537.6	-560.8	9.6
BaCO ₃ (s)	-1216	-1138	112.1
BaCl ₂ (s)	-858.6	-810.4	123.7
BaF ₂ (s)	-1207	-1157	96.36
BaO(s)	-553.5	-525.1	70.42
Ba(OH) ₂ (s)	-944.7	—	—
Ba(OH) ₂ ·8 H ₂ O(s)	-3342	-2793	427
BaSO ₄ (s)	-1473	-1362	132.2
Chlorine			
Cl(g)	121.7	105.7	165.2
Cl ⁻ (aq)	-167.2	-131.2	56.5
Cl ₂ (g)	0	0	223.1
ClF ₃ (g)	-163.2	-123.0	281.6
ClO ₂ (g)	102.5	120.5	256.8
Cl ₂ O(g)	80.3	97.9	266.2
Hydrogen			
H(g)	218.0	203.2	114.7
H ⁺ (aq)	0	0	0
H ₂ (g)	0	0	130.7
HBr(g)	-36.40	-53.45	198.7
HCl(g)	-92.31	-95.30	186.9
HCl(aq)	-167.2	-131.2	56.5
HClO ₂ (aq)	-51.9	5.9	188.3
HCN(g)	135.1	124.7	201.8
HF(g)	-271.1	-273.2	173.8
HI(g)	26.48	1.70	206.6
HNO ₃ (l)	-174.1	-80.71	155.6
HNO ₃ (aq)	-207.4	-111.3	146.4
H ₂ O(g)	-241.8	-228.6	188.8
H ₂ O(l)	-285.8	-237.1	69.91
H ₂ O ₂ (g)	-136.3	-105.6	232.7
H ₂ O ₂ (l)	-187.8	-120.4	109.6
H ₂ S(g)	-20.63	-33.56	205.8
H ₂ SO ₄ (l)	-814.0	-690.0	156.9
H ₂ SO ₄ (aq)	-909.3	-744.5	20.1
Nitrogen			
N(g)	472.7	455.6	153.3
N ₂ (g)	0	0	191.6
NF ₃ (g)	-124.7	-83.2	260.7
NH ₃ (g)	-46.11	-16.45	192.5
NH ₃ (aq)	-80.29	-26.50	111.3
NH ₄ ⁺ (aq)	-132.5	-79.31	113.4
NH ₄ Br(s)	-270.8	-175.2	113
NH ₄ Cl(s)	-314.4	-202.9	94.6
NH ₄ F(s)	-464.0	-348.7	71.96
NH ₄ HCO ₃ (s)	-849.4	-665.9	120.9

Last Name _____

Student Number _____

First Name _____

Quiz 3 – November 26 2015

Chemical Structure
Chemistry 1000 3.0 D
York University
Department of Chemistry

Notes and equations: All questions are to be answered. Non-programable calculators are allowed. Final answers must be in non-erasable ink for the quiz to be remarked. Total marks:30

$$R = 8.3145 \text{ J K}^{-1} \text{ mol}^{-1} = 0.082057 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

$$g = 9.807 \text{ m s}^{-2}$$

$$N_A = 6.022 \times 10^{23} \text{ molecules mol}^{-1}$$

$$a_0 = 53 \text{ pm}$$

$$R_H = 2.179 \times 10^{-18} \text{ J}$$

$$h = 6.62606876 \times 10^{-34} \text{ J s}$$

$$k = 1.38066 \times 10^{-23} \text{ J K}^{-1}$$

$$0 \text{ }^\circ\text{C} = 273.15 \text{ }^\circ\text{K}$$

$$c = 2.99792485 \times 10^8 \text{ m s}^{-1}$$

$$E = h\nu, \quad c = \lambda\nu, \quad \Delta E = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right), \quad \lambda = \frac{h}{m\nu}$$

Total marks: 30

Marks

1 1. Given the following electronic configurations identify the atom.

a. $[\text{Kr}]5s^2$ atom: Sr

b. $[\text{Ne}]3s^2 3p^6$ atom: Ar

1 2. Write the electronic configurations of the following atoms.

a. Ag configuration: $[\text{Kr}]5s^1 4d^{10}$

b. Cr configuration: $[\text{Ar}]4s^1 3d^5$

1 3. For $l=3$ what are the possible values of m_l ?

-3, -2, -1, 0, 1, 2, 3

- 1 4. Which electron, on average, is closer to the nucleus: an electron in the 2s or 3s orbital?

2s

- 6 5 a. For the following ions which has the largest ionic radius and which the smallest?
 I^- , Cl^- , Br^- .

largest: I^- smallest: Cl^-

- b. For the following ions which has the largest ionic radius and which the smallest?
 P^{3-} , Cl^- , S^{2-} .

largest: P^{3-} smallest: Cl^-

- c. For the following atoms which has the largest first ionization energy and which the smallest? Ne, Li, Na.

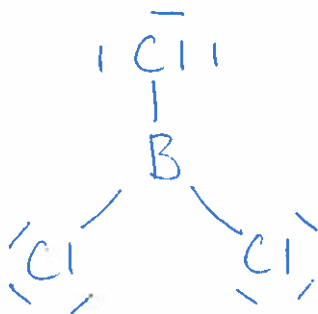
largest: Ne smallest: Na

- 4 6. Draw the most likely Lewis structures for the following molecules. Indicate any non-zero formal charges and draw lone pairs.

- a. ClO_2



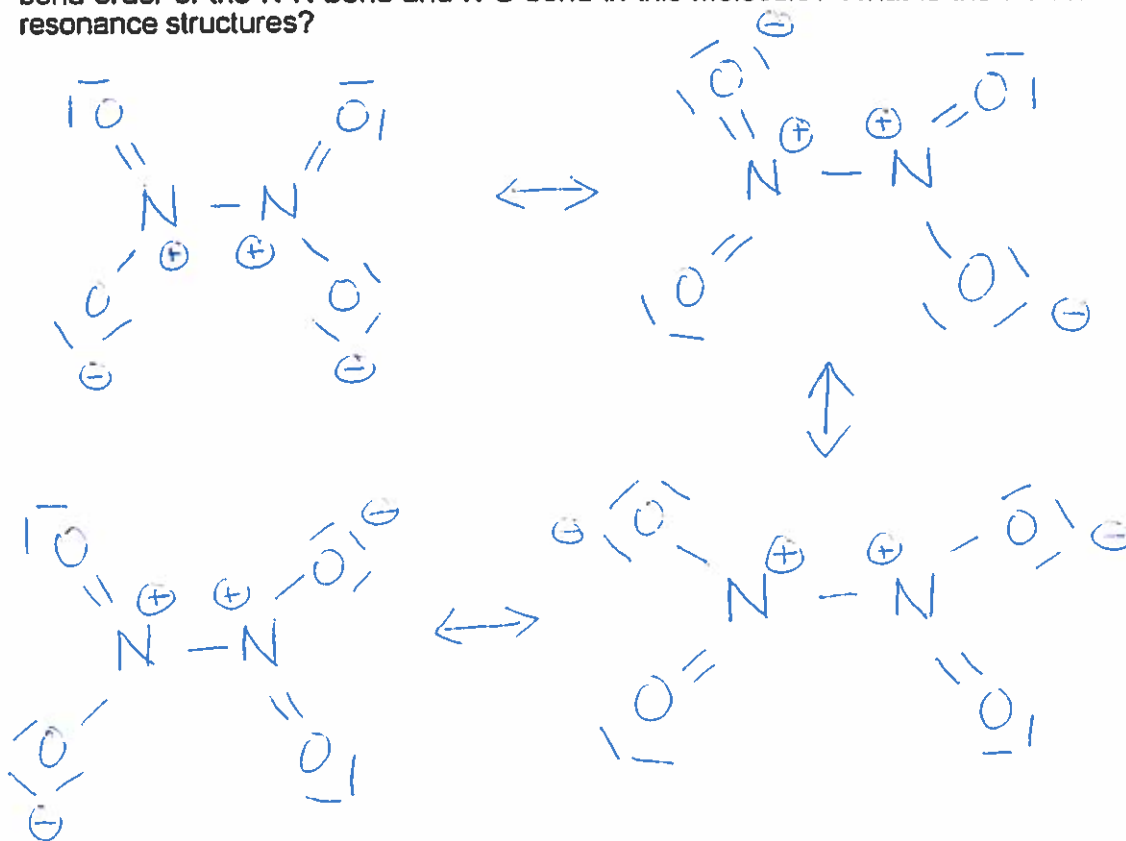
- b. BCl_3



- 5 7. Ultraviolet radiation and radiation of shorter wavelength can damage biomolecules as they carry enough energy to break bonds. A carbon-carbon bond takes 348 kJ mol^{-1} to break. What is the longest wavelength of radiation with enough energy to break carbon-carbon bonds?

$$\lambda = 342 \text{ nm}$$

- 3 8. The poisonous and colorless gas N_2O_4 is used in rocket fuel as an oxidant. For the most likely Lewis structure draw all the resonance forms of N_2O_4 . Indicate the formal charge on each atom in the resonance structure(s) and indicate lone pairs. What is the bond order of the N-N bond and N-O bond in this molecule? What is the total number of resonance structures?



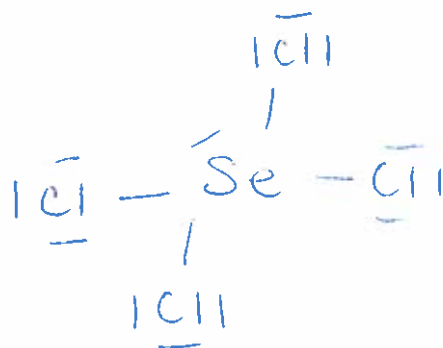
Total number of resonance structures: 4

N-N bond order: 1

N-O bond order: 1.5

6 9. Draw the Lewis structure for the following molecules and name the molecular geometry. Indicate any non-zero formal charges and draw lone pairs.

a. SeCl_4



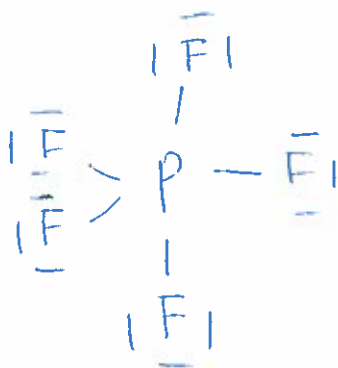
molecular geometry: see saw

b. H_3O^+



molecular geometry: trigonal pyramidal

c. PF_5



molecular geometry: trigonal bipyramidal

2 10. For the following molecular geometries give the number of bond pairs and number of lone pairs on the central atom.

a. square planar:

number of bond pairs: 4

number of lone pairs: 2

b. octahedral:

number of bond pairs: 6

number of lone pairs: 0

c. square pyramidal:

number of bond pairs: 5

number of lone pairs: 1

d. tetrahedral:

number of bond pairs: 4

number of lone pairs: 0

