Name (**in ink**) _____

Student Number (**in ink**) _____

Fall 2011 SC/CHEM 1000 A - Quiz #1

October 6, 2011

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 your final answer must be in ink.**

Time Allowed: 50 minutes **Total Marks = 30**

1. **(8 pts)** A balloon is filled with He(g) to a volume of 18.3 L and the pressure inside the balloon was measured to be 1280 torr at 26.0°C, and given to your 9 year old son, who immediately started complaining that it was "losing gas". After 20.0 minutes, the balloon shrunk to 17.8 L, but the pressure remained the same. Obviously there is a hole somewhere in the balloon, but it's too small to see. Your son demands that you estimate the diameter of the hole … and so do I. Please estimate the diameter of the hole in the balloon. I'll break the problem up into parts to make it easier.

A. **(2 pt)** Calculate the number of moles of He(g) initially in the balloon (before any leaked out).

1.255 mol

B. **(2 pts)** Calculate the collision frequency per unit area of the gas on the inside surface of the balloon at initial conditions (before any gas leaked out).

1.299×10^{28} atoms s^{-1} m^{-2}

C. **(2 pt)** Calculate the number of moles of gas that leaked out.

3.400×10^{-2}

D. **(2 pts)** Using your answers for parts B and C, estimate the diameter of the hole.

40.9 μm

2. **(6 pts)** Consider the following reaction,

$$3\ H_2(g) + CHCl_3(l) \rightarrow CH_4(g) + 3\ HCl(g)$$

This reaction is conducted in a sealed 1.80 L flask containing 4.02 g $CHCl_3$ and 2.20 atm H_2 at 25°C. Calculate the total pressure in the flask after the reaction is complete.

2.66 atm

3. **(6 pts)** 215 g (4.89 mol) of dry ice, $CO_2(s)$, is placed in a 1.98 L vessel containing 1.00 atm air, and the vessel was sealed tightly. After all the dry ice evaporated into $CO_2(g)$, the total pressure in the vessel was measured to be 45.8 atm at 25°C.

A. **(1 pt)** What is the partial pressure of $CO_2(g)$ in the vessel (yes, this is easy)?

44.8 atm

B. **(2 pts)** Use the Ideal Gas Law to calculate the $CO_2(g)$ pressure in the vessel.

60.4 atm

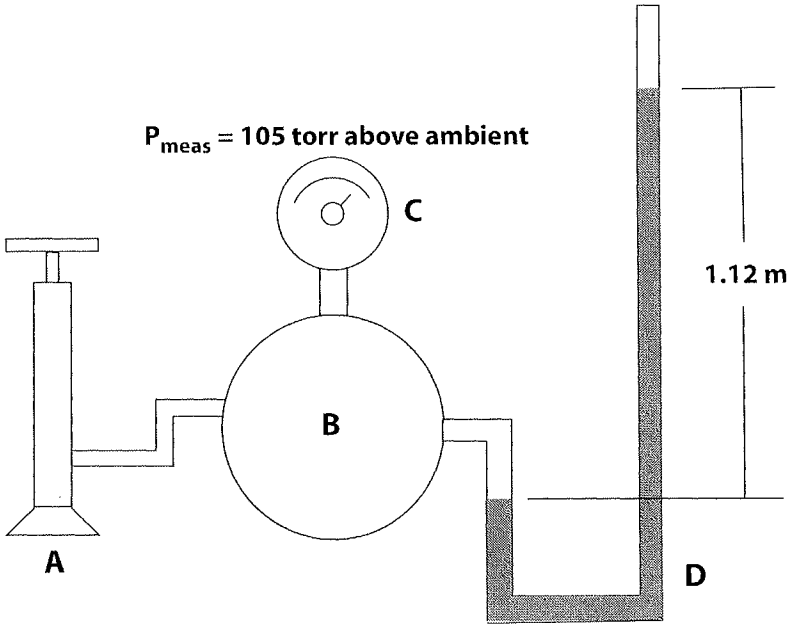
C. **(3. pts)** Use the van der Waals equation to calculate the $CO_2(g)$ pressure in the vessel, given the following constants for $CO_2(g)$: a = 3.59 L^2 atm mol^{-2}, and b = 0.0427 L mol^{-1}.

45.6 atm

4. **(4 pts)** The RMS average speed of a N_2 molecule in N_2 gas at room temperature is 515 m s^{-1}. At what temperature is the RMS average speed of the N_2 molecules equal to 120 km hr^{-1}, the typical speed of a car on the 407?

1.2 k

5. **(6 pts)** Your 9 year old son was in the kitchen on day, and became curious about the density of honey. In the kitchen he had no way of measuring weight or volume. So he decided to measure the density of honey by rigging up the following contraption using a bicycle tire pump(**A**), a vessel of unknown volume (**B**), a tire pressure gauge (**C**), and a U-shaped glass tube he found in the backyard (**D**). He put the honey in the glass tube, which is open at one end and connected to the vessel at the other, then pressurized the system with a few pushes on the tire pump. The pressure gauge read that the pressure in the system was 105 torr above ambient. Using a tape measure, he measured the height indicated in the diagram to be 1.12 m. From these data he was able to calculate the density of honey. Please do the same.



$1.28\ g\ mL^{-1}$

Equations

$PV = nRT$

$\Delta U = q + w$

$H = U + PV$

$w = -\int PdV$

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

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

$E = mc^2$

$E = h\nu$

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

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

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

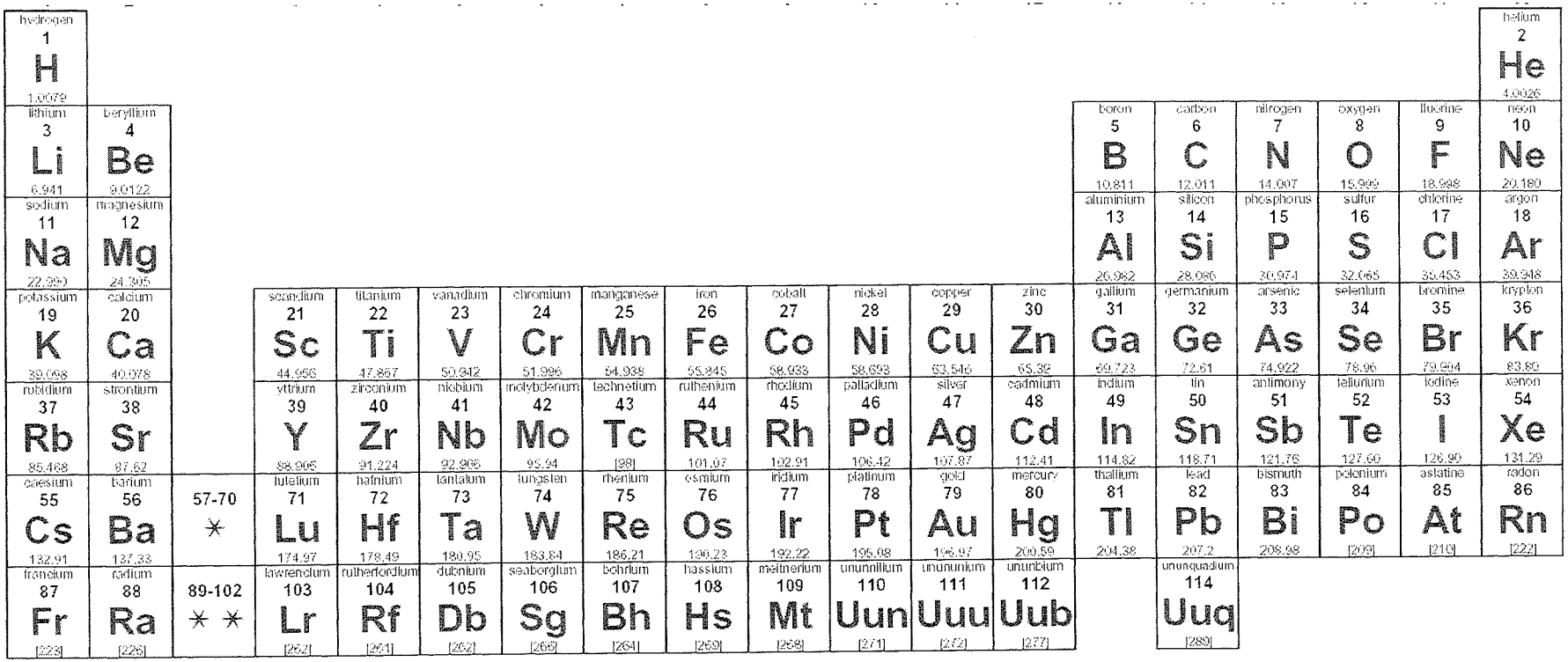
Fundamental Constants

$N_A = 6.022 \times 10^{23}\ mol^{-1}$
$g = 9.807\ m\ s^{-1}$
$R_H = 2.179 \times 10^{-18}\ J$
$c = 2.998 \times 10^{8}\ m\ s^{-1}$
$e^- = -1.602 \times 10^{-19}\ C$
$h = 6.626 \times 10^{-34}\ J\ s$
$R = 8.314\ J\ mol^{-1}\ K^{-1} = 0.08206\ L\ atm\ K^{-1}\ mol^{-1}$
$m_e = 9.109 \times 10^{-31}\ kg$
$m_p = 1.673 \times 10^{-27}\ kg$
$k = 1.381 \times 10^{-23}\ J\ K^{-1}$

Useful Data

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

$\rho_{H2O(l)} = 1.00\ g\ cm^{-3}$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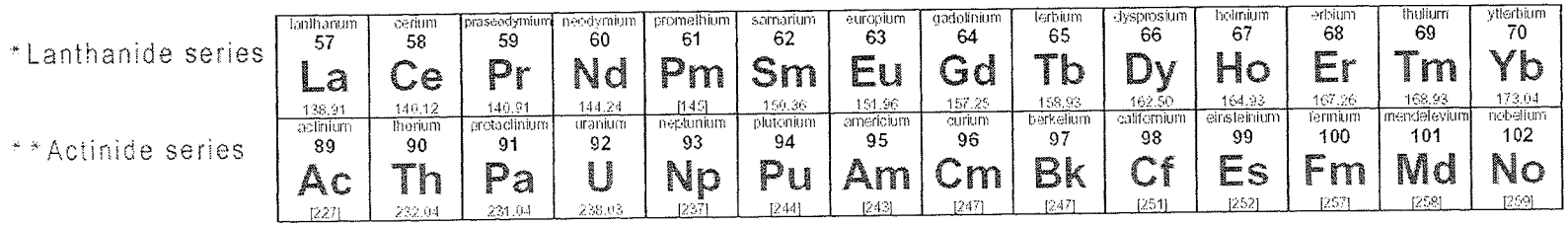
helium 2 He 4.0026
lithium 3 Li 6.941
beryllium 4 Be 9.0122
boron 5 B 10.811
carbon 6 C 12.011
nitrogen 7 N 14.007
oxygen 8 O 15.999
fluorine 9 F 18.998
neon 10 Ne 20.180
sodium 11 Na 22.990
magnesium 12 Mg 24.305
aluminium 13 Al 26.982
silicon 14 Si 28.086
phosphorus 15 P 30.974
sulfur 16 S 32.065
chlorine 17 Cl 35.453
argon 18 Ar 39.948
potassium 19 K 39.098
calcium 20 Ca 40.078
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 65.39
gallium 31 Ga 69.723
germanium 32 Ge 72.61
arsenic 33 As 74.922
selenium 34 Se 78.96
bromine 35 Br 79.904
krypton 36 Kr 83.80
rubidium 37 Rb 85.468
strontium 38 Sr 87.62
yttrium 39 Y 88.906
zirconium 40 Zr 91.224
niobium 41 Nb 92.906
molybdenum 42 Mo 95.94
technetium 43 Tc [98]
ruthenium 44 Ru 101.07
rhodium 45 Rh 102.91
palladium 46 Pd 106.42
silver 47 Ag 107.87
cadmium 48 Cd 112.41
indium 49 In 114.82
tin 50 Sn 118.71
antimony 51 Sb 121.76
tellurium 52 Te 127.60
iodine 53 I 126.90
xenon 54 Xe 131.29
caesium 55 Cs 132.91
barium 56 Ba 137.33
57-70 *
lutetium 71 Lu 174.97
hafnium 72 Hf 178.49
tantalum 73 Ta 180.95
tungsten 74 W 183.84
rhenium 75 Re 186.21
osmium 76 Os 190.23
iridium 77 Ir 192.22
platinum 78 Pt 195.08
gold 79 Au 196.97
mercury 80 Hg 200.59
thallium 81 Tl 204.38
lead 82 Pb 207.2
bismuth 83 Bi 208.98
polonium 84 Po [209]
astatine 85 At [210]
radon 86 Rn [222]
francium 87 Fr [223]
radium 88 Ra [226]
89-102 * *
lawrencium 103 Lr [262]
rutherfordium 104 Rf [261]
dubnium 105 Db [262]
seaborgium 106 Sg [266]
bohrium 107 Bh [264]
hassium 108 Hs [269]
meitnerium 109 Mt [268]
ununnilium 110 Uun [271]
unununium 111 Uuu [272]
ununbium 112 Uub [277]
ununquadium 114 Uuq [289]


*Lanthanide series
**Actinide series
lanthanum 57 La 138.91
cerium 58 Ce 140.12
praseodymium 59 Pr 140.91
neodymium 60 Nd 144.24
promethium 61 Pm [145]
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 173.04
actinium 89 Ac [227]
thorium 90 Th 232.04
protactinium 91 Pa 231.04
uranium 92 U 238.03
neptunium 93 Np [237]
plutonium 94 Pu [244]
americium 95 Am [243]
curium 96 Cm [247]
berkelium 97 Bk [247]
californium 98 Cf [251]
einsteinium 99 Es [252]
fermium 100 Fm [257]
mendelevium 101 Md [258]
nobelium 102 No [259]

Name (**in ink**) _____

Student Number (**in ink**) _____

Fall 2011 SC/CHEM 1000 A - Quiz #2

November 3, 2011

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 ink.**

Time Allowed: 50 minutes **Total Marks = 30**

1. **(2 pts)** What is the maximum number of electrons that can have the following quantum numbers?

(a) $n = 2$, $m_s = +½$ 4

(b) $n = 4$, $m_l = 1$ 6

(c) $n = 3$, $l = 2$ 10

(d) $n = 4$, $l = 3$, $m_l = -2$ 2

2. **(2 pts)** The ground-state electron configurations listed below are incorrect. Briefly explain what mistakes have been made in each one.

Al: $1s^2 2s^2 2p^4 3s^2 3p^3$ SHOULD BE $2p^1$

B: $1s^2 2s^2 2p^5$ SHOULD BE 1

F: $1s^2 2s^2 2p^6$ SHOULD BE 5

Ge: $[Kr] 3d^{10} 4s^2 4p^2$

SHOULD BE [Ar]

3. **(3 pts)** For each of the following species, write the ground-state electronic configuration in short hand notation.

Ga: [Ar] $3d^{10}\ 4s^2\ 4p^1$

Ag^+: [Kr] $4d^{10}$

Ir^{4+}: [Xe] $4f^{14}\ 5d^5$

Se^{2-}: [Ar] $3d^{10}\ 4s^2\ 4p^6$

Pb: [Xe] $4f^{14}\ 5d^{10}\ 6s^2\ 6p^2$

Zn^{2+}: [Ar] $3d^{10}$

4. **(4 pts)** Certain sunglasses have small crystals of silver chloride (AgCl) incorporated in the lenses. When the lenses are exposed to light of an appropriate wavelength, the following reaction occurs

$$AgCl \rightarrow Ag + Cl$$

The elemental silver is produced as nanophase particles that provide a uniform gray color that reduces the glare. If ΔH for the reaction above is 248 kJ mol^{-1}, calculate the maximum wavelength of light that can induce this process.

$\lambda_{max} = 482$ nm

5. **(4 pts)** Indicate which of the two species in each of the following pairs is smaller

(a) Cl or Cl^-

(b) Na or Na^+

(c) O^{2-} or S^{2-}

(d) Mg^{2+} or Al^{3+}

(e) Au^+ or Au^{3+}

6. **(6 pts)** Consider the reaction

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) \qquad \Delta H = -92.6 \text{ kJ mol}^{-1}$$

If 2.0 mol of N_2 is mixed with 6.0 mol of H_2 and the reaction is taken to completion at a constant pressure of 1.0 atm (so the volume of the vessel changes) and a constant temperature of 392 K,

(a) **(2 pts)** How many joules of work was done on the system?

13.0 kJ

(b) **(2 pts)** How much heat was released by the system?

− 185 kJ

(c) **(2 pts)** Calculate the change in internal energy (ΔU) of the system

− 172 kJ

7. **(5 pts)** You mix 88.6 g of water at 74.3°C with 57.9 g of water at 24.8°C in an insulated flask. What is the final temperature of the combined water?

$T_f = 54.7^\circ C$

8. **(4 pts)** Indicate the number of unpaired electrons in each of the following atoms or ions

(a) B 1

(b) Ne 0

(c) Sc 1

(d) Fe^{2+} 4

(e) Cu^{2+} 1

(f) Cu^{+} 0

(g) I 1

(h) La 1

Equations

$PV = nRT$

$\Delta U = q + w$

$H = U + PV$

$w = -\int PdV$

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

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

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

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

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Fundamental Constants

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Useful Data

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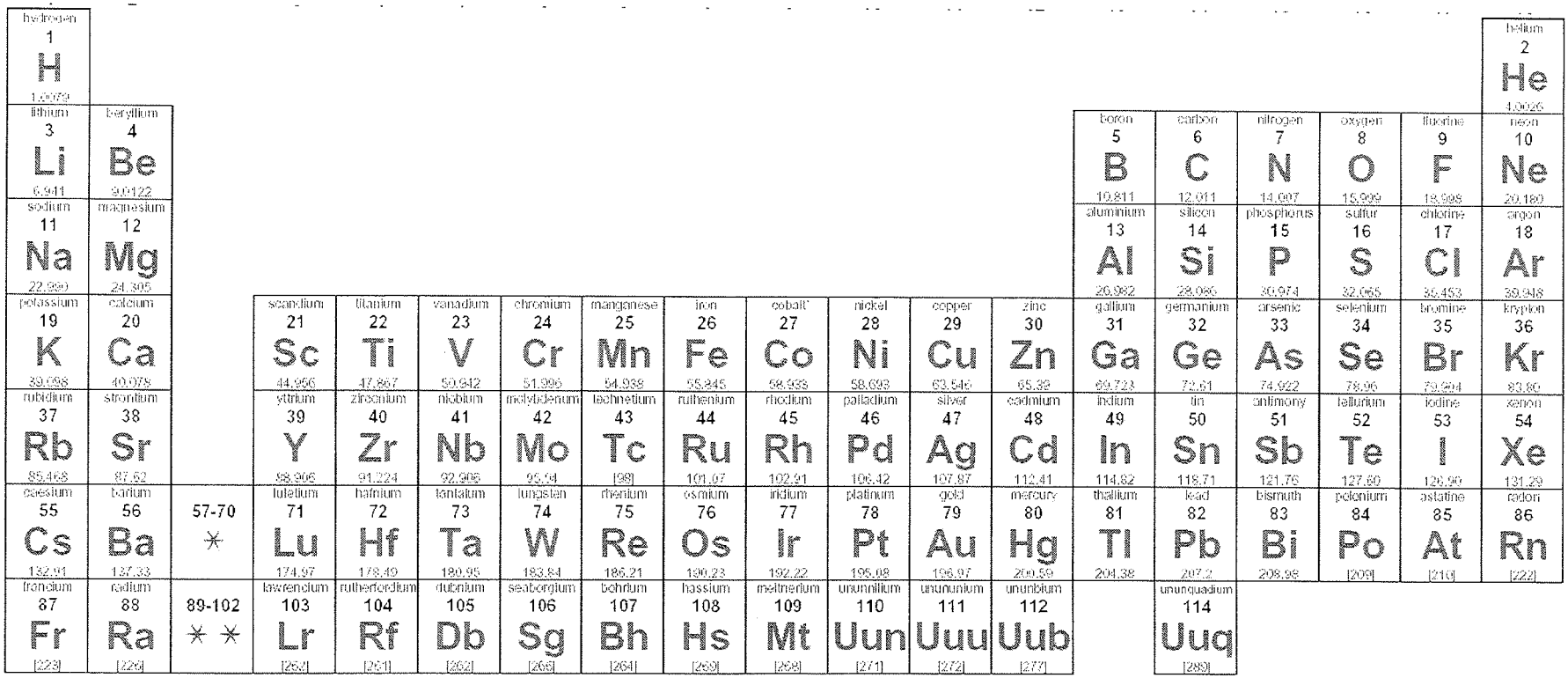
hydrogen 1 H 1.0079
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cobalt 27 Co 58.933
nickel 28 Ni 58.693
copper 29 Cu 63.546
zinc 30 Zn 65.39
gallium 31 Ga 69.723
germanium 32 Ge 72.61
arsenic 33 As 74.922
selenium 34 Se 78.96
bromine 35 Br 79.904
krypton 36 Kr 83.80
rubidium 37 Rb 85.468
strontium 38 Sr 87.62
yttrium 39 Y 88.906
zirconium 40 Zr 91.224
niobium 41 Nb 92.906
molybdenum 42 Mo 95.94
technetium 43 Tc [98]
ruthenium 44 Ru 101.07
rhodium 45 Rh 102.91
palladium 46 Pd 106.42
silver 47 Ag 107.87
cadmium 48 Cd 112.41
indium 49 In 114.82
tin 50 Sn 118.71
antimony 51 Sb 121.76
tellurium 52 Te 127.60
iodine 53 I 126.90
xenon 54 Xe 131.29
caesium 55 Cs 132.91
barium 56 Ba 137.33
57-70 *
lutetium 71 Lu 174.97
hafnium 72 Hf 178.49
tantalum 73 Ta 180.95
tungsten 74 W 183.84
rhenium 75 Re 186.21
osmium 76 Os 190.23
iridium 77 Ir 192.22
platinum 78 Pt 195.08
gold 79 Au 196.97
mercury 80 Hg 200.59
thallium 81 Tl 204.38
lead 82 Pb 207.2
bismuth 83 Bi 208.98
polonium 84 Po [209]
astatine 85 At [210]
radon 86 Rn [222]
francium 87 Fr [223]
radium 88 Ra [226]
89-102 * *
lawrencium 103 Lr [262]
rutherfordium 104 Rf [261]
dubnium 105 Db [262]
seaborgium 106 Sg [266]
bohrium 107 Bh [264]
hassium 108 Hs [269]
meitnerium 109 Mt [268]
ununnilium 110 Uun [271]
unununium 111 Uuu [272]
ununbium 112 Uub [277]
ununquadium 114 Uuq [289]
* Lanthanide series
lanthanum 57 La 138.91
cerium 58 Ce 140.12
praseodymium 59 Pr 140.91
neodymium 60 Nd 144.24
promethium 61 Pm [145]
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 173.04
* * Actinide series
actinium 89 Ac [227]
thorium 90 Th 232.04
protactinium 91 Pa 231.04
uranium 92 U 238.03
neptunium 93 Np [237]
plutonium 94 Pu [244]
americium 95 Am [243]
curium 96 Cm [247]
berkelium 97 Bk [247]
californium 98 Cf [251]
einsteinium 99 Es [252]
fermium 100 Fm [257]
mendelevium 101 Md [258]
nobelium 102 No [259]

Name (**in ink**) _____

Student Number (**in ink**) _____

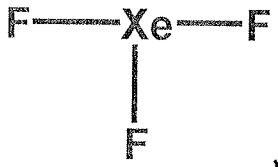
Fall 2011 SC/CHEM 1000 A - Quiz #3

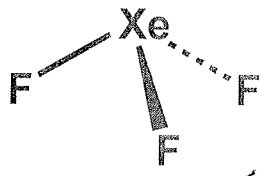
November 24, 2011

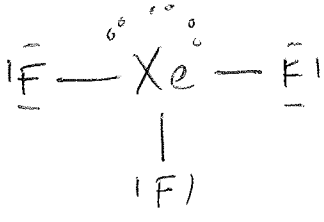
Calculators are permitted. Answer all questions on this paper; **additional paper for rough work is not permitted. You may carry out your work in pencil if you wish, but please write your final answer in ink.**

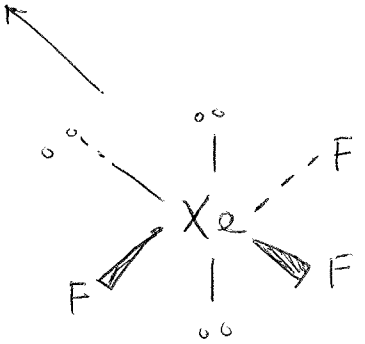
Time Allowed: 50 minutes **Total Marks = 30**

1. **(6 pts)** Consider the hypothetical anion XeF_3^-. Theoretically, this ion can exist in one of two forms show below, T-shaped (left) and trigonal pyramidal (right). Use VSEPR theory to determine with of these two forms would be the more likely structure should anyone ever succeed in making this anion. **NOTE: You MUST show your work, including a Lewis structure. An answer without demonstrating a logical progression into it will be marked wrong since there is a 50% chance of getting it right by random guess.**



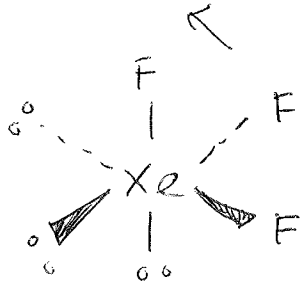






2 Possibilities

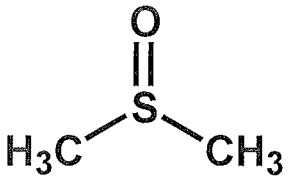
2 LP-LP



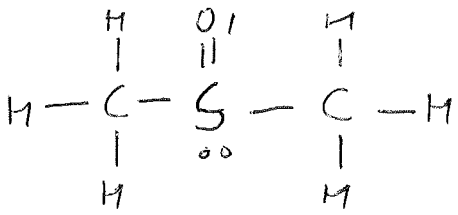
3 LP-LP

∴ T-SHAPE IS PREFERRED

2. Consider the hypervalent sulphur molecule dimethyl sulfoxide (DMSO), shown below.



(a) **(2 pts)** Please draw a full Lewis dot structure for this molecule.



(b) **(1 pts)** referring to your structure in part (a), what are the formal Lewis charges on

S 0

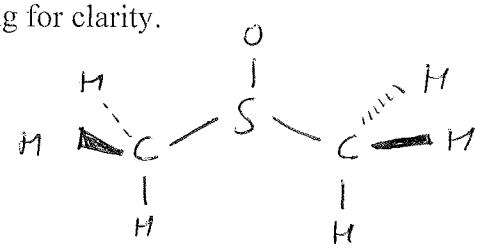
O 0

(c) **(2 pts)** using VSEPR theory, what is the local symmetry on

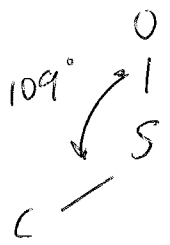
C T_d

O BIG PLAN

(d) **(2 pts)** draw a three-dimensional representation of the DMSO molecule, making sure to impart three-dimensionality using dotted lines and exploded lines. Please omit any lone pairs in this drawing for clarity.



(e) **(1 pt)** To within 4°, estimate the OSC bond angle



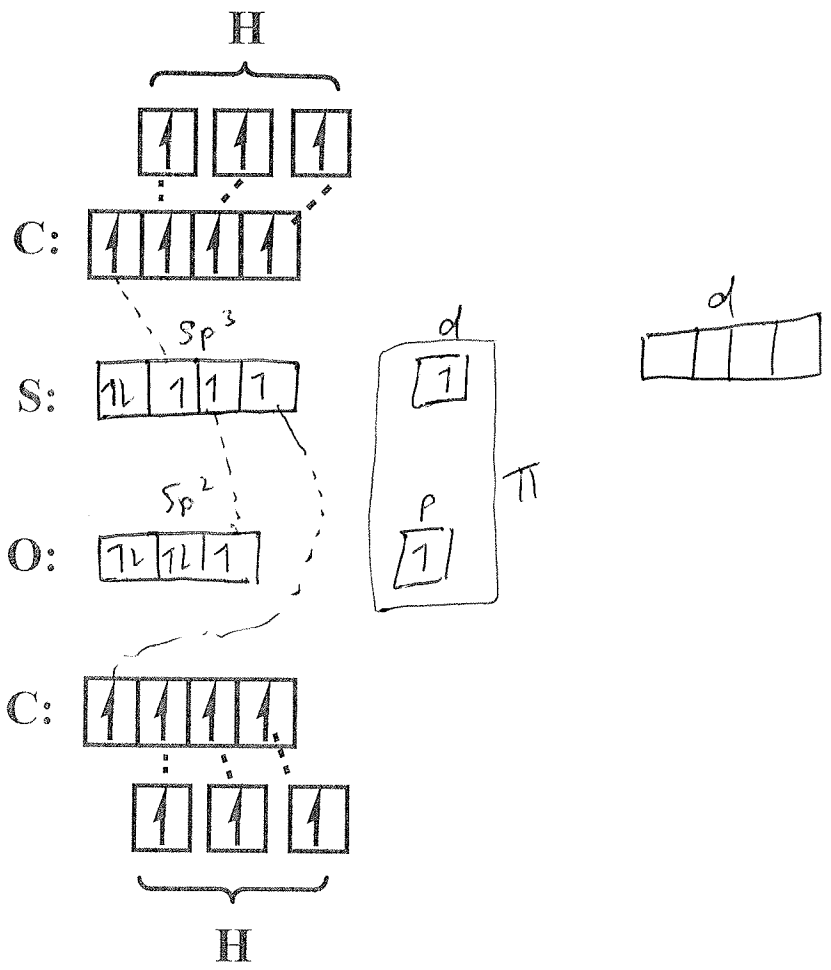
3. Referring to DMSO,

(a) **(2 pts)** The atomic orbital hybridization on carbon is sp^3. What are the atomic orbital hybridizations on

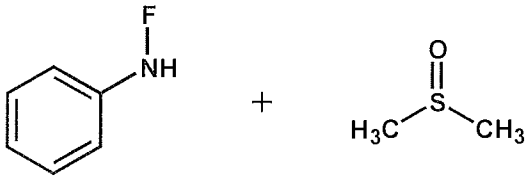
S sp^3

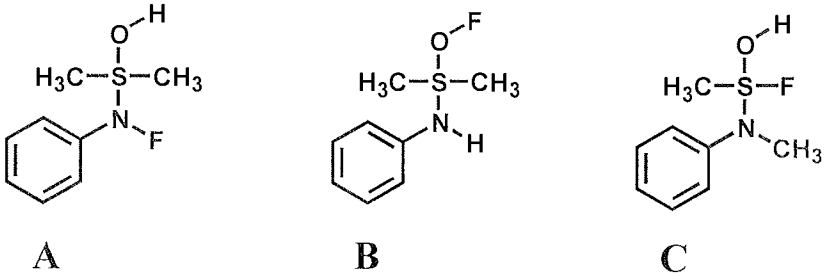
O sp^2

(b) **(4 pts)** Complete the valence-bond diagram for DMSO below. Make sure you include all necessary hybrid and unhybridized atomic orbitals, and all valence electrons. Label which electron pair in your diagram is responsible for the π bond in the molecule. I'll start it for you,



4. **(5 pts)** A chemist wants to try to create a novel substance as the product of nucleophilic attack of phenylfluoramine on dimethyl sulfoxide, as shown in the equation below.





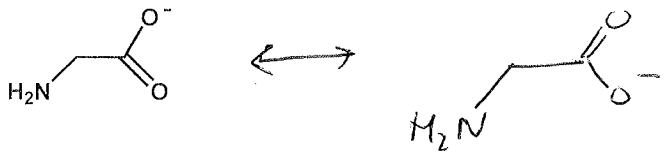
A **B** **C**

The chemist surmises that there might be three possible isomers of the product, A, B, or C, as shown above. Give this guy a hand by using the table of bond dissociation energies included in this quiz to predict which of the three isomers is the most energetically stable.

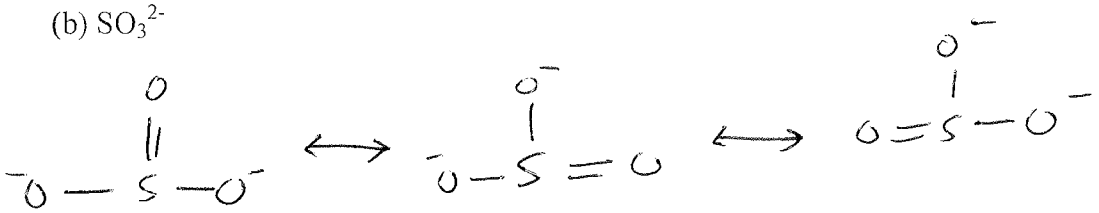
C

5. **(5 pts)** Draw all possible resonance structures for each of the following molecules

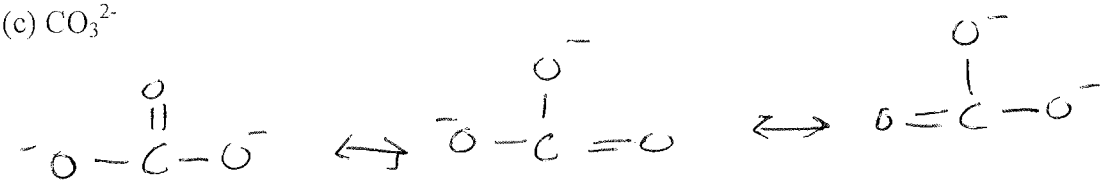
(a)



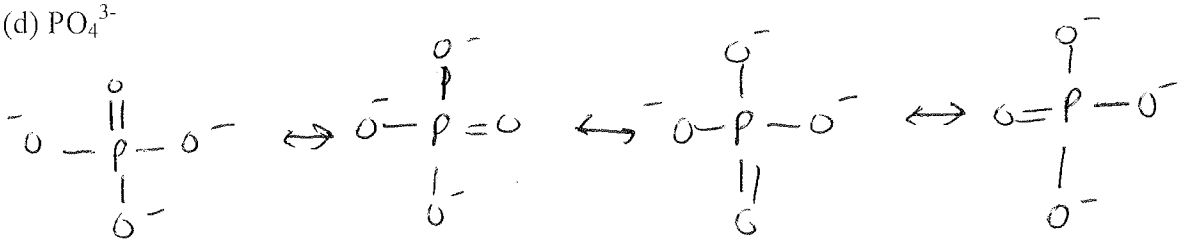
(b) SO_3^{2-}



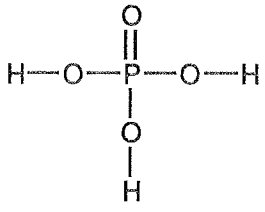
(c) CO_3^{2-}



(d) PO_4^{3-}



(e)



THIS IS THE ONLY ONE

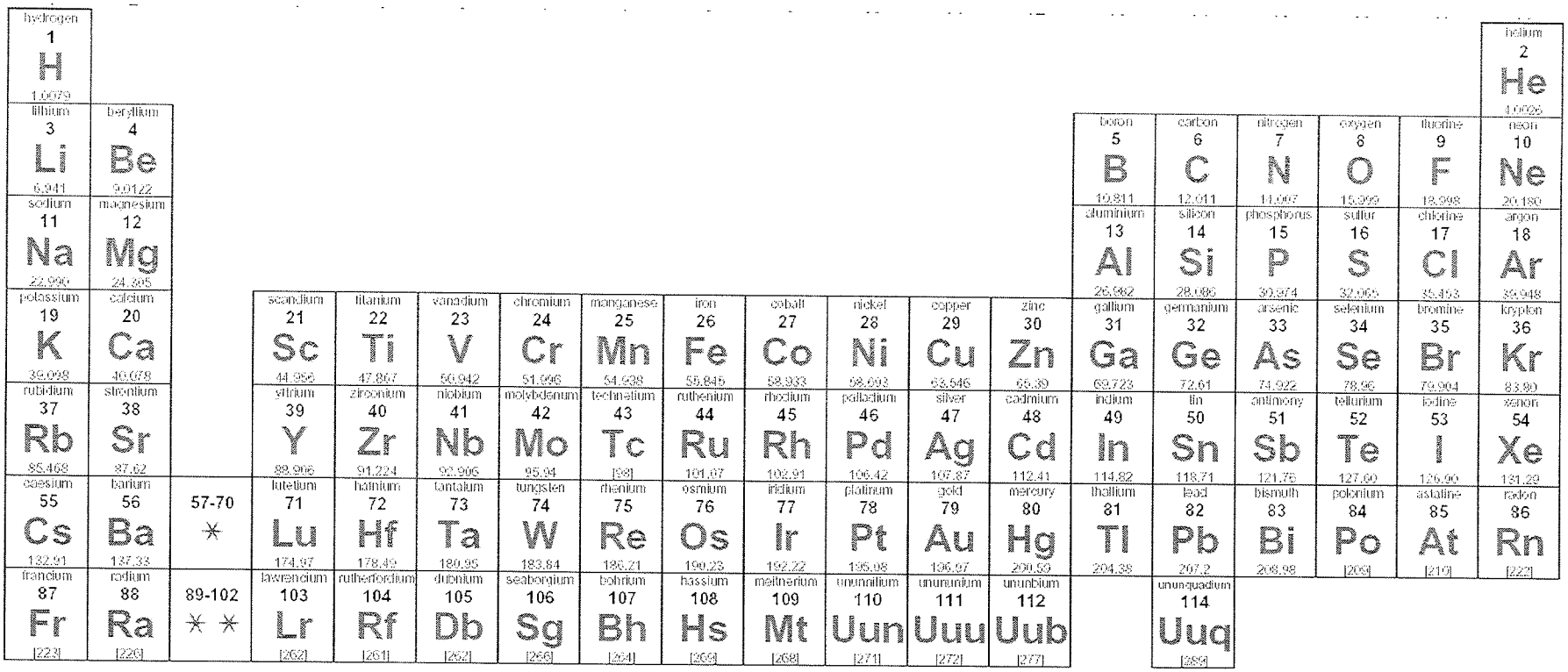
Table of Average Bond Energies (in kJ/mol)

Single Bonds

	I	Br	Cl	S	P	Si	F	O	N	C	H
H	299	366	431	347	322	323	566	467	391	416	436
C	213	285	327	272	264	301	486	336	285	356	
N	-	-	193	-	~200	355	272	201	160		
O	201	-	205	-	~340	368	190	146			
F	-	-	255	326	490	582	158				
Si	234	310	391	226	-	226					
P	184	264	319	-	209						
S	-	213	255	226							
Cl	209	217	242								
Br	180	193									
I	151										

Multiple Bonds

N = N	418	C = C	598
N ≡ N	946	C ≡ C	813
C = N	616	C = O (in CO_2, O=C=O)	803
C ≡ N	866	C = O (as in H_2C=O)	695
O = O (in O_2)	498	C ≡ O	1073


hydrogen 1 H 1.0079
helium 2 He 4.0026
lithium 3 Li 6.941
beryllium 4 Be 9.0122
boron 5 B 10.811
carbon 6 C 12.011
nitrogen 7 N 14.007
oxygen 8 O 15.999
fluorine 9 F 18.998
neon 10 Ne 20.180
sodium 11 Na 22.990
magnesium 12 Mg 24.305
aluminium 13 Al 26.982
silicon 14 Si 28.086
phosphorus 15 P 30.974
sulfur 16 S 32.065
chlorine 17 Cl 35.453
argon 18 Ar 39.948
potassium 19 K 39.098
calcium 20 Ca 40.078
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 65.39
gallium 31 Ga 69.723
germanium 32 Ge 72.61
arsenic 33 As 74.922
selenium 34 Se 78.96
bromine 35 Br 79.904
krypton 36 Kr 83.80
rubidium 37 Rb 85.468
strontium 38 Sr 87.62
yttrium 39 Y 88.906
zirconium 40 Zr 91.224
niobium 41 Nb 92.906
molybdenum 42 Mo 95.94
technetium 43 Tc [98]
ruthenium 44 Ru 101.07
rhodium 45 Rh 102.91
palladium 46 Pd 106.42
silver 47 Ag 107.87
cadmium 48 Cd 112.41
indium 49 In 114.82
tin 50 Sn 118.71
antimony 51 Sb 121.76
tellurium 52 Te 127.60
iodine 53 I 126.90
xenon 54 Xe 131.29
caesium 55 Cs 132.91
barium 56 Ba 137.33
57-70 *
lutetium 71 Lu 174.97
hafnium 72 Hf 178.49
tantalum 73 Ta 180.95
tungsten 74 W 183.84
rhenium 75 Re 186.21
osmium 76 Os 190.23
iridium 77 Ir 192.22
platinum 78 Pt 195.08
gold 79 Au 196.97
mercury 80 Hg 200.59
thallium 81 Tl 204.38
lead 82 Pb 207.2
bismuth 83 Bi 208.98
polonium 84 Po [209]
astatine 85 At [210]
radon 86 Rn [222]
francium 87 Fr [223]
radium 88 Ra [226]
89-102 * *
lawrencium 103 Lr [262]
rutherfordium 104 Rf [261]
dubnium 105 Db [262]
seaborgium 106 Sg [266]
bohrium 107 Bh [264]
hassium 108 Hs [269]
meitnerium 109 Mt [268]
ununnilium 110 Uun [271]
unununium 111 Uuu [272]
ununbium 112 Uub [277]
ununquadium 114 Uuq [289]
*Lanthanide series
lanthanum 57 La 138.91
cerium 58 Ce 140.12
praseodymium 59 Pr 140.91
neodymium 60 Nd 144.24
promethium 61 Pm [145]
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 173.04
**Actinide series
actinium 89 Ac [227]
thorium 90 Th 232.04
protactinium 91 Pa 231.04
uranium 92 U 238.03
neptunium 93 Np [237]
plutonium 94 Pu [244]
americium 95 Am [243]
curium 96 Cm [247]
berkelium 97 Bk [247]
californium 98 Cf [251]
einsteinium 99 Es [252]
fermium 100 Fm [257]
mendelevium 101 Md [258]
nobelium 102 No [259]

YORK UNIVERSITY
FW11 SC/CHEM 1000B 3.0

NAME:_____

STUDENT NUMBER:_____

Quiz No. 1 October 6, 2011

50 Minutes 30 Marks

NOTE: ALL FINAL ANSWERS MUST BE WRITTEN IN INK

$R = 8.314472\ JK^{-1}mol^{-1} = 0.0820574\ L\ atm\ K^{-1}\ mol^{-1}$
$k = 1.38066 \times 10^{-23}\ J\ K^{-1}$
Avogadro's number $N_A = 6.02214199 \times 10^{23}$ molecules mol^{-1}
1 standard atmosphere = 1.013×10^5 Pa = 760 torr (mm Hg)
Density of mercury = 13.6 g cm^{-3}, g = 9.80665 m s^{-2}
Acceleration due to gravity = 9.81 ms^{-2}
0°C = 273.15 K

Atomic masses: helium 4.0026, hydrogen 1.0079, carbon 12.011, nitrogen 14.0067, oxygen 15.9994, sodium 22.990.

MARKS

[5] 1. Automobile air bags are filled with N_2 from the decomposition of sodium azide (NaN_3, M.M. 65.01 g/mol) according to the following reaction.

$$2\ NaN_3(s) \rightarrow 2\ Na(s) + 3\ N_2(g)$$

How many grams of sodium azide are needed to generate 60.00 L of N_2 (M.M. 28.0134 g/mol) at 1.00 atm and 26.0°C?

106 g

[6] 2. Deep-sea divers use mixtures of helium and molecular oxygen in their breathing tanks. A diving shop placed 80.0g of O_2 and 20.0g of He in a 5.00 L tank at 298 K.

a) Determine the pressure in the tank.

36.7 atm

b) What is the mole fraction of O_2 in the tank?

0.333

[7] 3. What is the pressure of 5.00 mol of NH_3 in 2.00 L at 273 K when calculated using the ideal gas law and the van der Waals equation? For NH_3 the values for the van der Waals constants are $a = 4.17\ L^2\ atm/mol^2$ and $b = 0.0371$ L/mol.

35.7 atm

Under these conditions what is the cause of the deviation? Hint: a calculation is required before you can answer.

negative deviation caused by attractive forces between gas molecules

[5] 4. A small piece of metal with a 2.0×10^{-5} m^2 surface are is placed inside an ultrahigh vacuum chamber where the pressure is 1.0×10^{-7} Pa of O_2 and the temperature is 300 K. Calculate the number of O_2 molecules that hit the metal surface every second.

5.4×10^{10} molecules

[7] 5. a) In developing the kinetic-molecular theory of gases five assumptions are made, state three of them.

1) gases have a large number of small particles in random motion.
2) molecules occupy little volume
3) molecules collide with the walls and each other
4) No forces between molecules
5) Total energy remains constant

b) In a barometer, the atmospheric pressure is balanced by a liquid pressure. What are the two quantities of the liquid that must be known to determine the liquid pressure?

① density of the liquid
② height of liquid column

c) Determine how much faster a helium atom moves, on average, than a carbon dioxide molecule (CO_2, M.M. 44.0098 g/mol) held at the same temperature. Report your answer with 3 significant figures.

3.32 times faster

THE END

YORK UNIVERSITY
FW11 SC/CHEM 1000B 3.0

NAME:_____

STUDENT NUMBER_____

Quiz No. 2 November 3, 2011 50 Minutes 30 Marks

Calculator permitted. Additional paper for rough work is not permitted.
ALL FINAL ANSWERS MUST BE WRITTEN IN INK!

$R = 8.314472\ JK^{-1}mol^{-1} = 0.0820574\ L\ atm\ K^{-1}\ mol^{-1}$
$k = 1.38066 \times 10^{-23}\ J\ K^{-1}$
1 standard atmosphere = 1.013×10^5 Pa = 760 torr (mm Hg)
Avogadro's number $N_A = 6.02214199 \times 10^{23}$ molecules mol^{-1}
$0^oC = 273.15$ K
Specific heat of water = $4.184\ J\ g^{-1}\ K^{-1}$
$h = 6.626 \times 10^{-34}\ J\ s$ $c = 2.9979 \times 10^8\ m\ s^{-1}$
$R_H = 2.179 \times 10^{-18}\ J$ $a_0 = 53$ pm

Atomic masses in g/mol: carbon 12.011, chlorine 35.453, hydrogen 1.0079, oxygen 15.9994, sulphur 32.065, fluorine 18.9984, zinc 65.409.

MARKS

[5] 1. Using the information provided calculate the heat of reaction involved in the conversion of 25.00 g of methane (CH_4, M.M. 16.0426 g/mol) to chloroform ($CHCl_3$, M.M. 119.3779 g/mol):

$$CH_4\,(g) + 3\,Cl_2(g) \rightarrow CHCl_3(l) + 3\,HCl(g)$$

$C(graphite) + 2H_2(g) \rightarrow CH_4(g)$	$\Delta H^o = -92.3$ kJ
$C(graphite) + \frac{1}{2}\,H_2(g) + 3/2\,Cl_2(g) \rightarrow CHCl_3\,(l)$	$\Delta H^o = -74.5$ kJ
$\frac{1}{2}\,H_2(g) + \frac{1}{2}\,Cl_2(g) \rightarrow HCl(g)$	$\Delta H^o = -135.1$ kJ

-603.9 kJ

[8] 2. A 1.50 g sample of benzoic acid, C_6H_5COOH (M.M. 122.1232 g/mol), was burned in excess oxygen in a bomb calorimeter. The calorimeter had a heat capacity of 893 JK^{-1} and contained 775 g of water. The initial temperature of the calorimeter and the water contained in it was 22.50°C, which rose to 31.69°C when the combustion was complete.

a) Balance the equation for the combustion of benzoic acid:

$$C_6H_5COOH(s) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$$

b) Calculate the heat evolved when 1.50g of benzoic acid is burned in this calorimeter.

38.0 kJ

c) What is the molar heat of combustion at constant volume for benzoic acid?

-3.09×10^3 kJ mol^{-1}

[8] 3. a) An amount of 414.27 g of zinc sulfide (ZnS, M.M. 97.44 g mol^{-1}) reacts with 104.00g of oxygen gas (O_2, M.M. 31.9988 g/mol) at a constant temperature of 298.0 K and constant pressure of 1.00 atm. The reaction that takes place is:

$$2\ ZnS(s) + 3\ O_2(g) \rightarrow 2\ ZnO(s) + 2\ SO_2(g) \qquad \Delta H^\circ = -878.26\ kJ$$

(a) How much heat is released by the reaction?

951.48 kJ

(b) How much work is done by the atmosphere on the reacting mixture for the conditions stated above?

2684 J

[9] 4. a) Circle ALL the statements that apply to the "particle in a box problem" as developed by Schrödinger.

(A) In the "particle in the box problem", Schrödinger assumes the particle behaves according to classical physics.

(B) The energy of the particle of mass m in a box of dimension L depends only on the quantum number n.

(C) A cosine function is an acceptable solution for the "particle in a box", since the wave function can be non-zero at the edge of the box.

(D) The wave function, Ψ, corresponds to a standing wave within the boundary of the box.

(E) For n = 2, the maximum of Ψ^2 is in the middle of the box.

b) Calculate the frequency of the light required to promote an electron from the ground state to an excited state in the n = 5 energy level of the Bohr hydrogen atom.

$3.157 \times 10^{15}\ s^{-1}$

c) The following equation describes the radial part of the $\Psi(2s)$ wave function for a hydrogen atom. **Clearly** circle the term that gives rise to the node in the 2s orbital and give the value required for this to happen.

$$R(2s) = \frac{1}{2\sqrt{2}} \frac{1}{a_o^{3/2}} \left(2 - \frac{r}{a_o}\right)^2 e^{-r/2a_o}$$

$r = 2a_o$

THE END

YORK UNIVERSITY
F 11 SC/CHEM 1000B 3.0
Quiz No. 3

NAME:_____

STUDENT NUMBER:_____

November 24, 2011

50 Minutes 30 Marks

Calculator permitted. Additional paper for rough work is not permitted.
ALL FINAL ANSWERS MUST BE WRITTEN IN INK!

MARKS

[2] 1. Provide the electronic configuration of the Cu^{2+} and S using the spdf notation and identify them as paramagnetic or diamagnetic in the table below.

Element or ion	Electronic configuration (spdf notation)	Paramagnetic /diamagnetic
Cu^{2+}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$	para
S	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$	dia

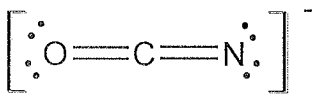
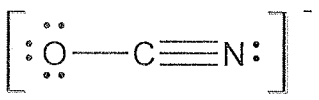
[3] 2. Three elements have electron configurations $1s^2\ 2s^2\ 2p^6\ 3s^2$, [Ar] $4s^2$ and $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$. The atomic radii of these elements, not necessarily in the same order, are 99, 160 and 231 pm. Identify the elements from the electronic configurations given and match the sizes with these elements.

Electronic Configuration	Element	Atomic Radius (pm)
$1s^2\ 2s^2\ 2p^6\ 3s^2$	Mg	160 pm
[Ar] $4s^2$	Ca	231 pm
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	Cl	99 pm

[2] 3. Arrange each of the following series of elements in order of increasing first ionization energy (i.e., place the element with the largest first ionization energy on the right, X < Y < Z).

Series of Elements	Smallest I_1 to Largest
C, Si, N	Si, C, N
Ga, O, Se	Ga, Se, O

[6] 4. Below are three resonance structures for the ion OCN^-. Assign formal charges to each atom in each structure. Rate the stability of these resonance structures from 1 through 3, with 1 indicating the most stable structure and 3 indicating the least stable one. Electronegativity values are listed in question 5 on page 3.

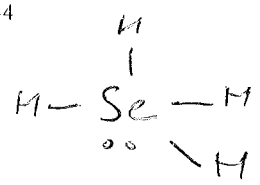
Resonance Structure	Formal charge on oxygen	Formal charge on carbon	Formal charge on nitrogen	Stability rating
	0	0	-1	2
	-1	0	0	1
	+1	0	-2	3

[5] 5. Consider the following electronegativities:

Element	Cl	H	P	Se	N	C	O
Electronegativity	3.0	2.1	2.1	2.4	3.0	2.5	3.5

a) Using the Lee Allen's method indicate the partial charges on each atom in the two molecules shown below. Show your work in the space provided. (Hint: start with the Lewis structures)

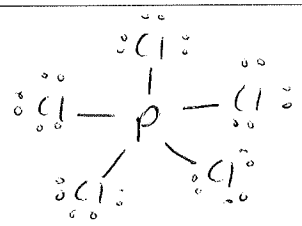
SeH_4



$q_H = 0.067$

$q_{Se} = -0.27$

PCl_5



$q_P = 0.88$

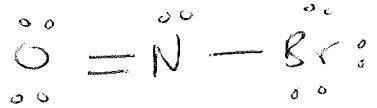
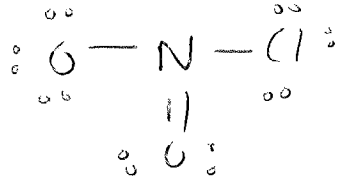
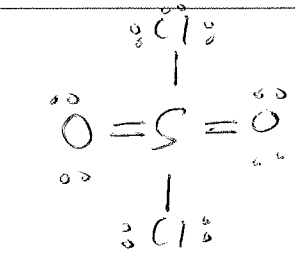
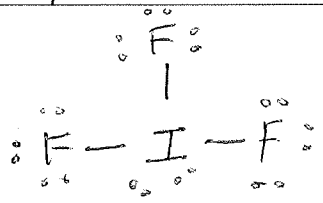
$q_{Cl} = -0.18$

b) Which of the bonds (H-Se or P-Cl) would be the least polar? Briefly justify your answer based on the information obtained above.

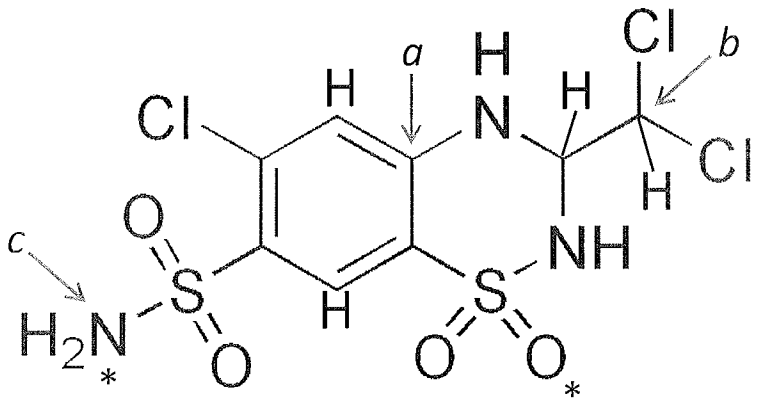
H-Se is least polar

ΔEN between H and Se < ΔEN between Cl and P

[8] 6. Use Lewis structure and VSEPR to predict the shapes of the following molecules. Draw the best Lewis structure and name the shape.

Molecules	Lewis Structure	Name the shape of the molecule
NOBr (where N is the central atom)		Bent
NO_2Cl (where N is the central atom)		Trigonal Planar
O_2SCl_2 (where S is the central atom)	 Expanded octet	Tetrahedral
IF_3		T-shape

[4] 7. Trichlormethiazide is a diuretic often used for the treatment of oedema (including that which is associated with heart failure and hepatic cirrhosis) and hypertension. Based on the structure given for trichlormethiazide answer the five questions listed below. Note that lone pairs are not shown in the structure.



a) How many lone pairs should be added to provide the proper Lewis structures on oxygen and nitrogen atoms labelled with "*"?

Elements marked with a "*"	Number of lone pair(s)
O	2
N	1

b) What is the hybridization of the carbons labelled using letters "*a* and *b*" and the hybridization of the nitrogen labelled "*c*"? In the same table list the ideal bond angles around atoms "*a* to *c*".

Element labels	Hybridization	Ideal bond angle in degrees
a	sp^2	120°
b	sp^3	109.5°
c	sp^3	109.5°

The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

THE END

Name (in ink):_____

Student Number (in ink):_____

Fall 2011 SC/CHEM 1000 C - Quiz #1

October 4, 2011

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

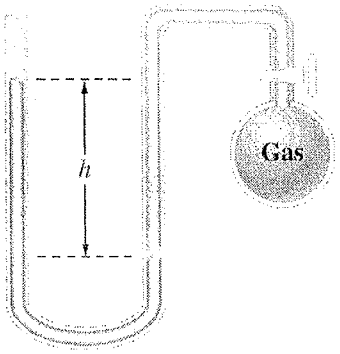
All final answers must be written in ink!

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

5 1. An experiment is set up, as shown to the right, in which a gas is confined in a bulb which is connected to a manometer with one end open to the atmosphere. The liquid in the manometer is water and the atmospheric pressure is 1.08 atm. If the difference in the heights of the water in the manometer is 11.7 inches, what is the pressure of the gas in the bulb? Your answer MUST be expressed in Torr. (**Note:** All measurements were made at 25°C.)



843 Torr

Marks

5 2. A balloon filled with helium has a volume of 1.35 L at 0.997 atm and 22.6°C. The balloon is released and rises to an altitude of 4.77 km where the temperature is -20.2°C and the atmospheric pressure is 427 Pa. What is the volume of the balloon at this altitude in litres? (Assume that the balloon does not leak nor does it burst.)

273 L

2 3. A large collection of helium atoms has an average speed of 1310 m/s. What is the temperature of this gas? Your answer MUST be expressed in °C.

51°C

Marks

7 4. A mixture of 39.5 g of ammonia, NH_3, and 27.2 g of molecular oxygen react according to the following equation:

$$4\ NH_3(g) + 3\ O_2(g) \rightarrow 2\ N_2(g) + 6\ H_2O(g)$$

The initial temperature of the reagents is 21.0°C and the reaction occurs in a rigid container with a volume of 27.5 L. What is the pressure in this container when the reaction reaches completion if the final temperature is also 21.0°C?

3.03 atm

Marks

7 5. A sample of oxygen gas is confined in a container at a pressure of 745 Torr and a temperature of 22^{0}C. Given that the average speed of the oxygen molecules is 442 m/s, what would be the rate of effusion of this oxygen gas if it could escape into a vacuum through a hole in the container that had a radius of 5.2 x 10^{-5} m?

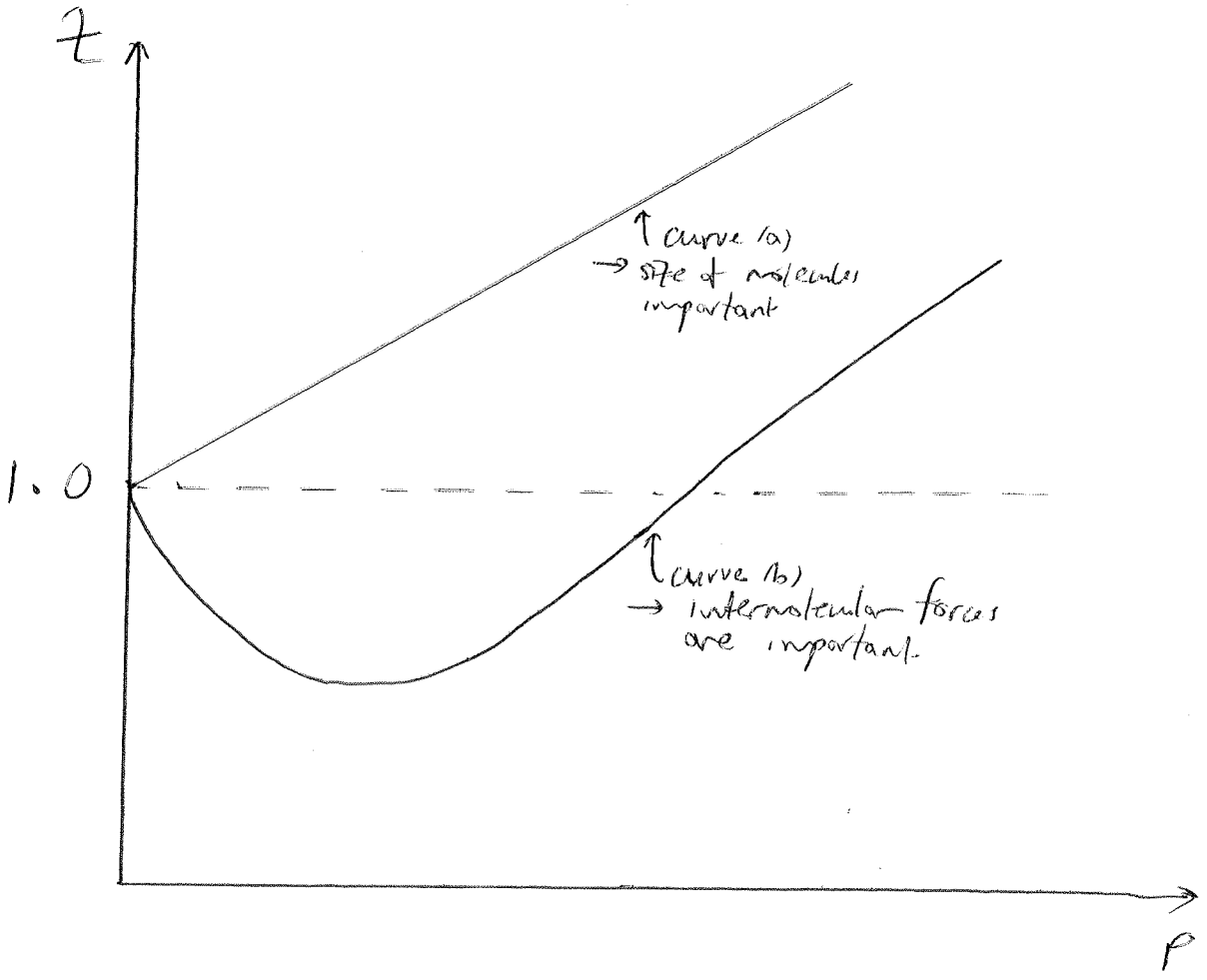
$2.3 \times 10^{19}\ s^{-1}$

Marks

4 6. The van der Waals equation may be expressed as

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

a) Sketch a graph of the compressibility factor versus pressure for a gas for which the non-ideal behaviour is primarily due to the size of the gas molecules.
b) On the same diagram, sketch the graph for a gas for which the non-ideal behaviour is primarily due to intermolecular forces.
Clearly label the identity of each curve on the graph.



Reference Page for CHEM 1000C Quiz 1

Constants:

R = 8.314472 $JK^{-1}mol^{-1}$ = 0.0820574 L atm K^{-1} mol^{-1}
k = 1.38066 x 10^{-23} J K^{-1}
g = 9.80665 m s^{-2}
1.00 atm = 1.013 x 10^5 Pa = 760 Torr (mm Hg)
1 mL = 1 cm^3
N_A = 6.02214199x10^{23} mol^{-1}
0°C = 273.15 K
π = 3.14159

density of water = 0.99707 g/mL @ 25°C
density of mercury = 13.5340 g/mL @25°C
1 inch = 2.54 cm

Equations:

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

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

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

volume of a sphere = $4/3\pi r^3$
circumference of a sphere = $2\pi r$

surface area of a sphere = $4\pi r^2$
diameter of sphere = 2r

area of a circle = πr^2
circumference of a circle = $2\pi r$

diameter of circle = 2r

Atomic Weights (g/mol):

H 1.0079 He 4.0026 O 15.9994 N 14.0067 Hg 200.59

Name:_____

Student Number:_____

Fall 2011 SC/CHEM 1000 C - Quiz #2

November 1, 2011

Calculators are permitted.
Answer all questions on this paper; **additional paper for rough work is not permitted.**

Time Allowed: 50 minutes **Total Marks = 30**

Marks

3 1. The volume of an ideal gas contracts from 8.42 L to 3.67 L as the result of a constant applied pressure of 1.48 atm. The system releases 628 J of heat during this process. Calculate ΔU for this process. Express your answer in Joules.

841 J

3 2. Consider the following combustion reaction:

$$C_6H_{12}(l) + 9\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(l) \qquad \Delta H^\circ = -3924\ kJ\ @\ 298K$$

What is the change in internal energy for this process at 298K?

−3917 kJ

Marks

5 3. Consider the following reaction:

$$CO(g) + 3\ H_2(g) \rightarrow CH_4(g) + H_2O(g)$$

Calculate the enthalpy change for this reaction using a suitable combination of the following :

$C(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H^\circ = -393.5$ kJ
$2\ C(s) + O_2(g) \rightarrow 2\ CO(g)$	$\Delta H^\circ = -221.0$ kJ
$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$	$\Delta H^\circ = -483.6$ kJ
$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$	$\Delta H^\circ = -802.7$ kJ

-205.7 KJ

Marks

5 4. A water heater is fuelled by the combustion of propane as described by the following reaction:

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(l)$$

a) Determine how much heat is released if 11.2 moles of propane are burned at 298K and a constant pressure of 1.00 bar.

-2.49×10^7 J

b) Assume that the water heater contains 146L of water at an initial temperature of 25.0°C. What will the water temperature rise to if all of the heat produced under the previous conditions is used to heat the water?

65.8 °C

Marks

3 5.The most prominent line in the atomic spectrum of mercury occurs at a wavelength of 253.652 nm. What is the energy of 0.625 moles of photons associated with the most prominent line? Express your answer in kJ.

295 kJ

3 6. For each of the following atomic orbitals, list ***ALL*** of the possible values for each of the specified quantum numbers.

Orbital	n	ℓ	m_ℓ
4d	4	2	-2, -1, 0, +1, +2
5f	5	3	-3, -2, -1, 0, +1, +2, +3

3 7. Provide the ground state electron configuration for each of the following using the condensed spdf notation. An abbreviation for the noble gas core may be used if you wish.

Species	electron configuration
As	[Ar] $4s^2$ $3d^{10}$ $4p^3$
Mn^{2+}	[Ar] $3d^5$
Ba	[Xe] $6s^2$

Marks

5 8. For each of the following, place your answer on the line provided.

a) Which one of Ca, O, Mg, or P has the largest first ionization energy?
Answer: O

b) Which one of As, K, P, or S has the highest electron affinity?
Answer: S

c) Which one of Cr, Mg, O, or Si is diamagnetic?
Answer: Mg

d) Which one of Ca^{2+}, Cl^{-}, K^{+} or S^{2-} has the smallest ionic radius?
Answer: Ca^{2+}

e) Which one of F, N, P, or Si has the largest atomic radius?
Answer: Si

Reference Page for CHEM 1000C Quiz 2

Constants:

0°C = 273.15 K 1 mL = 1 cm^3 1 nm = 10^{-9}m

R = 8.314472 $JK^{-1}mol^{-1}$ = 0.0820574 L atm K^{-1} mol^{-1} N_A = 6.02214199x10^{23} mol^{-1}

1.00 atm = 1.013 x 10^5 Pa = 760 torr (mm Hg) k = 1.38066 x 10^{-23} J K^{-1}

R_H = 2.179 X 10^{-18} J a_0 = 53 pm

h = 6.62606876 x 10^{-34} J s c = 2.99792458 x 10^8 m s^{-1}

Properties of Water:

specific heat of water = 4.184 J g^{-1} $°C^{-1}$ heat of fusion for water = 333 J g^{-1}

heat of vaporization of water = 2260 J g^{-1} density of water = 1.00 g mL^{-1}

Some Standard Enthalpies of Formation at 298K:

Substance	$\Delta H_f°$ (kJ/mol)
$CO_2(g)$	-393.5
$C_3H_8(g)$	-103.8
$H_2O(g)$	-241.8
$H_2O(l)$	-285.8

Atomic Weights (g/mol):

C 12.0107, O 15.9994, H 1.00794, N 14.00674

Periodic Table:

1 H 1.00794																1 H 1.00794	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	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 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (289) (287)		116 (289)		118 (293)

58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.03588	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

Name:_____

Student Number:_____

Fall 2011 SC/CHEM 1000 C - Quiz #3

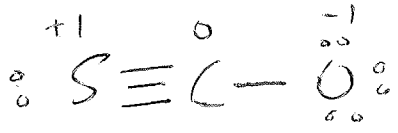
November 22, 2011

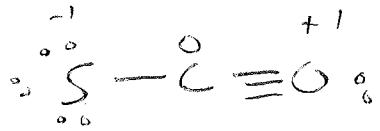
Calculators are permitted.
Answer all questions on this paper; **additional paper for rough work is not permitted.**

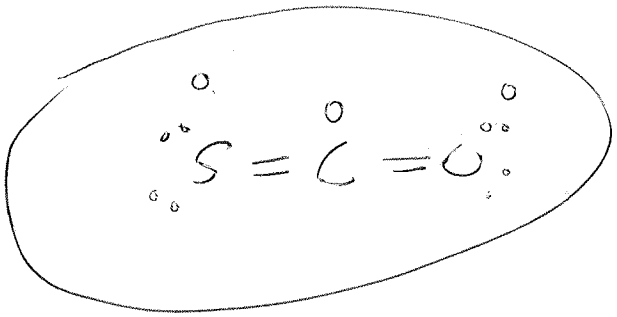
Time Allowed: 50 minutes **Total Marks = 30**

Marks

7 1. Show all of the resonance structures for SCO (carbon is the central atom). **All lone pair electrons must be shown** in these structures; expanded octets may be used when permissible. Assign **formal charges** to each atom in each resonance structure (**these MUST be shown on every structure**). Which resonance structure would be the most stable and why?

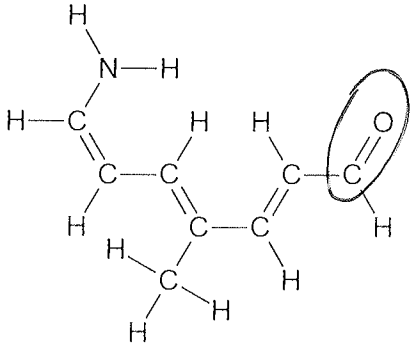






← most stable structure formal charges = 0

2 2. Consider the structure given below:



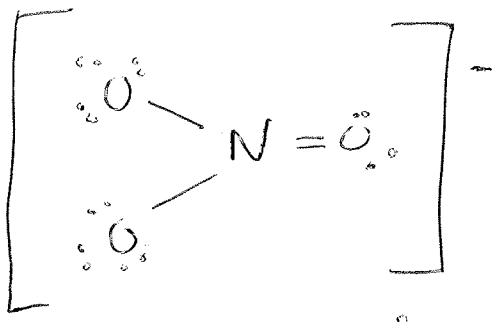
a) Circle the most polar bond in this molecule.

b) How many pi bonds are in this structure? 4

Marks

7 3. Draw the **most stable** Lewis structures for the anions NO_3^- and NO_4^{3-} in the space indicated below. **All lone pair electrons must be shown** in these structures; expanded octets may be used when permissible. Determine the ideal bond angles, shape, and bond order of the nitrogen-oxygen bond in each ion.

NO_3^-

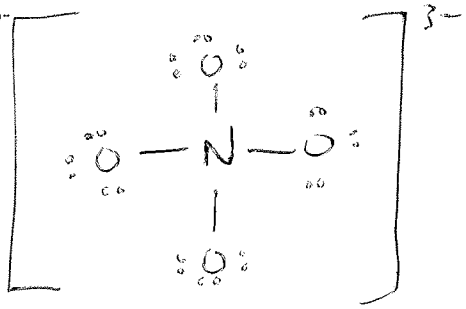


the ideal bond angle is 120°

the shape of the ion is trigonal planar

the nitrogen-oxygen bond order is 4/3

NO_4^{3-}



the ideal bond angle is 109.5°

the shape of the ion is tetrahedral

the nitrogen-oxygen bond order is 1

b) The nitrogen-oxygen bond length in one of these ions is 127 pm and 137 pm in the other. Which bond length corresponds to which ion? Explain your answer briefly.

As bond order ↑, bond length ↓

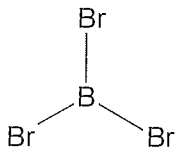
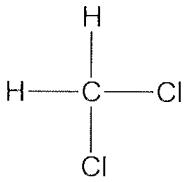
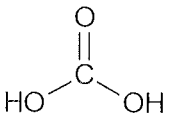
∴ N–O bond length = 127 pm in NO_3^-

and

137 pm in NO_4^{3-}

Marks

4 4. Determine the hybridization of the central atom in each of the following molecules.

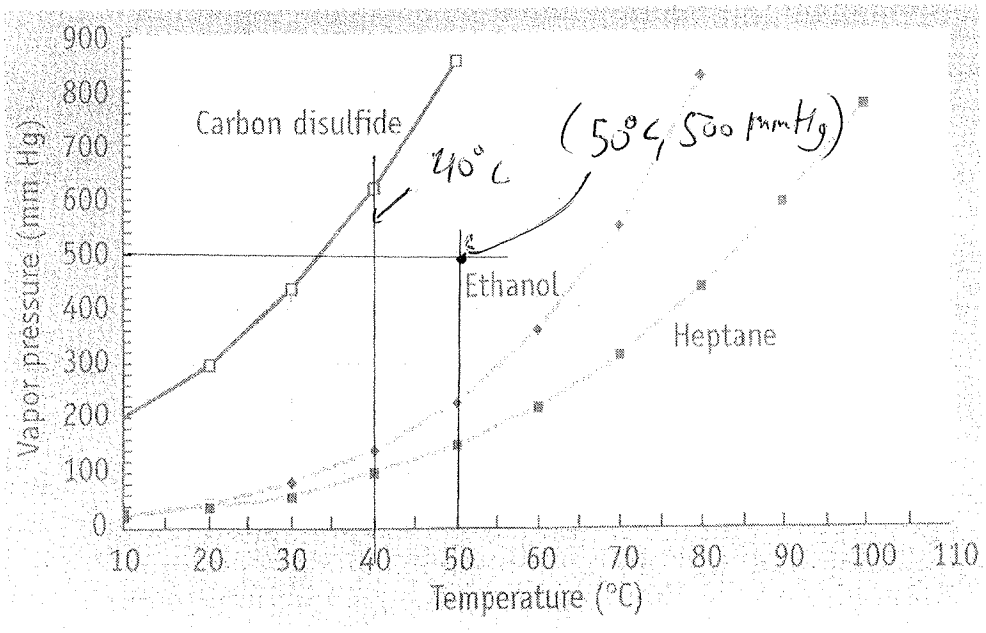
Molecule	Hybridization of central atom
	sp^2
O=C=O	sp
	sp^3
	sp^2

3 5. Calculate the molar enthalpy of vapourization of octane, C_8H_{18}, if its vapour pressure is 13.6 mmHg at 25°C and 45.3 mmHg at 50°C.

38.5 $kJ\,mol^{-1}$

Marks

3 6. Use the vapour pressure curves below to answer the questions that follow.



a) At 40°C, which one of these substances has the weakest intermolecular forces in the liquid phase. Briefly explain why.

Carbon disulfide

→ It has the highest vapour pressure so therefore it has the weakest intermolecular forces in the liquid phase. (Weaker intermolecular forces allow more molecules to escape into the gas phase.).

b) At a pressure of 500 mmHg and a temperature of 50°C, specify the phase of each of these substances.

Substance	Phase
carbon disulfide	gas
ethanol	liquid
heptane	liquid

Marks

4 7. a) The London forces are greater for hydrogen iodide, HI, than for hydrogen chloride, HCl. Briefly explain why.

HI is a larger molecule than HCl so it is more polarizable and therefore the london forces are greater.

b) The dipole-dipole forces are greater for HCl than HI. Briefly explain why.

The HCl bond is more polar ($\Delta EN = 0.9$) than the HI bond ($\Delta EN = 0.4$) and therefore the dipole-dipole forces in HCl are greater.

Reference Page for CHEM 1000C Quiz 3

Constants:

0°C = 273.15 K 1 mL = 1 cm^3 1 nm = 10^{-9}m

R = 8.314472 $JK^{-1}mol^{-1}$ = 0.0820574 L atm K^{-1} mol^{-1} N_A = 6.02214199x10^{23} mol^{-1}

1.00 atm = 1.013 x 10^5 Pa = 760 torr (mm Hg) k = 1.38066 x 10^{-23} J K^{-1}

R_H = 2.179 X 10^{-18} J a_0 = 53 pm

h = 6.62606876 x 10^{-34} J s c = 2.99792458 x 10^8 m s^{-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 S 2.5

Equations:

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

Atomic Weights (g/mol):

H 1.00794 Be 9.01218 C 12.011 N 14.0067 O 15.9994

Periodic Table of the Elements

	1 IA												13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.0079	2 IIA																2 He 4.0026
2	3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
3	11 Na 22.9898	12 Mg 24.3050	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
4	19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
5	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 114.82	50 Sn 118.710	51 Sb 121.75	52 Te 127.60	53 I 126.9045	54 Xe 131.29
6	55 Cs 132.9054	56 Ba 137.327	57 *La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.9665	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.9804	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 †Ac (227)	104 Rf (261)	105 Ha (262)	106 Sg (263)	107 Ns (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)							

*Lanthanide Series	58 Ce 140.115	59 Pr 140.9076	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.9253	66 Dy 162.50	67 Ho 164.9303	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.967
†Actinide Series	90 Th 232.0381	91 Pa 231.0359	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

Name: _____

Student Number: _____

Faculty of Science and Engineering
Final Examination
CHEM 1000 3.0 - Chemical Structure

December 13, 2011 7:00 - 9:00 p.m. 2 hours 100 Marks

- Calculators are permitted *but may not be shared*.
- *All cell phones must be turned off and placed out of reach.*
- The last three pages containing a periodic table, constants, equations and other useful data may be removed. *(Notes and/or other study aids are not permitted.)*
- Atomic masses are located on the periodic table.
- Extra paper for rough work is not permitted.
- Write your answers in the space provided. *Answers may not be submitted on the periodic table or other reference pages.*

Office Use Only	
Page	Mark
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
Total	

[9] 1. A storage tank of natural gas has a total pressure of 2.17 atm. The gases are uniformly mixed throughout the tank. A sample of the gas mixture contains 4.22 g of methane (CH_4, M = 16.043 g mol^{-1}), 1.23 g of ethane (C_2H_6, M = 30.069 g mol^{-1}), and 0.145 g of propane (C_3H_8, M = 44.096 g mol^{-1}). Calculate the partial pressure of each of the three gases in the tank.

$P_{CH_4} = 1.86$ atm

$P_{C_2H_6} = 0.289$ atm

$P_{C_3H_8} = 0.0233$ atm

... continue to next page

[10] 2. At 26 km above the earth's surface, the pressure is 2.16 x10^{-2} atm and the temperature is –50.6°C.

How many molecules are present in 12.8 L of air under these conditions?

9.12×10^{21} molecules

What is the density of the air under these conditions? (Give your answer as molecules m^{-3}.)

7.13×10^{23} molecules m^{-3}

If 12.8 L of air was collected at this altitude, what would its volume be if it was brought to the earth's surface where the pressure is 758.2 torr and the temperature is 22.5°C?

0.368 L

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[3] 3. A gas with a volume of 3.25 L expands to a volume of 12.46 L against a constant opposing pressure of 725.0 torr. What is the amount of work in kilojoules involved in this process?

-0.890 kJ

[7] 4. Given the following heats of reaction

$2\ Fe(s) + 3\ CO_2(g) \rightarrow Fe_2O_3(s) + 3\ CO(g)$ $\Delta H = +24.8$ kJ
$2\ Fe_3O_4(s) + CO_2(g) \rightarrow 3\ Fe_2O_3(s) + CO(g)$ $\Delta H = +46.4$ kJ
$FeO(s) + CO(g) \rightarrow Fe(s) + CO_2(g)$ $\Delta H = -1.10$ kJ

Determine the heat required to produce 2.45 mole of FeO from the reaction given below under conditions of constant pressure.

$Fe_3O_4(s) + CO(g) \rightarrow 3\ FeO(s) + CO_2(g)$

-8.74 kJ

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[10] 5. Vinyl chloride is an important chemical it is used mainly in the production of poly (vinyl chloride) or PVC which is used to make piping, floor tiles, clothing and toys. Vinyl chloride is made in a two step process. The balanced overall equation is:

$$2\ C_2H_4(g) + 2\ HCl(g) + O_2(g) \rightarrow 2\ C_2H_3Cl(g) + 2\ H_2O(g)$$

Use the bond energy data in the table at the end of this examination to determine the energy that accompanies the formation of one mole of vinyl chloride? Does the synthesis require an input of energy?

$\Delta H_{rxn} = -173$ kJ per mole of PVC

-ve, ∴ does not require input of energy

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[7] 6. An 801g block of an unknown metal at 15.2°C was placed in an insulated beaker containing 122 g of water initially at 70.1°C. After thermal equilibrium was reached, the final temperature of the water was 47.3°C. From these data, calculate the specific heat of the metal.

$C_{metal} = 0.453\ J g^{-1} {}^{\circ}C^{-1}$

[6] 7. For each series of elements in the table below, indicate whether the trend in each specified property increases along the series, or decreases.

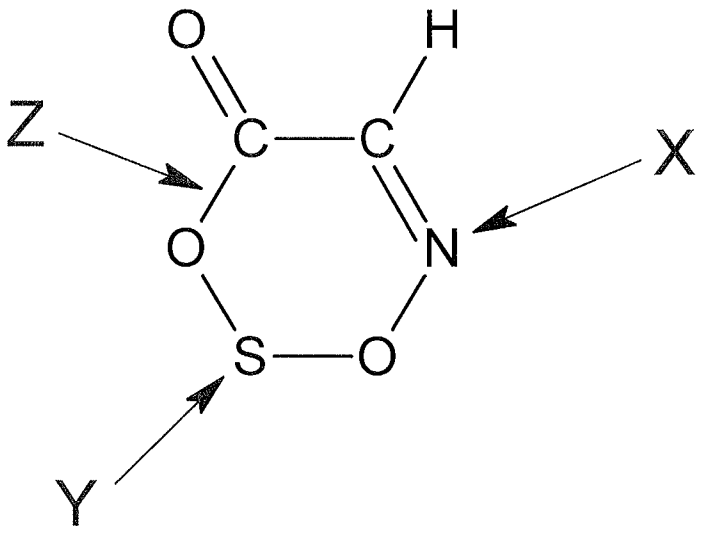
SERIES	PROPERTY		
	atomic radius	*electronegativity*	*ionization energy*
N to F	↓	↑	↑
N to Sb	↑	↓	↓
Al to Cl	↓	↑	↑
Li to Cs	↑	↓	↓

... continue to next page

[5] 8. For each set of atomic orbital quantum numbers, indicate whether the combination is allowed or not allowed.

n	l	m_l	m_s	allowed?(YES or NO)
2	0	0	-½	YES
3	1	-1	½	YES
3	3	0	½	NO
4	-1	2	½	NO
4	3	4	½	NO

[4] 9. Consider the following structure:



a) What is the hybridization of the nitrogen atom labeled X? sp^2

b) What is the hybridization of the sulfur atom labeled Y? sp^3

c) What orbitals overlap to form the bond labeled Z? C(sp^2) – O(sp^3)

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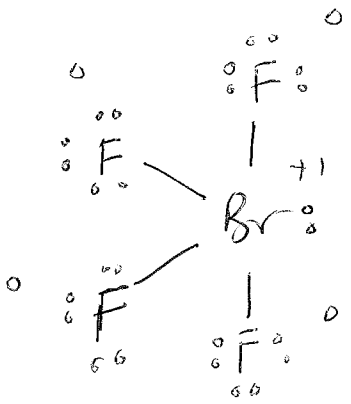
[11] 10. Provide the **most stable** Lewis Structure for each of the following ions.

- **all lone pair electrons must be shown** in these structures
- expanded octets may be used when permissible
- **indicate the formal charge** on each atom in the structure
- describe the shape of each ion
- indicate whether each ion is polar or non-polar

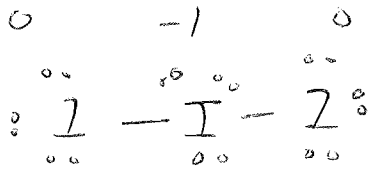
a) BrF_4^+



The shape is See Saw

Is the structure polar or non-polar? polar

b) I_3^-



The ideal bond angle is 180°

Is the structure polar or non-polar? non-polar

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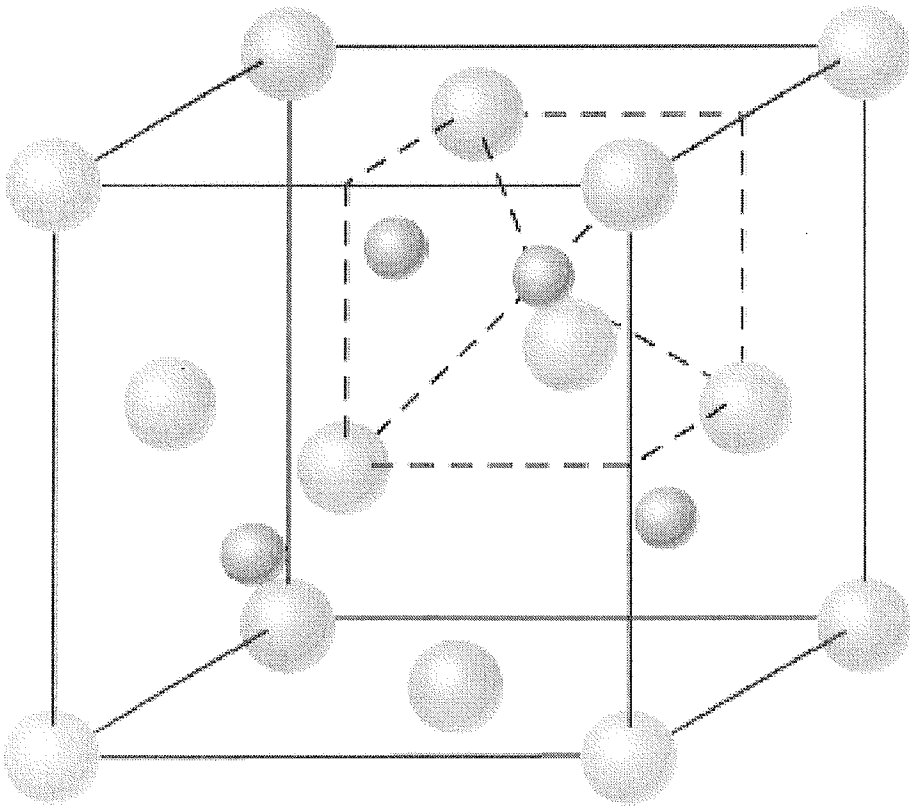
[3] 11. Briefly describe how an instantaneous dipole forms.

It is created by a momentary uneven distribution of electrons in an atom or molecule.

[4] 12. The unit cell for the zinc blend structure, ZnS, is given below:



= S^{2-} = Zn^{2+}

a) What is the structure described by the S^{2-} ions alone? fcc

b) What type of holes are filled by the Zn^{2+} ions? tetrahedral

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[5] 13. Sodium nitrate, $NaNO_3$, and magnesium nitrate, $Mg(NO_3)_2$, are both ionic salts.

a) Which one will have the larger lattice energy? $Mg(NO_3)_2$

b) Briefly explain the reasons why this ionic salt has the larger lattice energy.

⇒ Mg^{2+} is smaller than Na^+ so ions are closer together and therefore the coulombic forces attracting the ions are larger.

⇒ Mg^{2+} has a larger charge than Na^+, so the magnitude of the coulombic force of attraction will be greater.

[6] 14. Answer each of the following questions with "*increases*", "*decreases*", or "*does not change*".

a) If the surface area of a liquid decreases, its vapour pressure

does not change.

b) A liquid is placed in a closed container and allowed to come to equilibrium with its vapour. The container is opened briefly and more of the liquid is added. The system is allowed to come to equilibrium again. Compared to the original equilibrium, the vapour pressure of the liquid

does not change.

c) A liquid is placed in a closed cylinder and allowed to come to equilibrium with its vapour. The volume of the cylinder is decreased by sliding down a piston that acts as the lid of the container. The system is allowed to come to equilibrium again. Compared to the original equilibrium, the vapour pressure of the liquid

does not change.

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[10] 15. The density of beryllium is 1840 kg m^{-3} and it crystallizes in a face-centered cubic (fcc) structure. The atomic mass of beryllium is 9.0122 g mol^{-1}.

a) How many atoms are in the unit cell of beryllium?

4

b) What is the volume of the unit cell? (Provide your answer in m^3.)

$3.253 \times 10^{-29}\ m^3$

c) What is the atomic radius of beryllium? (Provide your answer in m.)

$r = 1.129 \times 10^{-10}\ m$

THE END

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

$c = 2.9979 \times 10^{8}$ m s^{-1}

$0^{o}C = 273.15$ K

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

$a_0 = 53$ pm

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

$R = 8.314472$ $JK^{-1}mol^{-1} = 0.0820574$ L atm K^{-1} mol^{-1}

1 mL = 1 cm^3

1 standard atmosphere = 1.013×10^{5} Pa = 760 torr (mm Hg)

1 m = 10^{2} cm = 10^{12} pm

Avogadro's number $N_A = 6.02214199 \times 10^{23}$ molecules mol^{-1}

specific heat of water = 4.184 J g^{-1} K^{-1}

specific heat of ice = 2.11 J g^{-1} K^{-1}

$\ddot{A}H_f^{o}$ $\{H_2O(l)\} = -285.8$ kJ mol^{-1}

$\ddot{A}H_f^{o}$ $\{H_2O(g)\} = -241.8$ kJ mol^{-1}

heat of vaporization of water = 44.0 kJ mol^{-1}

heat of fusion of water = 6.01 kJ mol^{-1}

$$u_m = \sqrt{\frac{2RT}{M}}; \quad u_{rms} = \sqrt{\frac{3RT}{M}}; \quad u_{av} = \sqrt{\frac{8RT}{\pi M}}; \quad E = \frac{3RT}{2}$$

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

$$d = \frac{PM}{RT}; \quad Z = \frac{PV}{nRT}; \quad \left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

$$E_n = \frac{-Z^2R_H}{n^2}; \quad r_n = \frac{n^2a_0}{Z}$$

$E = h\acute{i}$; $c = \acute{i}\ddot{e}$; $\ddot{A}H_{sub} = \ddot{A}H_{fus} + \ddot{A}H_{vap}$; $\ddot{A}H = \ddot{A}U + \ddot{A}PV$

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

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—C1	431	C—O	360	O=O	498
H—Br	364	C=O	736[b]	F—F	159
H—I	297	C—C1	339	C1—C1	243
				Br—Br	193
				I—I	151

[a] Although all data are listed with about the same precision (three significant figures), some values are actually known more precisely. Specifically, the values for the diatomic molecules H_2, HF, HCl, HBr, HI, N_2 (N≡N), O_2 (O=O), F_2, Cl_2, Br_2, and I_2 are actually bond-dissociation energies, rather than average bond energies.
[b] The value for the C=O bonds in CO_2 is 799 kJ/mol.

Vapour Pressure 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

WebElements: the periodic table on the world-wide web

www.webelements.com

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
hydrogen 1 **H** 1.0079																		helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122												boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305												aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		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	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.96	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	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]	ununbium 112 **Uub** [285]	ununtrium 113 **Uut** [284]	ununquadium 114 **Uuq** [289]	ununpentium 115 **Uup** [288]	ununhexium 116 **Uuh** [293]	ununseptium 117 — —	ununoctium 118 **Uuo** [294]

Key:

element name
atomic number
symbol
atomic weight (mean relative mass)

*lanthanoids	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	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** 173.06
**actinoids	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]

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 the most recently discovered elements beyond 112 and so those used here are IUPAC's temporary systematic names. In the USA and some other countries, the spellings **aluminum** and **cesium** are normal while in the UK and elsewhere the common spelling is **sulphur.**
Group labels: the numeric system (1–18) used here is the current IUPAC convention.
Atomic weights (mean relative masses): Apart from the heaviest elements, these are the IUPAC 2007 values and given to 5 significant figures. Elements for which the atomic weight is given within square brackets have no stable nuclides and are represented by the element's longest lived isotope reported at the time of writing.