CHEM 1515.001 – 1515.006
Exam I
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Name _____

TA's Name _____

Lab Section _____

INSTRUCTIONS:

1. This examination consists of a total of 8 different pages. The last three pages include a periodic table, a table of vapor pressures for water, a solubility table and some useful equations. All work should be done in this booklet.

2. PRINT your name, TA's name and your lab section number now in the space at the top of this sheet. DO NOT SEPARATE THESE PAGES.

3. Answer all questions that you can and whenever called for show your work clearly. Your method of solving problems should pattern the approach used in lecture. You do not have to show your work for the multiple choice or short answer questions.

4. No credit will be awarded if your work is not shown in problems 4, 5 and 7.

5. Point values are shown next to the problem number.

6. Budget your time for each of the questions. Some problems may have a low point value yet be very challenging. If you do not recognize the solution to a question quickly, skip it, and return to the question after completing the easier problems.

7. Look through the exam before beginning; plan your work; then begin.

8. Relax and do well.

	Page 2	Page 3	Page 4	Page 5	TOTAL
SCORES	_____ (26)	_____ (27)	_____ (26)	_____ (21)	_____ (100)

(12) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous. Soluble ionic compounds should be written in the form of their component ions.

a) $\mathbf{2}HCl_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow \mathbf{PbCl_{2(s)} + 2H^+_{(aq)} + 2NO_3^-{}_{(aq)}}$

b) $Na_2SO_{4(aq)} + Ba(NO_3)_{2(aq)} \rightarrow \mathbf{BaSO_{4(s)} + 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)}}$

c) $K_{(s)} + Cl_{2(g)} \xrightarrow{H_2O} \mathbf{2KCl_{(s)}}$

d) $Mg_{(s)} + CO_{2(g)} \xrightarrow{\Delta} \mathbf{2MgO_{(s)} + C_{(s)}}$

(4) 2a. Write the ionic and net ionic chemical equations for 1a) or 1b).

Ionic equations

1a $\mathbf{2H^+_{(aq)} + 2Cl^-_{(aq)} + Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} \rightarrow PbCl_{2(s)} + 2H^+_{(aq)} + 2NO_3^-{}_{(aq)}}$

1b $\mathbf{2Na^+_{(aq)} + SO_4^{2-}{}_{(aq)} + Ba^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} \rightarrow BaSO_{4(s)} + 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)}}$

Net Ionic eduation

1a $\mathbf{2Cl^-_{(aq)} + Pb^{2+}_{(aq)} \rightarrow PbCl_{2(s)}}$

1b $\mathbf{SO_4^{2-}{}_{(aq)} + Ba^{2+}_{(aq)} \rightarrow BaSO_{4(s)}}$

(10) 3. Identify the intermolecular attractive forces(s) present in the following substances. If more than one intermolecular force, indicate which is the most important.

a) HCN(l)

Dipole-dipole and dispersion forces…..dipole-dipole forces are the strongest for this molecule

b) CH_2F_2(l)

Dipole-dipole and dispersion forces…..dipole-dipole forces are the strongest for this molecule

c) Ne(l)

Dispersion forces

d) SO_3(l)

Dispersion forces

(17) 4a. The equilibrium vapor pressure for carbon disulfide, CS_2, at 10 ˚C is 192 mmHg. Predict the phase(s) present at 10 ˚C if 14.0 g of CS_2 are placed into a 10.00 L container (previously evacuated). Support your answer with an explanation, and any important calculations.

$$\mathbf{PV = nRT} \qquad \mathbf{P = \frac{nRT}{V}}$$

$$\mathbf{P = \frac{14.0\ g\ CS_2 \left(\frac{1\ mol}{76.0\ g}\right)\ (0.0821\ \frac{L \cdot atm}{mol \cdot K})(283\ K)}{10.0\ L} = 0.428\ atm}$$

$$\mathbf{0.428\ atm\left(\frac{760\ mmHg}{1\ atm}\right) = 325\ mmHg}$$

Since the equilibrium vapor pressure of CS_2 at 10˚C is less than the pressure calculate assuming all of the sample completely vaporized condensation must occur and both liquid and vapor are present in the container.

b. What phase(s) are present if the volume of the container were twice as large at the same temperature? (Assume no loss of CS_2)

If the volume is 20.0 L the pressure would be;

$$\mathbf{P_2 = \frac{P_1V_1}{V_2} = \frac{325\ mmHg \cdot 10.0\ L}{20.0\ L} = 163\ mmHg}$$

This calculated pressure is less than the equilibrium vapor pressure, so the phase present is vapor only.

(10)5a. The vapor pressure of cyclohexane at 20 ˚C is 78 mmHg and at 60 ˚C it is 390 mmHg. Calculate the heat of vaporization, ΔH°_{vap} for cyclohexane.

$$\mathbf{1n\left(\frac{vp_2}{vp_1}\right) = -\frac{\Delta H^\circ_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)}$$

$$\mathbf{1n\left(\frac{390\ mmHg}{78\ mmHg}\right) = -\frac{\Delta H^\circ_{vap}}{8.314\ \frac{J}{mol \cdot K}}\left(\frac{1}{333\ K} - \frac{1}{293\ K}\right)}$$

$$\mathbf{1n(5) = -\frac{\Delta H^\circ_{vap}}{8.314\ \frac{J}{mol \cdot K}}\ (3.00 \times 10^{-3}\ K^{-1} - 3.41 \times 10^{-3}\ K^{-1})}$$

$$\mathbf{1.61 = -\frac{\Delta H^\circ_{vap}}{8.314\ \frac{J}{mol \cdot K}}\ (-4.10 \times 10^{-4}\ K^{-1})}$$

$$\mathbf{1.61 = -\Delta H^\circ_{vap}\ (-4.93 \times 10^{-5})}$$

$$\mathbf{32.6\ \frac{kJ}{mol} = \Delta H^\circ_{vap}}$$

(16) 6. The boiling point of the first two binary hydrogen compounds in Group IV and V are shown in the Table below:

Compound	Boiling Point (˚C)
CH_4	–164
SiH_4	–112
H_2O	100
H_2S	–61

Explain why CH_4 has a lower boiling point compared to SiH_4, but H_2O has a higher boiling point compared to H_2S?

Both CH_4 and SiH_4 are nonpolar. The only intermolecular attractive force occurring in nonpolar compounds is dispersion forces. Dispersion forces depend on the number of electrons. Since CH_4 has fewer, less polarizable electrons it has a lower boiling point compared to SiH_4.

Both H_2O and H_2S are polar. Water has hydrogen-bonding intermolecular attractive forces which are much stronger than the dipole-dipole forces in H_2S. Both have dispersion forces, but dispersion forces are much weaker in these two compounds.

(10) 7. Tungsten crystallizes in a face-centered cubic unit cell. The atomic radius of a tungsten atom is 0.137 nm. Calculate the density, in g cm^{-3}, of the unit cell.

Face centered cubic unit cell has 4 atoms of tungsten per unit cell.

The mass of the unit cell is;

$$\textbf{4 W atoms}\left(\frac{\textbf{1 mol}}{\textbf{6.023 x}10^{\textbf{23}}\textbf{ atoms}}\right)\left(\frac{\textbf{184 g}}{\textbf{1 mol}}\right) = \textbf{1.22 x } 10^{-\textbf{21}}\textbf{ g}$$

The volume of the unit cell is;

$$\textbf{Edge length} = 2\sqrt{2}\cdot\ \textbf{(0.137 x } 10^{-\textbf{9}}\textbf{ m)}\left(\frac{\textbf{100 cm}}{\textbf{1 m}}\right) = \textbf{ 3.87 x } 10^{-\textbf{8}}\textbf{ cm}$$

$$\textbf{Volume} = \textbf{(3.87 x } 10^{-\textbf{8}}\textbf{ cm)}^{\textbf{3}} = \textbf{5.82 x } 10^{-\textbf{23}}\textbf{ cm}^{\textbf{3}}$$

$$\textbf{Density} = \left(\frac{\textbf{mass}}{\textbf{volume}}\right) = \left(\frac{\textbf{1.22 x } 10^{-\textbf{21}}\textbf{ g}}{\textbf{5.82 x } 10^{-\textbf{23}}\textbf{ cm}^{\textbf{3}}}\right) = \textbf{21.0}\ \frac{\textbf{g}}{\textbf{cm}^{\textbf{3}}}$$

(8) 8. For each of the following solids identify the type of attractive force(s) that exists?

a) SiO_2

Covalent bonding

b) N_2O_4

London dispersion forces

c) Mo

Metallic bonding

d) MgF_2

Ionic **bonding**

(13) 9a. Name the two phases involved in evaporation.

Liquid and vapor (gas)

b) Write a chemical equation to symbolically represent evaporation for a substance of your choosing.

$$\mathbf{H_2O}_{(l)} \rightarrow \mathbf{H_2O}_{(g)}$$

c) Is evaporation endothermic or exothermic?

endothermic

d. From a particulate level (atomic level) how does evaporation occur?

Particles of water in the liquid phase on the surface with sufficient energy are able to overcome the attractive forces holding them together in the liquid phase, and escape into the gas phase.

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 **H** 1.008																	2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
6	55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 (261)	105 (262)	106 (263)												

Lanthanides	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
Actinides	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	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)

Useful Information

$PV = nRT$

$R = 0.0821 \frac{L \cdot atm}{mol \cdot K} = 8.314 \frac{J}{mol \cdot K}$

$\ln\left(\frac{vp_2}{vp_1}\right) = -\frac{\Delta H^\circ_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

density of $H_2O = 1.00 \frac{g}{cm^3}$

$1\ nm = 10^{-9}\ m$

$1\ pm = 10^{-12}\ m$ $1\ atm = 760\ mmHg$

edge length (l) = 2r

edge length (l) = $2\sqrt{2} \cdot r$ edge length (l) = $\frac{4r}{\sqrt{3}}$

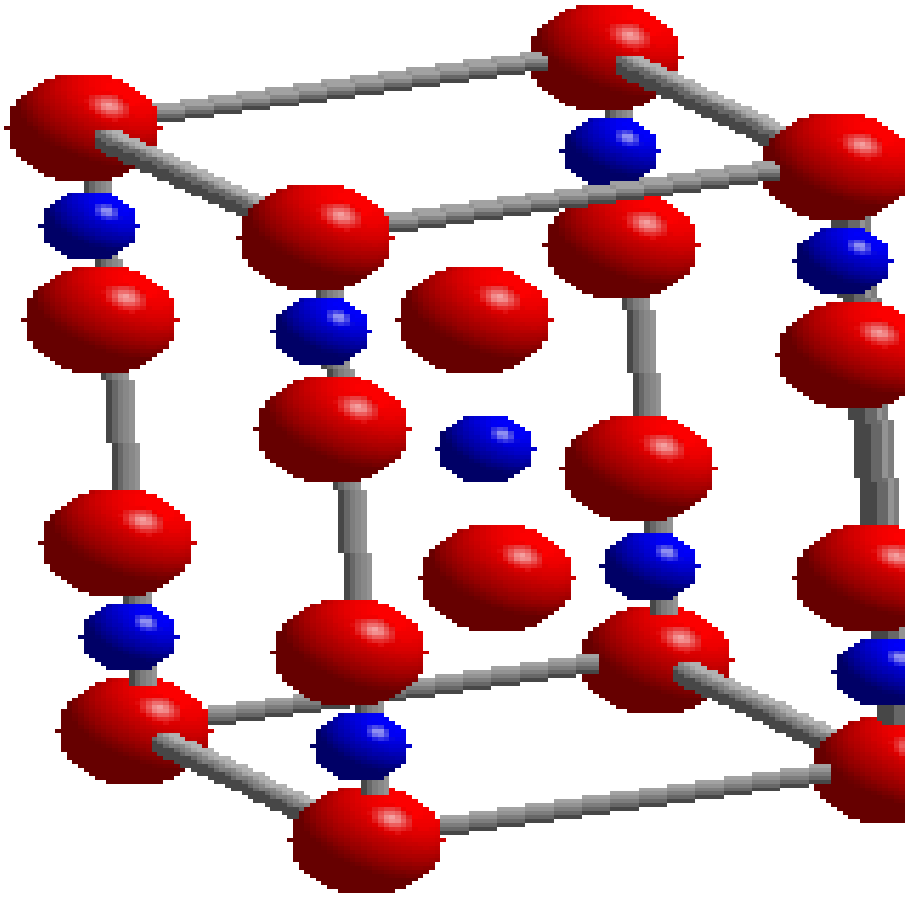
6.023×10^{23}

Temperature (°C)	Vapor Pressure(mmHg)	Temperature (°C)	Vapor Pressure(mmHg)
-5	3.2	50	92.5
0	4.6	55	118.0
5	6.52	60	149.4
10	9.20	65	187.5
15	12.8	70	233.7
20	17.5	75	289.1
25	23.8	80	355.1
30	31.8	85	433.6
35	42.1	90	525.8
40	55.3	95	633.9
45	71.9	100	760

Solubility Table

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
Cl^-	soluble	except Ag^+, Hg_2^{2+}, *Pb^{2+}
I^-	soluble	except Ag^+, Hg_2^{2+}, Pb^{2+}
SO_4^{2-}	soluble	except Ca^{2+}, Ba^{2+}, Sr^{2+}, Hg^{2+}, Pb^{2+}, Ag^+
CO_3^{2-}	insoluble	except Group IA and NH_4^+
PO_4^{3-}	insoluble	except Group IA and NH_4^+
^-OH	insoluble	except Group IA, *Ca^{2+}, Ba^{2+}, Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^+
Na^+	soluble	none
NH_4^+	soluble	none
K^+	soluble	none

*slightly soluble



(9) 8a. Describe what happened in the "ammonia fountain" experiment which was demonstrated in class. Recall a clamped 5.0 L round-bottom flask containing $NH_{3(g)}$ was suspended above a second 5.0 L round-bottom flask filled with $H_2O_{(l)}$ to which had been added a few drops of phenophthalein. The two flasks were connected by a glass tube which protruded through the rubber stoppered flask containing the ammonia. The flask containing water was open to the atmosphere. A small pipet bulb, containing water, was connected via a second glass rod which protruded through the rubber stoppered flask containing the ammonia. To begin the experiment a small amount of water was injected into the flask containing the $NH_{3(g)}$ by a slight squeeze of the pipet bulb.

b. Briefly provide an explanation for the observed behavior.

c. Do you think the solution process was exothermic or endothermic?

d. Using Lewis structures, draw a picture (and label) depicting the intermolecular interactions in the solution at the completion of the demonstration (after the fountain stopped.)