CHEM 1515.001 - 009
Exam II
John II. Gelder
March 5, 2003

Name _____

TA's Name _____

Section _____

INSTRUCTIONS:

1. This examination consists of a total of 9 different pages. The last four pages include a periodic table; useful mathematical equations and constants; a table of vapor pressures for water; a solubility table; and an activity series. 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 6b - 6d, 6f, 7a and 7b.

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	Page 6	TOTAL
SCORES	_____	_____	_____	_____	_____	_____
	(21)	(20)	(32)	(15)	(12)	(100)

(9) 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) $AgCl_{(s)} + \mathbf{2}NH_{3(aq)} \rightarrow \mathbf{Ag(NH_3)_2^+}_{(aq)} + \mathbf{Cl^-}_{(aq)}$

b) $Fe^{3+}_{(aq)} + SCN^-_{(aq)} \rightarrow \mathbf{FeSCN^{2+}}_{(aq)}$

c) $\mathbf{2}NaOH_{(aq)} + Cu(NO_3)_{2(aq)} \rightarrow \mathbf{Cu(OH)_2}_{(s)} + \mathbf{2NO_3^-}_{(aq)} + \mathbf{2Na^+}_{(aq)}$

(4) 2a. Write the ionic and net ionic chemical equation for 1c).

Ionic equation

$$\mathbf{2OH^-}_{(aq)} + \mathbf{2Na^+}_{(aq)} + \mathbf{2NO_3^-}_{(aq)} + \mathbf{Cu^{2+}}_{(aq)} \rightarrow \mathbf{Cu(OH)_2}_{(s)} + \mathbf{2NO_3^-}_{(aq)} + \mathbf{2Na^+}_{(aq)}$$

Net Ionic equation

$$\mathbf{2OH^-}_{(aq)} + \mathbf{Cu^{2+}}_{(aq)} \rightarrow \mathbf{Cu(OH)_2}_{(s)}$$

(8) 3. For the following four substances

Fe(s) Ne(s) C(s,diamond) NaBr(s)

predict the order of the melting points from highest to lowest.

Highest Lowest

C(s,diamond) > Fe(s) > NaBr(s) > Ne(s)

Explain, your order in terms of the types of attractive forces that occur in each solid.

The order is based on the strength of the attractive forces occurring in each substance. For C(s,diamond) the forces are extended covalent bonds. Every carbon atom in diamond is covalent bonded to four other carbon atoms in a 3-dimensional extended array.
Next is Fe(s) here metallic bonding is present. Metallic bonding is generally stronger than ionic bonding, which is what is occurring in NaBr(s).
Finally the weakest interaction occurs in Ne(s). Here the forces are weak (relatively) dispersion forces which arise as a result of instantaneous dipoles.

(12) 4. Given the three substances

CS_2 SO_2 SiO_2

a) Which substance is the most soluble in water? Explain.

The most soluble substance of the three is SO_2. It is polar. While CS_2 is nonpolar and SiO_2 has the very, very strong extended covalent structure. SiO_2 is not soluble in any solvent that we have discussed. So of the three substances SO_2 will have the highest solubility.

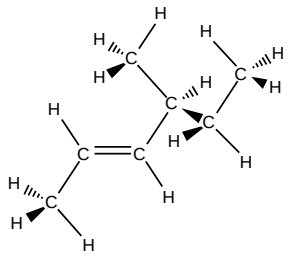
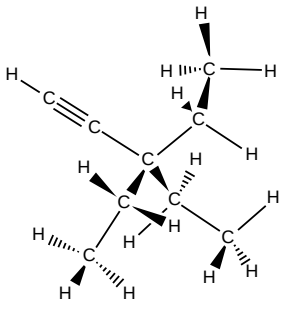
b) Which substance is the least soluble in water? Explain.

SiO_2 is the least soluble of the three substances. Due to its extended covalent structure, the strong covalent bonds between the Si and O atoms prevent any solvent from breaking down this structure.

c) For the remaining substance, identify a solvent it will dissolve. Explain why you selected the particular solvent.

CS_2 is nonpolar, so a nopolar solvent will be best. A solvent like benzene, C_6H_6, or carbon tetrachloride, or hexane each of which is nonpolar would work best.

(8) 5. Give the name or draw the complete Lewis structure (showing all C-H bonds for each of the following compounds.

	2,2,5,5-tetramethyl-3-hexyne
cis-4-methyl-2-hexene	

(47) 6a. When the ionic solid $(NH_4)_2SO_4$ dissolves in water the temperature of the solution decreases. In terms of the steps of the solution process explain why $(NH_4)_2SO_4$ dissolving in water is endothermic. (8)

Two factors govern the solubility of ionic compounds. The magnitude of the lattice energy and the hydration energy. Since the solution process is endothermic, more energy is required to overcome the lattice energy (solute-solute forces) than is liberated when the ions are hydrated by water.

b) You are responsible for preparing 250.00 mLs of a 0.450 M $(NH_4)_2SO_4$ solution using pure $(NH_4)_2SO_4$, distilled water and any equipment you require. Explain how you would prepare this solution. (show important calculations) (8)

weigh out 14.8 g (0.250 * 0.450 M * 132 g/mol) and add to the volumetric flask. Add about 175 mLs of water and dissolve, than add enough water to reach 250 mLs

c) The density of the solution in b) is 1.036 g cm^{-3}. Calculate the weight percent of the solute in the solution. (6)

Answer is 5.73%

d) Calculate the ideal freezing point of the solution in b). (10)

Answer is -2.57 ˚C remember that I = 3 for this salt.

6. (CONTINUED)

e) A student carefully determines the experimental freezing point of this solution. She finds the freezing point is –2.02 ˚C. How would you explain the difference between the experimental and the ideal freezing point of this solution? (6)

Since the experimental freezing point is higher compared to the calculated there must be fewer particles in the solution. This can only occur if ion-pairing is happening. The pairing of ions reduces the number of particles .

f) You are given a compound with the formula CH_4N_2. The experimental freezing point of a solution prepared by dissolving 4.40 g of CH_4N_2 in 1.150 kg. grams of water was found to be –0.26 ˚C.(9)

i) Is the compound ionic or covalent? Explain.

Calculate the I value. It is 1.6. That large an I value must be a strong electrolyte. If it is a strong electrolyte there must be ions…NH_4^+ and CN^-

ii) Re-write the formula to reflect the type of compound you indicated in i).

(12) 7. An unkown metal has a density of 10.5 g cm^{-3}. The metal crystallizes in a face-centered cubic unit cell system. The edge length of the cubic unit cell is 4.07 Å.

a) Determine the molar mass of the unknown metal. (7)

Use the unit cell edge length to calculate volume, and then use density to get grams in the unit cell. then use the number of atoms (4) and avogadro's number to get moles…grmas/mole = molar mass.

b) Determine the atomic radius of the unknown metal. (4)

Us e the relationship between edge length and atomic radius for fcc

c) What is the name and/or symbol for the unknown metal. (1)

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

1 pm = 10^{-12} m

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

6.02×10^{23}

$P_{solution} = \chi_{solvent} P^{\circ}_{solvent}$

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

$\Delta T = i k m$

$k_f(H_2O) = 1.86 \frac{^{\circ}C}{m}$

$k_b(H_2O) = 0.512 \frac{^{\circ}C}{m}$

edge length (l) = 2r

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

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

$\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ}$

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

Activity Series

Metal	Half-Reaction Reaction
Gold	$Au^{3+} + 3e^- \rightarrow Au$
Platinum	$Pt^{2+} + 2e^- \rightarrow Pt$
Mercury	$Hg^{2+} + 2e^- \rightarrow Hg$
Silver	$Ag^{+} + e^- \rightarrow Ag$
Copper	$Cu^{2+} + 2e^- \rightarrow Cu$
Hydrogen	$2H^{+} + 2e^- \rightarrow H_2$
Lead	$Pb^{2+} + 2e^- \rightarrow Pb$
Tin	$Sn^{2+} + 2e^- \rightarrow Sn$
Nickel	$Ni^{2+} + 2e^- \rightarrow Ni$
Cobalt	$Co^{2+} + 2e^- \rightarrow Co$
Iron	$Fe^{2+} + 2e^- \rightarrow Fe$
Chromium	$Cr^{3+} + 3e^- \rightarrow Cr$
Zinc	$Zn^{2+} + 2e^- \rightarrow Zn$
Manganese	$Mn^{2+} + 2e^- \rightarrow Mn$
Aluminum	$Al^{3+} + 3e^- \rightarrow Al$
Magnesium	$Mg^{2+} + 2e^- \rightarrow Mg$
Sodium	$Na^{+} + e^- \rightarrow Na$
Calcium	$Ca^{2+} + 2e^- \rightarrow Ca$
Barium	$Ba^{2+} + 2e^- \rightarrow Ba$
Potassium	$K^{+} + e^- \rightarrow K$
Lithium	$Li^{+} + e^- \rightarrow Li$

$\xrightarrow{H_2O}$