CHEM 1515.001 - 006
Exam II
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March 5, 2002

Name ______________________

TA's Name ______________________

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 a table of thermodynamic values. 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 6 and 8.
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	____ (22)	____ (18)	____ (24)	____ (18)	____ (18)	____ (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) $Fe(NO_3)_3$*(aq)* + KSCN*(aq)* → **$FeSCN^{2+}$*(aq)* + $3NO_3^-$*(aq)* + K^+*(aq)***

b) $CuSO_4$*(aq)* + **2**NaOH*(aq)* → **$2Na^+$*(aq)* + $2SO_4^{2-}$*(aq)* + $Cu(OH)_2$*(s)***

c) Na_2CO_3*(s)* + **2**HCl*(aq)* → **$2Na^+$*(aq)* + CO_2*(g)* + H_2O*(l)* + $2Cl^-$*(aq)***

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

Ionic equation

Na_2CO_3*(s)* + $2H^+$*(aq)* + $2Cl^-$*(aq)* → $2Na^+$*(aq)* + CO_2*(g)* + H_2O*(l)* + $2Cl^-$*(aq)*

Net Ionic equation

Na_2CO_3*(s)* + $2H^+$*(aq)* → $2Na^+$*(aq)* + CO_2*(g)* + H_2O*(l)*

(9) 3. Identify the interparticle attractive force(s) present in the solids of the following substances. If more than one interparticle force, indicate which is the most important.

a) NF_3

dipole-dipole and dispersion forces

Since all of the atoms are in the second period the most important force is dipole-dipole.

b) CH_3NH_2

hydrogen-bonding and dispersion forces. Again since all of the atoms are in the second period hydrogen-bonding is the most important attractive force.

c) KBr

ionic bonding is the only attractive force that is important. Dispersion forces are prsent but they are VERY small compared to ionic forces.

(12) 4. Account for each of the following observations about pairs of substances. In your answers, use appropriate principles of intermolecular forces. In each part, your answer must include references to <u>both</u> substances.

a) HF has normal boiling point = 20 ˚C where as HCl has a normal boiling point of –114 ˚C.

HF is a polar compound with hydrogen-bonding and dispersion forces.

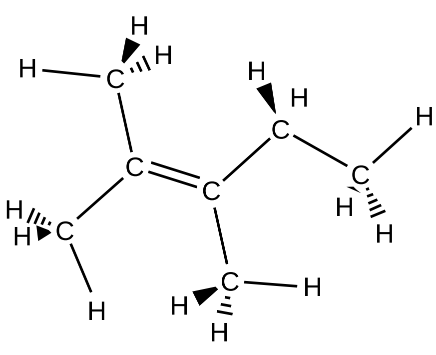
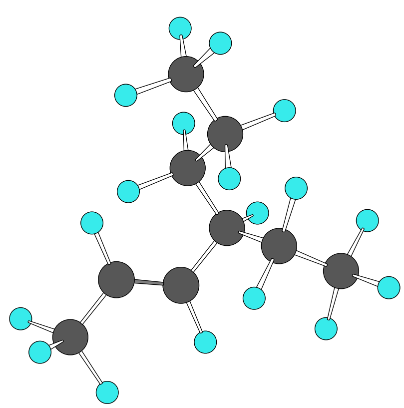
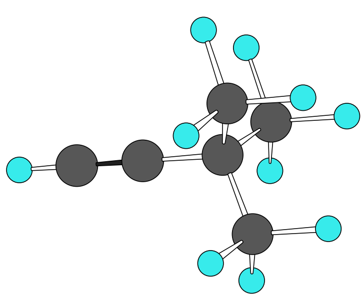
HCl is a polar compound with dipole-dipole and dispersion forces. Dispersion forces are the most important in HCl.

The hydrogen-bonding forces in HF are much stronger compared to the dispersion forces in HCl.

b) CCl_4 has normal boiling point = 76.7 ˚C where as CBr_4 has a normal boiling point of 189 ˚C.

Both compounds are nonpolar so the only attractive forces are dispersion forces. CBr_4 has more electrons and is more polarizable compared to CCl_4. So CBr_4 has the higher boiling point.

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

 **2,3-dimethyl-2-pentene**	4-ethyl-*trans*-2-heptene 	3,3-dimethyl-1-butyne 

(12) 6. Barium, Ba, crystallizes in one of the cubic unit cell systems. The edge length of its unit cell is 502 pm and the density of the metal is 3.50 g cm^{-3}. Determine the number of atoms in the cubic unit cell **and** identify the type of cubic cell.

$$\mathbf{502\ pm\left(\frac{10^{-12}\ m}{1\ pm}\right)\left(\frac{10^{2}\ cm}{1\ m}\right) = 5.02 \times 10^{-8}\ cm}$$

$$\mathbf{Volume = (5.02 \times 10^{-8}\ cm)^3 = 1.26 \times 10^{-23}\ cm^3}$$

$$\mathbf{1.26 \times 10^{-23}\ cm^3\ 3.50\ \frac{g}{cm^3} = 4.43 \times 10^{-22}\ g}$$

$$\mathbf{4.43 \times 10^{-22}\ g\left(\frac{1\ mol}{137\ g}\right)\left(\frac{6.023 \times 10^{23}\ atoms}{1\ mol}\right) = 1.95\ atoms}$$

So the unit cell must be body centered cubic

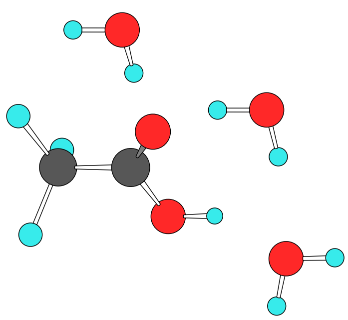
(12) 7a. Some solutions processes are exothermic while others are endothermic. Provide an explanation for this difference.

There are three steps to determine ΔH for a solution;

Step 1: **overcome the solute-solute attractive forces (endothermic)**
Step 2: **overcome the solvent- solvent attractive forces (endothermic)**
Step 3: **form new solute- solvent attractive forces (exothermic)**

The solution process is exothermic when Step 3 is more negative, than the sum of Steps 1 and 2. The solution process is endothermic if the sum of Step 1 and 2 is more positive than the absolute value of Step 3.

b) A substance with the formula $C_2H_4O_2$ is very soluble in water, but insoluble in CS_2. Suggest a structure for this substance that supports the solubility information. Indicate the intermolecular attractive force that explains the solubility.



Hydrogen-bonding occurs between the water molecules and the acetic acid molecule

(36) 8. An aqueous solution of Na_3PO_4 is prepared by mixing 16.4 g Na_3PO_4 with 500 g of water.

a) calculate the molality of the solution. (6)

$$\mathbf{16.4\ g\ Na_3PO_4\left(\frac{1\ mol}{164\ g}\right) = 0.100\ mol}$$

$$\mathbf{\left(\frac{0.100\ mol}{0.500\ kg}\right) = 0.200\ molal}$$

b) calculate the ideal freezing point of the solution. (6)

$$\mathbf{Na_3PO_4}\mathit{(aq)} \rightarrow \mathbf{3Na^+}\mathit{(aq)} + \mathbf{PO_4^{3-}}\mathit{(aq)}$$

i = 4 (ideal)

$\Delta T_f = ik_fm = 4 \cdot 1.86\ ˚C\ m^{-1} \cdot 0.200\ m = 1.49\ ˚C$

$T_f = -1.49\ ˚C$

c) the experimental freezing point was found to be –1.32 ˚C. Explain why the experimental and ideal freezing point are different. (6)

$\Delta T_f = ik_fm$
$1.32\ ˚C = i \cdot 1.86\ ˚C\ m^{-1} \cdot 0.200\ m = 1.49\ ˚C$
$i = 3.55$

The experimental freezing point is higher because there are fewer particles in the solution compared tot he ideal solution. There must be ion-pairing occuring to reduce the number of particles.

8. (Continued)

d) a new aqueous solution of sodium phosphate, Na_3PO_4, was prepared with a density of 1.05 g cm^{-3}. The molality of this solution was determined to be 0.320 molal.

i) calculate the weight percent of Na_3PO_4 in this solution. (6)

0.320 mol Na_3PO_4 per 1 kilogram of H_2O

$$\mathbf{0.320\ mol\left(\frac{164\ g}{1\ mol}\right) = 52.5\ grams}$$

$$\text{weight \%} = \left(\frac{\mathbf{52.5\ grams\ Na_3PO_4}}{\mathbf{52.5\ grams\ Na_3PO_4 + 1000\ g\ H_2O}}\right) \cdot \mathbf{100 = 4.99\ \%}$$

ii) calculate the molarity of the solution. (6)

total mass of the solution is 1052.5 grams

$$\mathbf{1052.5\ grams\left(\frac{1\ mL\ solution}{1.05\ g}\right) = 1002\ mL = 1.002\ L}$$

$$\mathbf{\frac{0.320\ mol}{1.002\ L} = 0.319\ M}$$

iii) describe how to prepare 1200 g of a 0.320 molal solution beginning with a 0.500 molal Na_3PO_4 solution and distilled water. (6)

$$\mathbf{1200\ gram\ solution\left(\frac{52.5\ grams\ Na_3PO_4}{52.5\ grams\ Na_3PO_4 + 1000\ g\ H_2O}\right) = 59.9\ g\ Na_3PO_4\ need}$$

A 0.500 molal solution contains

$$\mathbf{0.500\ mol\left(\frac{164\ g}{1\ mol}\right) = 82.0\ grams\ Na_3PO_4 \quad or \quad \left(\frac{82.0\ grams\ Na_3PO_4}{82.0\ grams\ Na_3PO_4 + 1000\ g\ H_2O}\right)}$$

$$\mathbf{59.9\ g\ Na_3PO_4\left(\frac{82.0\ grams\ Na_3PO_4 + 1000\ g\ H_2O}{82.0\ grams\ Na_3PO_4}\right) = 790\ grams\ of\ 0.500\ molal\ solution}$$

This says that 790 grams of a 0.500 molal Na_3PO_4 solution contains 59.9 g of Na_3PO_4. So if we add 1200 grams – 790 grams solution = 410 grams of H_2O to 790 grams of 0.500 molal Na_3PO_4 solution we would have 1200 grams of a 0.320 molal Na_3PO_4 solution.

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	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

$1 \text{ pm} = 10^{-12} \text{ m}$

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

6.02×10^{23}

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

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

$\Delta T = ikm$

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

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

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