Chemistry 141 Name

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Exam 4 May 19, 2011

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| --- | --- | --- |
|  | Points Earned | Points Possible |
| Page 1 multiple choice |  | 30 |
| Page 3 |  | 14 |
| Page 4 |  | 25 |
| Page 5 |  | 15 |
| Page 6 |  | 16 |
| Page 7 |  | 16 |
| Page 8 |  | 16 |
| Total |  | 132 |
| Percent Score |  | 100 |

Note: All work must be shown to receive credit. On calculation problems show answer with the correct number of significant figures using scientific notation if necessary.

Chemistry Formulas and Constants



Formulas

Kinetic energy = ½ mv2

w = -PΔV

Ptotal = P1+P2+P3+…

u = (3RT/MW)½

ΔG = ΔH - TΔS

PV = nRT

Rate ∝ (MW)-½

P1=*i*X1\*Ptotal

C = q/ΔT

w=dxF

E = IR

ΔGo = -nFEo

ΔG = - RTlnK

E = mc2

Ba(Na)2 = fruit

HΨ=EΨ

Amp = C/sec

Π= *i*MRT

E = hν = hc/λ

M1V1 = M2V2

Ptotal = P1 + P2 + P3 + …

M = mol/L

m = mol/kg solvent

Xi = moli/ moltotal

ΔTb = i(kb)(m)

ΔTf = i(kf)(m)

Psoln = (Psolv)(Xsolv)

pH = -log [H3O+]

pOH = -log[OH-]

[H3O+][OH-]= 1.0x10-14M2

pH+pOH = 14



Constants

1 angstrom = 10-8 cm

F = 9.65 x 104 C

h = 6.626 x 10-34 J sec

c= 2.9979 x 108 m/sec

e = 1.602 x 10-19 C

NA = 6.022 x 1023/mol

k = 1.381 x 10-23 J/K

K = oC + 273.16

Kw = 1.0 x 10-14M2

mass electron = 9.109 x 10-31 kg

R = 0.0821 L atm/mol K= 8.314 J/K mol= 1.987 cal.mol K= 62.4 L torr/mol K

Standard Temperature and Pressure = 0oC and 1 atm

Multiple Choice (30 points)

1. The normal boiling point for HBr is higher than the normal boiling point for HCl. This can be explained by
   1. larger dipole-dipole forces, larger dispersion forces, and larger hydrogen-bond forces for HBr.
   2. larger dispersion forces for HBr.
   3. larger hydrogen-bond forces for HBr.
   4. larger dipole-dipole forces for HBr.
2. Molecules of a liquid can pass into the vapor phase only if the
   1. vapor pressure of the liquid is high.
   2. molecules have sufficient kinetic energy to overcome the intermolecular forces in the liquid.
   3. temperature of the liquid is near its boiling point.



* 1. liquid has little surface tension.

1. Which drawing best represents hydrogen bonding?
   1. Drawing 1
   2. Drawing 2
   3. Drawing 3
   4. Drawing 4
2. Write the equilibrium equation for the **reverse** reaction:

2 CH4(*g*) + 3 O2(*g*) = 2 CO(*g*) + 4 H2O(*g*)



1. For the reaction: 4 HCl(*g*) + O2(*g*) 🡨🡪 2 Cl2(*g*) + 2 H2O(*l*), the equilibrium constant is 0.063 at 400 K. If the reaction quotient is 0.100, which of the following statements is correct?
   1. [Cl2] will decrease.
   2. [H2O] will increase.
   3. [HCl] will decrease.
   4. [O2] will decrease.
2. Calcium carbonate is relatively insoluble and the dissolution reaction is endothermic: CaCO3(*s*) ↔ Ca2+(*aq*) + CO32-(*aq*). Which change in reaction condition below will shift the equilibrium to the right?
   1. increase the temperature
   2. add an acid to react with CO3-2 ion
   3. add an anion with which Ca+2 is even more soluble than calcium carbonate
   4. All of the above will shift reaction to the right.
3. Which is expected to have the largest dispersion forces?
   1. C2H6
   2. CO2
   3. C8H18
   4. N2
4. Which one of the following statements does **not** describe the equilibrium state?
   1. The rate of the forward reaction is equal to the rate of the reverse reaction.
   2. The concentration of the reactants and products reach a constant level.
   3. The concentration of the reactants is equal to the concentration of the products.
   4. Equilibrium is dynamic and there is no net conversion to reactants and products.
5. Red blood cells are placed into pure water. Which of the following statements is true?
   1. The osmotic pressure inside the cells equals the osmotic pressure outside.
   2. Water molecules flow out of the red blood cells, causing them to collapse.
   3. The osmotic pressure of the cell contents increases, causing the cells to burst.
   4. Water flows into the red blood cells, causing them to swell and burst.
6. The magnitude of the heats of vaporization, fusion and sublimation of a substance reflect the
   1. strength of the covalent bonds between atoms in each molecule of the substance.
   2. strength of the intermolecular forces of the substance.
   3. density of the substance.
   4. magnitudes of the boiling and melting points of the substance.
7. The vapor pressure of a pure liquid increases as the
   1. temperature of the liquid phase decreases.
   2. temperature of the liquid phase increases.
   3. intermolecular attractive forces increase.
   4. average kinetic energy of the molecules in the liquid phase decreases.
8. The rubbing alcohol sold in drug stores often is composed of 70% isopropyl alcohol and 30% water. In this solution
   1. isopropyl alcohol is the solvent.
   2. water is the solvent.
   3. both water and isopropyl alcohol are solvents.
   4. neither water nor isopropyl alcohol is a solvent.
9. In general, as the temperature increases, the solubility of gases in water \_\_\_\_\_\_\_\_ and the solubility of most solids in water \_\_\_\_\_\_\_\_.
   1. decreases, increases
   2. increases, decreases
   3. decreases, decreases
   4. increases, increases
10. Choose the aqueous solution that has the highest boiling point. These are all solutions of nonvolatile solutes and you should assume ideal van't Hoff factors where applicable.
    1. 0.100 *m* NaNO3
    2. 0.100 *m* Li2SO4
    3. 0.200 *m* C3H8O3
    4. 0.060 *m* Na3PO4
    5. They all have the same boiling point.
11. Which change in the system will drive equilibrium to the left in the reaction below?

N2O5(*g*) ↔ NO2(*g*) + NO3(*g*)

* 1. decrease the amount of NO3
  2. increase the amount of N2O5
  3. increase the volume
  4. increase the pressure

Problems (85 points)

1. (5 points) Rationalize the trend in water solubility for the following simple alcohols

|  |  |
| --- | --- |
| Alcohol | Solubility (g/100 g H2O at 20oC) |
| Methanol CH3OH | soluble in all proportions |
| Ethanol CH3CH2OH | soluble in all proportions |
| Propanol CH3CH2 CH2 OH | soluble in all proportions |
| Butanol CH3CH2 CH2 CH2 OH | 8.14 |
| Pentanol CH3CH2 CH2 CH2 CH2 OH | 2.64 |
| Hexanol CH3CH2 CH2 CH2 CH2 CH2 OH | 0.59 |
| Heptanol CH3CH2 CH2 CH2 CH2 CH2 CH2 OH | 0.09 |

The hydroxyl group makes the alcohols soluble in water and the alkyl groups make it soluble in toluene. As the fraction of the alkyl portion of the molecule increases, its water solubility decreases.

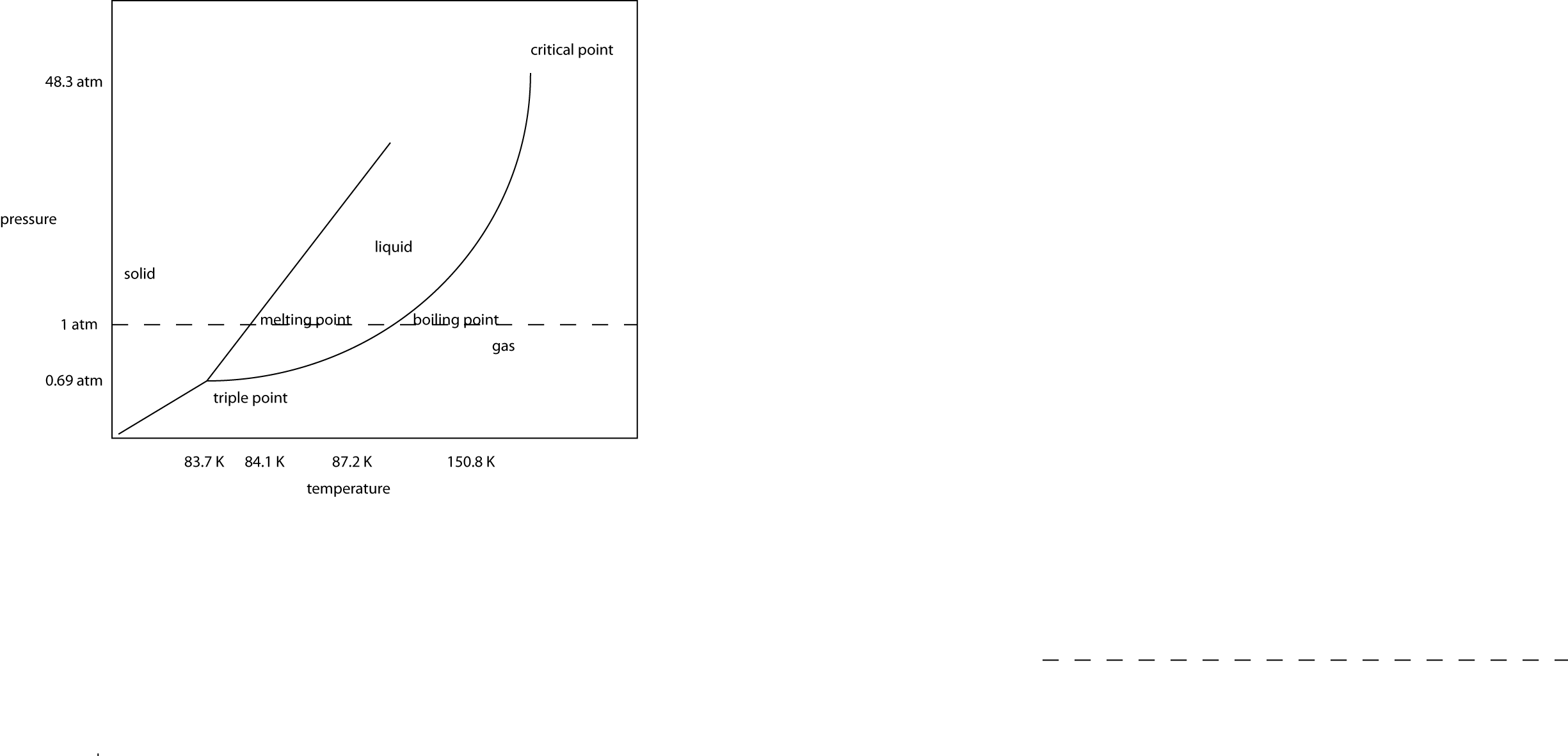
1. (6 points) In each group of substances, pick the one that has the given property. Justify your answer using descriptions of the types of intermolecular forces that are important as well as other factors determining liquid properties.
   1. higher viscosity:  or 

CH2O will have the have the higher viscosity because it is more polar due to the more electronegative oxygen atom. More polar means stronger intermolecular forces and a higher viscosity.

* 1. higher vapor pressure at 25oC: CH3CH2CH2CH3 or CH3CH2CH2CH2CH2CH2CH2CH2CH3

The dispersion forces for nonane, C9H18 are higher than for butane, C4H10 meaning that it is harder to evaporate so its vapor pressure will be lower.

1. (10 points) Argon has a normal boiling point of 87.2 K and a melting point (at 1 atm) of 84.1 K. Its critical temperature is 150.8 K and critical pressure is 48.3 atm. It has a triple point at 83.7 K and 0.69 atm. Sketch the phase diagram of argon. Which has the greater density, solid argon or liquid argon?



1. (8 points) A solution of sodium chloride in water has a vapor pressure of 19.6 torr at 25oC. The vapor pressure of pure water is 23.8 torr at 25oC and 71.9 torr at 45oC.
   1. What is the mole fraction of NaCl solute particles in this solution?

Or

* 1. What would be the vapor pressure of this solution at 45oC?

Or

1. (16 points) The umami taste of some foods is thought to be due to the presence of two amino acids, glutamate and aspartic acid. Sodium asparatate, Na2C4H5O4N (177.08 g/mol), is dissolved in water to make 21.6% solution which has a density of 1.12 g/mL at 20oC. Calculate
   1. The molarity of sodium asparate
   2. The molality of sodium asparate
   3. The freezing point of the solution (Kf, H2O= 1.86oC/m)

The freezing point will be -2.90 oC

Actually would be -8.70 due to dissociation in solution! +2 bonus points if catch this!

* 1. The osmotic pressure (in torr) of the solution

1. (6 points) Write the equilibrium expressions for the following reactions
   1. 2 PBr3(g) + 3 Cl2(g) 🡨🡪 2 PCl3(g) + 3 Br2(g)
   2. CuO(s) + H2(g) 🡨🡪 Cu(l) + H2O(g)
2. (10 points) The smell of ripe raspberries is due to p-hydroxyphenol-2-butanone, which has the empirical formula C5H6O. To find its molecular formula, you dissolve 0.135 g in 25.0 g of chloroform, CH3Cl. The boiling point of the solution is 61.82oC. What is the molecular formula of p-hydroxyphenol-2-butanone? (Normal boiling point chloroform is 61.70oC and Kbp is +3.63oC/m)

Molar mass = 163 g/mol so molecular formula is 2X empirical formula.

1. (12 points) Tell how the equilibrium shifts for each of the following and answer the additional questions for the reaction below:

2 SO3(g) 🡨🡪 2 SO2(g) + O2(g) ΔHo = +197 kJ

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Change to system | Shift (Circle one) | Question | Change |
|  |  |  |  |  |
|  | Oxygen gas is added | 🡪 🡨 NC | Moles of O2 | 🡩 🡫 NC ? |
| Moles o fSO2 | 🡩 🡫 NC ? |
|  | The volume of the container is decreased | 🡪 🡨 NC | Rate of the forward reaction | 🡩 🡫 NC ? |
| Concentration of SO3 | 🡩 🡫 NC ? |
|  | The temperature is decreased | 🡪 🡨 NC | Rate of reverse reaction | 🡩 🡫 NC ? |
| Value of K | 🡩 🡫 NC ? |
|  | Gaseous sulfur dioxide is removed | 🡪 🡨 NC | Rate of forward reaction | 🡩 🡫 NC ? |
| Rate of reverse reaction | 🡩 🡫 NC ? |

1. (16 points)Carbon tetrachloride can be produced by the following reaction:

CS2(g) + 3 Cl2(g) ⮀ S2Cl2(g) + CCl4(g) at 450K

2.60 mol of CS2 and 4.75 mol of Cl2 were placed in a 1.00 L flask and after equilibrium was achieved, the mixture contains 1.05 mol CCl4.

* 1. Determine the value of Kc for the reaction?

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | CS2(g) | + | 3 Cl2(g) | ⮀ | S2Cl2(g) | + | CCl4(g) |
| I | 1.300 M |  | 4.200 M |  | 0 M |  | 0 M |
|  | -x |  | -3x |  | + x |  | + x |
| E | 2.60 –x  = 2.60 – 1.05  =1.55 M |  | 4.75 – 3x  = 4.75 – 3(1.05) = 1.60 M |  | x M  = 1.05 M |  | x M  = 1.05 M |

* 1. What is the value of Kp at 450K?

Or

* 1. Calculate the value of Kc for the reaction

2S2Cl2(g) + 2 CCl4(g)⮀ 2CS2(g) + 6 Cl2(g) at 450 K

* 1. If 5.00 mol of S2Cl2, 5.00 mol CCl4, 1.00 mol CS2, and 1.00 mol Cl2 were introduced into a 3.00 L reaction vessel at 450K, would the reaction proceed in the forward or the reverse direction. Calculate the Q value and explain how this predicts the answer to this question.

The value of Q isgreater than the value of K so the reaction would proceed in the forward direction.

1. (8 points) At 25oC, K = 0.090 for the reaction below. Calculate the equilibrium concentrations of all species at equilibrium if 0.850 mol of HOCl is placed in a 1.0 L flask.

H2O(g) + Cl2O(g) 🡨🡪 2 HOCl(g)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | H2O(g) | + | Cl2O(g) |  | 2 HOCl(g) |
| I | 0 M |  | 0 M |  | 0.850 M |
|  | +x |  | +x |  | -2x |
| E | +x |  | +x |  | 0.850 - 2x |

[H2O]=[Cl2O]= 0.370 M

[HOCl] = 0.850 – 2(0.370 M) = 0.111 M

1. (8 points) For the equilibrium reaction

3 NO2(g) ⮀ N2O5(g) + NO(g) Kc = 3.45 x 10-11 M.

If a 4.00 L container initially holds 0.648 mol of NO2, how many moles of N2O5 will be present when this system reaches equilibrium. (Remember to change moles to molarity and back!!)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 3 NO2(g) |  | N2O5(g) | + | NO(g) |
| I | 0.1620 |  | 0 M |  | 0 M |
|  | -3 x |  | +x |  | + x |
| E | 0.162-3x |  | x |  | x |

Approximation good!

At equilibrium

[NO2] = 0.162 M

[N2O5] = 2.36 x 10-6 M

[NO] = 2.36 x 10-6 M