CHEM 1114 Exam 1. February 27, 2008

Name Key

(50)

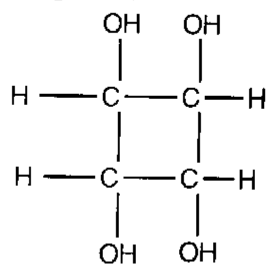
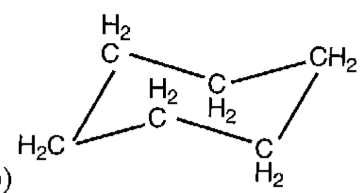
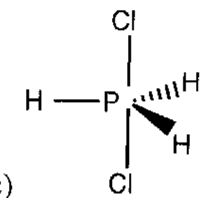
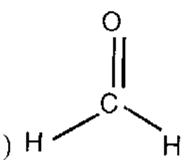
Useful information: $\ln\frac{[A]_t}{[A]_0} = -kt$, $\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$, $k = Ae^{-\frac{E_a}{RT}}$, $P_{solution} = P_A^0\chi_A + P_B^0\chi_B$,

$\Pi = MRT$, $R = 8.314\frac{J}{mol \bullet K}, 0.0821\frac{l \bullet atm}{mol \bullet K}$, $\Delta T_b = K_b c_m$, $\Delta T_f = -K_f c_m$, solubility=k•P,

$\ln P_{vap} = \frac{-\Delta H_{vap}}{RT} + C$, $\ln\frac{P_2}{P_1} = \frac{\Delta H_{vap}}{R}(\frac{1}{T_1} - \frac{1}{T_2})$ m=moles/kg

You must show work for credit.

(1) (4 points)

(a)  , (b)  ,(c)  (d) 

(a) Which of the molecules above should be soluble in water?

a and d

(b) Which should be soluble in nonpolar solvents?

b and c

(2)(4 pts) The solubility of N_2 in water is 3.8 x 10^{-3} M when the partial pressure of CO_2 is 0.0100 atm. What pressure of CO_2 would be required to form a 00.500 M solution of CO_2?

solubility = k • P

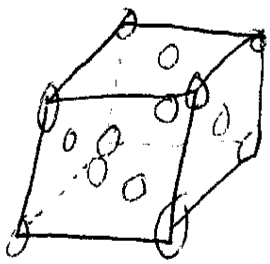
3.8×10^{-3} M = k(0.0100 atm)

0.38 M/atm = k

0.38 M/atm P = 0.500 M

P_{CO_2} = 1.3 atm

(3) Sketch a face centered cubic unit cell. How many atoms are contained inside the unit cell?



$8(\frac{1}{8}) = 1$ atom

$6(\frac{1}{2}) = 3$ atoms

4 atoms

(4)(4 pts) If a compound has a vapor pressure of 25 mm Hg at 50 °C, and its normal boiling point is 115 °C, what is its ΔH_{vap} ?

P_1 ... = 323 K

P_2 760 mm Hg at 115 °C $T_2 = 388$ K

$$\ln\frac{P_2}{P_1} = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\ln\frac{760\,mmHg}{25\,mmHg} = \frac{\Delta H_{vap}}{8.314\,\frac{J}{mol\,K}}\left(\frac{1}{323K} - \frac{1}{388K}\right)$$

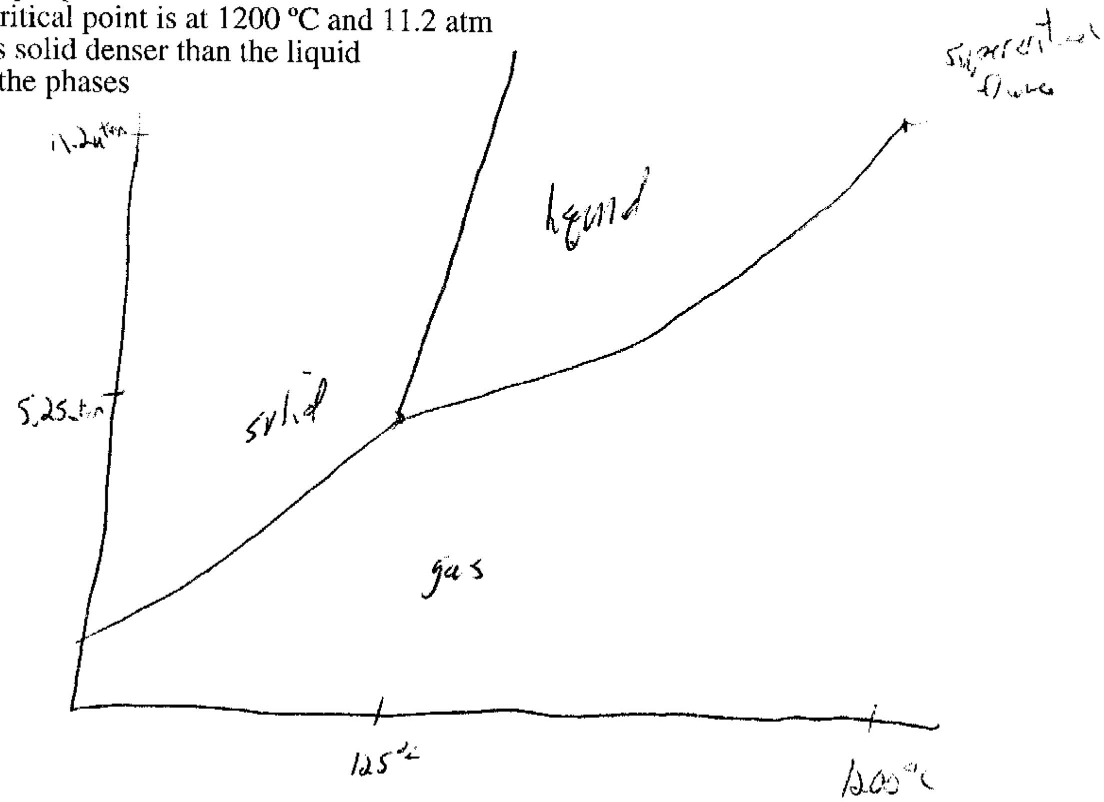
$$3.414 = \frac{\Delta H_{vap}}{8.314}\left(5.19\times10^{-4}\,\frac{1}{K}\right)$$

$$6.58\times10^{3}\,K = \frac{\Delta H_{vap}}{8.314\,\frac{J}{mol\,K}}$$

$$5.47\times10^{4}\,\frac{J}{mol} = \Delta H_{vap}$$

(5) (6 pts) (a) Sketch a phase diagram using the information given below

- The triple point is at 125 °C and 5.25 atm
- The critical point is at 1200 °C and 11.2 atm
- The is solid denser than the liquid
- label the phases



(b) What phase(s) is (are) present at 700 °C and 9 atm?

liquid

(6)(3 pts) Convert a 0.50 mole fraction solution of methanol(CH_3OH) in water to molality.

1 mole CH_3OH = 32.05 g

1 mole H_2O = 18.02 g/mole   molality = $\frac{\text{moles solute}}{\text{kg solvent}}$ = $\frac{1\text{ mole}}{0.01802\text{ kg}}$ = 55.5 m

(7)(4 points) If 15.0 g of acetone (CH_3COCH_3, MW = 58.09 g/mol) is added to 325 g of an unknown solvent, the freezing point of the mixture is 2.2 °C . The freezing point of the pure solvent is 5.7 °C. What is K_f for this solvent?

$\Delta T = -3.5°C = -K_f c_m$

15.0 g ÷ 58.09 g/mol = 2.58 × 10⁻¹ moles

$c_m = \frac{0.258\text{ mol}}{0.325\text{ kg}} = 0.795\text{ m}$

$-3.5°C = -K_f(0.795\text{ m})$

$4.4\frac{°C}{m} = K_f$

(8)(4 pts) What is the minimum pressure needed to get pure water from a 0.0150 M solution of Na_3PO_4 by reverse osmosis at 273K?

$\Pi = MRT$ $0.0150\text{ M } Na_3PO_4 \times \frac{4\text{ mole particles}}{1\text{ mole } Na_3PO_4} = 0.0600\text{ M}$

$\Pi = (0.0600\text{ M})(0.0821\frac{L\cdot atm}{mol\cdot K})(273\text{ K})$

$\Pi = 1.34\text{ atm}$

minimum pressure is >1.34 atm

(9)(6 points) From the following kinetic data, determine the form of the rate law.

$O_2 + 2C \rightarrow 2CO$

Experiment	Initial Concentrations $[O_2]$	$[C]$	Initial rate (in M/s)
1	0.21	0.15	1.8×10^{-5}
2	0.21	0.30	3.7×10^{-5}
3	0.10	0.30	4.5×10^{-6}

Write out the form of the rate law (you don't need to evaluate k)

rate = $k[O_2]^3[C]^0$

(10)(2 points) What intermolecular forces are present in CH_2Cl_2 and why?

dispersion + dipole dipole

(11)(3 points) rate = $k[NO][ClO]^2$

(a) What is the order of the rate with respect to [NO]?

1

(b) What is the order of the rate with respect to [ClO]?

2

(c) What is the overall order of the rate? 3rd

(12)(2 pts) The vapor pressure of a given liquid depends on

(A) volume of the container.

(B) barometric pressure.

(C) partial pressure of oxygen in the air.

(D) relative humidity of the air.

(E) temperature.

(13)(2 pts) A crystal of anhydrous CO_2 made up of

(A) a pattern of CO_3^{2-} ions and CO^{2-} ions

(B) atoms of carbon and oxygen alternately spaced in the crystal.

(C) a geometrical pattern of carbide ions and oxide ions in the crystal.

(D) molecules of CO_2

(14) (2 pts) How many atoms are in a unit cell of a body-centered cubic crystal?

(A) one (B) two (C) three (D) four

(extra credit) 6 points. The rate constant for a reaction is 2.2×10^{-3} 1/Ms at 298 K. If the energy of activation is 35 kJ/mol, at what temperature will the rate constant k = 0.500 1/Ms?

$k = Ae^{-E_a/RT}$

$2.2 \times 10^{-3} \frac{1}{Ms} = Ae^{\frac{-35000 \frac{J}{mol}}{(8.314 \frac{J}{mol\,K})(298K)}}$

$2.2 \times 10^{-3} \frac{1}{Ms} = Ae^{-14.1}$

$2.2 \times 10^{-3} \frac{1}{Ms} = A(7.3 \times 10^{-7})$

$3.00 \times 10^{3} \frac{1}{Ms} = A$

$0.500 \frac{1}{Ms} = 3.00 \times 10^{3} \frac{1}{Ms} e^{\frac{-35000 \frac{J}{mol}}{(8.314 \frac{J}{mol\,K})T}}$

$1.66 \times 10^{-4} = e^{\frac{-35000 \frac{J}{mol}}{(8.314 \frac{J}{mol\,K})T}}$

$-8.70 = \frac{-35000 \frac{J}{mol}}{(8.314 \frac{J}{mol\,K})T}$

$2.07 \times 10^{-3} = \frac{1}{T}$ $T = 484K$