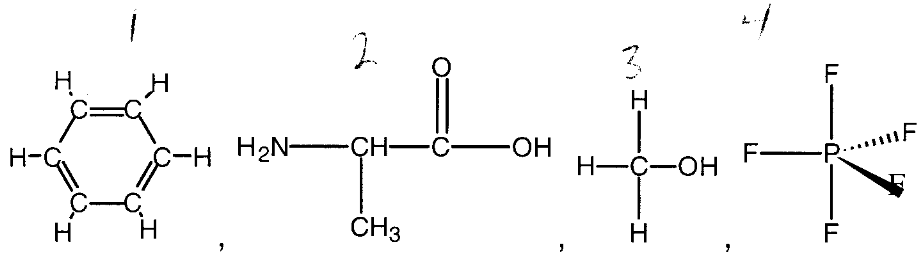
US 111 Exam 1, Spring 2004
Name Key

(1)



(a)Which of the following molecules would you expect to be soluble in fat?

1+4 nonpolar

(b) Which would you expect to be soluble in water?

2+3 hydrophilic

(2) $C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$

For the reaction above, relate the rate of the reaction expressed in terms of the appearance of CCl_4, appearence of HCl, and the disappearance of Cl_2. Make all three rates equal to

$$-\frac{d[C_2H_5OH]}{dt} = -\frac{d[O_2]}{3dt} = \frac{d[CO_2]}{2dt} = \frac{d[H_2O]}{3dt}$$

(3) From the following kinetic data, determine the form of the rate law.

$2HgCl_2 + C_2O_4^{2-} \longrightarrow 2Cl^- + 2CO_2 + Hg_2Cl_2$

Experiment	Initial Concentrations $[HgCl_2]$	$[C_2O_4^{2-}]$	Initial rate (in M/s)
1	0.105	0.15	1.8×10^{-5}
2	0.105	0.30	7.1×10^{-5}
3	0.052	0.30	3.5×10^{-5}

Write out the rate law including the value of the rate constant k.

$$\frac{\text{rate 2}}{\text{rate 1}} = \frac{7.1\times10^{-5}}{1.8\times10^{-5}} = \frac{k[HgCl_2]^m[C_2O_4^{2-}]^n}{k[HgCl_2]^m[C_2O_4^{2-}]^n} = \frac{k(0.105)^m(0.30)^n}{k(0.105)^m(0.15)^n}$$

$$3.94 = \frac{(0.30)^n}{(0.15)^n} = 2^n$$

$n = 2$

$$\text{rate} = k[HgCl_2][C_2O_4^{2-}]^2$$

$$1.8\times10^{-5}\ \tfrac{M}{s} = k(0.105\,M)(0.15\,\tfrac{M}{s})^2$$

$$\boxed{7.6\times10^{-3}\ \tfrac{1}{M^2 s} = k}$$

$$\frac{\text{rate 2}}{\text{rate 3}} = \frac{7.1\times10^{-5}}{3.5\times10^{-5}} = \frac{k(0.105)^m(0.30)^2}{k(0.052)^m(0.30)^2}$$

$$2.1 = 2.02^m$$

$m = 1$

$$\text{rate} = (7.6\times10^{-3}\ \tfrac{1}{M^2 s})[HgCl_2][C_2O_4^{2-}]^2$$

(4) $2\ C_2H_4$ -----> C_4H_8

The reaction above is found to be first order in $[C_2H_4]$. If the rate constant k, is 4.91 x 10^{-3} 1/~~M~~s and $[C_2H_4]_0$ = 0.158 M, (a) what is the half life of the reaction? and (b) What will $[C_2H_4]$ be at t = 450 s?

(a) $\ln\frac{[C_2H_4]_t}{[C_2H_4]_0} = (-4.91\times10^{-3}\ \tfrac{1}{s})t$

$\ln 0.5 = (-4.91\times10^{-3}\ \tfrac{1}{s})t$

$\boxed{141\,s = t_{1/2}}$

(b) $\ln\frac{[C_2H_4]_{450}}{0.158\,M} = -(4.91\times10^{-3}\ \tfrac{1}{s})(450\,s)$

$\ln\frac{[C_2H_4]_{450}}{0.158\,M} = -2.21$

$\frac{[C_2H_4]_{450}}{0.158\,M} = 0.110$

$\boxed{[C_2H_4]_{450} = 0.0173\,M}$

(5) H_2 + ICl ---> HI + HCl (slow step)
HI + ICl ---> I_2 + HCl (fast step)

(overall) H_2 + 2ICl ---> I_2 + 2HCl

Using the information from the above reaction mechanism, answer the following questions

(a) Write the rate law for the reaction

rate = $k[H_2][ICl]$

(b) What is the molecularity of the reaction? bimolecular

(c) List any catalysts or intermediates in the mechanism above.

HI is an intermediate

(6)(4 pts) The solubility of O_2 in water is 1.38×10^{-3} M if P_{O_2} = 25.0 mm of Hg. What pressure of O_2 would be required to form a 0.100 M solution of O_2?

solubility = $k P_{O_2}$

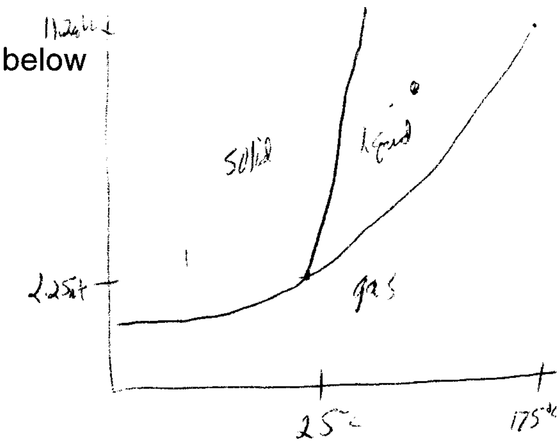
1.38×10^{-3} M = k(25.0 mmHg)

$5.52 \times 10^{-5} \frac{M}{mmHg} = k$

$0.100 M = (5.52 \times 10^{-5} \frac{M}{mmHg}) P_{O_2}$

$1{,}810$ mmHg = P_{O_2}

(7) (6 pts)
(a) Sketch a phase diagram using the information given below
- The triple point is at 25 ºC and 2.25 atm
- The critical point is at 175 ºC and 11.2 atm
- The solid is denser than the liquid



(b) What phase(s) is (are) present at 75 ºC and 5 atm?

liquid

(8)(4 pts) If a compound has a vapor pressure of 75 mm Hg at 50 ºC, and 275 mm H at 85 ºC, what is it's ΔH_{vap}?

50°C = 323 K
85°C = 358 K

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

$$\ln \frac{275\,mmHg}{75\,mmHg} = \frac{\Delta H_{vap}}{8.314\,\frac{J}{mole\,K}}\left(\frac{1}{323\,K} - \frac{1}{358\,K}\right)$$

$$10.8\,\frac{J}{mole\,K} = \Delta H_{vap}\left(3.03\times10^{-4}\,\frac{1}{K}\right)$$

$$3.57\times10^{4}\,\frac{J}{mole} = \Delta H_{vap}$$

$$35.7\,\frac{kJ}{mole} = \Delta H_{vap}$$

(9)(4 pts) What is the difference between a solution and a suspension?

a solution is one phase. A suspension has more than one phase. A dispersed phase is suspended in the other phase. (milk)

(10)(4 pts) Convert a 0.25 mole fraction of sodium chloride in water to molality.

assume 0.25 moles NaCl
$0.75 \text{ moles } H_2O$

$0.75 \text{ moles } H_2O \times 18.02 \text{ g/mole} = 13.51 \text{ g } H_2O$

$$\frac{0.25 \text{ moles NaCl}}{\text{kg } H_2O} = \frac{0.250 \text{ moles NaCl}}{0.01351 \text{ g } H_2O} = 18.5 \text{ m}$$

(11)(4 pts) The freezing point of nitrobenzene is 5.7 ºC. When 5.23 g of an unkn molecular compound is added to 115 g of nitrobenzene, the freezing point of the solution is -2.2 ºC. What is the molecular weight of the unknown if K_f = 5.24 ºC/n

$\Delta T_f = -K_f C_m$ $\quad$ $\Delta T_f = -2.2°C - 5.24°C = -7.4°C$

$-7.4°C = -(5.24 °C/m) C_m$

$$\frac{7.4°C}{5.24 °C/m} = C_m = 1.41 \text{ m}$$

$$1.41 \text{ m} = \frac{x \text{ moles}}{0.115 \text{ kg}}$$

$x \text{ mol} = 0.162 \text{ moles}$

$$\frac{5.23 \text{ g}}{0.162 \text{ moles}} = 32.2 \text{ g/mole}$$

(12)(4 pts) (a)What is the minimum pressure needed to get pure water from a 0.0200 M solution of $CaCl_2$ by reverse osmosis at 350K?

$\Pi = MRT$ $M = 3(0.0200M) = 0.0600M$ because $CaCl_2$ breaks into 3 particles

$\Pi = (0.0600M)(0.0821 \frac{L\,atm}{mol\,K})(350K)$

$\Pi = 1.72$ atm

(b) Would it be easier or harder to get pure water from the above solution at room temperature? Explain why or why not

Easier. $\Pi = MRT$, as T decreases, Π decreases.

Extra Credit:
The half life is the time it takes for the concentration to be reduced to 1/2 the initial amount. This is just a convinient amount. You could talk about a 1/3 life or a 1/10 time. What would be the expression for the tenth time of a second order reaction?

2 A ----> B

$\frac{1}{[A]_t} = kt + \frac{1}{[A_0]}$ at the $\frac{1}{10}$ life $[A]_t = \frac{1}{10}[A]_0$

$\frac{1}{\frac{1}{10}[A]_0} = kt + \frac{1}{[A_0]}$

$\frac{10}{[A]_0} - \frac{1}{[A]_0} = kt$

$\frac{9}{[A]_0} = kt$

$t_{\frac{1}{10}} = \frac{9}{k[A]_0}$