Chemistry 141 Name

Dr. Cary Willard

Exam 4 December 9-10, 2013

|  |  |  |
| --- | --- | --- |
|  | Points Earned | Points Possible |
| Page 3 multiple choice |  | 30 |
| Page 5 |  | 18 |
| Page 6 |  | 18 |
| Page 7 |  | 7 |
| Page 8 |  | 16 |
| Page 9 |  | 8 |
| Page 10 |  | 7 |
| Total |  | 104 |
| 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+…

ΔG = ΔH - TΔS

PV = nRT

P1=*i*X1∙Ptotal

C = q/ΔT

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

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 = oC + 273.16

Kw = 1.0 x 10-14M2

Kf water = 1.86oC/m

Kb water = 0.512oC/m

Kf benzene = 5.12oC/m

Kb benzene = 2.53oC/m

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 two strands in DNA are held together by \_\_\_\_\_\_\_\_.
	1. dispersion forces
	2. dipole-dipole forces
	3. hydrogen bonding
	4. ion-dipole forces
2. Identify the place which has the highest boiling point of water.
	1. Death Valley, 282 feet below sea level
	2. A pressurized passenger jet, 35,000 feet
	3. New Orleans, sea level
	4. Mt. Everest, 29035 feet
	5. Denver, Colorado, 5280 feet
3. Which substance below has the strongest intermolecular forces?
	1. BY2, ΔHvap = 26.7 kJ/mol
	2. A2X, ΔHvap= 39.6 kJ/mol
	3. C3X2, ΔHvap = 36.4 kJ/mol
	4. DX2, ΔHvap = 23.3 kJ/mol
	5. EY3, ΔHvap = 21.5 kJ/mol
4. Define triple point.
	1. The temperature, pressure, and density for a gas.
	2. The temperature at which the boiling point equals the melting point.
	3. The temperature and pressure where liquid, solid, and gas are equally stable and are in equilibrium.
	4. The temperature that is unique for a substance.
	5. The temperature at which the solid and liquid co-exist.
5. Consider the phase diagram shown. Choose the statement below that is TRUE.
	1. The triple point of this substance occurs at a temperature of 31°C.
	2. The line separating the solid and liquid phases represents the ΔHvap.
	3. At 10 atm of pressure, there is no temperature where the liquid phase of this substance would exist.
	4. The solid phase of this substance is higher in density than the liquid phase.
	5. None of the above are true.
6. Place the following substances in order of **increasing** boiling point.

CH3CH2OH He CH3OCH3

* 1. CH3CH2OH < He < CH3OCH3
	2. He < CH3CH2OH < CH3OCH3
	3. CH3CH2OH < CH3OCH3 < He
	4. CH3OCH3 < He < CH3CH2OH
	5. He < CH3OCH3 < CH3CH2OH
1. Which of the following statements is TRUE?
	1. In general, the solubility of a solid in water decreases with increasing temperature.
	2. In general, the solubility of a gas in water decreases with increasing temperature.
	3. The solubility of a gas in water usually increases with decreasing pressure.
	4. The solubility of an ionic solid in water decreases with increasing temperature.
	5. None of the above statements are true.
2. What is the strongest type of intermolecular force present in Cl2?
	1. dispersion
	2. ion-dipole
	3. dipole-dipole
	4. hydrogen bonding
	5. none of the above
3. In liquid propanol, CH3CH2CH2OH which intermolecular forces are present?
	1. Only dipole-dipole and ion-dipole forces are present.
	2. Only dispersion and dipole-dipole forces are present.
	3. Only hydrogen bonding forces are present.
	4. Dispersion, hydrogen bonding and dipole-dipole forces are present.
4. A solution containing more than the equilibrium amount is called \_\_\_\_\_\_\_\_.
	1. an unsaturated solution
	2. a dilute solution
	3. a supersaturated solution
	4. a concentrated solution
	5. a saturated solution
5. Soap has an ionic and a polar end. It works well to remove oil by
	1. surrounding the oil with the nonpolar end, and the water interacts with the polar end.
	2. surrounding the oil with the polar end, and the water interacts with the nonpolar end.
	3. surrounding the oil and water with the polar end.
	4. surrounding the oil and water with the nonpolar end.
6. Choose the aqueous solution below with the **lowest** freezing point. These are all solutions of nonvolatile solutes and you should assume ideal van't Hoff factors where applicable.
	1. 0.075 *m* NaBrO4
	2. 0.075 *m* KCN
	3. 0.075 *m* KNO2
	4. 0.075 *m* LiCl
	5. 0.075 *m* (NH4)3PO4
7. Give the direction of the reaction, if K >> 1.
	1. The forward reaction is favored.
	2. The reverse reaction is favored.
	3. Neither direction is favored.
	4. If the temperature is raised, then the forward reaction is favored.
	5. If the temperature is raised, then the reverse reaction is favored.
8. In which of the following reactions will Kc = Kp?
	1. 4 NH3(g) + 3 O2(g) ⇌ 2 N2(g) + 6 H2O(g)
	2. SO3(g) + NO(g) ⇌ SO2(g) + NO2(g)
	3. 2 N2(g) + O2(g) ⇌ 2 N2O(g)
	4. 2 SO2(g) + O2(g) ⇌ 2 SO3(g)
	5. None of the above reactions have Kc = Kp.
9. Which of the following statements is TRUE?
	1. Dynamic equilibrium occurs when the rate of the forward reaction equals the rate of the reverse reaction.
	2. The equilibrium constant for the forward reaction is equal to the equilibrium constant for the reverse reaction.
	3. A reaction quotient (Q) larger than the equilibrium constant (K) means that the reaction will favor the production of more products.
	4. Dynamic equilibrium indicates that the amount of reactants and products are equal.

Problems (85 points)

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. (6 points) Draw at least three molecules of water and show the hydrogen bonds that form between them.

1. (6 points) Write the appropriate equilibrium constant for each of the following reactions.
	1. 2 KClO3(s) ⇋ 2 KCl(s) + 3 O2(g) Kp =
	2. 4 CH3Cl(g) + 2 Cl2(g) ⇋ 4 CH2Cl2(g) + 2 H2(g) Kc =
2. (18 points) A 1.274 m solution of lysine (C6H14N2O2) has a density of 1.387 g/mL at 25oC. Calculate
	1. the mass percent of lysine

In 1 kg of water

And

* 1. the mole fraction of lysine
	2. The morality of lysine
	3. The vapor pressure of water at 25oC is 23.8 torr. What is the vapor pressure of the lysine solution under these same conditions?
	4. What is the freezing point of the lysine solution?
	5. What is the osmotic pressure of the lysine solution at 20oC?
1. (7 points) A solution is made by dissolving 2.02 g of an unknown compound in enough water to make 175.0 mL of solution. The osmotic pressure of this solution is 1.93 atm at 25oC.
	1. What is the approximate molar mass of the compound?
	2. An elemental analysis of the compound indicated that the empirical formula is C3H5O2. What is the molecular formula of the compound?

Molar mass = 146 g/mol so molecular formula is 2X empirical formula.

1. (16 points) A toxicologist studying mustard gas, S(CH2CH2Cl)2, a blistering agent, prepares a mixture of 0.675 M SCl2 and 0.973 M C2H4 and allows it to react at room temperature (20.0oC):

SCl2(g) + 2 C2H4(g)⇋ S(CH2CH2Cl)2 (g)

At equilibrium, [S(CH2CH2Cl)2]= 0.350 M.

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | SCl2(g) | + | 2 C2H4(g) | ⮀ | S(CH2CH2Cl)2(g) |
| I | 0.675 M |  | 0.973 M |  | 0 M |
| Δ | −x |  | −2x |  | + 2x |
| E | 0.675 − x= 0.675 – 0.175=0.500 M |  | 0.973 −2x = 0.973 −0.350 = 0.623 M |  | 2x = 0.350 Mx = 0.175 M |

* 1. What is the value of Kp at 20.0oC?

Or

* 1. Calculate Kc for 2 S(CH2CH2Cl)2 (g) ⇋ 2 SCl2(g) + 4 C2H4(g)
	2. If 1.00 mol of S(CH2CH2Cl)2, 3.00 mol SCl2, and 3.00 mol C2H4, were introduced into a 2.00 L reaction vessel at 20oC, would the original 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 is less 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 0.650 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 |  | 0.650 M |
|  | +x |  | +x |  | -2x |
| E | +x |  | +x |  | 0.650 - 2x |

[H2O]=[Cl2O]= 0.283 M

[HOCl] = 0.650 – 2(0.283 M) = 0.084 M

[H2O] =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[Cl2O] = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[HOCl] = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. (7 points) Answer the following questions based on the reaction

2 NO(g) + O2(g) <==> 2 NO2(g) + heat

* 1. If O2 is added to the reaction vessel (circle the correct answer)
		1. The rate of the forward reaction will (increase, decrease, stay the same).
		2. The rate of the reverse reaction will (increase, decrease, stay the same).
	2. If the total volume of the system is decreased (T remains constant) the equilibrium will shift to the (right, left, stay the same)
	3. If the temperature is increased
		1. The equilibrium will shift to the (right, left, stay the same)
		2. The value of K will (increase, decrease, stay the same)
	4. Show graphically how the concentrations of O2 and NO2 change when NO is removed.

[O2]

[NO2]

Removal of NO