Chemistry 141 Name

Dr. Cary Willard

Exam 4 May 21, 2009

|  |  |  |
| --- | --- | --- |
|  | Points Earned | Points Possible |
| Page 1 multiple choice |  | 20 |
| Page 3 |  | 15 |
| Page 4 |  | 20 |
| Page 5 |  | 22 |
| Page 6 |  | 12 |
| Page 6 |  | 16 |
| Extra credit |  | 5 |
| Total |  | 105 |
| 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

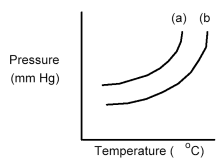
mass electron = 9.109 x 10-31 kg

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

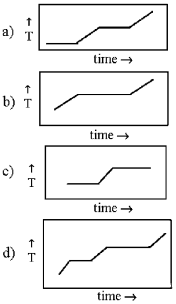
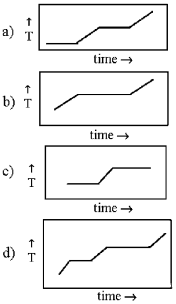
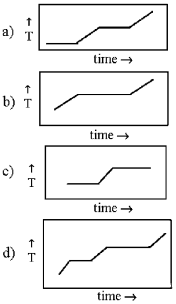
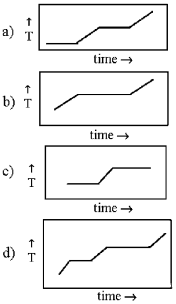
Standard Temperature and Pressure = 0oC and 1 atm

Multiple Choice (20 points)

1. The normal boiling point for HBr is higher than the normal boiling point for HCl. This can be explained by
   1. larger dispersion forces for HBr.
   2. larger dipole-dipole forces for HBr.
   3. larger hydrogen-bond forces for HBr.
   4. larger dipole-dipole forces, larger dispersion forces, and larger hydrogen-bond forces for HBr.
2. Molecules of a liquid can pass into the vapor phase only if the
   1. temperature of the liquid is near its boiling point.
   2. liquid has little surface tension.
   3. Intermolecular forces are very low.
   4. vapor pressure of the liquid is high.
   5. molecules have sufficient kinetic energy to overcome the intermolecular forces in the liquid.
3. Which drawing best represents hydrogen bonding?
   1. 
   2. 
   3. 
   4. 
   5. 
4. For a liquid solution made by dissolving a solid or a gas in a liquid, the
   1. liquid is the solvent.
   2. liquid is the solute.
   3. Gas is the solute.
   4. solvent is the component present in the greatest amount.
   5. solute is the component present in the greatest amount.
5. The following diagram shows a close-up view of the vapor pressure curves for a pure solvent and a solution containing a nonvolatile solute dissolved in this solvent.

Which curve is the solvent and what happens to the boiling point when the solute is dissolved in the solvent?

* 1. Curve (a) is the solvent and the boiling point decreases.
  2. Curve (a) is the solvent and the boiling point increases.
  3. Curve (b) is the solvent and the boiling point decreases.
  4. Curve (b) is the solvent and the boiling point increases.
  5. Unable to determine

1. Which of the following statements is **true** for a supersaturated solution?
   1. The solute in the solution is at equilibrium with undissolved solute.
   2. A supersaturated solution is more than 50% solute by mass.
   3. The solution contains more than the equilibrium amount of solute.
   4. The solution is stable and the solute will not precipitate.
   5. Supersaturated solutions form if the solute is allowed to soak in the solvent long enough.
2. Consider a compound that undergoes sublimation at 125o and a pressure of one atm. Which of the following could be a heating curve appropriate for heating the compound from 100o to 150o?
   1. 
   2. 
   3. 
   4. 
3. Write the equilibrium equation for the **reverse** reaction:

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

* 1. *Kp =* 
  2. *Kp =* 
  3. *Kp =* 
  4. *Kp =* 

1. 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. Equilibrium is dynamic and there is no net conversion to reactants and products.
   3. The equilibrium constant depends on temperature.
   4. The concentration of the reactants and products reach a constant level.
   5. The concentration of the reactants is equal to the concentration of the products.
2. 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 **not** correct?
   1. [H2O] will increase.
   2. [Cl2] will decrease.
   3. [HCl] will increase.
   4. [O2] will increase.
   5. Unable to determine

Problems (85 points)

1. (6 points) Water at room temperature is placed in a flask connected by rubber tubing to a vacuum pump, and the pump is turned on. After several minutes, the volume of the water has decreased and what remains has turned to ice. Explain.

The water begins to evaporate in the low temperature environment. This evaporation requires energy which comes from the kinetic energy of the water sample. Since the kinetic energy is removed from the water its temperature decreases and it eventually freezes.

1. (9 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.
   1. higher boiling point: CH3CH3  or CH3CH2CH2CH2CH3

The pentane has the higher boiling point because it has more electrons making it more polarizable. The more polarizable molecule will have the greatest dispersion forces and therefore the highest boiling point.

* 1. higher vapor pressure at 25oC: CH3CH2CH3  or CH3OCH3

The pentane has the higher vapor pressure.

Both molecules have similar molar masses and similar dispersion forces, but the ether molecule is polar meaning that it will also have dipole-dipole interactions. This means that it will have stronger intermolecular forces and a lower vapor pressure.

* 1. highest viscosity CH3OCH3 or CH3CH2OH

Ethanol will have the higher viscosity.

Both molecules have similar dispersion forces and both are polar. The ethanol has the ability to form hydrogen bonds however which means that it will have the strongest intermolecular forces and the higher viscosity.

1. (20 points) Lactose, C12H22O11, is a naturally occurring sugar found in mammalian milk. A 1.335 M solution of lactose in water has a density of 1.2432 g/mL at 20oC. (vapor pressure of pure water at 20oC = 17.5 torr) Calculate
   1. The mass percent lactose
   2. The mole fraction of lactose
   3. The molality of lactose
   4. The boiling point of the solution (Kb, H2O= 0.51oC/m)

The boiling point will be 100.87oC

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

1. (8 points) Met-enkephalin is one of the so-called endorphins, a class of naturally occurring morphine like chemicals in the brain. What is the molecular mass of met-enkephalin if 20.0 mL of an aqueous solution containing 15.0 mg met-enkephalin at 25oC has an osmotic pressure of 24.2 torr.
2. (8 points) Methanol (CH3OH) is manufactured by the reaction of carbon monoxide with hydrogen in the presence of a ZnO/Cr2O3 catalyst:

 Ho = −91 kJ

For each of the following changes indicate whether the reaction shifts to the right (🡪), shifts to the left (🡨), or no shift (NC). Then answer the question regarding the shift with increases (🡩) decreases (🡫) no change (NC) or unable to determine (?)..

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Change to system | Shift (Circle one) | Question | Change |
|  | Add CO(g) | 🡪 🡨 NC | Concentration of CO | 🡩 🡫 NC ? |
|  | Raise temperature | 🡪 🡨 NC | Rate forward reaction | 🡩 🡫 NC ? |
|  | Reduce volume | 🡪 🡨 NC | Concentration of CH3OH | 🡩 🡫 NC ? |
|  | Add ZnO/Cr2O3 | 🡪 🡨 NC | Mol of H2 | 🡩 🡫 NC ? |

1. (6 points) Write the equilibrium expressions for the following reactions
   1. Fe2O3(s) + 3 CO(g) 🡨🡪 2 Fe(l) + 3 CO2(g)
   2. H2(g) + S(s) 🡨🡪 Cu(l) + H2S(g)
2. (12 points) When 1.50 mol of CO2 and an excess of solid carbon are heated in a 20.0 L container at 1100K, the equilibrium concentration of CO is 7.00 x 10-2 M. The equilibrium reaction is

C(s) + CO2(g)  2 CO(g)

* 1. What is the equilibrium concentration of CO2?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | C(s) | + | CO2(g) |  | 2 CO(g) |
| I |  |  | 0.0750 M |  | 0 M |
|  |  |  | - x |  | + 2x |
| E |  |  | 0.0750 – x  = 0.0050M |  | 2x = 0.0700  x=0.0350 |

* 1. What is the value of Kc at 1100K?
  2. What is the value of Kp in atm at 1100K?
  3. What is the value of Kp for the reaction at 1100 K?

4 CO(g)  2 C(s) + 2 CO2(g)

1. (8 points) The air pollutant NO is produced in automobile engines from the high temperature reaction N2(g) + O2(g)  2 NO(g) with Kc=1.7 x 10-3 at 2300K. If the initial concentrations of N2 and O2 at 2300 K are both 1.40 M, what are the concentrations of NO, N2, and O2 when the reaction mixture reaches equilibrium?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | N2(g) | + | O2(g) |  | 2 NO(g) |
| I | 1.40 M |  | 1.40 M |  | 0 M |
|  | -x |  | -x |  | +2x |
| E | 1.40M-x |  | 1.40M-x |  | 2x |

[N2]=[O2]=1.40 M=0.028 M=1.37 M

[NO] = 2(0.28 M) = 0.56 M

1. (8 points) At a certain temperature, the reaction PCl5(g)  PCl3(g) + Cl2(g) has an equilibrium constant Kc = 5.8 x 10-3 M. Calculate the equilibrium concentrations of PCl5, PCl3, and Cl2 if only PCl5 is present initially, at a concentration of 0.160 M. Use the method of successive approximations.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | PCl5(g) |  | PCl3(g) | + | Cl2(g) |
| I | 0.160 M |  | 0 M |  | 0 M |
|  | -x |  | +x |  | +x |
| E | 0.160-x |  | x |  | x |

1st approx x = 0.030 M

2nd approx x = 0.027 M

3rd approx x = 0.028 M

4th approx – 0.028 M

Extra Credit (5 points)

A 0.100 g sample of the weak acid HA (molar mass = 110.0 g/mol) is dissolved in 500.0 grams of water. The freezing point of the resulting solution is -0.056oC. Calculate the value of Ka for this acid. Assume molarity equals molality for this solution.

(Hint: For an acid dissociating HA🡸🡺 H+1 + A-1, Ka = [H+1][A-1]/[HA])