Chemistry 141 Name

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Exam 4 December, 2009

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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

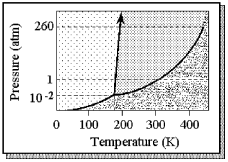
mass electron = 9.109 x 10-31 kg

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 (20 points)

1. Which of the following compounds exhibits hydrogen bonding?
   1. CH3Cl
   2. H3C-O-CH3
   3. HI
   4. NH3
2. In liquid pentanol, CH3CH2CH2CH2CH2OH which intermolecular forces are present?
   1. Dispersion, hydrogen bonding and dipole-dipole forces are present.
   2. Only dispersion and dipole-dipole forces are present.
   3. Only dipole-dipole and ion-dipole forces are present.
   4. Only hydrogen bonding forces are present.
3. When a narrow diameter glass tube is inserted into a body of water, water rises in the tube and its surface inside is concave upwards. Which statement, concerning the strength of the intermolecular forces between glass and water molecules compared to those between water molecules, is accurate?
   1. The forces of attraction between the glass and water are the same as those in water.
   2. The forces of attraction between the glass and water are weaker than those in water.
   3. Intermolecular forces are irrelevant to this situation.
   4. The forces of attraction between the glass and water are stronger than those in water.
4. 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. wavelength of light from emitted photons.
5. 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.



The phase diagram of a substance is shown at the right.

1. The approximate normal melting point of this substance is
   1. 300 K.
   2. 190 K.
   3. 430 K.
   4. 100 K.
2. 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.
3. Which of the following should **most** favor the solubility of an ionic solid in water?
   1. a high lattice energy for the solid and a high hydration energy for its ions
   2. a low lattice energy for the solid and a high hydration energy for its ions
   3. a low lattice energy for the solid and a low hydration energy for its ions
   4. a high lattice energy for the solid and a low hydration energy for its ions
4. In which case should CO2(*g*) be more soluble in water?
   1. The total pressure is 1 atm and the partial pressure of CO2 is 0.03 atm.
   2. The total pressure is 3 atm and the partial pressure of CO2 is 2 atm.
   3. The total pressure is 1 atm and the partial pressure of CO2 is 0.5 atm.
   4. The total pressure is 5 atm and the partial pressure of CO2 is 1 atm.
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. Which of the following solutions will have the lowest freezing point?
   1. 0.015 *m* MgCl2
   2. 0.0100 *m* NaCl
   3. 0.035 *m* CH3CH2CH2OH
   4. 0.0100 *m* Li2SO4
7. Which of the following changes in reaction conditions will **not** alter the composition of a homogeneous equilibrium mixture of gases?
   1. decreasing the temperature
   2. addition of reactants or products
   3. addition of a catalyst
   4. increasing the pressure or volume
8. For which one of the following reactions will *Kc* = *Kp*?
   1. ZnO(*s*) + CO(*g*) ⮀ Zn(*s*) + CO2(*g*)
   2. CO(*g*) + 2 H2(*g*) ⮀ CH3OH(*g*)
   3. COCl2(*g*) ⮀ CO(*g*) + Cl2(*g*)
   4. 2 O3(*g*) ⮀ 3 O2(*g*)
9. The decomposition of nitrosyl bromide is exothermic: 2 NOBr(*g*) ⮀ 2 NO(*g*) + Br2(*g*). Which of the following changes in reaction condition will shift the reaction to the left?
   1. increase the container volume
   2. add more NOBr
   3. decrease the temperature
   4. none of the above
10. Which statement is **true** for a reaction with *Kc* equal to 2.43 x 10-12?
    1. The reaction proceeds nearly all the way to completion.
    2. There are appreciable concentrations of both reactants and products.
    3. The reaction proceeds hardly at all towards completion.
    4. Increasing the temperature will not change the value of *Kc*.

Problems (85 points)

1. (5 points) If you wanted to formulate a new compound that could be used in an instant cold pack, would you select a compound with a positive or negative value of Hsoln in water? Justify your answer.

I would choose a substance with a + DHsoln in water. That means that when it dissolves in water it will pull heat out of the surroundings thus making them cooler.

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 as well as other factors determining liquid properties.
   1. higher boiling point: Br2 or I2

I2 will have the higher boiling point because it is more polarizable due to the larger number of electrons. The more polarizable, the stronger the London forces making the IM attractions stronger and increasing the boiling point.

* 1. higher vapor pressure at 25oC:  or 

Because the tri-alcohol has three hydroxyls to hydrogen bond, it will have stronger intermolecular forces and a lower vapor pressure. Propanol will have the higher vapor pressure.

* 1. highest viscosity  or 

the straight chain molecule will have the highest viscosity because it is more able to make contact with other molecules.

1. (25 points) MSG or monosodium glutamate, NaC5H8O4N, is an amino acid salt used as a flavor enhancer. A 38.5% by mass solution of MSG in water has a density of 1.432 g/mL at 20oC. (vapor pressure of pure water at 20oC = 17.5 torr) Calculate
   1. The molarity of MSG
   2. The mole fraction of MSG
   3. The molality of MSG
   4. The freezing point of the solution (Kf, H2O= 1.86oC/m)

The freezing point will be -6.88 oC

Actually would be -13.8 due to dissociation in solution! +2 bonus points if catch this!

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

1. (5 points) One manufacturer’s instructions for setting up an aquarium specify that if boiled water is used, the water must be cooled to room temperature and allowed to stand overnight before fish are added. Why is this necessary?

The solubility of oxygen is decreased significantly when the water is heated. You must let the water sit to redissolve the oxygen gas so that the fish will not die!

1. (10 points) The combustion analysis of L-carnitine, an organic compound thought to build muscle strength, yielded 52.16% C, 9.38% H, 8.69% N, and 29.78% O. The osmotic pressure of a 100.00 mL solution of 0.322 g of L-carnitine was found to be 0.501 atm at 32oC. Determine the empirical formula, molar mass, and molecular formula for L-carnitine.

Molar mass = 161 g/mol so molecular formula and empirical formula are the same.

1. (10 points) The four substances HCl, I2, HI, and Cl2 are mixed in a reaction vessel and allowed to reach equilibrium in the endothermic reaction

2 HCl(g) + I2(s) ⮀ 2 HI(g) + Cl2(g)

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 I2(s) | 🡪 🡨 NC | Moles of Cl2 | 🡩 🡫 NC ? |
|  | Remove Cl2 | 🡪 🡨 NC | Rate of the forward reaction | 🡩 🡫 NC ? |
|  | Add HCl(g) | 🡪 🡨 NC | Concentration of HI | 🡩 🡫 NC ? |
|  | Raise temperature | 🡪 🡨 NC | Concentration of HCl | 🡩 🡫 NC ? |
|  | Reduce volume | 🡪 🡨 NC | Moles of I2 | 🡩 🡫 NC ? |

1. (6 points) Write the equilibrium expressions for the following reactions
   1. 2 H2S(g) + 3 O2(g) ⮀ 2 SO2(g) + 2 H2O(g)
   2. 4 Bi(s) + 3 O2(g) ⮀ 2 Bi2O3(s)
2. (16 points) A reaction mixture consisting of 2.00 mol CO and 3.00 mol H2 is placed in a 10.0 L reaction vessel at 800K. At equilibrium, 0.478 mol CH4 is present in the system. The reaction that takes place is

CO(g) + 3 H2(g) ⮀ CH4(g) + H2O(g) at 1200K

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

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | CO(g) | + | 3 H2(g) | ⮀ | CH4(g) | + | H2O(g) |
| I | 0.200 M |  | 0.300 M |  | 0 M |  | 0 M |
|  | -x |  | -3x |  | + x |  | + x |
| E | 0.200 –x  = 0.152 M |  | 0.300 – 3x  = 0.157 M |  | x M = 0.0478 M |  | x M  = 0.0478 M |

* 1. What is the value of Kp at 1200K?

Or

* 1. Calculate the value of Kc for the reaction 2 CH4 + 2 H2O ⮀ 2 CO + 6 H2 at 1200 K
  2. If 5.00 mol of CO, 5.00 mol H2, 1.00 mol CH4, and 1.00 mol H2O were introduced into a 3.00 L reaction vessel at 1200K, 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 is less than the value of K so the reaction would proceed in the forward direction forming more methane and water.

1. (8 points) At 500K, the equilibrium constant for the reaction Cl2(g) + Br2(g) ⮀ 2 BrCl (g) is 0.031. If 1.500 mol of Cl2 and 1.500 mol of Br2 are introduced into a 1.00 L flask at 500K and allowed to come to equilibrium, calculate the final concentrations of all of the components of the reaction flask.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Cl2(g) | + | Br2(g) |  | 2 BrCl(g) |
| I | 1.50 M |  | 1.50 M |  | 0 M |
|  | -x |  | -x |  | +2x |
| E | 1.50M-x |  | 1.50M-x |  | 2x |

[Br2]=[Cl2]=1.50 M-0.121 M=1.38 M

[BrCl] = 2(0.121 M) = 0.243 M

1. (8 points) For the reaction 2 NH3(g) ⮀ N2(g) + 3 H2(g), Kc = 0.395 at 350oC. A 25.6 g sample of NH3 is placed in a 5.00 L reaction vessel and heated to 350oC. What are the equilibrium concentrations of NH3, H2, and N2? (You will want to use the method of successive approximations for this one!)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 2 NH3(g) |  | N2(g) | + | 3 H2(g) |
| I |  |  | 0 M |  | 0 M |
|  | -2 x |  | +x |  | + 3x |
| E | 0.301-2x |  | x |  | 3 x |

1st approx x = 0.191 M

2nd approx x = 0.099 M

3rd approx x = 0.112 M

4th approx – 0.097 M

5th approx x = 0.113 M

6th approx x = 0.094

At equilibrium

[NH3] = ~ 0.1 M

[N2] = ~ 0.1 M

[H2] = ~ 0.3 M