R = 8.31 joule/mol K.

**Assume that all reactions in this exam take place at 298.15K**

**Thermodynamic Quantities. (At 298.15 K )**

|  |  |  |  |
| --- | --- | --- | --- |
| Substance | **ΔHof kJ/mol)** | **ΔGof (kJ/mol)** | **So (J/mol K)** |
| C6H6 (*l*) | 49.0 | 124.5 | 172.8 |
| C6H6(g) | 82.9 | 129.7 | 269.2 |
| C2H4(g) | 52.30 | 68.11 | 219.4 |
| C2H5OH(*l*) | -277.7 | -174.76 | 160.7 |
| H2(g) | 0 | 0 | 130.58 |
| Cl(g) | 121.7 | 105.7 | 165.2 |
| CO2(g) | –393.5 | – 394.4 | 213.6 |
| C2H6(g) | –84.68 | –32.89 | 229.5 |
| HCl(g) |  | – 95.27 |  |
| H2O(*l*) | -285.85 | -236.81 | 69.96 |

Heat of combustion of ethanol C2H5OH(*l)*  + 3 O2(g) ➞ 2 CO2(g)  + 3 H2O(g)

ΔH° = –1234.76 kJ/mol ΔG = ΔG° + RT Ln Q

Some Ksp values:

BaCO3 5.0 x 10–9

CaF2 3.9 x 10–11

Mg(OH)2 1.8 x 10–11

Ka values:

Boric acid, H3BO3 5.8 x 10–10 ( K1 only - the others are too small to matter to us)

Acetic acid HC2H3O2 1.8 x 10–5

Formic acid, HCOOH 1.8 x 10–4

Kb values:

ammonia, NH31.8 x 10–5

Brooklyn College Chemistry Department

Second Lecture test in chemistry 2. Spring 2011.

Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Part I: Multiple Choice and fill -in questions. These must be answered in the spaces provided with the questions. (1 and 3/4 pts each)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_1. What is the molar solubility of CaF2 in water? .

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_2. Using the same Ksp, what is the solubility of CaF2 in a solution which is

0.100 molar in the soluble salt NaF ?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_3. What is the maximum Mg2+ concentration that will avoid precipitation in a solution of pH = 10 ?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_4. The dissolving of BaCO3 in water is endothermic. Which of the following would increase the Ksp of BaCO3? A) Addition of HNO3 to

the solution B) Addition of Ba(NO3)2 to the solution

C) Increasing the temperature of the solution D) Increasing the external

pressure on the solution.

\_\_\_\_\_\_\_5. For which of the following salts does the Ksp equal the molar solubility squared?

A) AgCl B) Ag2CrO4 C) PbI2 D) Al2(SO4)3

For the following questions, 6 to 12, the answers are +, –, or 0. (assume that T=298K)

\_\_\_\_\_\_\_7. ΔGof , the free energy of formation, of N2(g)

\_\_\_\_\_\_\_8. ΔH° f, the standard enthalpy of formation, of CO2(s)

\_\_\_\_\_\_\_9 ΔGof of NH3(g), given that the equilibrium constant for the reaction

N2(g) + 3 H2(g) ➞ 2 NH3(g) is 6.7 x 105

\_\_\_\_\_\_\_10. S° , the standard molar entropy of NaCl(s) at 298 K.

\_\_\_\_\_\_\_11. ΔS° for the reaction 2 Na(s) + Cl2(g) ➞ 2 NaCl(s)

\_\_\_\_\_\_\_12. ΔG° for the condensation of benzene, C6H6(g) ➞ C6H6(ℓ)

\_\_\_\_\_\_\_13. For which of the following processes are ΔG° , ΔH°, and ΔS° all positive in

sign at 25°C ? A) melting of ice B) condensation of water vapor

C) freezing of water D) decomposition of liquid water to hydrogen and oxygen gas.

\_\_\_\_\_\_14. Reactions for which the signs of ΔH and ΔS are **both** negative will be spontaneous

A) at high temperatures B) at low temperatures C) at all temperatures D) at no temperatures

\_\_\_\_\_\_\_\_\_\_\_\_\_15. ΔH° for the melting of ice at 0°C, (the heat of fusion) is 6.0 kJ/mole.

What is ΔS° for the melting of ice at that temperature?

\_\_\_\_\_\_\_\_\_\_\_\_\_16. What is the pH of a 0.200 molar solution of boric acid?

\_\_\_\_\_\_\_\_\_\_\_\_\_17. What molarity of acetic acid will produce a solution that has a pH of

2.80?

\_\_\_\_\_\_\_\_\_\_\_\_\_18. What is the [H+] in a 0.020 molar solution of HNO3 ?

\_\_\_\_\_\_\_\_\_\_\_\_\_19. If a solution of KOH has a pH of 13.298, what is the molarity of the KOH solution?

\_\_\_\_\_\_\_\_\_\_\_\_\_20. What is the pH of a solution that contains 0.200 mole of NH3 and 0.200 mole of NH4Cl in an aqueous solution with a volume of 246 mL ?

\_\_\_\_\_\_\_\_\_\_\_\_\_21. A 1.00 molar solution of acetic acid is titrated with a 2.00 molar solution of NaOH. What is the pH of the solution at the equivalence point?

\_\_\_\_\_\_\_\_\_\_\_\_\_22. How can 100. mL of sodium hydroxide solution with a pH of 13.00 be converted to a sodium hydroxide solution with a pH of 12.00?

A) By diluting the solution with distilled water to a total volume of 108 mL

B) By diluting the solution with distilled water to a total volume of 200. mL

C)By diluting the solution with distilled water to a total volume of 1.00 L

D) By adding 100 mL of 0.10 M HCl E) By adding 100 mL of 0.10 M NaOH

\_\_\_\_\_\_\_\_\_\_\_23. Which of the following solutions would have an [H+] of 9.0 x 10−6 ?

A) 2.0 mol of HC2H3O2 and 1.00 mol of NaC2H3O2 in a volume of 2.0 liters

B) 50.0 mL of 2.0 M HC2H3O2  mixed with 100 mL of 1.0 M NaC2H3O2

C) 50.0 ml o f 1.0 M HC2H3O2 mixed with 50.0 mL of 2.0 M NaC2H3O2

D) 50.0 mL of 1.0 M HC2H3O2 mixed with 50.0 mL of 1.0 M NaOH

E) 50.0 mL of 1.0 M HC2H3O2 mixed with 50.0 mL of 0.50 M HCl

H2PO4–(aq) + HC2O4– ⇄ HPO42–(aq) + H2C2O4 (aq)

\_\_\_\_\_\_24. If K < 1 for the reaction represented above, which of the following is the strongest base?

A) H2O B) H2PO4–(aq) C) HPO42–(aq) D) H2C2O4(aq) E) HC2O4–(aq)

PLEASE ANSWER ALL OF THE LONG ITEMS THAT FOLLOW IN THE BLUE BOOKLETS.

The point values are indicated in parentheses after each question.

I. The Ksp of CaF2 is 3.9 x 10–11 .

(5) Show calculations, and predict whether a precipitate will form when 50.0 mL of

1.00x 10–3 molar Ca(NO3)2 is mixed with 200.0 mL of 2.00 x 10–4 molar NaF.

II. For the combustion of liquid ethanol, C2H5OH(*l*) + 3O2(g) ➞ 2 CO2(g) + 3 H2O(*l*)

(12)

A. Find ΔG°, ΔH°, and ΔS° at 298.15 K. (note that the combustion given on the accompanying chart forms **gaseous** water, while this question refers to formation of liquid water)

B. Find the standard molar entropy, S°, of O2(g) .

C. By comparing your value for ΔG° from part A with the value given on the chart for the combustion of ethanol with the formation of **gaseous** water, find the free energy of vaporization of water in kJ/mol. (ΔG° for H2O(ℓ) ➞ H2O(*g*) )

III. 25.0 mL of 0.400 M HCl is titrated with 0.800 M NaOH. Find the pH of the solution

(7)

A. before any base is added

B. after the addition of 10.0 mL of the NaOH

C. after the addition of 12.5 mL of the NaOH.

IV. A buffer is prepared by mixing 0.200 mole of HCOOH, formic acid, with 0.300 mole of sodium formate, NaHCOO, in a volume of 200. mL.

(7) A. What is the initial pH of the buffer.

B. What is the pH of the buffer after the addition of 200 mL. of water?

C. What is the pH of the buffer after the addition of 50.0 mL of 1.00 molar HCl?

D. (Extra Credit) How many grams of NaOH must be added to the original solution described in the problem to achieve a pH of 4.00?

V. A. Find the equilibrium constant at 298 K for the reaction H2(g)+ Cl2(g) → 2 HCl(g)

(8) B. Find the value of ΔG for this reaction at 298 K when the partial pressures of the three gases are as follows: H2 = 3.00 atm, Cl2 = 3.00 atm, HCl = 4.00 x 10−5 atm.

VI. CH3NH2(aq) + H2O (ℓ) ⇄ CH3NH3 +(aq) + OH− (aq)

(12) In aqueous solution, methyl amine reacts as represented above. In 0.0180 M CH3NH2(aq) at 25° C, the hydroxide ion concentration, [OH−], is 2.60 x 10−3 M. In answering the following, assume that the temperature is constant, and the volumes are additive.

a) Write the equilibrium-constant expression for the reaction indicated above

b) Determine the pH of 0.0180 M CH3NH2(aq)

c) Determine the value of the ionization constant, Kb, for CH3NH2(aq)

**(note: you will need this value to do parts e (i) and (ii). If you are unable to determine the Kb, you may use a value of 4.5 x 10−5 in part e)**

d) Determine the percent ionization of CH3NH2 in 0.0180 M CH3NH2(aq)

e) In an experiment, a 20.0 mL sample of 0.0180 M CH3NH2(aq) was placed in a flask and titrated to the equivalence point and beyond using 0.0120 M HCl(aq)

i) Determine the volume of 0.0120 M HCl that was added to reach the equivalence point.

ii) Determine the pH of the solution in the flask after a total of 15.0 mL of 0.0120 M HCl was added.

iii) Determine the pH of the solution in the flask after a total of 40.0 mL of 0.0120 M HCl was added.

VII. The reaction that occurs when silver ion is treated with concentrated ammonia solution,

(3) 2 NH3(aq)+ Ag+ → [Ag(NH3)2]+ is considered a Lewis acid-base reaction.

Define Lewis acids, and identify the Lewis acid in this reaction. Explain your selection.

VIII. Sodium carbonate, Na2CO3, is soluble in water.

(7) A. Predict whether solutions of sodium carbonate are acidic, basic, or neutral

B. Write a balanced chemical equation that shows what happens when

carbonates are dissolved in water. In your equation, identify all of the Bronsted acids and Bronsted bases

C. Predict whether each of the following salts is acidic, basic, or neutral:

i. CuCl2 ii. NH4NO3 iii. CaBr2

HONORS PROBLEM: A 20.0 mL solution of an unknown weak acid, of unknown molarity was titrated with a solution of NaOH, also of unknown molarity. The pH was monitored throughout the titration.

The pH of the acid before the addition of the NaOH was 3.20 .

The equivalence point, marked by a sudden large jump in pH occured upon the addition of 30.0 mL of the base.

The pH after 10.0 mL of base was added was 5.70

The pH after 20.0 mL of base was added was 6.30

Find:

A. The Ka of the acid B. The molarity of the acid C. The molarity of the base D. The pH of the solution at the equivalence point.