Final Examination Data Sheets.

Constants: *F* = 96500 coulombs per mole of electrons. R = 8.31 joule/mol K.

*E* = *E*0 - 0.0592 log Q ΔG = −nF*E* ΔG° = −RTLnK

n

**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 |
| SO2(g) | −296.9 | −300.4 | 248.5 |
| C2H4(g) | 52.30 | 68.11 | 219.4 |
| C2H5OH(*l*) | -277.7 | -174.76 | 160.7 |
| H2(g) | 0 | 0 | 130.58 |
| Br2(g) | 30.71 | 3.14 | 245.3 |
| CO2(g) | -393.5 | -394.4 | 213.6 |
| H2O(g) | –241.82 | –228.57 | 188.83 |
| H2O(*l*) | -285.83 | -237.13 | 69.96 |

Selected Ksp Values: Some Standard Reduction Potentials in Water at 25oC.

BaSO4  1.1x10–10 Potential (V) Reduction half reaction

AgCl 1.8 x 10–10 +2.76 F2(g) + 2 e– ➞ 2 F–(aq)

BaF2 1.7 x 10–6 +1.36 Cl2(g) + 2e– ➞ 2 Cl–(aq)

Co(OH)2 1.3 x 10–15 +1.06 Br2(ℓ) + 2e− ➞2 Br−(aq )

**Ka values** 0.80 Ag+(aq) + e– ➞ Ag(s)

HC2H3O2 1.8 x 10–5 +0.77 Fe3+(aq) + e– ➞ Fe2+(aq) +0.34 Cu2+(aq) + 2 e– ➞ Cu(s)

HBrO 2.5 x 10–9 +0.34 Cu2+(aq) + 2e−**➞** Cu(s)

HF 6.8 x 10−4 –0.28 Ni2+(aq) + 2 e– **➞**Ni(s)

**Kb values** −0.44 Fe2+(aq) + 2 e– **➞**Fe(s)

NH3 1.8 x 10–5 –0.76 Zn2+(aq) + 2 e– **➞** Zn(s)

HONH2 1.1 x 10–8 –1.66 Al3+(aq) + 3 e– **➞** Al(s)

**Touro College Chemistry Final Examination, August 2014**

Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Section\_\_\_\_\_\_\_\_\_\_\_ (1 to 58 are 1.5 pts. each)

Consider the following data for the reaction represented by the chemical equation (questions 1 to 40 are 1.6 points each)

2A(g) + 2 B(g)  2 C(g) + D(g)

|  |  |  |  |
| --- | --- | --- | --- |
| Experiment | Initial [A] (M) | Initial [B] (M) | Initial rate. of formation of D (M/s) |
| 1 | 0.120 | 0.150 | 2.0x10-3 |
| 2 | 0.120 | 0.300 | 4.0x10-3 |
| 3 | 0.060 | 0.300 | 1.0x10-3 |
| 4 | 0.030 | 0.150 | 1.2 x 10–4 |
| 5 | 0.500 | ? | 2.3x10-4 |

\_\_C\_\_\_\_1. The rate law of this reaction is Rate = A) k [A][B]

B)k [A] [B]2 C)k [A]2 [B] D)k [A]2 [B]2

\_\_C\_\_\_\_2. The numerical value of the rate constant is A) 0.74 B) 1.48 C) 0.93 D)0.11

\_\_A\_\_\_\_3. The initial concentration of B in experiment 5 is A) 9.9x10–4 M

B) 0.050 M C) 0.025 M D)9.0 x 10–4 M

\_\_\_A\_\_\_4. Suppose that the gas phase reaction H2 + 2 ICl  2 HCl + I2

proceeds by the following mechanism:

1. H2 + ICl  HI + HCl

2. HI + ICl  HCl + 2 I

3. 2 I  I2

If the rate law is found to be Rate = k [H2][ICl], then the rate determining step is

A) the first step B) the second step C) the third step

\_\_B\_\_\_\_5. Suppose that the decomposition of gaseous substance X is first order. If the initial pressure of X is 2.00 atm, and the pressure after 15.0 seconds is

0.500 atm, what is the rate constant for the decomposition? (sec-1)

A) 15 B) 0.0924 C) 0.10 D) 0.0670

\_\_\_C\_\_6. At a certain high temperature, N2 gas at 1.00 atm is mixed with H2 gas at 2.00 atm. The reaction N2(g) + 3 H2(g)  2 NH3(g) occurs and reaches equilibrium. At equilibrium, the pressure of NH3 gas is found to be 1.20 atm. What is the Kp of the reaction ?

A) 160 B) 0.18 C) 450 D) 0.80

\_\_\_\_C\_\_7. The reaction N2(g) + 3 H2(g)  2 NH3(g) has a ΔH̊ of –92 kJ. The effect of an increase in temperature on this reaction would be A) a decrease in both the rate constant and the equilibrium constant B) an increase in both the rate constant and the equilibrium constant. C) an increase in the rate constant, and a decrease in the equilibrium constant. D) a decrease in the rate constant, and an increase in the equilibiurm constant

\_\_\_\_B\_\_8. At 448oC the Kc for H2(g) + I2(g)  2 HI(g) is 50.5 .If in an equilibrium mixture

of the three gases, the [H2(g)] is 0.200 M, and the [HI(g)] is 0.300 M, what is the

molarity of the I2 gas? A) 3.00 M B) 0.00891 M C) 9.18x10-4M D) 2.9 x10–2 M

9 through 13: 2 SO3(g) + S(s) ⇌ 3 SO2(g) ΔH̊ = –100.3 kJ

Once this system has reached equilibrium, indicate how each of the following changes would affect the quantity of SO2(g) . ( Increase, decrease, or no effect.)

\_\_\_\_\_D\_\_\_\_\_\_\_\_\_\_9. The volume of the reaction vessel is decreased.

\_\_\_\_\_\_I\_\_\_\_\_\_\_\_\_10. The temperature is decreased.

\_\_\_\_\_\_\_N\_\_\_\_\_\_\_\_11. Additional sulfur is added to the system.

\_\_\_\_\_\_\_\_\_D\_\_\_\_\_\_12. Some SO3 leaks out of the system.

\_\_\_\_\_\_\_\_\_A\_\_\_\_\_\_13. We can predict that at 298 K, for this reaction,

A) ΔG̊ is – and ΔS̊ is + B) ΔG̊ is + and ΔS̊ is –

C) ΔG̊ is + and ΔS̊ is + D) ΔG̊ is – and ΔS̊ is –

\_\_\_4.0 x 10-10\_\_\_\_14. What is the [OH–] in a solution in which the [H+] is 2.5 x 10–5 M ?

\_\_\_\_12.95\_\_\_\_\_\_\_\_\_\_15. What is the pH of a 0.090 molar solution of NaOH ?

\_\_\_HPO42-\_\_\_\_\_\_\_\_\_\_\_16. What is the conjugate base of H2PO4–  ?

The reaction NH2–  + H2S ⇄ NH3 + HS–  has a HIGH equilibrium

constant. (goes mainly to the product side)

\_\_\_\_\_NH2-\_and HS-\_17. Identify the two Bronsted-Lowry bases in this reaction.

B\_\_\_\_\_\_\_\_\_\_\_\_18. Based on the high equilibrium constant we can conclude that

A) NH3 is a stronger base than NH2–  B) NH2 – isa stronger base than HS–

C) H2S is a stronger base than NH3 D) NH3 is a stronger acid than H2S

\_\_\_\_D\_\_\_\_\_\_\_\_\_19. What is the Ka of a monoprotic acid, HA, if a 0.100 molar solution of the

acid has a pH of 3.50 ? A) 3.16 x 10–3 B) 0.350 C)1.00 x 10–8 D)1.00 x 10–6

\_\_\_\_\_\_D\_\_\_\_\_\_\_20. The Kb of trimethylamine, (CH3)3N, is 6.4 x 10–5. What is the pH of

a 0.0200 molar solution of the base? A) 2.95 B) 8.11 C) 5.89 D) 11.05

\_\_\_\_\_\_A\_\_\_\_\_\_\_21. What is the [H+] in a solution containing 0.400 mole of sodium acetate dissolved in 500. mL of 0.400 molar acetic acid? A) 9.0 x 10–6 M B) 1.8 x 10–5 M

C) 3.6 x 10–5 M D) 7.2 x 10–5 M

\_\_\_\_\_A\_\_\_22. What is the molar solubility of BaF2, based on the listed Ksp?

A) 0.0075 M B) 0.012 M C) 0.0013 M D) 4.4x10-6 M

\_\_\_\_787 kJ\_\_23. What is ΔH̊ for the decomposition of two moles of CO2(g) to C(s) and O2(g) ?

\_\_\_\_\_A\_\_\_\_24. Which of the following 1.0 mole samples is likely to have the highest entropy?

A) NO2(g) at 300. K and 0.50 atm. B) H2(g) at 300 K and 1.00 atm.

C) Ne(g) at 298 K and 0.50 atm. D) O2(g) at 250 K and 2.00 atm.

\_\_B\_\_\_\_\_\_25. If a reaction is spontaneous at low temperatures, but NOT spontaneous at high temperatures, then A) ΔH and ΔS are both + B) ΔH and ΔS are both -

C) ΔH is + while ΔS is – D) Δ H is – while Δ S is +

\_\_B\_\_\_26. What is the value of ΔG̊ at 298 K for a reaction that has an equilibrium constant of

2.5 x 107 at that temperature?

A) +42 kJ B) – 42 kJ C) – 4.2 x 104 kJ D) + 4.2 x 104 kJ

\_\_\_\_C\_\_\_27. A chemical cell is set up to generate electricity by linking a half cell containing

Zn in 1.00 molar Zn(NO3)2 to one containing Ag in 1.00 molar AgNO3.

The standard potential, E̊ of this cell would be A) 0.04 volts B) 0.84 volts

C) 1.56 volts D) 2.73 volts

\_\_\_-.13v\_\_\_\_28. E̊ for the reaction Zn(s) + Pb2+(aq) ➞ Zn2+(aq) + Pb(s) is 0.63 volts.

What is the standard reduction potential for the half reaction Pb2+ + 2 e-  Pb ?

\_\_-120 kJ\_\_\_\_\_29. What is the standard free energy change, ΔG̊ for the reaction shown in question 28? (Zn(s) + Pb2+(aq) Zn2+(aq) + Pb(s) )

\_\_B\_\_\_\_\_\_\_30. Which is the strongest reducing agent of the following? A) Cu B) Zn

C) Ag D) Ag+

\_\_\_C\_\_\_\_31. A chemical cell contains an iron electrode immersed in 1.00 M Fe(NO3)2

connected to a copper electrode immersed in 1.00 M Cu(NO3)2 . A salt bridge

connects the two solutions. The negative pole is the

A) copper, which is oxidized in the reaction B) iron, which is reduced in the reaction

C) iron, which is oxidized in the reaction D) copper, where ions are reduced in the

reaction. (The net reaction is between iron and copper (II) ions)

\_\_C\_\_\_\_\_32. If Eo for a certain redox reaction is positive , which **must** also be true?

A) ΔSo is negative B) ΔGo is positive C) Keq is > 1. D) ΔHo is negative.

\_\_\_B\_\_\_\_33. If Eo for a certain redox reaction is positive, which **cannot** also be true?

A) ΔSo is negative B) ΔGo is positive C) Keq is > 1. D) ΔHo is negative

\_\_\_D\_\_\_34. Identify the ion that is reduced in the reaction (in aqueous solution)

Fe2+ + H+ + MnO4–  Fe3+ + Mn2+ + H2O. ( not balanced)

A) Fe2+ B) Fe3+ C) H+ D) MnO4–

\_\_\_A\_\_\_\_35. How many grams of Al metal can be produced from the electrolysis of molten

AlCl3 using a current of 10.0 ampere for 9650 seconds? A) 9.0 g B) 18 g

C) 27 g D) 81g

\_\_\_A\_\_\_\_36. Which aqueous ion would react spontaneously with Cu(s)?

A) Ag+ B) Zn2+ C) Ni2+ D) Al3+

\_\_\_\_\_\_\_37. How many grams of water would be required to dissolve 4.00 grams of NaOH

to a molality of 0.200 m ?

\_\_\_\_\_\_\_38. What is the molality of NaCl in an aqueous solution that is 5.00 % NaCl by mass?

\_\_\_\_\_\_\_\_\_39. Given that the Kf for water is 1.86̊/m , what is the freezing point of a solution

containing 2.00 mol of the non-electrolyte ethylene glycol in 500 g of water?

\_\_\_\_\_\_\_\_40. Which of the following 1.00 m aqueous solutions would have the highest normal

boiling point? A) KCl B) NaNO3 C) CaCl2 D) CuSO4

(not covered on your exam)

Long Items. Show work. All answers go on these sheets, NOT in the blue booklets.

I. Cobalt(II) hydroxide is nearly insoluble in water.

A.Write a chemical equation for the dissolving of Co(OH)2 in water (2 pts)

Co(OH)2 ⭢ Co2+ + 2 OH-

B. What is the maximum molarity of Co2+ ion that could remain in solution, if the

solution has a pH of 9.20 ? (5 pts)

[OH-] = 1.6 x 10-5 . Ksp given as 1.3 x 10-15 [Co2+] = 5.2 x 10-6 M

C. Is cobalt(II) hydroxide more soluble or less soluble at a pH of 9.20 than it is in pure water? Explain. ( mathematical calculation is not necessary for full credit) (3 pts)

It is less soluble, since the [OH-] concentration is greater at pH 9.2 than it is in pure water. Increasing the concentration of a common ion decreases solubility.

II. Magnesium metal reacts with hydrochloric acid to produce magnesium chloride and hydrogen gas. Write the balanced net half reaction for the REDUCTION that occurs in this process. ( 3 pts)

2 H+ + 2 e- ⭢ H2

III. Aluminum metal is obtained via the electrolysis of aluminum oxide. The maximum current available in most homes in NY is 25.0 amperes. How long would it take to produce 6.00 grams of aluminum through this electrolysis using 25.0 amperes? (see steps A and B before pIroceeding)

A. Write the balanced chemical equation for the electrolysis. ( 2 points)

2 Al2O3 ⭢ 4 Al + 3 O2

B. Calculate the time in **hours**. Show work. ( 4 points)

Moles of Al = 6.00/ 27.0 Multiply by 3 electrons per Al to get moles of electrons. ( 0.667)

moles of electrons = ( amps )(seconds)/96500 So 0.667 = 25 x/96500 = 2570 seconds, or 0.715 hours

IV. A standard chemical cell is constructed using 1.00 molar solutions of Ni(NO3)2 and Zn(NO3)2 , zinc metal, and nickel metal.

A. Draw a labeled diagram of the cell. Indicate on your diagram

1. the direction of electron flow through the connecting wire

2. The + pole

3. The cathode

The electrons flow from the Zn to the Ni through the wire. The Ni is the + pole, and the Ni is the cathode. See diagram of chemical cell shown in text, and remember to show the salt bridge.

( 8 pts)

B. (answer “increases,” “decreases” or “remains the same.”

( 4 pts)

1. When additional solid Ni(NO3)2 is dissolved in the nickel half cell,

the voltage \_\_\_\_inc\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. If the size of the zinc electrode is increased, the voltage \_\_\_\_remains the same\_\_\_\_\_

C. Write a balanced equation for the reaction that occurs in this cell. ( 2 pts)

Zn + Ni2+ ⭢ Zn2+ + Ni

D. Find *E*o for the cell, in volts. ( 2 pts)

0.48 volts

E. Find ΔGo for the reaction you wrote in part C. ( 2 pts)

-93 kJ

F. Find the voltage produced by this cell when the Zn2+ is 1.99 molar, and the

[Ni2+] is 0.0100 molar ( 3 pts)

0.41 volts

Extra Credits: A. What was Galvani’s first name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_?