Chemistry 2, Lecture test 1.

Solutions, Kinetics and Equilibrium

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

Short items. Write the answer in the space provided to the left of the question number. Questions 1 to 24 are 2 and 1/3 pts each.

\_\_\_\_\_\_\_\_\_1. If the unit for the rate constant for a reaction is atm−2 sec−1 the overall rate order for that reaction is A) zero B) first C) second D) third E) fourth

Questions 2 to 7 are based on the reaction N2(g) + 3 H2(g) → 2 NH3(g).

At 298 K, the Kp for this reaction is 6.7 x 105 . ΔH° for the reaction as written is −92 kJ.

 Choices: ( for questions 2 to 5)

 A. increase the temperature

 B. decrease the temperature

 C. decrease the volume of the container in which the reaction is

 occurring.

 D. Increase the container volume

 E. Add a catalyst.

\_\_\_\_\_\_\_\_\_2. Which method would increase the rate constant of the reaction?

\_\_\_\_\_\_\_\_\_3. Which method would increase the equilibrium constant of the reaction?

\_\_\_\_\_\_\_\_\_4. Which method would increase the reaction rate without affecting the equilibrium concentrations?

\_\_\_\_\_\_\_\_\_5. Which method would produce a larger yield of ammonia at equilibrium, but would NOT change the equilibrium constant?

\_\_\_\_\_\_\_\_\_6. If at equilibrium at 298 K the pressure of nitrogen is .0200 atm, and the pressure of hydrogen is 0.0300 atm, what pressure of ammonia gas is needed to maintain equilibrium?

\_\_\_\_\_\_\_\_\_7. If at a certain temperature, the instantaneous rate of formation of ammonia

 is 0.0200 atm/minute, what is the instantaneous rate of disappearance of hydrogen under the same conditions? A) 0.0200 atm/min

 B) 0.015 atm/min C) 0.0300 atm/min D) 0.013 atm/min

 E) 0.0600 atm/min

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_8. The reaction 2 H2 + 2 NO → 2 H2O + N2 (all gases) is found, at a certain temperature to obey the rate law Rate = k[H2][NO]2, where k= 3.00 x 10-2 M−2/s for the production of N2 . What is the rate of production of N2 when both the hydrogen and the NO are 0.200 molar?

\_\_\_\_\_\_\_\_\_\_\_\_9. For the same reaction, 2 H2 + 2 NO → 2 H2O + N2 (all gases),

 if the value of the Kc at 600 K is 3.00 x 10-8 what is the value of the Kp at that temperature?

\_\_\_\_\_\_\_\_\_\_\_\_10. Based on the Kc given above, for the same reaction, if H2 and NO are introduced into a reaction vessel in which they are each initially 2.00 molar, what will the concentration of N2 gas be at equilibrium?

\_\_\_\_\_\_\_\_\_\_\_\_11. If a first order reaction has a half life of 693 seconds, what is the numerical value of the rate constant for that reaction?

\_\_\_\_\_\_\_\_\_\_\_\_12. As the temperature increases, the half life of a first order chemical reaction will A) increase B) decrease C) stay the same

Suppose that a chemical reaction proceeds through the following sequence of steps:

1. H2O2 (g) → H2O(g) + ½ O2(g)

2. SO2(g) + H2O(g) → H2SO3(g)

3. H2SO3(g) + ½ O2(g) → H2SO4(ℓ)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_13. Write the balanced equation for the overall reaction

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_14. If the first step is rate determining, write the rate law for the reaction.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_15. If the THIRD step is rate determining, write the rate law for the reaction.

\_\_\_\_\_\_\_\_\_\_\_\_\_16. What is the molality of a solution that contains 20.0 grams of NaOH dissolved in 200. grams of water?

\_\_\_\_\_\_\_\_\_\_\_\_\_17. What is the mole fraction of ethanol in an aqueous solution that is

 8.00 molal in ethanol?

\_\_\_\_\_\_\_\_\_\_\_\_\_18. What is the molality of HCl in an aqueous solution that is 30.0 % HCl by mass?

 Given the following data for the FIRST order decomposition of H2O2 at some temperature

Time (seconds) Concentration (Molarity)

0 2.000

5 1.34

10 0.899

15 0.602

\_\_\_\_\_\_\_\_\_\_\_\_\_\_19. What is the rate constant for the reaction at this temperature? (include correct unit)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_20. What is the half life of the H2O2 in seconds?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_21. How long will it take, starting at time zero, for the molarity to reach a concentration of 0.200 molar?

Given the following mechanism for a reaction, where A, B, C, D, E all represent substances: A + B → C (fast, equilibrium)

 C + A→ D ( slow, rate determining)

 D + A → E + B (fast)

\_\_\_\_\_\_\_\_\_\_\_\_22. Which letter in this mechanism represents a catalyst?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_23. What is the rate law ?

\_\_\_\_\_\_\_\_\_\_\_\_\_24. Given that the freezing pt. depression constant for water is 1.86°/m, what is the freezing point of a 0.200 molal aqueous solution of KCl ?

25. The vapor pressure of pure water at 95°C is about 600. torr. What is the vapor pressure above an aqueous solution that contains 180 grams of the nonelectrolyte glucose, and 360 grams of water? (show work)

(4)

26. When 80.00 grams of a certain non-electrolyte are dissolved in 200.0 grams of water, the solution freezes at a temperature of −2.00°C . (Kf of water is 1.86°/m)

 A. What is the molality of the solution? (2)

 B. What is the molar mass of the solute? (3)

27. If, at a certain temperature, the Kp for the reaction

 S(g) + O2(g) ⇄ SO2(g)  is 4.0 x 108 and the Kp for the reaction 2 S(g) + 3 O2 (g) ⇄ 2 SO3(g)  is 2.0 x 106 , then at that temperature what is the numerical value of the Kp for the reaction

 2 SO2 (g) + O2(g) ⇄ 2 SO3(g) ?

(3)

28. At a different temperature, SO2(g) and O2(g)  are pumped into a reaction vessel so that both gases have an initial pressure of 2.00 atm. (see reaction above)

 At equilibrium, it is found that the pressure of the SO2  has dropped to 0.50 atm.

(3) A. Find the equilibrium pressures of all three gases in the system. Show work. (same reaction, 2 SO2 (g) + O2(g) ⇄ 2 SO3(g) )

(3) B. Find the value of the Kp for the reaction at this temperature

29. The reaction 2 SO2 (g) + O2(g) ⇄ 2 SO3(g) is exothermic.

 Based on your answers to questions 27 and 28, was the temperature in question 28 higher or lower than that in 27? Explain your answer. (3)

30. A*(aq)* + 2 B*(aq)* ® 3 C*(aq)* + D*(aq)*

For the reaction above, carried out in solution of 30°C, the following kinetic data were obtained:

|  |  |  |
| --- | --- | --- |
| Experiment | Initial Conc. of Reactants(mole.liter-1) | Initial Rate of formation of D(mole.liter-1.min-1) |
|  | Ao | Bo |  |
| 1 |  0.240 | 0.480 | 4.00 |
| 2 |  0.240 | 0.120 | 0.250  |
| 3 |  0.360 | 0.240 | 1.50 |
| 4 |  0.120 | 0.120 | 0.125 |
| 5 |  0.240 | 0.0600 | 0.0625 |
| 6 |  0.0140 | 1.35 | ? |
| 7 | 0.480 | ? | 4.00 |
|  |  |  |  |

 a) Write the rate law expression for this reaction. (Show how you obtained your rate orders) ( 4 pts)

 b) Calculate the value of the specific rate constant, k, and include correct units. (3)

 c) Find the value of the initial rate of this reaction in experiment 6

 (3)

 d) Find the concentration of B in experiment 7.

 (3)

31. Solid ammonium carbonate decomposes at high temperatures.

 (NH4)2CO3(s) ⇄ 2 NH3(g) + CO2(g) + H2O(g)

 A sample of the solid is placed in an empty, sealed container. At equilibrium it is found that the concentration of ammonia in the container is 4.00 molar.

 What is the Kc at that temperature?

 (3)

32. Consider the reaction C(s) + CO2(g) ⇄ 2 CO(g) + heat. ( 10 points total)

 (ΔH° is < 0 )

 A. What would be the effect on the equilibrium quantity of CO (g) of

 1. Decreasing the container volume.

 2. Decreasing the temperature

 3. Increasing the quantity of carbon in the system

 4. Adding a catalyst to the system.

 B. The system has reached equilibrium. What would now be the effect on the **quantity of carbon** of removing some CO2 from the system?

HONOR PROBLEM. 

K1 is the Keq at T1 K2 is the equilibrium constant at T2 . R is 8.31 J/mol K

For the reaction N2(g) + 3 H2(g) ⇄ 2 NH3(g) ΔH° is −92.0 kJ.

For this reaction at 298 K, Kp is 6.7 x 105 .

At what temperature would the Kp of this reaction be equal to 1.00 ?