Exam 1

# Part 1: Multiple Choice (2 points each)

## Directions: Please circle the *best* answer for each of the following questions.

1. 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 statement is not correct?

1. [HCl] will increase
2. [O2] will increase
3. [Cl2] will decrease
4. [H2O] will increase
5. not enough information
6. For Cu2+ and CO2, which will behave as a Lewis acid toward OH- in water?
7. only Cu2+
8. only CO2
9. both
10. neither
11. not enough information
12. What is the conjugate base of the Brønsted-Lowry acid HPO42-?
13. H3PO4
14. H2PO4-
15. HPO42-
16. PO43-
17. none of the above
18. What factor affects the rate of a chemical reaction?
19. collision frequency
20. fraction of collisions with sufficient energy
21. orientation of molecules
22. b and c
23. all of the above
24. Give the characteristic of a zero order reaction have only one reactant.
    1. The rate of the reaction is not proportional to the concentration of the reactant.
    2. The rate of the reaction is proportional to the square of the concentration of the reactant.
    3. The rate of the reaction is proportional to the square root of the concentration of the reactant.
    4. The rate of the reaction is proportional to the natural logarithm of the concentration of the reaction.
    5. The rate of the reaction is directly proportional to the concentration of the reactant.
25. Which equilibrium below is homogeneous?
26. 2 CO (g) + O2 (g) ⮀ 2 CO2 (g)
27. BaSO4 (s) ⮀ Ba2+ (aq) + SO42- (aq)
28. 2 H2O2 (l) ⮀ 2 H2O (l) + O2 (g)
29. NH4NO3 (s) ⮀ N2O (g) + 2 H2O (g)
30. all of the above
31. Kw, at 40°C is 2.92 x 10-14, what is the [H3O+] for a neutral solution?
32. [H3O+] =1.00 x 10-7 M
33. [H3O+] > 1.71 x 10-7 M
34. [H3O+] = 1.71 x 10-7 M
35. [H3O+] < 1.71 x 10-7 M
36. None of the above
37. The chemical formula for sulfurous acid is
38. H2SO3 (aq)
39. H2S (aq)
40. H­2SO4 (aq)
41. H2S2O7 (aq)
42. SO3 (aq)
43. Place the following in order of increasing acid strength: HBrO2 HBrO3 HBrO HBrO4
    1. HBrO2 < HBrO4 < HBrO < HBrO3
    2. HBrO < HBrO2 < HBrO3 < HBrO4
    3. HBrO2 < HBrO3 < HBrO4 < HBrO
    4. HBrO4 < HBrO2 < HBrO3 < HBrO
    5. HBrO < HBrO4 < HBrO3 < HBrO2
44. When using the SpectroVis
    1. be sure to calibrate the SpectroVis using alcohol.
    2. it is okay if there are air bubbles in the cuvette.
    3. it measures the concentration of the solution.
    4. be sure to wipe off finger prints and water off the cuvette before putting it into the SpectroVis.
    5. all of the above

# Part 2: Short Answer

## Directions: Answer each of the following questions. Be sure to use complete sentences where appropriate. For full credit be sure to show all of your work.

1. When 2.55 g of an unknown weak acid (HA) with a molar mass of 85.0 g/mol is dissolved in 250.0 g of water, the freezing point of the resulting solution is -0.257 °C (kf for water is 1.86 °C/*m*) (14 points).
   1. Calculate the value for the van’t Hoff factor, i.
   2. What is the molarity of the acid?

* 1. What is the molarity of the dissociated acid, A-?
  2. Calculate the Ka for the unknown weak acid.

1. The central idea of the collision model is that molecules must collide in order to react. Give two reasons why not all collisions of reactant molecules result in production formation (4 points).
2. Which solution has the higher pH? Explain (10 points).
   1. A 0.1 M solution of an acid with Ka = 1 × 10-4 or one with Ka = 4 × 10-5.
   2. A 0.1 M solution of an acid with pKa = 3.0 or one with a pKa = 3.5.
   3. A 0.1 M solution or a 0.01 M solution of a weak acid.
   4. A 0.1 M solution of a weak acid or a 0.1 M solution of a strong base.
   5. A 0.1 M solution of an acid or a 0.01 M solution of a weak acid.
3. Is the rate of an overall reaction lower, higher, or equal to the average rate of the individual steps? Explain (3 points).
4. How are the forward and reverse reaction rates related in a system at chemical equilibrium (3 points)?
5. The following set of data was obtained by the method of initial rates for the reaction (15 points):

2 HgCl2 (aq) + C2O42- (aq) 🡪 2 Cl- (aq) + 2 CO2 (g) + Hg2Cl2 (s)

What is the rate law for the reaction including k?

|  |  |  |
| --- | --- | --- |
| [HgCl2] (M) | [C2O42-] (M) | Rate (M/s) |
| 0.10 | 0.10 | 1.3 x 10-7 |
| 0.10 | 0.20 | 5.2 x 10-7 |
| 0.20 | 0.20 | 1.0 x 10-6 |

1. The decomposition of dinitrogen pentaoxide

2 N2O5 (g) → 4 NO2 (g) + O2 (g)

has the following rate equation: rate = k[N2O5]. It has been found experimentally that the decomposition is 20.5% complete in 13.0 h at 298 K (11 points).

1. Calculate the rate constant and half-life at 298 K.
2. Calculate the activation energy for the reaction from the observed rate constants: k at 25 °C = 3.46 × 10-5 s-1 and k at 55 °C = 1.5 × 10-3 s-1.

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1. What is a reaction quotient, Q (3 points)?
2. Although the depletion of stratospheric ozone threatens life on Earth today, its accumulation was one of the crucial processes that allowed life to develop in prehistoric times. Reaction rate is expressed in terms of changes in concentration of reactants and products (5 points).
   1. Write a balanced equation for:
   2. At a given instant, the reaction rate in terms of [O2] is 2.17 × 10-5 mol/L∙s. What is it in terms of [O3]?
3. Morphine (C17H19NO3), a narcotic used in painkillers, is a weak organic base. If the pH of a 7.0 × 10-4 M solution of morphine is 9.50 (12 points).
   1. What is the pOH of the solution?
   2. What are the equilibrium concentrations?
   3. What is the Kb of the solution?
   4. What is the pKb?