Exam 2

# Part 1: Multiple Choice (2 points each)

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

1. It is sometimes true that the current occupants of a lab
	1. won’t be aware of some lab hazards.
	2. will be aware of some lab hazards, but generally dismiss the hazard since experience has shown that the hazard does not cause safety problems.
	3. will be aware of some lab hazards.
	4. all of the above
	5. none of the above
2. You have a summer job as an intern in an analytical chemistry laboratory. You are about to titrate a solution of nicotine (p*K*b = 6.0), which is a base similar to ammonia, with a standard hydrochloric acid solution. Two pH indicators are available for you to use: thymol blue (p*K*a = 3.47) and phenolphthalein (p*K*a = 9.4). Which indicator do you select as being the more appropriate one to use?
3. Both indicators would work equally well because at the equivalence point the pH of the solution changes very sharply from strongly basic to strongly acidic.
4. Phenolphthalein is the better choice because it is one of the most commonly used pH indicators.
5. Neither of these indicators would work because their p*K*a values are not close to 7.00, which is the pH of the solution at the equivalence point.
6. Phenolphthalein is the better choice because the sample pH at the equivalence point will be close to the p*K*a value of 9.4.
7. Thymol blue is the better choice because the sample pH at the equivalence point will be close to the p*K*a value of 3.47.
8. A 0.500 g sample of an unknown substance was titrated with a 0.1 *M* HCl solution. Another 0.500 g sample of it was titrated with a 0.1 *M* NaOH solution. The resulting titration curves are illustrated here. What is the sample?

* 1. Na2CO3
	2. NaHCO3
	3. H2CO3
	4. CO2
	5. There is no way to tell.
1. Which rate law is termolecular?
	1. Rate = k[A]0
	2. Rate = k[A][B]
	3. Rate = k[A][C]
	4. Rate = k[A]
	5. Rate = k[A]3
2. The slowest step in a reaction mechanism is called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ step.
3. activation
4. elementary
5. rate law
6. rate-determining
7. intermediate
8. A solution of hexaamminechromium(III) chloride, [Cr(NH3)6]Cl3, is yellow. What is the coordination number of the central metal ion?
	1. 2
	2. 4
	3. 6
	4. 8
	5. 9
9. A rate is equal to 0.0200 M/s. If [A] = 0.100 M and rate = k[A]0, what is the new rate if the concentration of [A] is increased to 0.200 M?
	1. 0.0200 M/s
	2. 0.0400 M/s
	3. 0.0600 M/s
	4. 0.0800 M/s
	5. 0.100 M/s
10. Identify the methods used to monitor a reaction as it occurs in the reaction flask.
11. Polarimeter
12. Spectrometer
13. Pressure measurement
14. none of the above
15. all of the above
16. 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
17. If you hear a fire alarm, you should
	1. finish the particular procedure that you are involved with before leaving the lab.
	2. ask your lab partner if it is safe to leave.
	3. leave the lab immediately, taking a moment to shut off electrical equipment and gas burners, if it is safe to do so.
	4. make sure that you see something on fire before overreacting to the situation.
	5. ignore the fire alarm; it’s probably nothing.

# 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. Do all titrations of samples of strong monoprotic acids with solutions of strong bases have the same pH at their equivalence point? Explain why or why not (5 points).

Yes; strong acid-base neutralization reactions yield water and a salt, which will have a pH of 7.

1. Describe the solubility of calcium fluoride in each of the following solutions compared to its solubility in water. Be sure to explain your answers (6 points).
	1. In a 0.10 M sodium chloride solution

**No change**, neither the sodium nor the chloride ions would react with the calcium or fluoride ions.

* 1. In a 0.10 M sodium fluoride solution

The solid would be **less soluble** due to the common ion effect. The 0.10 M sodium fluoride would add more fluoride ions to the solution, which would shift the reaction to the left making more solid.

* 1. In a 0.10 M hydrochloric acid solution

The hydrogen ions would react with the fluoride ions to create hydrofluoric acid making the solid **more soluble**.

1. A common laboratory method for preparing a precipitate is to mix solutions containing the component ions Does a precipitate form when 0.100 L of 0.0035 M Pb(C2H3O2)2 is mixed with 0.100 L of 0.013 M KBr? The Ksp of the precipitate is 4.67 × 10-6. Show work to justify your answer (6 points).

PbBr2 (s) Pb2+ (aq) + 2 Br­- (aq) Ksp = [Pb2+][Br-]2

Qsp < Ksp, therefore a precipitate will not form.

1. Two compounds with general formulas AX and AX2 have Ksp = 1.5 x 10-5 M. Which of the two compounds has the higher molar solubility? Be sure to explain your answer (5 points).

Therefore, AX2 has the higher molar solubility.

1. Adding hydrochloric acid would cause the calcium fluoride to become more soluble as the hydrogen ions react with the fluoride ions to form the weak acid hydrofluoric acid shifting the reaction to the right. Consider a solution prepared by mixing 50.00 mL of 2.50 M ammonia, NH3, with 50.00 mL of 0.00100 M silver nitrate, AgNO3. The following reactions may occur in the solution (12 points):
2. NH3 (aq) + H2O (l) NH4+ (aq) + OH- (aq) Kb = 1.8 × 10-5
3. Ag+ (aq) + NH3 (aq) AgNH3+ (aq) K1 = 2.1 × 103
4. AgNH3+ (aq) + NH3 (aq) Ag(NH3)2+ (aq) K2 = 8.2 × 103
	1. Which reaction does not go to completion? \_\_\_\_\_i\_\_\_\_\_\_
	2. What are the equilibrium concentrations of Ag+, AgNH3+, and Ag(NH3)2+?

First, complete a limiting reagent experiment:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Ag+ (aq) +  | 2 NH3 (aq) → | Ag(NH3)2+ (aq)  |
| I |  |  | 0 M |
| C |  |  |  |
| E |  |  |  |

Then look at equilibrium:

AgNH3+ (aq) + NH3 (aq) Ag(NH3)2+ (aq)

Ag+ (aq) + NH3 (aq) AgNH3+ (aq)

To summarize:

,, and

1. Calcium hydroxide (slaked lime) is a major component of mortar, plaster, and cement, and solutions of Ca(OH)2 are used in industry as a strong, inexpensive base (12 points).
	1. Calculate the molar solubility of Ca(OH)2 in water is Ksp = 6.5 × 10-6.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Ca(OH)2 (s)  | Ca2+ (aq) +  | 2 OH- (aq) |
| I | n/a | 0 M  | ~0M |
| C | n/a | +S | + 2S |
| E | n/a | S = 1.2 × 10-2 M  | 2S = (2)(1.2 × 10-2 M) = 2.4 × 10-2M  |

Check

* 1. What is its solubility in 0.10 M Ca(NO3)2?

|  |  |  |  |
| --- | --- | --- | --- |
|  | Ca(OH)2 (s)  | Ca2+ (aq) +  | 2 OH- (aq) |
| I | n/a | 0.10 M | ~0M |
| C | n/a | +S | + 2S |
| E | n/a | 0.10 M + S =0.10 M + 4.0 × 10-3 M ≈ 0.10 M | 2S =2(4.0 × 10-3 M) =8.0 × 10-3 M  |

Approximation check

Check

1. On average, someone who falls through the ice covering a frozen lake is less likely to experience anoxia (lack of oxygen) than someone who falls into a warm pool and is underwater for the same length of time. Why (3 points)?

At lower temperatures, the bodily reactions that use oxygen are slower than at higher temperatures.

1. Two first order reactions have activation energies of 15 and 150 kJ/mol. Which reaction will show the larger increase in rate as temperature is increased (3 points)?

The reaction with Ea = 150 kJ/mol

1. The reaction that occurs in a Breathalzer, a device used to determine the alcohol level in a person’s bloodsteam is given below. If the rate of appearance of chromium(III) sulfate, Cr2(SO4)3 is 1.24 mol/min, what is the rate of disappearance of C2H6O (5 points)?

2 K2Cr2O7 (aq) + 8 H2SO4 (aq) + 3 C2H6O (aq) → 2 Cr2(SO4)3 (aq) + 2 K2SO4 (aq) + 11 H2O (l)

10. The balanced equation for the reaction of nitrogen monoxide and chlorine gases is:

2 NO (g) + Cl2 (g) → 2 NOCl (g)

the experimentally determined rate law is: rate = k[NO]2[Cl2]

A suggested mechanism is

NO (g) + Cl2 (g)NOCl2 (g)  fast

NOCl2 (g) + NO (g)  2 NOCl (g)  slow

Is this an acceptable mechanism? Explain why or why not (8 points).

Is the first condition met?

 NO (g) + Cl2 (g⮀ NOCl2 (g)  fast

+ NOCl2 (g) + NO (g)  2 NOCl (g)  slow

2 NO (g) + Cl2 (g) 🡪 2 NOCl (g)

Yes, the first condition is met.

Is the second condition met?

The proposed rate law for the rate determine step is:

rate2 = k2[NOCl2][NO], this as an intermediate in it. To get rid of the intermediate we need to take the reversible reaction into account.

rate1 = rate-1

k1[NO][Cl2] = k-1[NOCl2]

Solve for the intermediate:

Plug this into the proposed rate law from the rate-determining step:

Let

This proposed rate law matches the experimentally determined rate law. Therefore, the mechanism is valid.

1. 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 |

Rate = (1.3 x 10-4 1/M2 s)[HgCl2] [C2O42-]2