Exam 2

# Part 1: Multiple Choice (2 points each)

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

1. A complex ion contains
	1. a central nonmetal ion bound to one or more ligands.
	2. an anion bound to water.
	3. water bound to one or more ligands.
	4. a central metal ion bound to one or more ligands.
	5. ammonia bound to water.
2. Give the characteristic of a first-order reaction having 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 concertation of the reactant.
	4. The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.
	5. The rate of the reaction is directly proportional to the concentration of the reactant.
3. What data should be plotted to show that the experimental concentration data fits a zeroth-order reaction?
	1. ln[reactant] vs. time
	2. 1/[reactant] vs. time
	3. ln(k) vs. 1/T
	4. ln(k) vs. Ea
	5. [reactant] vs. time
4. In the hydrogenation of double bonds, a catalyst is needed. In the first step, the reactants must come into contact with a metal surface. This step is known as
	1. adsorption.
	2. diffusion.
	3. reaction.
	4. desportion.
	5. absorption.
5. Which rate law has a molecularity of two?
	1. Rate = k[A]0
	2. Rate = k[A][B]
	3. Rate = k[A][B][C]
	4. Rate = k[A]
	5. Rate = k[A]3
6. Give the expression for Kf for Fe(CN)63–.
	1.  \_
	2. 
	3. 
	4. [Fe3+] [CN–]6
	5. 
7. Describe the solubility of Al(OH)3 with respect to pH.
	1. soluble at low pH, insoluble in pH-neutral solution, and soluble at high pH.
	2. soluble at low pH, insoluble in pH-neutral solution, and insoluble at high pH.
	3. insoluble at low pH, insoluble in pH-neutral solution, and soluble at high pH.
	4. soluble at low pH, in pH-neutral solution, and at high pH.
	5. pH has no effect on the solubility.
8. For a particular process ΔG is less than ΔH. Therefore,
9. ΔS is positive
10. ΔS is negative
11. ΔS is zero
12. ΔS is negative if ΔH is positive and ΔS is positive if ΔH is negative.
13. ΔS is one
14. When pouring a liquid form a reagent bottle
	1. you should pour away from the label.
	2. you should hold the lid between the your figures.
	3. you should pour the liquid into a beaker and then into a graduated cylinder.
	4. a and b only
	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. 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 0.30 M Ca(NO3)2 is mixed with 0.200 L of 0.060 M NaF? The Ksp of the precipitate is 3.2 × 10-11. Show work to justify your answer (6 points).

CaF2 (s) Ca2+ (aq) + 2 F­- (aq) Ksp = [Ca2+][F-]2

Qsp > Ksp, therefore a precipitate will form.

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. A solution contains 2.2  10–3 M in Cu2+ and 0.33 M in LiCN. If the Kf for Cu(CN)42– is 1.0  1025, how much copper ion remains at equilibrium (10 points) ?

|  |  |  |  |
| --- | --- | --- | --- |
|  | Cu2+ (aq) +  | 4 CN- (aq) |  Cu(CN)42- (aq |
| I | 2.2 × 10-3 M | 0.33 M | 0 M |
| C | -2.2 × 10-3 M | -4(2.2 × 10-3 M) | +2.2 × 10-3 M |
| E | 0 M | 0.33 M | 2.2 × 10-3 M |

To figure out how many copper(II) ions remain in the solution consider the reverse reaction:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Cu(CN)42- (aq)  | Cu2+ (aq) +  | 4 CN- (aq) |
| I | 2.2 × 10-3 M | 0 M | 0.33 M |
| C | -x | +x | +4x |
| E | 2.2 × 10-3 M –x =2.2 × 10-3 M -1.9 × 10-26 M ≈ 2.2 × 10-3 M  | x = 1.9 × 10-26 M | 0.33 M + 4x =0.33 M + 4(1.9 × 10-26 M) ≈ 0.33 M |

1. Calculate K (6 points).

Cu(OH)2(*aq*)  Cu2+(*aq*) + 2 OH–(*aq*) Ksp = 1.6  10–19

Cu2+(*aq*) + 4 NH3(*aq*)  Cu(NH3)42+(*aq*) Kf = 1.7  1013

Cu(OH)2(*aq*) + 4 NH3(*aq*)  Cu(NH3)42+(*aq*) + 2 OH–(*aq*) K = ?

1. In aqueous solution, hypobromite ion, BrO-, reacts to produce bromate ion, BrO3-, and bromide ion, Br-, in the unbalanced chemical equation: BrO- (aq) → BrO3- (aq) + Br- (aq)
	1. Write the balanced redox reaction using the half-reaction method (13 points).

Reduction: **(**BrO- (aq) + 2 H+ (aq) + 2 e- → Br- (aq) + H2O (l) **) × 2**

Oxidation: + BrO- (aq) + 2 H2O (l) → BrO3- (aq) + 4 H+ (aq) + 4 e-

2 BrO- (aq) + 4 H+ (aq) + 4 e- + BrO- (aq) + 2 H2O (l) → 2 Br- (aq) + 2 H2O (l)  + BrO3- (aq) + 4 H+ (aq) + 4 e-

3 BrO- (aq) → 2 Br- (aq) + BrO3- (aq)

* 1. A plot of 1/[BrO-] vs. time is linear. Is the reaction zero, first, or second order?\_\_\_second
	2. The slope is equal to 0.056 M-1s-1. If the initial concentration of BrO- is 0.80 M, how long will it take one-half of the BrO- ion to react?

slope = k = 0.056 M-1s-1

[BrO-]0 = 0.80 M

[BrO-] = 0.80 M/2 = 0.40 M

1. Is the activation energy for a forward reaction the same as the activation energy for the reverse of the same reaction? Use a sketch of a reaction energy diagram (4 points).

The relationship between the activation energy of the forward and reverse reactions is related by the energy difference between the reactants and products. If the reactants are higher in energy than the products, the activation energy for the forward reaction will be smaller than the activation energy for the reverse reaction and vice versa. (A sketch showing this relationship should be included).

1. Consider the Ksp values for two compounds:

MZ, Ksp = 1.5  10–20 and MZ2, Ksp = 1.5  10-20.

Why don't these compounds have the same molar solubility (4 points)?

These two compounds have the same solubility product constant, but that does not mean they have the same molar solubilities. Since the first compound contains 2 ions and the second compound contains 3 ions, their solubility product expressions differ and therefore their molar solubilities must differ. Compound MZ2 will have a higher molar solubility.

1. What is the entropy of a perfect crystal? Show a calculation with your answer (3 points).
2. Why can't we say that a spontaneous reaction is a fast reaction (5 points)?

Spontaneity is a thermodynamic quantity that determines if a reaction will occur and to what extent. The speed of a reaction is not related to the spontaneity. A spontaneous reaction can be very slow.

1. How many microstates are possible in a collection of four particles that are present, with

two particles each in two connected flasks? Sketch them below (5 points).

There are six microstates.

1,2|3,4

1,3|2,4

1,4|2,3

3,4|1,2

2,4|1,3

2,3|1,4

1. Octane, C8H18, a hydrocarbon used in gasoline, has molecules that consist of a long, flexible chain of eight carbon atoms with hydrogen atoms attached. It does not burn smoothly in automobile engines, causing a noisy condition known as “knocking.” Isooctane, a less flexible, branched isomer of octane with the formal name 2,2,4-trimethylpentane, burns more smoothly. The octane rating of isooctane is 100, that of octane is close to 0. To improve the octane rating of gasoline, some of the octane is converted to isooctane (12 points).

 octane ⮀ isooctane

|  |  |  |  |
| --- | --- | --- | --- |
| Compound | ΔHfº (kJ/mol) | ΔGfº (kJ/mol) | ΔSº (J/mol K) |
| Octane | -208.2 | + 16.7 | + 467.2 |
| Isooctane | -225.0 | + 12.8 | + 423.0 |

1. Calculate the change in entropy.

ΔSrº = Σ nSº(products) – Σ nSº(reactants)

ΔSrº = (1 mol)(423.0 J/mol K) – (1 mol)(467.2 J/mol K)

ΔSrº = -44.2 J/mol K

1. Interpret the change in entropy for the conversion in terms of molecular structure and freedom of movement.

The molecular structure for isooctane results in its being less flexible, with less freedom of movement, hence its atomic arrangement is more ordered. So there is a decrease in entropy as octane is converted to isooctane.