Exam 2

# Part 1: Multiple Choice (2 points each)

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

1. Which of the following is TRUE?
   1. An effective buffer has a [base]/[acid] ratio in the range of 10 - 100.
   2. A buffer is most resistant to pH change when [acid] = [conjugate base].
   3. An effective buffer has very small absolute concentrations of acid and conjugate base.
   4. A buffer cannot be destroyed by adding too much strong base. It can only be destroyed by adding too much strong acid.
   5. none of the above are true
2. Which compound will be more soluble in acidic solution than in pure water?
   1. PbCl2
   2. FeS
   3. Ca(ClO4)2
   4. CuI
   5. none of the above

1. Given the following equation: N2O (*g*) + NO2 (*g*) → 3 NO (*g*) ΔG°rxn = -23.0 kJ

Calculate ΔGorxn for: 3 NO (*g*) → N2O (*g*) + NO2 (*g*)

* 1. -23.0 kJ
  2. 69.0 kJ
  3. -69.0 kJ
  4. -7.67 kJ
  5. 23.0 kJ

1. A ligand is a molecule or ion that acts as a
   1. Lewis acid
   2. Bronsted-Lowry acid
   3. Bronsted-Lowry base
   4. Lewis base
   5. none of the above
2. Molecules become more orderly when \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
   1. water freezing
   2. ice melting
   3. water evaporating
   4. salt dissolving in water
   5. dry ice subliming
3. What is the sign of ΔSuniv for a biological system?
   1. positive
   2. negative
   3. zero
   4. It depends on the system.
   5. positive and negative
4. For a saturated solution:
   1. Q > Ksp
   2. Q < Ksp
   3. Q = Ksp
   4. Q ≠ Ksp
   5. none of the above
5. Which statement is true?
   1. K > 1, ΔG°rxn is positive.
   2. K < 1, ΔG°rxn is negative.
   3. ΔG°rxn = 0 at equilibrium.
   4. ΔGrxn = 0 at equilibrium.
   5. none of the above
6. Which of the following statements is true?
   1. A spontaneous reaction is always a fast reaction.
   2. The entropy of a system always decreases for a spontaneous process.
   3. Perpetual motion machines are a possibility in the near future.
   4. There is a “heat tax” for every energy transaction.
   5. none of the above
7. 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. A 50.00 mL sample of a diprotic acid is titrated with 0.125 M potassium hydroxide. If 53.47 mL of base is required to reach the second equivalence point, what is the concentration of the acid (6 points)?

H2A (aq) + 2 KOH (aq) → 2 H2O (l) + K2A (aq)

1. Bromocresol green, Ka = 2.0 x 10-5, is yellow in its protonated form (HX) and blue in its ionized form (X-) (6 points).
   1. As what pH will bromocresol green be a perfect green color?
   2. What is the effective range of the buffer? pKa ± 1 = 3.70 to 5.70
   3. What color would bromocresol green solution be at pH = 2? Yellow
2. 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 (3 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. Why can't we say that a spontaneous reaction is a fast reaction (3 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. The Ksp for magnesium hydroxide is 2.06 × 10-13 at 25 °C. Suppose the 75.0 mL of a sodium hydroxide solution with a pOH of 2.58 is mixed with 125.0 mL of a 0.018 M magnesium chloride (18 points).
   1. What is the diluted concentration of hydroxide ions?
   2. What is the diluted concentration of magnesium ions?

* 1. Will a precipitate form? If so, calculate the equilibrium concentrations of magnesium and hydroxide ions.

Ksp < Qsp, therefore a precipitate will form.

First Stoichiometry:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mg2+ (aq) + | OH- (aq) → | Mg(OH)2 (s) |
| I | 0.011 M | 0.00099 M | 0 M |
| C | -x | -2x | +x |
| E | 0.011 M – x =  0.011 M – 0.00049 M =  0.01051 M ≈ 0.011 M | 0.00099 M – 2x =  0 M | x = 0.00049 M |

The limiting reagent is OH-, therefore

Second Equilibrium:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mg(OH)2 (s) | Mg2+ (aq) + | 2 OH- (aq) |
| I |  | 0.011 M | 0 M |
| C |  | +x | +2x |
| E |  | 0.011 M + x =  0.011 M + 2.2 × 10-6 M ≈  0.011 M | 2x =  2(2.2 × 10-6 M) =  4.4 × 10-6 M |

Check x is small approximation:

Check Ksp value:

, close enough when round off error is considered.

1. Would the following compound increase in solubility or have no change in solubility when the acidity of the solution is increased (4 points)?
   1. Magnesium carbonate increase
   2. Barium hydroxide increase
   3. Lead(II) bromide no change
   4. Silver iodide no change
2. Does the pH of the solution increase, decrease, or stay the same when you (3 points)
   1. add solid ammonium chloride to a dilute aqueous solution of ammonia? decrease
   2. add solid sodium acetate to a dilute aqueous solution of acetic acid? increase
   3. add solid sodium chloride to a dilute aqueous solution of sodium hydroxide? no change
3. Decide whether each of the following statements is true or false. If false, rewrite it to make it true (6 points).
   1. The entropy of a substance increases on going from the liquid to the vapor state at any temperature.

True

* 1. An exothermic reaction will always s be spontaneous.

False. Whether an exothermic system is spontaneous also depends on the entropy change for the system.

* 1. Reactions with a positive ∆rH° and a positive ∆rS° can never be product favored.

False. Reactions with +∆rH° and +∆rS° are product favored at higher temperatures.

* 1. If ∆rG° for a reaction is negative, the reaction will have an equilibrium constant greater than 1.

True

1. For a particular reaction ΔH°rxn = -124 kJ, ΔS°rxn = 256 J/K, and T = 292 K (8 points).
2. Calculate ΔSuniverse.
3. Predict whether the reaction will be spontaneous or nonspontaneous. Show calculations to justify your answer.

A negative ΔG°rxn indicates that the process will be spontaneous.

1. Suggest a method for separating a precipitate consisting of a mixture of solid CuS and solid Cu(OH)­2 (3 points).

Cu(OH)2 will dissolve in a nonoxidizing acid such as HCl, whereas CuS will not.

1. Consider the balanced equation (12 points):

6 OH- (aq) + 3 I2 (s) 🡪 IO3- (aq) + 3 H2O (l) + 5 I- (aq)

1. Calculate ∆G° for the reaction at 25 °C.

|  |  |
| --- | --- |
| Substance | ∆G° f (kJ/mol) |
| I2 (s) | 0 |
| IO3- (aq) | -128.0 |
| I- (aq) | -51.57 |
| H2O (l) | -237.1 |
| OH- (aq) | -157.3 |

ΔG°f = [(1 mol)(ΔG° IO3- (aq)) + (3 mol)(ΔG° H2O (l)) + (5 mol)(ΔG° I- (aq))] – [(6 mol)(ΔG° OH- (aq) + (3 mol)(ΔG° I2 (s))]

ΔG°f = [(1 mol)(-128.0 kJ/mol) + (3 mol)(-237.1 kJ/mol) + (5 mol)(-51.57 kJ/mol)] – [(6 mol)(-157.3 kJ/mol) + (3 mol)(0 kJ/mol)]

ΔG°f = -128.0 kJ + -711.3 kJ + -257.85 kJ – (-943.8 kJ)

ΔG°f = -153.4 kJ

1. Is the reaction spontaneous or nonspontaneous under standard-state conditions? Spontaneous
2. What pH is required for the reaction to be at equilibrium at 25 °C when [I-] = 0.10 M and [IO3-] = 0.50 M?
3. The temperature dependence of the equilibrium constant of the reaction:

N2 (g) + O2 (g) 2 NO (g)

which makes an important contribution to atmospheric nitrogen oxides, can be expressed as ln(Kp) = 2.5 -21700/(T/K) (8 points).

1. What is the standard enthalpy of the forward process?
2. What is the standard entropy of the forward process?