Exam 1

# Part 1: Multiple Choice (2 points each)

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

1. Which statement(s) does your instructor often say during lab?
   1. Your safety goggles don’t protect you if they aren’t over your eyes.
   2. There’s no eating or drinking in lab.
   3. There is trash in your cup sink.
   4. All of the above
   5. None of the above
2. Safety shields are used when
   1. No other eye protection is needed.
   2. There is some higher probability of an explosion or evolution of toxic gas.
   3. No other eye protection is available.
   4. It is ergonomically more convenient than using splash goggles or face shields.
   5. All of the above
3. Which equilibrium below is homogeneous?
4. 2 CO (g) + O2 (g) 2 CO2 (g)
5. BaSO4 (s) Ba2+ (aq) + SO42- (aq)
6. 2 H2O2 (l) 2 H2O (l) + O2 (g)
7. NH4NO3 (s) N2O (g) + 2 H2O (g)
8. all of the above
9. The equilibrium constant for the neutralization of mercaptoethanate ion is 5.24 × 109.

H+ (aq) + SCH2CH2OH- (aq) HSCH2CH2OH (aq) A solution of mercaptoethanate in water

* 1. is almost entirely ionized.
  2. is almost entirely unionized.
  3. is about one-half ionized.
  4. is a strong acid.
  5. is completely dissociated.

1. The pH and concentration of several nitrous acid (Ka = 4.6 × 10-4) solutions is given below. In which case can you not make the simplifying assumption that x is small?
   1. 1.82, 0.500 M
   2. 2.18, 0.100 M
   3. 2.72, 0.0100 M
   4. b and c
   5. all of the above
2. Ranking the following in order of increasing acid strength: H2S, HI, H2O, HCl
   1. H2S < HI < H2O < HCl
   2. HCl < H2O < H2S < HI
   3. H2O < H2S < HCl < HI
   4. HCl < HI < H2O < H2S
   5. HI < H2S < HCl < H2O
3. At 40°C the [H3O+] = 1.71 × 10-7 M. What is the pH for a neutral solution?
   1. 14
   2. 13.53
   3. 0.9999
   4. 1.71 × 10-7
   5. not enough information
4. pH indicators
   1. are strong acids.
   2. have characteristic colors in their various protonated and deprotonated forms.
   3. have characteristic pKHIn values.
   4. b and c
   5. all of the above
5. Which buffer system is the best choice to create a buffer with pH = 7.20?
   1. HC2H3O2/KC2H3O2 (Ka = 1.8 × 10-5)
   2. NH3/NH4Cl (Kb = 1.76 × 10-5)
   3. HClO2/KClO2 (Ka = 1.1 × 10-2)
   4. HClO/KClO (Ka = 2.9 × 10-8)
   5. all of the above
6. The graph shows the percent ionization of two acids as a function of concentration in water. Which line describes the behavior of acetic acid?
   1. a

a

* 1. b
  2. c

b

* 1. a and b
  2. a and c

# 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 rapid reversible reactions always have greater yields of product than slow reversible reactions? Explain why or why not (3 points).

No. The equilibrium may favor either products or reactants, depending on the thermodynamic energy difference. The rate at which a reversible reaction occurs does not change the energy of the products or reactants.

1. Henry’s law predicts that the solubility of a gas in a liquid increases with its partial pressure Explain Henry’s law in relation to Le Châtelier’s principle (3 points).

According to Le Châtelier’s principle, an increase in the partial pressure (or concentration) of O2 above the water shifts the equilibrium to the right so that more oxygen becomes dissolved in the water. This is consistent with Henry’s law.

1. A mixture of 0.0200 mol oxygen gas and 0.0200 mol dinitrogen monoxide is placed in a 1.00 L reaction vessel at 25 °C. When the reaction is at equilibrium 0.0200 mol nitrogen dioxide is present (14 points).

2 N2O (g) + 3 O2 (g) 4 NO2 (g)

1. What are the equilibrium concentrations of oxygen and dinitrogen monoxide gas?

2 N2O (g) + 3 O2 (g)  4 NO2 (g)

I 0.0200 M 0.020 M 0 M

C -2x -3x +4x

E 0.0200 M – 2x 0.0560 M – 3x 4x

F 0.0200 M – (2(0.00500 M)) = 0.0200 M – (3(0.00500 M)) = 0.0200 M

0.0100 M 0.0050 M

4x = 0.0200 M

x = 0.00500 M

1. Calculate Kc for the reaction at equilibrium.
2. How will Kc change if the reaction is reversed?

Kc` = 1/Kc = 1/1.3 × 104 M-1 = 7.8 × 10-5 M

1. Describe a solution (solute and concentration) that has a negative pH value (3 points).

[H3 O+] is greater than 1 M. One example is 2.5 M hydrochloric acid with a pH of -0.40.

1. Explain why the Ka1 of H2SO4 is much greater than the Ka1 of H2SeO4 (3 points).

Sulfur is more electronegative than selenium. The higher electronegativity on the sulfur atom stabilizes the anion HSO4- more than the anion HSeO4-.

1. Morphine is isolated from opium and has the chemical formula C17H19NO3. It is a base and accepts one proton per molecule. A 0.676 g sample of opium is found to require 8.92 mL of 1.15 × 10-2 M solution of sulfuric acid for neutralization (15 points).
   1. Write the balanced acid-base neutralization reaction:

2 C17H19NO3 (s) + H2SO4 (aq) (C17H19NO3H)2SO4 (aq)

or

2 C17H19NO3 (s) + H2SO4 (aq) 2 C17H19NO3H+ (aq) + SO42- (aq)

* 1. Assuming that morphine is the only acid or base present in opium, calculate the mass of morphine in the sample of opium.
  2. Assuming that morphine is the only acid or base present in opium, calculate the percent morphine in the sample of opium.

1. How does diluting a pH 4.00 bugger with an equal volume of pure water affect its pH (3 points)?

The pH will not change.

1. How many moles of H3O+ or OH- must you add to 5.6 L of HA solution to adjust its pH from 4.52 to 5.25? Assume a negligible volume change (6 points).

The solution increases in pH therefore OH- was added.

1. For NaC7H5O2, write a net ionic equation that shows how the anion acts as a base (3 points):

C7H5O2- (aq) + H2O (l) HC7H5O2 (aq) + OH- (aq)

1. Explain why (12 points):
   1. The pH of a 0.1 M solution of potassium bromide is 7.0.

K+ is the counterion of the strong base KOH and therefore does not have a strong affinity for hydroxide ions. Br- is the counter of the strong acid HBr and therefore does not have a strong affinity for hydrogen ions.

* 1. The pH of a 0.1 M solution of aluminum chloride is 3.92.

In solution the Al3+ ion becomes hydrated to Al(H2O)63+, which can react with water:

Al(H2O)63+ (aq) + H2O (l) Al(H2O)5(OH)2+ (aq) + H3O+ (aq)

Therefore it produces an acidic solution.

Cl- is the counter of the strong acid HCl and therefore does not have a strong affinity for hydrogen ions.

* 1. The pH of a 0.1 M lithium hydroxide solution is 13.25.

Li+ is the counterion of the strong base LiOH and therefore does not have a strong affinity for hydroxide ions.

OH-has a strong affinity for hydrogen ions.

* 1. The pH of a 0.1 M sodium bicarbonate is 8.33.

Na+ is the counterion of the strong base NaOH and therefore does not have a strong affinity for hydroxide ions.

HCO3- is the counterion of a weak acid so it reacts with water to produce hydroxide ions:

HCO3- (aq) + H2O (l) H2CO3 (aq) + OH- (aq)

Therefore, it produces a basic solution.

1. A buffered solution contains 0.25 M ammonia (Kb = 1.8 × 10-5) and 0.40 M ammonium chloride (15 points).
   1. What are the major species in this buffer solution? \_\_\_NH3, NH4+, Cl-
   2. Calculate the pH of this solution.

There are two ways to solve this problem:

First way using an ICE table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | NH3 (aq) + | H2O (l) | OH- (aq) | + NH4+ (aq) |
| I | 0.25 M | n/a | 10-7 M ≈ 0 M | 0.40 M |
| C | -x |  | +x | +x |
| E | 0.25 M – x =  0.25 M – 1.1 × 10-5 M ≈  0.25 M |  | x = 1.1 × 10-5 M | 0.40 M + x =  0.40 M + 1.1 × 10-5 M ≈ 0.40 M |

Using the x is small approximation:

Is the approximation valid?

Yes, the approximation is valid. Plug x into the table to obtain the concentration values.

Calculate pOH then pH

Second using the Henderson-Hasselbach equation:

* 1. Calculate the pH of the solution that results when 0.10 moles of gaseous hydrogen chloride is added to 1.0 L of the buffered solution.

First do a limiting reagent problem:

|  |  |  |  |
| --- | --- | --- | --- |
|  | NH3 (aq) + | H+ (aq) | NH4+ (aq) |
| I |  | 0.10 mol |  |
| C | - 0.10 mol | - 0.10 mol | + 0.10 mol |
| E | 0.15 mol | 0 mol | 0.50 mol |

Then do an equilibrium problem:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | NH3 (aq) + | H2O (l) | OH- (aq) | + NH4+ (aq) |
| I |  | n/a | 10-7 M ≈ 0 M |  |
| C | -x |  | +x | +x |
| E | 0.15 M – x =  0.15 M – 5.4 × 10-6 M ≈  0.15 M |  | x = 5.4 × 10-6 M | 0.50 M + x =  0.50 M + 5.4 × 10-6 M ≈ 0.50 M |

Using the x is small approximation:

Is the approximation valid?

Yes, the approximation is valid. Plug x into the table to obtain the concentration values.

Calculate pOH then pH

Or using the Henderson-Hasselbach equation: