**Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Aqueous Equilibria Quiz (134 points)**

1) Which one of the following pairs cannot be mixed together to form a buffer solution?

|  |  |
| --- | --- |
| A) | HONH2, HONH3Cl |
| B) | NaCl, HCl |
| C) | RbOH, HF |
| D) | KOH, HNO2 |
| E) | H2SO3, KHSO3 |

2) What change will be caused by addition of a small amount of HCl to a solution containing fluoride ions and hydrogen fluoride?

|  |  |
| --- | --- |
| A) | The concentration of hydronium ions will increase significantly. |
| B) | The concentration of fluoride ions will increase as will the concentration of hydronium ions. |
| C) | The concentration of hydrogen fluoride will decrease and the concentration of fluoride ions will increase. |
| D) | The concentration of fluoride ion will decrease and the concentration of hydrogen fluoride will increase. |
| E) | The fluoride ions will precipitate out of solution as its acid salt. |

3) In a solution, when the concentrations of a weak acid and its conjugate base are equal,

|  |  |
| --- | --- |
| A) | the system is not at equilibrium. |
| B) | the buffering capacity is significantly decreased. |
| C) | the -log of the [H+] and the -log of the Ka are equal. |
| D) | all of the above are true. |

4) Of the following solutions, which has the greatest buffering capacity?

|  |  |
| --- | --- |
| A) | 0.821 M HF and 0.217 M NaF |
| B) | 0.821 M HF and 0.909 M NaF |
| C) | 0.100 M HF and 0.217 M NaF |
| D) | 0.121 M HF and 0.667 M NaF |
| E) | They are all buffer solutions and would all have the same capacity. |

5) According to the Arrhenius concept, an acid is a substance that \_\_\_\_\_\_\_\_\_\_.

|  |  |  |
| --- | --- | --- |
| A) | is capable of donating one or more H+ | |
| B) | causes an increase in the concentration of H+ in aqueous solutions | | |
| C) | can accept a pair of electrons to form a coordinate covalent bond | | |
| D) | reacts with the solvent to form the cation formed by autoionization of that solvent |
| E) | tastes bitter |

6) A BrØnsted-Lowry acid is defined as a substance that \_\_\_\_\_\_\_\_\_\_.

|  |  |  |
| --- | --- | --- |
| A) | | increases Ka when placed in H2O |
| B) | decreases [H+] when placed in H2O | |
| C) | increases [OH-] when placed in H2O | |
| D) | | acts as a proton acceptor |
| E) | acts as a proton donor | |

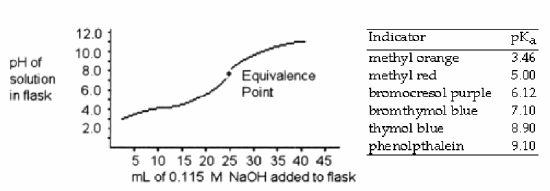
7) Which of the following could be added to a solution of sodium acetate to produce a buffer?

|  |  |
| --- | --- |
| A) | acetic acid only |
| B) | acetic acid or hydrochloric acid |
| C) | hydrochloric acid only |
| D) | potassium acetate only |
| E) | sodium chloride or potassium acetate |

8) Which one of the following is the weakest acid?

|  |  |
| --- | --- |
| A) | HF (Ka = 6.8 x 10-4) |
| B) | HClO (Ka = 3.0 x 10-8) |
| C) | HNO2 (Ka = 4.5 x 10-4) |
| D) | HCN (Ka = 4.9 x 10-10) |
| E) | Acetic acid (Ka = 1.8 x 10-5) |

Use the following graph and table to answer questions 9 and 10



9) A 25.0 mL sample of a solution of an unknown compound is titrated with a 0.115 M NaOH solution. The titration curve above was obtained. The unknown compound is \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | a strong acid |
| B) | a strong base |
| C) | a weak acid |
| D) | a weak base |
| E) | neither an acid nor a base |

10) A 25.0 mL sample of a solution of a monoprotic acid is titrated with a 0.115 M NaOH solution. The titration curve above was obtained. Which of the following indicators would be best for this titration?

|  |  |
| --- | --- |
| A) | methyl red |
| B) | bromthymol blue |
| C) | thymol blue |
| D) | phenolpthalein |
| E) | bromocresol purple |

11) In which of the following aqueous solutions would you expect AgCl to have the lowest solubility?

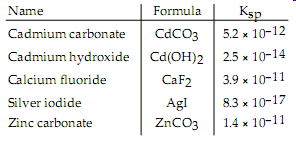
|  |  |
| --- | --- |
| A) | pure water |
| B) | 0.020 M BaCl2 |
| C) | 0.015 NaCl |
| D) | 0.020 AgNO3 |
| E) | 0.020 KCl |

12) Classify the following compounds as weak acids (W) or strong acids (S):

|  |  |  |  |
| --- | --- | --- | --- |
|  | nitrous acid | hydrochloric acid | hydrofluoric acid |

|  |  |  |
| --- | --- | --- |
| A) | | W W W |
| B) | S S S | |
| C) | S W W | |
| D) | W S S | |
| E) | | W S W |

*Consider the following table of Ksp values.*



13) Which compound listed below has the greatest molar solubility in water?

|  |  |
| --- | --- |
| A) | CdCO3 |
| B) | Cd(OH)2 |
| C) | AgI |
| D) | CaF2 |
| E) | ZnCO3 |

14) The Ka of benzoic acid is 6.30  10-5. The pH of a buffer prepared by combining 50.0 mL of 1.00 M potassium benzoate and 50.0 mL of 1.00 M benzoic acid is \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | 1.705 |
| B) | 0.851 |
| C) | 3.406 |
| D) | 4.201 |
| E) | 2.383 |

15) HA is a weak acid. Which equilibrium corresponds to the equilibrium constant Kb for A-?

|  |  |
| --- | --- |
| A) | HA (aq) + H2O (l)  H2A+ (aq) + OH- (aq) |
| B) | A- (aq) + H3O+ (aq)  HA (aq) + H2O (l) |
| C) | HA (aq) + OH- (aq)  H2O (l) + H+ (aq) |
| D) | A- (aq) + H2O (l)  HA (aq) + OH- (aq) |
| E) | A- (aq) + OH- (aq)  HOA2- (aq) |

16) The concentration of fluoride ions in a saturated solution of barium fluoride is \_\_\_\_\_\_\_\_\_\_ M. The solubility product constant of BaF2 is 1.7  10-6.

|  |  |
| --- | --- |
| A) | 3.8  10-4 |
| B) | 3.0  10-3 |
| C) | 1.5  10-2 |
| D) | 7.5  10-3 |
| E) | 1.4  10-4 |

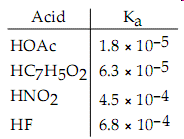
17) Determine the Ksp for magnesium hydroxide (Mg(OH)2) where the solubility of Mg(OH)2 is 1.4  10-4 M.

|  |  |
| --- | --- |
| A) | 2.7  10-12 |
| B) | 1.1  10-11 |
| C) | 2.0  10-8 |
| D) | 3.9  10-8 |
| E) | 1.4  10-4 |

18) What is the solubility (in M) of PbCl2 in a 0.15 M solution of HCl? The Ksp of PbCl2 is 1.6  10-5.

|  |  |
| --- | --- |
| A) | 2.0  10-3 |
| B) | 1.1  10-4 |
| C) | 1.8  10-4 |
| D) | 7.1  10-4 |
| E) | 1.6  10-5 |

19) Using the data in the table, which of the conjugate bases below is the strongest base?



|  |  |
| --- | --- |
| A) | OAc- |
| B) | C7H5O2- |
| C) | NO2- |
| D) | F- |
| E) | OAc- and C7H5O2- |

20) Calculate the percent ionization of formic acid (HCO2H) in a solution that is 0.219 M in formic acid. The Ka of formic acid is 1.77  10-4.

|  |  |
| --- | --- |
| A) | 3.94  10-5 |
| B) | 0.0180 |
| C) | 2.84 |
| D) | 0.280 |
| E) | 12.2 |

21)A solution is prepared by dissolving 0.23 mol of hydrofluoric acid and 0.27 mol of sodium fluoride in water sufficient to yield 1.00 L of solution. The addition of 0.05 mol of HCl to this buffer solution causes the pH to drop slightly. The pH does not decrease drastically because the HCl reacts with the \_\_\_\_\_\_\_\_\_\_ present in the buffer solution. The Ka of hydrofluoric acid is 1.36  10-3.

|  |  |
| --- | --- |
| A) | H2O |
| B) | H3O+ |
| C) | fluoride ion |
| D) | hydrofluoric acid |
| E) | This is a buffer solution: the pH does not change upon addition of acid or base. |

22) A solution of NaF is added dropwise to a solution that is 0.0144 M in Ba2+. When the concentration of F- exceeds \_\_\_\_\_\_\_\_\_\_ M, BaF2 will precipitate. Neglect ∆volumes. For BaF2, Ksp = 1.7  10-6.

|  |  |
| --- | --- |
| A) | 5.9  10-5 |
| B) | 1.1  10-2 |
| C) | 2.4  10-8 |
| D) | 2.7  10-3 |
| E) | 1.2  10-4 |

23) Which will occur if a 0.1 M solution of a weak acid is diluted to 0.01 M at constant temperature?

A) [H+] will decrease to 0. 01 M.

B) pH will decreases

C) Percentage ionization will increase.

D) *K*a will increase.

24) A buffer of pH 4.1 is to be prepared from a weak acid and its salt. The best acid from which to prepare the buffer is

A) phthalic acid, *K*1 = 1.3 x 10–3 (first ionization)

B) hydrogen phthalate, *K*2 = 3.9 x 10–5 (second ionization of phthalic acid)

C) benzoic acid, *K* = 6.3 x 10–5

D) hydrocyanic acid, *K* = 4 x 10–10

25) Which of the following aqueous solutions has the highest [OH-]?

|  |  |
| --- | --- |
| A) | a solution with a pH of 3.0 |
| B) | a 1 x 10-4 M solution of HNO3 |
| C) | a solution with a pOH of 12.0 |
| D) | pure water |
| E) | a 1 x 10-3 M solution of NH4Cl |

26) Of the following substances, an aqueous solution of \_\_\_\_\_\_\_\_\_\_ will form basic solutions.

|  |  |  |  |
| --- | --- | --- | --- |
| NaHS | Cu(NO3)2 | KHCO3 | NaF |

|  |  |
| --- | --- |
| A) | NaHS, Cu(NO3)2 |
| B) | KHCO3, NaHS |
| C) | NaF only |
| D) | NaF, KHCO3 |
| E) | NaHS, KHCO3 and NaF |

27) A 0.1 M aqueous solution of \_\_\_\_\_\_\_\_\_\_ will have a pH of 7.0 at 25.0°C.

|  |  |  |  |
| --- | --- | --- | --- |
| NaOCl | KCl | NH4Cl | Ca(OAc)2 |

|  |  |
| --- | --- |
| A) | NaOCl |
| B) | KCl |
| C) | NH4Cl |
| D) | Ca(OAc)2 |
| E) | KCl and NH4Cl |

28) Of the following, which is the strongest acid?

|  |  |
| --- | --- |
| A) | HIO |
| B) | HIO4 |
| C) | HIO2 |
| D) | HIO3 |
| E) | The acid strength of all of the above is the same. |

29) The conjugate base of H2PO4- is \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | PO4-3 |
| B) | H2PO4 |
| C) | H3PO4 |
| D) | HPO4-2 |
| E) | none of the above |

30) HZ is a weak acid. An aqueous solution of HZ is prepared by dissolving 0.020 mol of HZ in sufficient water to yield 1.0 L of solution. The pH of the solution was 4.93 at 25.0°C. The Ka of HZ is \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | 1.2 x 10-5 |
| B) | 6.9 x 10-9 |
| C) | 1.4 x 10-10 |
| D) | 9.9 x 10-2 |
| E) | 2.8 x 10-12 |

31) The acid-dissociation constants of sulfurous acid (H2SO3) are Kal = 1.7 x 10-2 and Ka2 = 6.4 x 10-8 at 25.0°C. Calculate the pH of a 0.163 M aqueous solution of sulfurous acid.

|  |  |
| --- | --- |
| A) | 4.53 |
| B) | 1.28 |
| C) | 1.86 |
| D) | 6.21 |
| E) | 1.93 |

32) The acid-dissociation constant, Ka, for gallic acid is 4.57 x 10-3. What is the base-dissociation constant, Kb, for the gallate ion?

|  |  |
| --- | --- |
| A) | 4.57 x 10-3 |
| B) | 2.19 x 10-12 |
| C) | 5.43 x 10-5 |
| D) | 7.81 x 10-6 |
| E) | 2.19 x 102 |

33) What is the pH of a 0.035 M aqueous solution of barium hydroxide?

|  |  |
| --- | --- |
| A) | 12.85 |
| B) | 12.54 |
| C) | 1.46 |
| D) | 10.41 |
| E) | 1.15 |

34) A substance that is capable of acting as both an acid and as a base is \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | autosomal |
| B) | conjugated |
| C) | amphoteric |
| D) | saturated |
| E) | miscible |

35) The magnitude of Kw indicates that \_\_\_\_\_\_\_\_\_\_.

|  |  |
| --- | --- |
| A) | water autoionizes very slowly |
| B) | water autoionizes very quickly |
| C) | water autoionizes only to a very small extent |
| D) | the autoionization of water is exothermic |

AP Questions (4 points each part)

1) Hydrofluoric Acid dissociates in water according to the above reaction:

HF (aq) + H2O(aq) ↔ H3O+ (aq) +F- (aq)  Ka = 7.2x10-4

(a) Write the equilibrium-constant expression for the dissociation of HF(aq) in water.

(b) Calculate the molar concentration of H3O+ in a 0.40M HF solution.

HF(aq) reacts with NaOH(aq) according to the reaction below. HF(aq) + OH- (aq) → H2O(l) + F- (aq)

A volume of 15mL of 0.40M NaOH (aq)  is added to 25mL of 0.40M HF (aq) solution. Assume volumes are additive.

(c) Calculate the number of moles of HF(aq) remaining in the solution.

(d) Calculate the molar concentration of F-(aq) in the solution.

(e) Calculate the pH of the solution.

2) At 25ºC the solubility product constant, Ksp, for strontium sulfate, SrSO4, is 7.6×10-7. The solubility product constant for strontium fluoride, SrF2, is 7.9x10-10.

(a) What is the molar solubility of SrSO4 in pure water at 25ºC?

(b) What is the molar solubility of SrF2 in pure water at 25ºC?

(c) An aqueous solution of Sr(NO3)2 is added slowly to 1.0 liter of a well-stirred solution containing 0.020 mole F- and 0.10 mole SO42- at 25ºC. (You may assume that the added Sr(NO3)2 solution does not materially affect the total volume of the system.)

1. Which salt precipitates first?

2. What is the concentration of strontium ion, Sr2+, in the solution when the first precipitate begins to form?

3) A 2.00 × 10-3 mole sample of pure acetylsalicylic acid was dissolved in 15.00 mL of water and then titrated with 0.100 *M* NaOH*(aq)*. The equivalence point was reached after 20.00 mL of the NaOH solution had been added. Using the data from the titration, shown in the table below, determine

a) the value of the acid dissociation constant, *Ka*, for acetylsalicylic acid and

b) the pH of the solution after a total volume of 25.00 mL of the NaOH solution had been added (assume that volumes are additive).

|  |  |
| --- | --- |
| Volume of 0.100M NaOH Added (mL) | pH |
| 0.00 | 2.22 |
| 5.00 | 2.97 |
| 10.00 | 3.44 |
| 15.00 | 3.92 |
| 20.00 | 8.13 |
| 25.00 | ? |

4) A 1.22 g sample of a pure monoprotic acid, HA, was dissolved in distilled water. The HA solution was then titrated with 0.250 *M* NaOH. The pH was measured throughout the titration, and the equivalence point was reached when 40.0 mL of the NaOH solution had been added. The data from the titration are recorded in the table below.

|  |  |
| --- | --- |
| Volume of 0.250 *M* NaOH Added (mL) | pH of Titrated Solution |
| 0.00 | ? |
| 10.0 | 3.72 |
| 20.0 | 4.20 |
| 30.0 | ? |
| 40.0 | 8.62 |
| 50.0 | 12.40 |

(a) Explain how the data in the table above provide evidence that HA is a weak acid rather than a strong acid.

(b) Write the balanced net-ionic equation for the reaction that occurs when the solution of NaOH is added to the solution of HA .

(c) Calculate the number of moles of HA that were titrated.

(d) Calculate the molar mass of HA .

The equation for the dissociation reaction of HA in water is shown below.

HA(*aq*) + H2O(*l*) ↔H3O+(*aq*) + A−(*aq*) *Ka* = 6.3 × 10−5

(e) Assume that the initial concentration of the HA solution (before any NaOH solution was added) is 0.200 *M.* Determine the pH of the initial HA solution.

(f) Calculate the value of [H3O+] in the solution after 30.0 mL of NaOH solution is added and the total volume of the solution is 80.0mL.