Spring 2009 CH 302:

30 Practice Problems Covering the Equilbrium Problem Types You Will Find on Exam 2.

Answer Key

1) The pH of an equimolar solution of acetic acid + sodium acetate is found to be 4.75.
What will happen to the pH of this solution if we dilute it with water to twice the initial volume?

- **A.** The pH will rise and be higher than 4.75.
- **B.** The pH will fall and be lower than 4.75.
- **C.** The pH will remain 4.75.
- **D.** No answer is possible without knowing the actual initial concentrations.

Answer: C

2) The pH of a solution that is 0.25 M $(NH_4)_2SO_4(aq)$ and 0.50 M $NH_3(aq)$ is:

- **A.** 4.75
- **B.** 8.95
- **C.** 9.25
- **D.** 9.56

Answer: C

3) What will be the pH in a titration in which 5.0 mL of 0.120 M $HNO_3(aq)$ is added to 25.0 mL of 0.240 M KOH(aq)?

- **A.** 0.74
- **B.** 13.26
- **C.** 13.33
- **D.** 13.38

Answer: B

4) The volume, in mL, calculated to one decimal point, of 0.25 M HCl(aq) required to reduce the pH of 50 mL of a 0.40 M ammonia solution to a value of 7.00 would be:

- **A.** 80.0
- **B.** 79.6
- **C.** 50.0
- **D.** 49.8

Answer: B

5) A buffer solution of volume 200.0 mL is 0.250 M $Na_2HPO_4(aq)$ and 0.250 M $KH_2PO_4(aq)$. The pH resulting from the addition of 50.0 mL of 0.100 M NaOH(aq) to the buffer solution will be

- **A.** 7.12
- **B.** 7.21
- **C.** 7.30
- **D.** 12.77

Answer: C

6) After the addition of 150 mL of 0.100 M KOH(aq) to 100 mL of 0.100 M $H_2SO_4(aq)$,

- **A.** the pH of the final solution will be 1.92.
- **B.** the pH of the final solution will be greater than 1.92, but less than 7.00.
- **C.** the pH of the final solution will be 7.00.
- **D.** the pH of the final solution will be greater than 7.00, but less than 13.00.

Answer: A

7) The molar concentration (to two significant figures) of chloride ions in a saturated solution of silver chloride is:

- **A.** 0.8×10^{-10} mol·L^{-1}
- **B.** 1.6×10^{-10} mol·L^{-1}
- **C.** 0.8×10^{-5} mol·L^{-1}
- **D.** 1.3×10^{-5} mol·L^{-1}

Answer: D

8) The molar concentration (to two significant figures) of iodide ions in a saturated solution of lead iodide is:

- **A.** 1.4×10^{-8} mol·L^{-1}
- **B.** 1.2×10^{-4} mol·L^{-1}
- **C.** 1.5×10^{-3} mol·L^{-1}
- **D.** 3.0×10^{-3} mol·L^{-1}

Answer: D

9) What is the solubility of Ag_2CrO_4 ($K_{sp} = 1.12 \times 10^{-12}$) in grams per 100 mL of 0.100 M solution $AgNO_3$?

- **A.** 1.5×10^{-9}
- **B.** 3.2×10^{-8}
- **C.** 3.7×10^{-9}

- **D.** 1.8×10^{-8}

Answer: C

10) When sodium nitrite is added to $HNO_2(aq)$,

- **A.** the equilibrium concentration of HCOOH(aq) decreases.
- **B.** the pH of the solution increases.
- **C.** the K_a increases.
- **D.** the pH of the solution does not change.
- **E.** the pH of the solution decreases.

Answer: B

11) 100 mL of each of the following solutions is mixed; which one of the mixed solutions is a buffer?

- **A.** 1.0 M $NH_3(aq)$ + 0.6 M KOH(aq)
- **B.** 1.0 M $NH_4Cl(aq)$ + 1.0 M KOH(aq)
- **C.** 1.0 M $NH_3(aq)$ + 0.4 M HCl(aq)
- **D.** 1.0 M $NH_4Cl(aq)$ + 0.4 M HCl(aq)
- **E.** 1.0 M $NH_3(aq)$ + 1.0 M HCl(aq)

Answer: C

12) Choose the effective pH range of an aniline/anilinium chloride buffer. The value of the K_b for aniline is 4.3×10^{-10}.

- **A.** 3.6–5.6
- **B.** 8.4–10.4
- **C.** 1.1–3.1
- **D.** 5.1–7.1
- **E.** 10.1–12.1

Answer: A

13) Which of the following mixtures gives a buffer with a pH greater than 7.0? For HCNO, $K_a = 2.2 \times 10^{-4}$ and for NH_3, $K_b = 1.8 \times 10^{-5}$.

- **A.** 10 mL of 0.1 M $NH_3(aq)$ + 10 mL of 0.1 M HCl(aq)
- **B.** 10 mL of 0.1 M HCNO(aq) + 10 mL of 0.1 M NaOH(aq)
- **C.** 10 mL of 0.1 M HCNO(aq) + 5.0 mL of 0.1 M NaOH(aq)
- **D.** 10 mL of 0.1 M $NH_3(aq)$ + 10 ml of 0.1 M HCNO(aq)
- **E.** 10 mL of 0.1 M $NH_3(aq)$ + 5.0 mL of 0.1 M HCl(aq)

Answer: E

14) If a small amount of a strong base is added to buffer made up of a weak acid, HA, and the sodium salt of its conjugate base, NaA, the pH of the buffer solution does not change appreciably because

- **A.** the K_a of HA is changed.
- **B.** No reaction occurs.
- **C.** the strong base reacts with A^- to give HA, which is a weak acid.
- **D.** the strong base reacts with HA to give AOH and H^+.
- **E.** the strong base reacts with HA to give A^-, which is a weak base.

Answer: E

15) At the stoichiometric point in the titration of 0.130 M HCOOH(aq) with 0.130 M KOH(aq),

- **A.** the pH is 7.0.
- **B.** [HCOOH] = 0.0650 M.
- **C.** [HCO_2–] = 0.130 M.
- **D.** the pH is greater than 7.
- **E.** the pH is less than 7.

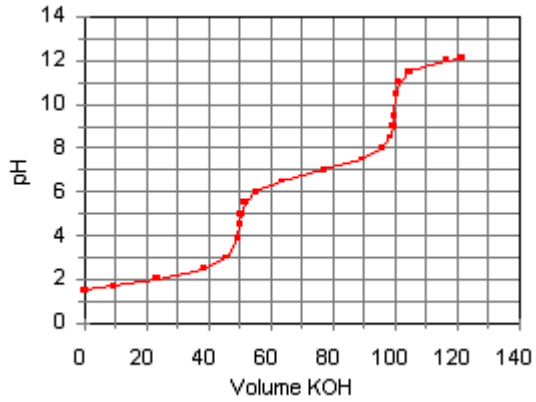
Answer: D

16) For the titration of 50.0 mL of 0.020 M aqueous salicylic acid with 0.020 M KOH(aq), calculate the pH after the addition of 55.0 mL of KOH(aq). For salycylic acid, pK_a = 2.97.

- **A.** 10.98
- **B.** 7.00
- **C.** 11.26
- **D.** 12.02
- **E.** 12.30

Answer: A

17) The titration curve for the titration of 0.100 M H_2SO_3(aq) with 0.100 M KOH(aq) is given below.

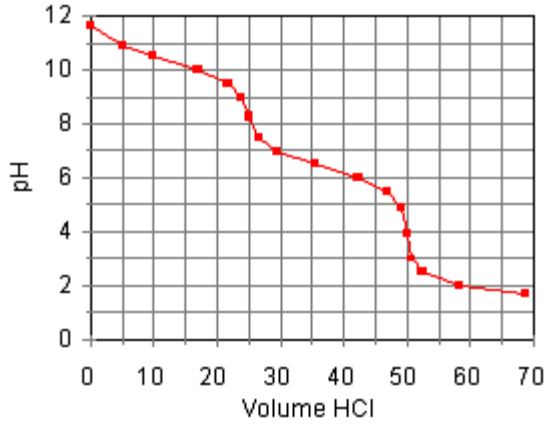


Estimate pK_{a1} and pK_{a2} of H_2SO_3.

Answer

Answer: pKa1 ~ 2.0 and pKa2 ~ 6.9

18) The titration curve for the titration of 0.100 M $Na_2CO_3(aq)$ with 0.100 M $HClO_4(aq)$ is:



The main species in the solution after the addition of 35 mL of $HClO_4$ are

- **A.** HCO_3^-, H_2CO_3, Na^+, and ClO_4^-.
- **B.** H_2CO_3, Na^+, and ClO_4^-.
- **C.** CO_3^{2-}, HCO_3–, Na^+, and ClO_4^-.
- **D.** CO_3^{2-}, Na^+, and ClO_4^-.
- **E.** HCO_3^-, Na^+, and ClO_4^-.

Answer: A

19) What is the relationship between the solubility in water, s, and K_{sp} for the ionic solid $Ca_3(PO_4)_2$?

- **A.** $K_{sp} = 72s^5$
- **B.** $K_{sp} = 5s$
- **C.** $K_{sp} = 6s^2$
- **D.** $K_{sp} = s^5$

Answer: A

20) Which of the following water-insoluble salts is more soluble in 1.0 M $HClO_4$(aq)?

- **A.** AgBr
- **B.** PbF_2
- **C.** Hg_2Br_2
- **D.** PbI_2
- **E.** $AgClO_4$

Answer: B

21) If equal volumes of 0.004 M $Pb(NO_3)_2$(aq) and 0.004 M KI(aq) are mixed, what reaction, if any, occurs? The value of K_{sp} for PbI_2 is 1.4×10^{-8}.

- **A.** The solution turns purple because of formation of I_2.
- **B.** PbI_2(s) precipitates.
- **C.** KNO_3(s) precipitates.
- **D.** No reaction occurs.
- **E.** The value of K_{sp} changes to 9×10^{-9}.

Answer: D

22) If you wish to increase the solubility of silver benzoate, a preservative, you would

- **A.** add sodium hydroxide.
- **B.** decrease the pH.
- **C.** add sodium acetate.
- **D.** add sodium benzoate.
- **E.** add silver nitrate.

Answer: B

23) Rank, from greater to least, the equilibrium concentration of species formed when 0.2M H_2SO_4 is placed in solution.

Answer

Answer: $H_+ > HSO_4^- > SO_4^{=} > OH^- > H_2SO_4$

24) You have watched a fellow student derive the exact solution for a dilute strong acid in water. Feel free to derive a similar solution for a dilute weak acid case (or look at the equation in the notes.) How many more unknowns are there for the dilute weak acid than the dilute weak acid? What is the number of coefficients in

the charge balance equation for weak acid case? How

Answer

Answer: There are four unknowns for the weak acid (proton, hydroxide, HA and A-) and only three for the strong acid case (H+, OH- and the salt of the strong acid.) There are three coefficients in the charge balance equation: H+ = A- + OH-

25) Consider the following solutions made by dumpling a polyprotic acid, H3Y, or its salts into water (hint, get rid of those pesky spectators): Solution I: H3Y Solution II: Li2NaY Solution III: K2HY and K2NaY Solution IV: CaHY What are the simple acid/base equations you would use to find the pH for these solutions?

Answer

Answer:
Solution I: H_3Y----a weak acid
Solution II: Li_2NaY----a weak base
Solution III: K_2HY and K_2NaY----a buffer
Solution IV: CaHY----amphiprotic

26) A solution is made by placing 100 ml of 0.3M ammonia and 200 ml of 0.5M ammonium nitrate in water. What is the buffer capacity for this solution?

Answer

Answer: 0.03 moles of capacity for strong acid and 0.1 moles of capacity for strong base.

27) Place a drop of aqueous HCl on chalk (calcium carbonate) and watch the fizzing begin. Name all the chemical species formed from the carbonate and their associated chemical equilibria.

Answer

Answer: Calcium carbonate dissolves in the water according to its K_{sp}. The carbonate forms bicarbonate in a first protonation step (1/Ka2), the bicarbonate forms carbonic acid in a second protonation step (1/Ka1) and carbon dioxide is expelled from water in accordance with Henry's Law.

28) Consider a solution made by placing 10^{-8} M KOH and 0.1 M ammonia in water. Rank from most to least, the species that provide the greatest number of hydroxides.

- **A.** water> KOH > ammonia
- **B.** KOH > ammonia > water
- **C.** KOH > water > ammonia
- **D.** ammonia ? water > KOH

Answer: D

29) Assuming equal amounts of each are placed in water, which of the following compounds produces the strongest acid?

- **A.** The acid of sodium formate which has a K_b of 10^{-9}?
- **B.** Acetic acid which has a salt with a K_b of 5×10^{-10}?

- **C.** Pure water
- **D.** Tartaric acid which has a K_a of 1×10^{-6}
- **E.** Ammonia which has a salt with a K_a of 5×10^{-10}?

Answer: B

30) Which of the following solutions would not require more than one equilbrium constant to accurately calculate pH?

- **A.** A mixture of methanol and water.
- **B.** A 0.1 M solution of sulfuric acid.
- **C.** A solution of sodium bicarbonate.
- **D.** A 10^{-6} M solution of ammonia?
- **E.** An equimolar solution of Na_2LiPO_4 and Na_2HPO_4?

Answer: E