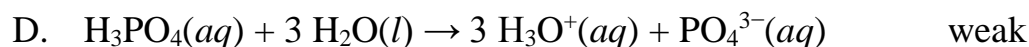
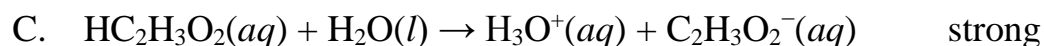
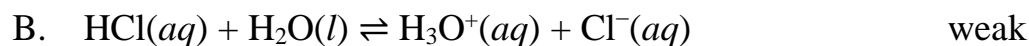
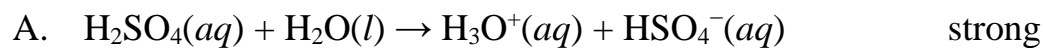

Unless otherwise stated, solutions are aqueous and equilibria are measured at 25 °C.

1. Which answer gives the acid ionization reaction and strength for the acid listed?



2. A 0.20 M solution of a monoprotic acid has a percent ionization of 4.5%. Determine the K_a value of the acid.

A. 4.5×10^{-3}

C. 4.2×10^{-4}

B. 1.8×10^{-5}

D. 1.3×10^{-2}

3. Calculate the pH of a solution that contains 0.020 M HCl and 0.40 M HOCl (hypochlorous acid, $K_a = 2.9 \times 10^{-8}$).

A. 1.45

C. 1.89

B. 1.70

D. 2.19

4. What is the final pH when 25.0 mL of 0.0100 M KOH is mixed with 75.0 mL of 0.0200 M $\text{Sr}(\text{OH})_2$?

A. 1.502

C. 10.236

B. 6.995

D. 12.512

5. Use the appropriate K_a value given below to determine the K_b of ClO^- .

$$K_a(\text{HClO}_2) = 1.1 \times 10^{-2} \quad K_a(\text{HClO}) = 2.9 \times 10^{-8}$$

- A. 3.4×10^{-7}
- B. 1.0×10^{-7}
- C. 2.9×10^{-8}
- D. HClO is a strong acid; therefore, ClO^- has no measurable base strength.

6. Which of the following salts dissolves in water to give a solution in the indicated pH range?

- A. LiNO_3 , $\text{pH} > 7$
- B. $\text{KC}_2\text{H}_3\text{O}_2$, $\text{pH} > 7$
- C. NH_4Cl , $\text{pH} = 7$
- D. NaF , $\text{pH} < 7$

7. Rank the following three acids from strongest to weakest acid.

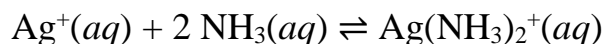
H_2O (first ionization), HCl , HF

- A. $\text{H}_2\text{O} > \text{HF} > \text{HCl}$
- B. $\text{HCl} = \text{HF} > \text{H}_2\text{O}$
- C. $\text{HF} > \text{HCl} > \text{H}_2\text{O}$
- D. $\text{HCl} > \text{HF} > \text{H}_2\text{O}$

8. Which of the following acids has the **smallest** K_a value?

- A. HBrO
- B. HBrO_2
- C. HBrO_3
- D. HBrO_4

9. Which statement is true for the reaction given below:



- A. Ag^+ is a Lewis base; it is an electron pair donor.
 - B. Ag^+ is a Lewis acid; it is an electron pair acceptor.
 - C. NH_3 is a Lewis acid; it is an electron pair donor.
 - D. NH_3 is a Lewis acid; it is an electron pair acceptor.
-

10. Which of the following describes a solution that resists changes in pH when an acid or a base is added?

- A. An electrolytic solution
- B. A neutral solution comprised of a strong acid and strong base in equal molar amounts
- C. A solution that contains significant amounts of a weak acid and its conjugate base
- D. A solution that contains significant amounts of a strong acid and its conjugate base

11. A buffer made of benzoic acid ($\text{HC}_7\text{H}_5\text{O}_2$, $K_a = 6.5 \times 10^{-5}$) and sodium benzoate ($\text{NaC}_7\text{H}_5\text{O}_2$) has a pH of 4.99. What is true about the ratio of base to acid for this buffer?

- A. $[\text{C}_7\text{H}_5\text{O}_2^-] = 2[\text{HC}_7\text{H}_5\text{O}_2]$
- B. $[\text{C}_7\text{H}_5\text{O}_2^-] = [\text{HC}_7\text{H}_5\text{O}_2]$
- C. $[\text{C}_7\text{H}_5\text{O}_2^-] < [\text{HC}_7\text{H}_5\text{O}_2]$
- D. $[\text{C}_7\text{H}_5\text{O}_2^-] > [\text{HC}_7\text{H}_5\text{O}_2]$

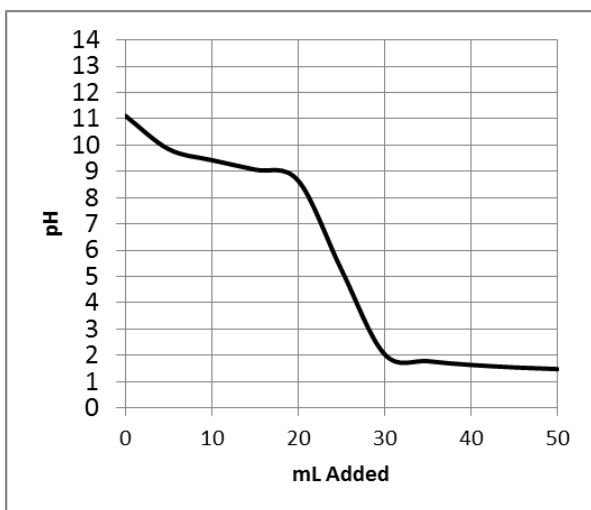
12. A few milliliters of 0.10 M HBr is added to 100.0 mL of a buffer containing 0.10 M $\text{HC}_2\text{H}_3\text{O}_2$ (acetic acid) and 0.15 M $\text{NaC}_2\text{H}_3\text{O}_2$ (sodium acetate). Which of the following reactions represents the neutralization of the strong acid?

- A. $\text{H}_2\text{O}(l) + \text{HC}_2\text{H}_3\text{O}_2(aq) \rightarrow \text{C}_2\text{H}_3\text{O}_2^-(aq) + \text{H}_3\text{O}^+(aq)$
- B. $\text{H}_3\text{O}^+(aq) + \text{C}_2\text{H}_3\text{O}_2^-(aq) \rightarrow \text{HC}_2\text{H}_3\text{O}_2(aq) + \text{H}_2\text{O}(l)$
- C. $\text{H}^+(aq) + \text{HC}_2\text{H}_3\text{O}_2(aq) \rightarrow \text{H}_2\text{C}_2\text{H}_3\text{O}_2^+(aq)$
- D. $\text{OH}^-(aq) + \text{H}_3\text{O}^+(aq) \rightarrow \text{H}_2\text{O}(l)$

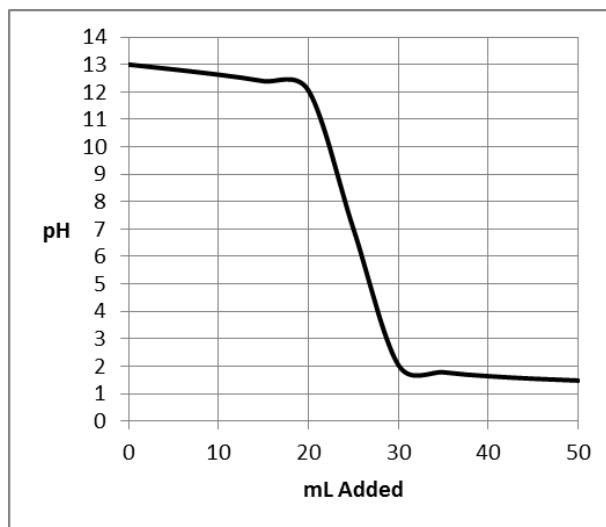
13. Below are four different sodium acetate/acetic acid buffer solutions. Which would be the most effective buffer for the addition of a strong acid?

- A. 0.10 M $\text{NaC}_2\text{H}_3\text{O}_2$ /0.10 M $\text{HC}_2\text{H}_3\text{O}_2$
 - B. 0.10 M $\text{NaC}_2\text{H}_3\text{O}_2$ /0.20 M $\text{HC}_2\text{H}_3\text{O}_2$
 - C. 0.20 M $\text{NaC}_2\text{H}_3\text{O}_2$ /0.10 M $\text{HC}_2\text{H}_3\text{O}_2$
 - D. 0.020 M $\text{NaC}_2\text{H}_3\text{O}_2$ /0.010 M $\text{HC}_2\text{H}_3\text{O}_2$
-

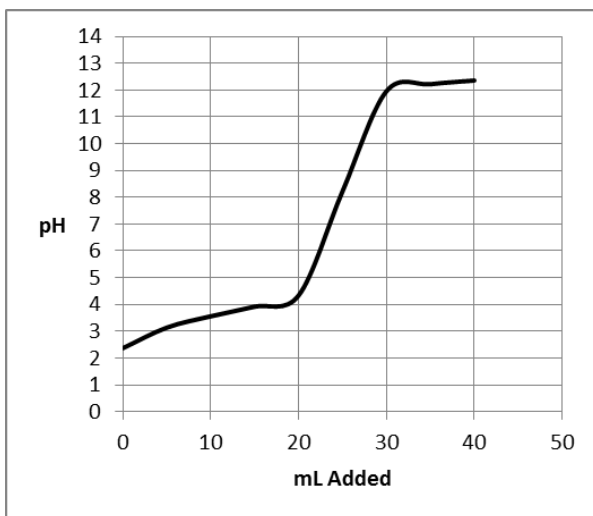
14. A flask containing 25.0 mL of 0.100 M strong base is titrated with a 0.100 M strong acid. Which graph below best represents the change in pH during the titration?



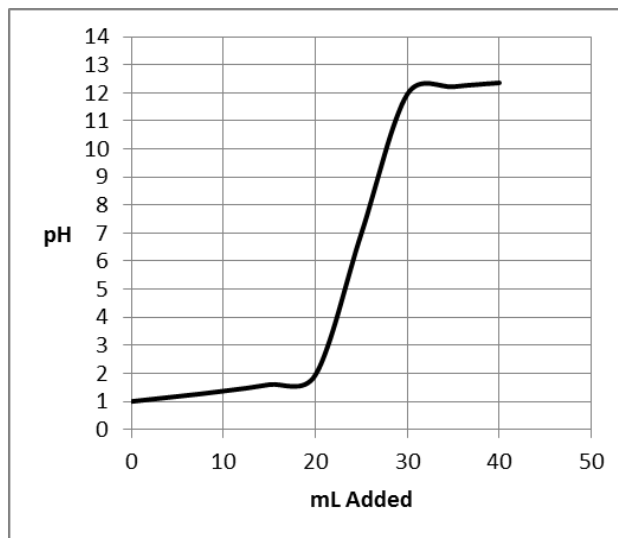
Graph I



Graph II



Graph III



Graph IV

- A. Graph I
B. Graph II

- C. Graph III
D. Graph IV
-

15. Calculate the pH of a solution at the point when 20.20 mL of 0.10 M HCl is titrated with 10.10 mL of 0.20 M NH_3 . $K_b(\text{NH}_3) = 1.8 \times 10^{-5}$.

A. 9.33

C. 8.70

B. 4.62

D. 5.22

16. Calculate the pH after 10.0 mL of 0.450 M HI is added to 10.0 mL of a 0.225 M nicotine solution. $K_b(\text{nicotine}) = 1.0 \times 10^{-6}$.

A. 8.379

C. 0.949

B. 12.468

D. 2.062

17. An indicator is red in its acid form and yellow in its ionized (conjugate base) form. When an acidic solution containing this indicator is titrated with a basic solution, what color changes will occur?

A. red \rightarrow orange \rightarrow yellow

C. orange \rightarrow red \rightarrow yellow

B. yellow \rightarrow orange \rightarrow red

D. red \rightarrow yellow \rightarrow orange

18. Which of the following salts is the **least** soluble?

A. BaF_2 , $K_{sp} = 2.45 \times 10^{-5}$

C. PbCl_2 , $K_{sp} = 1.17 \times 10^{-5}$

B. CaF_2 , $K_{sp} = 1.46 \times 10^{-10}$

D. PbBr_2 , $K_{sp} = 4.67 \times 10^{-6}$

19. Calculate the molar solubility of $\text{Cd}(\text{OH})_2$ in pure water. K_{sp} of $\text{Cd}(\text{OH})_2$ is 7.2×10^{-15} .

A. $3.23 \times 10^{-6} \text{ M}$

C. $6.67 \times 10^{-12} \text{ M}$

B. $7.44 \times 10^{-20} \text{ M}$

D. $1.22 \times 10^{-5} \text{ M}$

20. Which of the following salts is/are **more** soluble in an acidic solution than in pure water?



A. PbCl_2 and PbBr_2

B. CaF_2 only

C. BaF_2 and CaF_2

D. All salts are equally soluble in acid and in pure water.

21. A solution is $1.50 \times 10^{-4} \text{ M}$ in $\text{Ca}(\text{NO}_3)_2$ and $3.40 \times 10^{-5} \text{ M}$ in NaF . $K_{\text{sp}}(\text{CaF}_2) = 1.46 \times 10^{-10}$. Which of the following statements is true?

A. $Q = 1.73 \times 10^{-13}$ and **a precipitate** will form.

B. $Q = 1.73 \times 10^{-13}$ and **no precipitate** will form.

C. $Q = 5.10 \times 10^{-9}$ and **a precipitate** will form.

D. $Q = 5.10 \times 10^{-9}$ and **no precipitate** will form.

22. An aqueous solution is 0.010 M in Ag^+ and 0.010 M in Al^{3+} . When sufficient PO_4^{3-} is added to the solution, both Ag_3PO_4 ($K_{\text{sp}} = 8.89 \times 10^{-17}$) and AlPO_4 ($K_{\text{sp}} = 9.84 \times 10^{-21}$) will precipitate from the solution. What minimum concentration of PO_4^{3-} is needed to begin precipitation of the salt that precipitates first?

A. 9.8×10^{-19} M

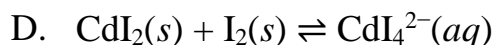
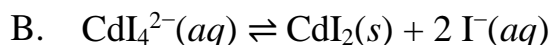
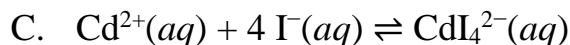
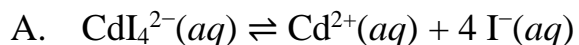
C. 5.4×10^{-21} M

B. 8.2×10^{-13} M

D. 8.2×10^{-13} M

23. Which of the following reaction equations is associated with the formation constant (K_f) below?

$$K_f(\text{CdI}_4^{2-}) = 2 \times 10^6$$



24. Which species does **not** increase the solubility of AgI ?



25. Select the **true** statement from the choices below.

A. A spontaneous process occurs rapidly and without outside intervention.

B. A nonspontaneous process occurs slowly and without outside intervention.

C. A nonspontaneous process occurs without outside intervention, but nonspontaneity does not determine the rate of the process.

D. A spontaneous process occurs without outside intervention, but spontaneity does not determine the rate of the process.

26. Which statement is **true**?

- A. All exothermic reactions are spontaneous.
- B. All endothermic reactions are nonspontaneous.
- C. The increase in disorder or randomness in the universe drives reactions.
- D. The increase in order in the universe drives reactions.

27. Which of the following processes is accompanied by a **decrease** in entropy of the system?

- A. Freezing of water
- B. Evaporation of water
- C. Mixing of methanol and water
- D. Sublimation of dry ice

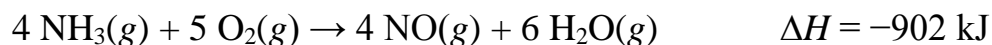
28. Which balanced chemical equation shows the **greatest increase** in entropy for the reaction?

- A. $2 \text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)$
- B. $2 (\text{NH}_4)_2\text{CO}_3(s) \rightarrow 2 \text{NH}_3(g) + \text{CO}_2(g) + \text{H}_2\text{O}(g)$
- C. $\text{CO}(g) + 2 \text{H}_2(g) \rightarrow \text{CH}_3\text{OH}(g)$
- D. $\text{SnO}_2(s) + \text{H}_2(g) \rightarrow \text{Sn}(s) + \text{H}_2\text{O}(g)$

29. Which statement is **true**?

- A. The entropy change of the surroundings is positive for exothermic reactions.
- B. The entropy change of the surroundings is negative for exothermic reactions.
- C. If the entropy change of a reaction is negative, the entropy change of the surroundings is necessarily negative.
- D. If the entropy change of a reaction is positive, the entropy change of the surroundings is necessarily negative.

30. What is the change in the entropy of the surroundings for the following reaction conducted at 35.0 °C?



- A. 22.4 kJ/K
 - B. 1.78 kJ/K
 - C. 78.6 kJ/K
 - D. 2.93 kJ/K
-

Answer Key:

1. A
2. C
3. B
4. D
5. A
6. B
7. D
8. A
9. B
10. C
11. D
12. B
13. C
14. B
15. D
16. C
17. A
18. B
19. D
20. C
21. B
22. A
23. C
24. D
25. D
26. C
27. A
28. B
29. A
30. D