

**Questions 1-5** refer to the following information.

A student titrates 20.0 mL of 1.0 M NaOH with 2.0 M formic acid,  $\text{HCO}_2\text{H}$  ( $K_a = 1.8 \times 10^{-4}$ ). Formic acid is a monoprotic acid.

1. How much formic acid is necessary to reach the equivalence point?

- ☐ A. 10.0 mL
- ☐ B. 20.0 mL
- ☐ C. 30.0 mL
- ☐ D. 40.0 mL

2. At the equivalence point, is the solution acidic, basic, or neutral? Why?

- ☐ A. Acidic; the strong acid dissociates more than the weak base
- ☐ B. Basic; the only ion present at equilibrium is the conjugate base
- ☐ C. Basic; the higher concentration of the base is the determining factor
- ☐ D. Neutral; equal moles of both acid and base are present

3. If the formic acid were replaced with a strong acid such as HCl at the same concentration (2.0 M), how would that change the volume needed to reach the equivalence point?

- ☐ A. The change would reduce the amount, as the acid now fully dissociates.
- ☐ B. The change would reduce the amount, because the base will be more strongly attracted to the acid.
- ☐ C. The change would increase the amount, because the reaction will now go to completion instead of equilibrium.
- ☐ D. Changing the strength of the acid will not change the volume needed to reach equivalence.

4. Which of the following would create a good buffer when dissolved in formic acid?

- ☐ A.  $\text{NaCO}_2\text{H}$
- ☐ B.  $\text{HC}_2\text{H}_3\text{O}_2$
- ☐ C.  $\text{NH}_3$
- ☐ D.  $\text{H}_2\text{O}$

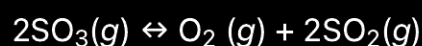
5.  $\text{CH}_3\text{NH}_2(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{OH}^-(aq) + \text{CH}_3\text{NH}_3^+(aq)$

The above equation represents the reaction between the base methylamine ( $K_b = 4.38 \times 10^{-4}$ ) and water. Which of the following best represents the concentrations of the various species at equilibrium?

- ☐ A.  $[\text{OH}^-] > [\text{CH}_3\text{NH}_2] = [\text{CH}_3\text{NH}_3^+]$
- ☐ B.  $[\text{OH}^-] = [\text{CH}_3\text{NH}_2] = [\text{CH}_3\text{NH}_3^+]$
- ☐ C.  $[\text{CH}_3\text{NH}_2] > [\text{OH}^-] > [\text{CH}_3\text{NH}_3^+]$
- ☐ D.  $[\text{CH}_3\text{NH}_2] > [\text{OH}^-] = [\text{CH}_3\text{NH}_3^+]$

**Questions 6-10** refer to the following information.

The following reaction is found to be at equilibrium at 25°C:



$$\Delta H = -198 \text{ kJ/mol}$$

6. What is the expression for the equilibrium constant,  $K_c$ ?

- ☐ A.  $\frac{[\text{SO}_3]^2}{[\text{O}_2][\text{SO}_2]^2}$

- ☐  $\frac{[\text{O}_2][\text{SO}_2]^2}{[\text{SO}_3]^2}$
- ☐ C.  $\frac{[\text{O}_2][\text{SO}_2]^2}{[\text{SO}_3]^2}$
- ☐ D.  $\frac{[\text{O}_2]2[\text{SO}_2]}{2[\text{SO}_3]}$

7. Which of the following would cause the reverse reaction to speed up?

- ☐ A. Adding more  $\text{SO}_3$
- ☐ B. Raising the pressure
- ☐ C. Lowering the temperature
- ☐ D. Removing some  $\text{SO}_2$

8. The value for  $K_c$  at  $25^\circ\text{C}$  is 8.1. What must happen in order for the reaction to reach equilibrium if the initial concentrations of all three species was  $2.0\text{ M}$ ?

- ☐ A. The rate of the forward reaction would increase, and  $[\text{SO}_3]$  would decrease.
- ☐ B. The rate of the reverse reaction would increase, and  $[\text{SO}_2]$  would decrease.
- ☐ C. Both the rate of the forward and reverse reactions would increase, and the value for the equilibrium constant would also increase.
- ☐ D. No change would occur in either the rate of reaction or the concentrations of any of the species.

9. Which of the following would cause a reduction in the value for the equilibrium constant?

- ☐ A. Increasing the amount of  $\text{SO}_3$
- ☐ B. Reducing the amount of  $\text{O}_2$
- ☐ C. Raising the temperature
- ☐ D. Lowering the temperature

10. The solubility product,  $K_{sp}$ , of  $\text{AgCl}$  is  $1.8 \times 10^{-10}$ . Which of the following expressions is equal to the solubility of  $\text{AgCl}$ ?

- ☐ A.  $\left(1.8 \times 10^{-10}\right)^2$  molar
- ☐ B.  $\frac{1.8 \times 10^{-10}}{2}$  molar
- ☐ C.  $1.8 \times 10^{-10}$  molar
- ☐ D.  $\sqrt{1.8 \times 10^{-10}}$  molar

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