1. In the reaction \( H_2CO_3 + H_2O \rightleftharpoons HCO_3^- + H_3O^+ \), the Bronsted acids are
   A. \( H_2CO_3 \) and \( H_2O \).
   B. \( HCO_3^- \) and \( H_2CO_3 \).
   C. \( H_2O \) and \( H_3O^+ \).
   D. \( H_3O^+ \) and \( H_2CO_3 \).
   E. \( H_2O \) and \( HCO_3^- \).

2. In the reaction
   \( HSO_4^- (aq) + OH^- (aq) \rightleftharpoons SO_4^{2-} (aq) + H_2O(l) \), the conjugate acid–base pairs are
   \( \text{pair 1} \): \( HSO_4^- \) and \( SO_4^{2-} \); \( \text{pair 2} \): \( H_2O \) and \( OH^- \).
   A. \( HSO_4^- \) and \( SO_4^{2-} \); \( H_2O \) and \( OH^- \).
   B. \( HSO_4^- \) and \( H_3O^+ \); \( SO_4^{2-} \) and \( OH^- \).
   C. \( HSO_4^- \) and \( OH^- \); \( SO_4^{2-} \) and \( H_2O \).
   D. \( HSO_4^- \) and \( H_2O \); \( OH^- \) and \( SO_4^{2-} \).
   E. \( HSO_4^- \) and \( OH^- \); \( SO_4^{2-} \) and \( H_2O \).

3. Identify the conjugate base of \( HSO_4^- \) in the reaction
   \( H_2PO_4^- + HSO_4^- \rightleftharpoons H_3PO_4 + SO_4^{2-} \).
   A. \( H_2PO_4^- \)
   B. \( H_2SO_4 \)
   C. \( H_2O \)
   D. \( H_3PO_4 \)
   E. \( SO_4^{2-} \)

4. Which one of these statements about strong acids is always true?
   A. All strong acids have H atoms bonded to electronegative oxygen atoms.
   B. Strong acids are 100% ionized in water.
   C. The conjugate base of a strong acid is itself a strong base.
   D. Strong acids are very concentrated acids.
   E. Strong acids produce solutions with a higher pH than weak acids.

5. The \( OH^- \) concentration in a \( 7.5 \times 10^{-3} \) M \( Ca(OH)_2 \) solution is
   A. \( 7.5 \times 10^{-3} \) M
   B. \( 1.5 \times 10^{-2} \) M
   C. \( 1.3 \times 10^{-12} \) M
   D. \( 1.0 \times 10^{-7} \) M
   E. \( 1.0 \times 10^{-14} \) M

6. A 0.10 M \( HF \) solution is 8.4% ionized.
   Calculate the \( H^+ \) ion concentration.
   A. 0.84 M
   B. 0.12 M
   C. 0.10 M
   D. 0.084 M
   E. \( 8.4 \times 10^{-3} \) M

\[
[H^+] = 0.084 \times 0.10 \ M = 8.4 \times 10^{-3} \ M
\]

7. A 0.10 M \( NH_3 \) solution is 1.3% ionized.
   Calculate the \( H^+ \) ion concentration.
   \( NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^- \)
   A. \( 1.3 \times 10^{-3} \) M
   B. \( 7.7 \times 10^{-2} \) M
   C. \( 7.7 \times 10^{-12} \) M
   D. 0.13 M
   E. 0.10 M

\[
[OH^-] = 0.013 \times 0.10 \ M = 1.3 \times 10^{-3} \ M
\]
\[
[H^+] = \frac{1 \times 10^{-14}}{1.3 \times 10^{-3}} = 7.7 \times 10^{-12} \ M
\]

8. Calculate the pH of a 0.10 M \( HCN \) solution that is 0.0070% ionized.
   A. 1.00
   B. 0.00070
   C. 3.15
   D. 5.15
   E. 7.00

\[
[H^+] = 0.00070 \times 0.10 \ M = 7.0 \times 10^{-6} \ M
\]
\[
pH = -\log(7.0 \times 10^{-6}) = 5.15
\]

9. Calculate the pH of a 1.6 M \( KOH \) solution.
   A. 1.60
   B. -0.20
   C. 0.20
   D. 14.20
   E. 13.80

\[
[OH^-] = 1.6 \ M
\]
\[
[H^+] = \frac{1 \times 10^{-14}}{1.6} = 6.3 \times 10^{-15} \ M
\]
\[
pH = -\log(6.3 \times 10^{-15}) = 14.20
\]
10. Diet cola drinks have a pH of about 3.0, while milk has a pH of about 7.0. How many times greater is the $H_3O^+$ concentration in diet cola than in milk?
   A. 2.3 times higher in diet cola than in milk
   B. 400 times higher in diet cola than in milk
   C. 0.43 times higher in diet cola than in milk
   D. 1,000 times higher in diet cola than in milk
   E. 10,000 times higher in diet cola than in milk
   \[ \Delta pH = 4.0; \quad 10^{-\Delta pH} = 10^4 = 10,000 \]

11. What is the pH of a solution prepared by mixing 10.0 mL of a strong acid solution with pH = 2.00 and 10.0 mL of a strong acid solution with pH = 6.00?
   A. 2.0
   B. 2.3
   C. 4.0
   D. 6.0
   E. 8.0
   Find mol $H^+$ in each solution, add & divide by total volume:
   \[ [H^+] = \frac{0.100010 \text{ mmol}}{20.0 \text{ mL}} = 5.0005 \times 10^{-3} \text{ M} \]
   \[ \text{pH} = -\log(5.0005 \times 10^{-3}) = 2.30 \]

12. Acid strength decreases in the series HI > HSO$_4^-$ > HF > HCN. Which of these anions is the weakest base?
   A. I$^-$
   B. SO$_4^{2-}$
   C. F$^-$
   D. CN$^-$

13. Arrange the acids HOBr, HBrO$_3$, and HBrO$_2$ in order of increasing acid strength.
   A. HOBr < HBrO$_3$ < HBrO$_2$
   B. HOBr < HBrO$_2$ < HBrO$_3$
   C. HBrO$_2$ < HOBr < HBrO$_3$
   D. HBrO$_3$ < HOBr < HBrO$_2$
   E. HBrO$_3$ < HBrO$_2$ < HOBr

14. When comparing acid strength of binary acids HX, as X varies within a particular group of the periodic table, which one of these factors dominates in affecting the acid strength?
   A. bond strength
   B. electron withdrawing effects
   C. percent ionic character of the H–X bond
   D. solubility
   E. Le Châtelier's principle

15. Which one of these net ionic equations represents the reaction of a strong acid with a weak base?
   A. $H^+(aq) + OH^-(aq) \rightarrow H_2O(aq)$
   B. $H^+(aq) + CH_3NH_2(aq) \rightarrow CH_3NH_3^+(aq)$
   C. $OH^-(aq) + HCN(aq) \rightarrow H_2O(aq) + CN^-(aq)$
   D. $HCN(aq) + CH_3NH_2(aq) \rightarrow CH_3NH_3^+(aq) + CN^-(aq)$

16. Predict the direction in which the equilibrium will lie for the reaction
   \[ H_2CO_3 + F^- \rightleftharpoons HCO_3^- + HF. \]
   $K_a(H_2CO_3) = 4.2 \times 10^{-7}; \quad K_a(F^-) = 1.4 \times 10^{-11}$
   A. to the right
   B. to the left
   C. in the middle
   Must compare $K_a$s or $K_b$s so convert:
   \[ K_a(HF) = \frac{1.0 \times 10^{-14}}{1.4 \times 10^{-11}} = 7.1 \times 10^{-4} \]
   \[ K_a(HCO_3^-) = \frac{1.0 \times 10^{-14}}{4.2 \times 10^{-7}} = 2.4 \times 10^{-8} \]
   $K_a(HF) > K_a(H_2CO_3)$ or $K_a(HCO_3^-) < K_a(F^-)$. Since the stronger acid and stronger base are on the right, the reaction equilibrium lies to the left.

17. Which of the following yields an acidic solution when dissolved in water?
   A. NO$_3$
   B. LiOH
   C. K$_2$O
   D. NaCl
   E. Ca(OH)$_2$

18. In the reaction CaO(s) + SO$_2$(g) ⇌ CaSO$_3$(s),
   A. O$^{2-}$ acts as a Lewis base, and SO$_2$ acts as a Lewis acid.
   B. Ca$^{2+}$ acts as a Lewis base, and SO$_4^{2-}$ acts as a Lewis acid.
   C. SO$_4^{2-}$ acts as a Lewis base, and SO$_2$ acts as a Lewis acid.
   D. SO$_2$ acts as a Lewis base, and O$^{2-}$ acts as a Lewis acid.
   E. SO$_2$ acts as a Lewis base, and Ca$^{2+}$ acts as a Lewis acid.

19. Which one of the following salts will form an acidic solution on dissolving in water?
   A. LiBr
   B. NaF
   C. KOH
   D. FeCl$_3$
   E. NaCN