1. Identify the Brønsted-Lowry acids and bases in the following equation.  
A = Brønsted-Lowry ACID,  B = Brønsted-Lowry BASE.

\[ \text{HSO}_3^- + \text{CN}^- \rightleftharpoons \text{HCN} + \text{SO}_4^{2-} \]

(a) B A B A  
(b) B B A A  
(c) A B B A  
(d) B A A B

2. The dihydrogenphosphate ion, \( \text{H}_2\text{PO}_4^- \), has both a conjugate acid and a conjugate base. These are, respectively:

(a) \( \text{H}_3\text{PO}_4 \), \( \text{PO}_4^{3-} \)  
(b) \( \text{H}_2\text{PO}_4 \), \( \text{H}_2\text{O} \)  
(c) \( \text{H}_2\text{O} \), \( \text{CO}_2 \)  
(d) \( \text{HPO}_4^{2-} \), \( \text{PO}_4^{3-} \)  
(e) \( \text{NH}_2\text{OH}^- \), \( \text{NH}_4\text{OH} \)

3. Choose the couple which is not a conjugate acid-base pair.

(a) \( \text{HCO}_3^- \), \( \text{CO}_2^- \)  
(b) \( \text{H}_2\text{O}^+ \), \( \text{H}_2\text{O} \)  
(c) \( \text{OH}^- \), \( \text{O}_2^- \)  
(d) \( \text{H}_2\text{PO}_4^- \), \( \text{HPO}_4^{2-} \)  
(e) \( \text{NH}_2\text{OH}^- \), \( \text{NH}_4\text{OH} \)

4. The ionisation constant of water, \( K_w \), at 37 °C is \( 2.42 \times 10^{-14} \) mol L\(^{-2} \). What is the pH for a neutral solution at this normal temperature of the human body?

(a) 0  
(b) 6.8  
(c) 7.0  
(d) 7.2  
(e) 14

5. Which of the following reactions is associated with the definition of \( K_a \)?

(a) \( \text{Al}^{3+} + 6\text{H}_2\text{O} \rightleftharpoons \text{[Al(OH)_3]^+} \)  
(b) \( \text{[Al(OH)_4]^+} \)  
(c) \( \text{OCl}^- + \text{H}_2\text{O} \rightleftharpoons \text{HOCl} + \text{OH}^- \)  
(d) \( \text{CN}^- + \text{H}^+ \rightleftharpoons \text{HCN} \)  
(e) none of these

6. Using the following \( K_a \) values, indicate the correct order of base strength.

\( \text{HNO}_2 \) \( K_a = 4.0 \times 10^{-4} \);  
\( \text{HF} \) \( K_a = 7.2 \times 10^{-4} \);  
\( \text{HCN} \) \( K_a = 6.2 \times 10^{-10} \)

(a) \( \text{CN}^- > \text{NO}_2^- > \text{F}^- > \text{H}_2\text{O} > \text{Cl}^- \)  
(b) \( \text{Cl}^- > \text{H}_2\text{O} > \text{F}^- > \text{NO}_2^- > \text{CN}^- \)  
(c) \( \text{CN}^- > \text{F}^- > \text{NO}_2^- > \text{Cl}^- > \text{H}_2\text{O} \)  
(d) \( \text{H}_2\text{O} > \text{CN}^- > \text{NO}_2^- > \text{F}^- > \text{Cl}^- \)  
(e) none of these

7. The pH of a solution is raised from 3 to 5. Which of the following statements describing this process is false.

(a) The pOH will be lowered from 11 to 9.  
(b) The \( [\text{OH}^-] \) will be decreased by a factor of 20.  
(c) The final \( [\text{H}^+] \) (at pH = 5) is \( 10^{-10} \) M.  
(d) The initial \( [\text{H}^+] \) (at pH = 3) is \( 10^{-3} \) M.  
(e) The initial solution could be 0.001 M HNO_3.

8. Calculate the pH of a 0.10 M solution of Ca(OH)_2.

(a) 13.30  
(b) 13.00  
(c) 0.20  
(d) 0.10  
(e) none of these

9. Nitrous acid, \( \text{HNO}_2 \), has an ionisation constant \( K_a = 4.0 \times 10^{-4} \). The pH of 0.25 M \( \text{HNO}_2 \) is:

(a) 2.09  
(b) 2.30  
(c) 2.70  
(d) 3.70  
(e) none of these

10. The sodium salt, NaA, of a weak acid is dissolved in water; no other substance is added. Which of these statements (to a close approximation) is true?

(a) \( [\text{H}^+] = [\text{A}^-] \)  
(b) \( [\text{H}^+] = [\text{OH}^-] \)  
(c) \( [\text{A}^-] = [\text{OH}^-] \)  
(d) \( [\text{H}^+] = [\text{A}^-] \)  
(e) none of these

11. The pH of a 0.6 M solution of a weak acid is 4.0. What percent of the acid has ionised?

(a) 0.02%  
(b) 0.06%  
(c) 2%  
(d) 4%  
(e) 7%

12. What is the equilibrium constant for the following reaction?

\( \text{N}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{HN}_3 + \text{H}_2\text{O} \)

The \( K_a \) value for \( \text{HN}_3 \) is \( 1.9 \times 10^{-5} \).

(a) \( 5.3 \times 10^{10} \)  
(b) \( 1.9 \times 10^{-9} \)  
(c) \( 1.9 \times 10^{-5} \)  
(d) \( 5.3 \times 10^4 \)  
(e) \( 1.9 \times 10^9 \)
13. Rank the following 1.0 M solutions in order of decreasing pH.

- NaCN
- H2S
- KOH
- CaCl2
- HI

(a) CaCl2 > NaCN > H2S > HI > KOH
(b) KOH > CaCl2 > HI > NaCN > H2S
(c) H2S > HI > NaCN > KOH > CaCl2
(d) NaCN > CaCl2 > KOH > HI > H2S
(e) KOH > CaCl2 > HI > NaCN > H2S

14. HCN (aq) + HCO3- (aq) = CN- (aq) + H2CO3 (aq)

If $K_a < 1$ for the above reaction, what is the strongest base in this system?

(a) HCN
(b) HCO3-
(c) H2CO3
(d) H2O
(e) none of these

15. What is the pH of a solution that is 0.2 M in acetic acid ($K_a = 1.8 \times 10^{-5}$) and 0.2 M in sodium acetate?

- 4.77
- 5.4
- 7.0
- 8.6
- 9.3

16. Consider a solution consisting of the following two buffer systems:

- $H_2CO_3$ and $HCO_3^-$
- $H_2PO_4^-$ and $HPO_4^{2-}$

At pH 6.4, which one of the following is true of the relative amounts of acid and conjugate base?

(a) $[H_2CO_3] > [HCO_3^-]$ and $[H_2PO_4^-] > [HPO_4^{2-}]$
(b) $[HCO_3^-] > [HCO_3^-]$ and $[HPO_4^{2-}] > [HPO_4^{2-}]$
(c) $[H_2CO_3] < [HCO_3^-]$ and $[H_2PO_4^-] < [HPO_4^{2-}]$
(d) $[H_2CO_3] < [HCO_3^-]$ and $[HPO_4^{2-}] < [HPO_4^{2-}]$
(e) none of these