1. Identify the Bronsted-Lowry acids and bases in the following equation.

\[ \text{HNO}_2 + \text{CN}^- \rightarrow \text{H}_2\text{CN}^- + \text{NO}_2^- \]

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

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

(a) \( \text{H}_2\text{CO}_3 \) > \( \text{HCO}_3^- \) and \( \text{H}_2\text{PO}_4^- \) > \( \text{HPO}_4^{2-} \)
(b) \( \text{CN}^- \) > \( \text{H}_2\text{CN}^- \) > \( \text{NO}_2^- \) > \( \text{CN}^- \)
(c) \( \text{CN}^- \) > \( \text{F}^- \) > \( \text{NO}_2^- \) > \( \text{CN}^- \)
(d) \( \text{CN}^- \) > \( \text{F}^- \) > \( \text{NO}_2^- \) > \( \text{CN}^- \)

3. The pH for a neutral solution at this normal temperature of the human body?

(a) 0
(b) 5.4
(c) 7.0
(d) 7.2
(e) 8.0

4. The acid-base problem set contains several reactions and their associated equilibrium constants. For each reaction, calculate the pH at the indicated concentration of the weak acid. For example, \( \text{H}_2\text{CO}_3 \) + \( \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{HCO}_3^- \)

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

5. Which of the following reactions is associated with the definition of a conjugate acid-base pair?

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

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) \( \text{HCN} \) > \( \text{F}^- \) > \( \text{NO}_2^- \) > \( \text{CN}^- \)
(b) \( \text{CN}^- \) > \( \text{F}^- \) > \( \text{NO}_2^- \) > \( \text{CN}^- \)
(c) \( \text{CN}^- \) > \( \text{F}^- \) > \( \text{NO}_2^- \) > \( \text{CN}^- \)
(d) \( \text{CN}^- \) > \( \text{F}^- \) > \( \text{NO}_2^- \) > \( \text{CN}^- \)
(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 pH will be decreased from 3 to 5.
(b) The [H^+] will be decreased by a factor of 20.
(c) The final [OH^-] will be increased by a factor of 20.
(d) The initial [H^+] and [OH^-] will be increased by a factor of 20.
(e) none of these

8. Calculate the pH of a 0.1 M solution of Ca(OH)_2.

(a) 12.3
(b) 13.0
(c) 13.5
(d) 1.0
(e) none of these

9. A concentrated solution of HNO_3 has an ionisation constant \( K_a = 4.0 \times 10^{-2} \). The pH of 0.25 M HNO_3 is:

(a) 5.0
(b) 2.0
(c) 1.0
(d) none of these

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

\( \text{CN}^- + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CN}^- + \text{OH}^- \)

(a) 0.06%
(b) 2%
(c) 4%
(d) 7%
(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) 0.06%
(b) 0.006%
(c) 0.6%
(d) 4%
(e) 7%

12. What is the electrode potential for the following reaction?

\( \text{N}_2\text{H}_4 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{N}_2 + \text{H}_2\text{O} \)

(a) 0.9 x 10^-5
(b) 1.9 x 10^-5
(c) 1.9 x 10^-10
(d) 1.9 x 10^-11
(e) none of these

17. What volumes of 0.20 M solutions of \( \text{HNO}_3 \) and \( \text{KNO}_3 \) are required to make 1 L of a buffer of pH 3.000 solution. \( \text{K}_a \) for \( \text{HNO}_3 = 4.00 \times 10^{-4} \)

(a) 300 mL of each
(b) 286 mL \( \text{HNO}_3 \), 714 mL \( \text{KNO}_3 \)
(c) 433 mL \( \text{HNO}_3 \), 567 mL \( \text{KNO}_3 \)
(d) 714 mL \( \text{HNO}_3 \), 286 mL \( \text{KNO}_3 \)
(e) 387 mL \( \text{HNO}_3 \), 413 mL \( \text{KNO}_3 \)

18. 75.0 mL of 0.050 M HCN (\( K_a = 6.2 \times 10^{-10} \)) is titrated with 0.50 M NaOH. What volume of NaOH solution is required to reach the stoichiometric end point?

(a) 75.0 mL
(b) 7.50 mL
(c) 750 mL
(d) Cannot be solved without being given the pH at the end point
(e) none of these

19. 1.00 M of acid taken from a lead storage battery was pipetted into a flask. Deionised water and phenolphthalein indicator were added, and the solution titrated with 0.50 M NaOH until a pink colour appeared. 12.5 mL of NaOH were required. What mass (to within 5%) of \( \text{H}_2\text{SO}_4 \) is present in 1.00 L of the battery acid?

(a) 240 g
(b) 440 g
(c) 580 g
(d) 790 g

20. 75.0 mL of 0.050 M HCN (\( K_a = 6.2 \times 10^{-10} \)) is being titrated with 0.50 M NaOH. What is the [H^+] in the solution after 3.0 mL of 0.50 M NaOH have been added?

(a) 1.4 x 10^-7 M
(b) 4.4 x 10^-7 M
(c) 5.2 x 10^-7 M
(d) 9.3 x 10^-8 M
(e) none of these