Equilibrium and acids and bases practice problems

1) In a chemical system at equilibrium,
   A) all of the reactants have been converted to products.
   B) all chemical reactions have stopped.
   C) the reactants and products have stopped reacting and their concentrations are no longer changing.
   D) the forward and reverse reactions are occurring at equal rates and the concentrations of reactants and products are not changing.

2) A chemical reaction has an equilibrium constant of $3.6 \times 10^{-4}$. What will be true about the system when equilibrium is achieved?
   A) The reaction will not occur.
   B) The reaction will go to completion.
   C) There will be more reactants than products at equilibrium.
   D) There will be more products than reactants at equilibrium.
   E) There will be significant concentrations of both reactants and products at equilibrium.

3) Write the equilibrium constant expression for each of the following:
   a) $\text{C}(s) + \text{CO}_2(g) \rightleftharpoons 2\text{CO}(g)$

   b) $2\text{NOBr}(g) \rightleftharpoons 2\text{NO}(g) + \text{Br}_2(g)$

   c) $2\text{H}_2(g) + \text{S}_2(g) \rightleftharpoons 2\text{H}_2\text{S}(g)$

   d) $\text{C}(s) + \text{H}_2\text{O}(g) \rightleftharpoons \text{H}_2(g) + \text{CO}(g)$

   e) $\text{NH}_3(g) + \text{HCl}(g) \rightleftharpoons \text{NH}_4\text{Cl}(s)$

   f) $3\text{Ca}^{2+}(aq) + 2\text{PO}_4^{3-}(aq) \rightleftharpoons \text{Ca}_3(\text{PO}_4)_2(s)$
Questions 4-7 are based on the following reaction at equilibrium:

\[ \text{C(s) + H}_2\text{O(g) \rightleftharpoons H}_2\text{O(g) + CO(g)} \quad \Delta H \text{ is positive (endothermic)} \]

4) What would be the effect of removing \( \text{H}_2 \) gas from the reaction vessel?
   
   A) The reaction will shift to the left.
   B) The reaction will shift to the right.
   C) Removing \( \text{H}_2 \) gas will have no effect.
   D) Additional information is needed to answer this question.

5) What would be the effect of increasing the pressure by compressing the system?
   
   A) The reaction will shift to the left.
   B) The reaction will shift to the right.
   C) Increasing the pressure will have no effect.
   D) Additional information is needed to answer the question.

6) What would be the effect of adding 3.5 g of C(s)?
   
   A) The reaction will shift to the left.
   B) The reaction will shift to the right.
   C) The position of the equilibrium will not change.
   D) Additional information is needed to answer this question.

7) What would be the effect of increasing the temperature?
   
   A) The reaction will shift to the left.
   B) The reaction will shift to the right.
   C) Increasing the temperature will have no effect.
   D) Additional information is needed to answer this question.

8) Iron metal reacts with oxygen gas to produce iron(III) oxide (rust). What will be the effect of increasing the partial pressure of oxygen gas in a closed reaction vessel?
   
   A) The iron metal will catch fire.  
   B) More iron oxide will be produced.  
   C) The amount of iron oxide will decrease.  
   D) The reaction mixture will explode.
9) According to Bronsted and Lowry, what is the definition of an acid and a base?

10) Identify the acid, base, conjugate acid and conjugate base in the following reactions:

\[ \text{NH}_3(\text{aq}) + \text{CH}_3\text{COOH}(\text{aq}) \Rightarrow \text{NH}_4^+(\text{aq}) + \text{CH}_3\text{COO}^- (\text{aq}) , \]

\[ \text{HClO}_4(\text{aq}) + \text{NH}_3(\text{aq}) \Rightarrow \text{ClO}_4^- (\text{aq}) + \text{NH}_4^+(\text{aq}) \]

11) The ionization of hydrocyanic acid in water occurs as shown:

\[ \text{HCN}(\text{aq}) + \text{H}_2\text{O}(l) \Rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{CN}^- (\text{aq}) \]

What is the \( K_a \) expression for HCN?

12) In pure, pure water, what are the relative concentrations of the hydronium ion and the hydroxide ion?

A) The concentrations are equal: \( [\text{OH}^-] = 1.0 \times 10^{-14} \text{ M}, \ [\text{H}_3\text{O}^+] = 1.0 \times 10^{-14} \text{ M} \)
B) The concentrations are equal: \( [\text{OH}^-] = 1.0 \times 10^{-7} \text{ M}, \ [\text{H}_3\text{O}^+] = 1.0 \times 10^{-7} \text{ M} \)
C) The concentrations are not equal: \( [\text{OH}^-] = 1.0 \times 10^{-14} \text{ M}, \ [\text{H}_3\text{O}^+] = 1.0 \text{ M} \)
D) The concentrations are not equal: \( [\text{OH}^-] = 1.0 \text{ M}, \ [\text{H}_3\text{O}^+] = 1.0 \times 10^{-14} \text{ M} \)

13) The ion-product constant of water uses the symbol \___________\ and has a value of \___________\ at 25 °C.

A) \( K_C, 1.0 \times 10^{-14} \)  \quad B) \( K_a, 1.0 \times 10^{-14} \)  \quad C) \( K_w, 1.0 \times 10^{-14} \)  \quad D) \( K_w, 1.0 \times 10^{-7} \)
14) An aqueous solution has a pH of 7.3. We would consider this solution to be:
   A) very acidic  
   B) slightly acidic  
   C) neutral  
   D) slightly basic  
   E) very basic

15) What is the \([\text{H}_3\text{O}^+]\) in an aqueous solution if \([\text{OH}^-] = 6.6 \times 10^{-4}\) M?
   A) 1.5 x 10^{-11} M  
   B) 5.4 x 10^{-10} M  
   C) 3.6 x 10^{-7} M  
   D) 3.18 M  
   E) 10.82 M

16) What is the pH of a solution with \([\text{H}_3\text{O}^+] = 6.6 \times 10^{-4}\) M?
   A) 1.52 x 10^{-11}  
   B) 5.44 x 10^{-10}  
   C) 3.65 x 10^{-7}  
   D) 3.18  
   E) 10.82

17) What is the pH of a solution with \([\text{OH}^-] = 6.6 \times 10^{-4}\) M?
   A) 1.52 x 10^{-11}  
   B) -5.44 x 10^{-10}  
   C) 3.65 x 10^{-7}  
   D) 3.18  
   E) 10.82

18) What is the pOH of a solution with a pH of 3.7?
   A) 2.50  
   B) 10.3  
   C) 14.0  
   D) 0.250  
   E) 0.115

19) Calculate the \(\text{H}_3\text{O}^+\) concentration in a sample of acid rain with a pH of 3.90.
   A) 1.0 x 10^{-4} M  
   B) 0.62 M  
   C) 1.3 x 10^{-4} M  
   D) 7.7 x 10^{-9} M  
   E) 1.2 x 10^4 M

20) What is the pH of a 0.050 M solution of hydrochloric acid?
   A) 13.00  
   B) 5.00  
   C) 1.30  
   D) 12.69  
   E) 9.0

21) What is the pH of a 0.050 M solution of barium hydroxide?
   A) 13.00  
   B) 5.00  
   C) 1.30  
   D) 12.69  
   E) 9.0