1) Which of the following statements is FALSE?

A) When K >> 1, the forward reaction is favored and essentially goes to completion.
B) When K << 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.
C) When K ≈ 1, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.
D) K >> 1 implies that the reaction is very fast at producing products.
E) All of the above statements are true.

2) The equilibrium constant is given for two of the reactions below. Determine the value of the missing equilibrium constant.

$$A(g) + B(g) \rightleftharpoons AB(g) \qquad K_c = 0.24$$
$$AB(g) + A(g) \rightleftharpoons A_2B(g) \qquad K_c = 3.8$$
$$2\ A(g) + B(g) \rightleftharpoons A_2B(g) \qquad K_c = ?$$

A) 4.0
B) 0.91
C) 3.6
D) 16
E) 0.63

3) The reaction below has a K_c value of 1.0×10^{12}. What is the value of K_p for this reaction at 500 K?

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$$

A) 4.2×10^{-11}
B) 1.0×10^{12}
C) 2.4×10^{-12}
D) 4.1×10^{13}
E) 2.4×10^{10}

4) Express the equilibrium constant for the following reaction.

$$P_4(s) + 5\ O_2(g) \rightleftharpoons P_4O_{10}(s)$$

A) $K = \dfrac{[P_4][O_2]^5}{[P_4O_{10}]}$

B) $K = \dfrac{[P_4O_{10}]}{[P_4][O_2]^5}$

C) $K = [O2]^{-5}$

D) $K = [O2]^{5}$

E) $K = \dfrac{[P_4O_{10}]}{[P_4][O_2]^{1/5}}$

5) Determine the value of K_c for the following reaction if the equilibrium concentrations are as follows: $[N_2]_{eq} = 3.6$ M, $[O_2]_{eq} = 4.1$ M, $[N_2O]_{eq} = 3.3 \times 10^{-18}$ M

$$2\,N_2(g) + O_2(g) \rightleftharpoons 2\,N_2O(g)$$

A) 2.2×10^{-19}

B) 4.5×10^{18}

C) 2.0×10^{-37}

D) 5.0×10^{36}

E) 4.9×10^{-17}

6) Consider the following reaction, equilibrium concentrations, and equilibrium constant at a particular temperature. Determine the equilibrium concentration of $H_2O(g)$.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad K_c = 9.0 \times 10^{3}$$

$$[C_2H_4]_{eq} = 0.015\text{ M} \qquad [C_2H_5OH]_{eq} = 1.69\text{ M}$$

A) 9.9×10^{-7} M

B) 80. M

C) 1.0 M

D) 1.68 M

E) 0.013 M

7) Consider the following reaction:

$$CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4H_2(g)$$

A reaction mixture initially contains 0.50 M CH4 and 0.75 M H_2S. If the equilibrium concentration of H_2 is 0.44 M, find the equilibrium constant (K_c) for the reaction.

A) 0.23

B) 0.038

C) 2.9

D) 10.

E) 0.34

8.A reaction mixture contains 0.39 M SO_2, 0.14 M NO_2 , 0.11 M SO_3 and 0.14 M NO. Which of the following statements is TRUE concerning this system?

A) The reaction will shift in the direction of reactants.
B) The equilibrium constant will decrease.
C) The reaction will shift in the direction of products.
D) The reaction quotient will decrease.
E) The system is at equilibrium.

9) Which of the following statements is TRUE?

A) If Q < K, it means the reverse reaction will proceed to form more reactants.
B) If Q > K, it means the forward reaction will proceed to form more products.
C) If Q = K, it means the reaction is at equilibrium.
D) All of the above are true.
E) None of the above are true.

10) Consider the following reaction at equilibrium. What effect will adding more SO_3 have on the system?

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

A) The reaction will shift in the direction of products.
B) The reaction will shift to decrease the pressure.
C) No change will occur since SO_3 is not included in the equilibrium expression.
D) The reaction will shift in the direction of reactants.
E) The equilibrium constant will decrease.

11) Consider the following reaction at equilibrium. What effect will reducing the volume of the reaction mixture have on the system?

$$CuS(s) + O_2(g) \rightleftharpoons Cu(s) + SO_2(g)$$

A) The equilibrium constant will decrease.
B) No effect will be observed.
C) The reaction will shift to the right in the direction of products.
D) The equilibrium constant will increase.
E) The reaction will shift to the left in the direction of reactants.

12) Consider the following reaction at equilibrium. What effect will adding 1 atm of Ar to the reaction mixture have on the system?

$$2H_2S(g) + 3O_2(g) \rightleftharpoons 2H_2O(g) + 2SO_2(g)$$

A) The reaction will shift to the right in the direction of products.

B) No effect will be observed.
C) The reaction will shift to the left in the direction of reactants.
D) The equilibrium constant will decrease.
E) The equilibrium constant will increase.

13) Consider the following reaction at equilibrium. What effect will increasing the temperature have on the system?

$$Fe_3O_4(s) + CO(g) \rightleftharpoons 3FeO(s) + CO_2(g) \qquad \Delta H° = +35.9 \text{ kJ}$$

A) The reaction will shift to the left in the direction of reactants.
B) The equilibrium constant will increase.
C) The equilibrium constant will decrease.
D) No effect will be observed.
E) The reaction will shift to the right in the direction of products.

14) How is the reaction quotient (Q) different from an equilibrium constant (Kc) for a given reaction?

15) What is the conjugate acid of HCO_3^- ?

A) H_3O^+
B) H_2O
C) CO_3^{2-}
D) OH^-
E) H_2CO_3

16) Which of the following is a STRONG base?

A) Cl^-
B) NH_3
C) CH_3OH
D) NO_3^-
E) KOH

17) Which of the following statements is TRUE?

A) A strong acid is composed of a proton and an anion that have a very strong attraction for one another.
B) A weak base is composed of a cation and an anion with a very weak attraction between them.
C) A strong acid has a strong conjugate base.
D) The conjugate base of a very weak acid is stronger than the conjugate base of a strong acid.

E) None of the above statements are true.

18) Which of the following acids is the STRONGEST? The acid is followed by its K_a value.

A) HF, 3.5×10^{-4}
B) HCN, 4.9×10^{-10}
C) HNO_2, 4.6×10^{-4}
D) $HCHO_2$, 1.8×10^{-4}
E) $HClO_2$, 1.1×10^{-2}

19) Determine the K_b for CN^-. The K_a for HCN is 4.9×10^{-10}.

A) 4.9×10^{-14}
B) 2.3×10^{-9}
C) 1.4×10^{-5}
D) 2.0×10^{-5}
E) 3.7×10^{-7}

20) Calculate the concentration of OH^- in a solution that contains 3.9×10^{-4} M H_3O^+ at 25°C. Identify the solution as acidic, basic or neutral.

A) 2.6×10^{-11}M, acidic
B) 2.6×10^{-11}M, basic
C) 3.9×10^{-4}M, neutral
D) 2.7×10^{-2}M, basic
E) 2.7×10^{-2}M, acidic

21) Determine the pH of a 0.023 M HNO_3 solution.

A) 12.36
B) 3.68
C) 1.64
D) 2.30
E) 2.49

22) Determine the $[H_3O^+]$ in a 0.265 M HClO solution. The K_a of HClO is 2.9×10^{-8}.

A) 1.1×10^{-10}M
B) 7.7×10^{-9}M
C) 1.3×10^{-6}M
D) 4.9×10^{-4}M

E) 8.8×10^{-5}M

23) Determine the K_a of an acid whose 0.294 M solution has a pH of 2.80.

A) 1.2×10^{-5}
B) 8.6×10^{-6}
C) 2.7
D) 4.9×10^{-7}
E) 5.4×10^{-3}

24) Determine the pH of a solution that is 0.15 M $HClO_2$ ($K_a = 1.1\times10^{-2}$) and 0.15 M HClO ($K_a = 2.9\times10^{-8}$).

A) 4.18
B) 9.82
C) 12.55
D) 1.45
E) 3.55

25) Determine the $[OH^-]$ concentration in a 0.235 M NaOH solution.

A) 4.25×10^{-14} M
B) 0.470 M
C) 2.13×10^{-14} M
D) 0.198 M
E) 0.235 M

26) Determine the pH of a 0.188 M NH_3 solution. The K_b of NH_3 is 1.76×10^{-5}.

A) 5.480
B) 2.740
C) 8.520
D) 11.260
E) 12.656

27) Which of the following is a Lewis base?

A) AlF_3
B) H_2O
C) SiF_4
D) C_5H_{12}
E) None of the above are Lewis bases.

28) Place the following in order of increasing acid strength.

$HBrO_2$ $HBrO_3$ $HBrO$ $HBrO_4$

A) $HBrO_2 < HBrO_4 < HBrO < HBrO_3$
B) $HBrO < HBrO_2 < HBrO_3 < HBrO_4$
C) $HBrO_2 < HBrO_3 < HBrO_4 < HBrO$
D) $HBrO_4 < HBrO_2 < HBrO_3 < HBrO$
E) $HBrO < HBrO_4 < HBrO_3 < HBrO_2$

28. MATCHING. Choose the item in column 2 that best matches each item in column1.

60) Arrhenius acid	A) proton accepter
61) Arrhenius base	B) produces hydroxide ions in aqueous solution
62) Bronsted-Lowry base	C) electron pair donator
63) Lewis acid	D) electron pair accepter
64) Lewis base	E) produces protons in aqueous solution

29. For the reaction system, $H_2(g) + X_2(g) \equiv 2\ HX(g)$, $K_c = 24.4$ at 300 K. A system made up from these components which is at equilibrium contains 0.200 moles of X_2 and 0.600 moles of HX in a 4.00 liter container. Calculate the number of moles of $H_2(g)$ present at equilibrium.

a. 0.059 mol
b. 0.074 mol
c. 0.123 mol
d. 0.148 mol
e. 0.295 mol

30. A study of the system, $4\ NH_3(g) + 7\ O_2(g) \equiv 2\ N_2O_4(g) + 6\ H_2O(g)$, was carried out. A system was prepared with $[NH_3] = [O_2] = 3.60$ M as the only components initially. At equilibrium, $[N_2O_4]$ is 0.60 M. Calculate the equilibrium concentration of NH_3.

a. 3.00 M
b. 2.10 M
c. 3.30 M
d. 1.80 M
e. 2.40 M