Study Guide 5

Student: _____

1. Consider the two gaseous equilibria

   $SO_2(g) + (1/2)O_2(g) \rightleftharpoons SO_3(g)$ K_1

   $2SO_3(g) \rightleftharpoons SO_2(g) + O_2(g)$ K_2

   The values of the equilibrium constants K_1 and K_2 are related by

   A. $K_2 = K_1^2$
   B. $K_2^2 = K_1$
   C. $K_2 = 1/K_1^2$
   D. $K_2 = 1/K_1$
   E. none of these.

2. The equilibrium constant for the reaction $Ni(s) + 4CO(g) \rightleftharpoons Ni(CO)_4(g)$ is 5.0×10^4 at 25ºC. What is the equilibrium constant for the reaction

   $Ni(CO)_4(g) \rightleftharpoons Ni(s) + 4CO(g)$?

   A. 2.0×10^{-5}
   B. 2.5×10^9
   C. 5.0×10^4
   D. 5.0×10^{-4}
   E. 2.0×10^{-3}

3. Calculate K_p for the reaction $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$ at 400°C if K_c at 400°C for this reaction is 2.1×10^{-2}.

   A. 2.1×10^{-2}
   B. 1.7×10^{-3}
   C. 0.70
   D. 1.2
   E. 3.8×10^{-4}

4. On analysis, an equilibrium mixture for the reaction $2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$ was found to contain 1.0 mol H_2S, 4.0 mol H_2, and 0.80 mol S_2 in a 4.0 L vessel. Calculate the equilibrium constant, K_c, for this reaction.

A. 1.6
B. 3.2
C. 12.8
D. 0.64
E. 0.8

5. The reaction $A(g) + 2B(g) \rightleftharpoons C(g)$ was allowed to come to equilibrium. The initial amounts of reactants placed into a 5.00 L vessel were 1.0 mol A and 1.8 mol B. After the reaction reached equilibrium, 1.0 mol of B was found. Calculate K_c for this reaction.

A. 0.060
B. 5.1
C. 17
D. 19
E. 25

6. Phosgene, $COCl_2$, a poisonous gas, decomposes according to the equation

$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$. Calculate K_p for this reaction if $K_c = 0.083$ at 900ºC.

A. 0.125
B. 8.0
C. 6.1
D. 0.16
E. 0.083

7. Equilibrium is established for the reaction $2X(s) + Y(g) \rightleftharpoons 2Z(g)$ at 500K, $K_c = 100$. Determine the concentration of Z in equilibrium with 0.2 mol X and 0.50 M Y at 500K.

A. 3.2 M
B. 3.5 M
C. 4.5 M
D. 7.1 M
E. None of these.

8. Consider the reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$, for which $K_c = 0.10$ at 2,000ºC. Starting with initial concentrations of 0.040 M of N_2 and 0.040 M of O_2, determine the equilibrium concentration of NO.

A. 5.4×10^{-3} M
B. 0.0096 M
C. 0.011 M
D. 0.080 M
E. 0.10 M

9. Hydrogen iodide decomposes according to the equation $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$, for which $K_c = 0.0156$ at 400ºC. 0.550 mol HI was injected into a 2.00 L reaction vessel at 400ºC. Calculate the concentration of HI at equilibrium.

A. 0.138 M
B. 0.220 M
C. 0.550 M
D. 0.275 M
E. 0.0275 M

10. At 700 K, the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ has the equilibrium constant $K_c = 4.3 \times 10^6$, and the following concentrations are present: $[SO_2] = 0.10$ M; $[SO_3] = 10.$ M; $[O_2] = 0.10$ M.
Is the mixture at equilibrium? If not at equilibrium, in which direction (as the equation is written), *left to right* or *right to left*, will the reaction proceed to reach equilibrium?

A. Yes, the mixture is at equilibrium.
B. No, *left to right*
C. No, *right to left*
D. There is not enough information to be able to predict the direction.

11. For the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, $K_c = 50.2$ at 445ºC. If $[H_2] = [I_2] = [HI] = 1.75 \times 10^{-3}$ M at 445ºC, which one of the following statements is *true*?

A. The system is at equilibrium, thus no concentration changes will occur.
B. The concentrations of HI and I_2 will increase as the system approaches equilibrium.
C. The concentration of HI will increase as the system approaches equilibrium.
D. The concentrations of H_2 and HI will fall as the system moves toward equilibrium.
E. The concentrations of H_2 and I_2 will increase as the system approaches equilibrium.

12. For the following reaction at equilibrium, which choice gives a change that will shift the position of equilibrium to favor formation of more products?

$2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$, $\Delta H^o_{rxn} = 30$ kJ/mol

A. Increase the total pressure by decreasing the volume.
B. Add more NO.
C. Remove Br_2.
D. Lower the temperature.
E. Remove NOBr selectively.

13. For the following reaction at equilibrium in a reaction vessel, which one of the changes below would cause the Br_2 concentration to *increase*?

$2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$, $\Delta H^o_{rxn} = 30$ kJ/mol

A. Lower the temperature.
B. Remove some NO.
C. Remove some NOBr.
D. Compress the gas mixture into a smaller volume.

14. In which of the following gas-phase equilibria is the yield of products increased by increasing the total pressure on the reaction mixture?

A. $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$
B. $2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$
C. $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$
D. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

15. A. Fill in the table below, which refers to the following reaction:

$2NO(g) + Br_2(g) \rightleftharpoons 2NOBr(g)$

Concentration (M)	[NO]	[Br$_2$]	[NOBr]
Initial	2.5	5.0	1.0
Change	___	___	___
Equilibrium	2.0	___	___

B. Calculate K_c.

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16. 75.0 g of $PCl_5(g)$ is introduced into an evacuated 3.00 L vessel and allowed to reach equilibrium at 250ºC.

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

If $K_p = 1.80$ for this reaction, what is the total pressure inside the vessel at equilibrium.

A. 2.88 atm
B. 2.27 atm
C. 4.54 atm
D. 7.42 atm
E. 9.69 atm

17. Consider the chemical reaction $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$.

The equilibrium is to be established in a 1.0 L container at 1,000 K, where $K_c = 4.0 \times 10^{-2}$. Initially, 1,220 moles of $NH_3(g)$ are present.

A. Estimate the equilibrium concentration of $H_2(g)$.
B. Estimate the equilibrium concentration of $N_2(g)$.
C. Calculate K_p for the reaction.

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18. In the reaction $HSO_4^-(aq) + OH^-(aq) \rightleftharpoons SO_4^{2-}(aq) + H_2O(l)$, the conjugate acid-base pairs are

	pair 1	pair 2
A.	HSO_4^- and SO_4^{2-};	H_2O and OH^-.
B.	HSO_4^- and H_2O;	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.

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19. Identify the conjugate acid of HCO_3^- in the following reaction:

$HCO_3^- + HPO_4^{2-} \rightleftharpoons H_2CO_3 + PO_4^{3-}$

A. H_2O
B. HCO_3^-
C. H_2CO_3
D. PO_4^{3-}
E. HPO_4^{2-}

20. The OH^- concentration in a 1.0×10^{-3} M $Ba(OH)_2$ solution is

A. 0.50×10^{-3} M.
B. 1.0×10^{-3} M.
C. 2.0×10^{-3} M.
D. 1.0×10^{-2} M.
E. 0.020 M.

21. What is the H^+ ion concentration in a 4.8×10^{-2} M KOH solution?

A. 4.8×10^{-2} M
B. 1.0×10^{-7} M
C. 4.8×10^{-11} M
D. 4.8×10^{-12} M
E. 2.1×10^{-13} M

22. Calculate the H^+ ion concentration in a 8.8×10^{-4} M $Ca(OH)_2$ solution.

A. 8.8×10^{-4} M
B. 1.8×10^{-3} M
C. 2.2×10^{-11} M
D. 1.1×10^{-11} M
E. 5.7×10^{-12} M

23. Calculate the pH of a 6.71×10^{-2} M NaOH solution.

A. 12.83
B. 2.17
C. 11.82
D. 6.71
E. 1.17

24. 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

25. The pOH of a solution is 9.60 Calculate the hydrogen ion concentration in this solution.

A. 2.5×10^{-10} M
B. 6.0×10^{-9} M
C. 4.0×10^{-5} M
D. 2.4×10^{-4} M
E. 1.0×10^{-14} M

26. Acid strength decreases in the series HI > HSO_4^- > HF > HCN. Which of the following anions is the *weakest* base?

A. I^-
B. SO_4^{2-}
C. F^-
D. CN^-

27. Which of the following will act as a Lewis acid?

A. NH_3
B. NH_4^+
C. H_2O
D. BF_3
E. F^-

28. Which one of the following salts will form a *basic* solution upon dissolving in water?

A. NaI
B. NaF
C. NH_4NO_3
D. LiBr
E. $Cr(NO_3)_3$

29. Which one of the following salts will form an *acidic* solution upon dissolving in water?

A. LiBr
B. NaF
C. NH_4Br
D. KOH
E. NaCN

30. Write the formula for the conjugate base of $H_2PO_4^-$.

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31. A solution containing $NH_3(aq)$ and $NH_4Cl(aq)$ has a pH of 9.5. What is the $[NH_3]/[NH_4^+]$ ratio in this solution? (For ammonia, $K_b = 1.8 \times 10^{-5}$.)

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