Representative Exam Questions
On The Topic of Equilibrium
(Includes Acid / Base Equilibria)

1. If a chemical equilibrium very much favors the products over the reactants, what would we expect its equilibrium constant to be like?

   a) We would expect the equilibrium constant to be a very large number.

   b) We would expect the equilibrium constant to be a very small number.

   c) We would not be able to make any prediction about the size of the equilibrium constant, because its numerical value conveys no information on what is favored in the equilibrium.

2. If a chemical reaction reaches equilibrium very quickly, what would we expect its equilibrium constant to be like?

   a) We would expect the equilibrium constant to be a very large number.

   b) We would expect the equilibrium constant to be a very small number.

   c) We would not be able to make any prediction about the size of the equilibrium constant, because its numerical value conveys no information on the time required to reach equilibrium.

3. What is always true about a chemical reaction when it is at equilibrium?

   a) The concentrations of all the reactants are zero.

   b) All substances shown in the reaction have equal concentrations.

   c) The forward reaction rate is equal to the reverse reaction rate.

   d) Both the forward and reverse reaction have come to a stop.

4. Chemical equilibrium is said to be

   a) static b) dynamic

5. A negative equilibrium constant is obtained

   a) when a reaction is elementary

   b) when a reaction is non-elementary

   c) when the reaction is exothermic in the forward direction

   d) when you reverse the direction of a reaction that initially had a positive equilibrium constant

   e) under no circumstances

6. For any chemical reaction that reaches an equilibrium, it is possible to write a balanced equilibrium equation and a corresponding equilibrium constant expression. On what factors will the numerical value of the equilibrium constant depend?

   a) None. A given reaction has a characteristic numerical value for its equilibrium constant that applies under all conditions.

   b) Temperature

   c) The choice of coefficients used to balance the equation describing the reaction.

   d) Whether the reaction is elementary or non-elementary

   e) Both b and c

7. Given the equilibrium reaction

   2A(g) + 2BC(g) <----------> AB_2(g) + AC_2(g) $K_C = 4$

   what is the numerical value of the equilibiurm constant (K_C) for the reaction

   AB_2(g) + AC_2(g) <----------> 2A(g) + 2BC(g) $K_C = ?$

   a) -4   b) -2   c) 0.25   d) 0.50   e) 4

8. Given the equilibrium reaction

$A(g) + 2B(g) \longleftrightarrow AB_2(g)$ $K_C = 9$

what is the numerical value of the equilibrium constant (K_C) for the reaction

$2A(g) + 4B(g) \longleftrightarrow 2AB_2(g)$ $K_C = ?$

a) 3 b) 4.5 c) 9 d) 18 e) 81

9. Given the equilibrium reactions

$AB(g) \longleftrightarrow A(g) + B(g)$ $K_C = 0.5$

$2A(g) + B_2(g) \longleftrightarrow A_2B(g) + B(g)$ $K_C = 6$

what is the equilibrium ocnstant (K_C) for the following reaction?

$3A(g) + B_2(g) \longleftrightarrow A_2B(g) + AB(g)$ $K_C = ?$

a) 3 b) 5.5 c) 6.5 d) 12 e) 36

10. The reaction

$2NH_3(g) \longleftrightarrow N_2(g) + 3H_2(g)$

has $K_C = 6.46 \times 10^{-3}$ at 300 ^oC. What is the value of K_P for the reaction at this same temperature? Note that R = 0.0820584 (L atm) / (K mol). Temperatures must be in Kelvin units.

a) 2.62×10^{-4} b) 0.159 c) 0.304

d) 3.91 e) 14.3

11. The reaction

$N_2O_4(g) \longleftrightarrow 2NO_2(g)$

has $K_P = 0.145$ at 25 ^oC. What is K_C for the reaction at this same temperature? Note that R = 0.0820584 (L atm) / (K mol). Temperatures must be in Kelvin units.

a) 5.93×10^{-3} b) 7.07×10^{-2} c) 0.297

d) 3.55 e) 24.6

12. Sulfur trioxide gas, SO_3, was put in a heated reaction vessel and maintained at a temperature of 700 ^oC. Some of the SO_3 decomposed into SO_2 and O_2 gases, and an equilibrium was established between the SO_3, SO_2, and O_2. The chemical equation describing this equilibrium is

$2SO_3(g)$ <----------> $2SO_2(g)$ + $O_2(g)$

The equilibrium concentrations of these three gases were determined and found to be

$[SO_3]_{eq} = 1.14 \times 10^{-2}$ M

$[SO_2]_{eq} = 8.64 \times 10^{-3}$ M

$[O_2]_{eq} = 4.32 \times 10^{-3}$ M

What is the numerical value of the equilibrium constant for this reaction at 700 ^oC?

a) 1.56×10^{-4} b) 2.48×10^{-3} c) 5.81×10^{-2}

d) 4.72×10^{2} e) 6.38×10^{3}

13. At 395 ^oC, an equilibrium mixture of CO, Cl_2, and $COCl_2$ was found to have the following concentrations:

$[CO]_{eq} = 6.5 \times 10^{-3}$ M

$[Cl_2]_{eq} = 1.4 \times 10^{-3}$ M

$[COCl_2]_{eq}$ = unspecified

The equilibrium reaction for this chemical system is as follows:

$CO(g)$ + $Cl_2(g)$ <----------> $COCl_2(g)$ $K_C = 1.2 \times 10^{3}$ at 395 ^oC

What is the concentration of $COCl_2$ in this mixture at 395 ^oC?

a) 7.4×10^{-9} M b) 8.8×10^{-6} M c) 3.5×10^{-3} M

d) 6.9×10^{-3} M e) 1.1×10^{-2} M

14. Into a 10.00 L reaction vessel, a chemist placed 0.381 moles of HI, 0.492 moles of H_2, and 0.773 moles of I_2 at 425 ^oC. The chemical equation for the equilibrium of HI, H_2, and I_2 is as follows:

2HI(g) <----------> H_2(g) + I_2(g) $K_C = 1.84$ at 425 ^oC

What can be said about this chemical system?

a) This is an equilibrium mixture. No net reaction will occur.

b) This is not an equilibrium mixture. Some of the H_2 and I_2 will combine to form HI until equilibrium is reached.

c) This is not an equilibrium mixture. Some of the HI will decompose into H_2 and I_2 until equilibrium is reached.

15. A 5.00 L reaction vessel at 3900 ^oC initially contained 0.200 moles each of N_2 and O_2 gases. These reacted to form NO as described by the following equation:

N_2(g) + O_2(g) <----------> 2NO(g) $K_C = 0.0123$ at 3900 ^oC

How many moles of NO will be present in the container when the system has reached equilibrium?

a) 8.91×10^{-3} mol   b) 2.10×10^{-2} mol   c) 4.23×10^{-2} mol

d) 7.66×10^{-2} mol   e) 1.85×10^{-1} mol

16. What is the pH of a 3.88 M NH_3 solution? NH_3 is a weak base that establishes the following equilibrium when dissolved in water:

NH_3(aq) + H_2O(l) <----------> NH_4^+(aq) + OH^-(aq) $K_b = 1.8 \times 10^{-5}$

The math is no worse than a quadratic, even if you don't approximate, but it should be ok to approximate in this problem.

a) 2.1   b) 8.6   c) 9.2   d) 11.9   e) 12.8

17. What is the $[H_3O^+]$ in a 2.50 M HClO solution? Hypochlorous acid, HClO, is a weak acid with the following equilibrium equation:

$HClO(aq) + H_2O(l)$ <----------> $H_3O^+(aq) + ClO^-(aq)$ $K_a = 3.5 \times 10^{-8}$

The math is no worse than a quadratic, even if you don't approximate, but it should be ok to approximate in this problem.

a) 3.4×10^{-11} b) 5.5×10^{-8} c) 5.1×10^{-6}

d) 3.0×10^{-4} e) 2.3×10^{-2}

18. What is the $[OH^-]$ in a 0.0100 M HCl solution? Note that HCl is a strong acid. It ionizes completely when dissolved in water:

$HCl(aq)$ ==========> $H^+(aq) + Cl^-(aq)$

Enough HCl was added to provide 0.0100 moles of HCl for each liter of solution, but once added to water, it exists entirely as ions -- no molecular HCl is found in the solution.

a) 1.0×10^{-12} b) 1.0×10^{-10} c) 1.0×10^{-8}

d) 1.0×10^{-4} e) 1.0×10^{-2}

19. What is the pOH of a 4.20 M hydrocyanic acid (HCN) solution? Note that hydrocyanic acid is a weak acid that establishes the following equilibrium in water:

$HCN(aq) + H_2O(l)$ <----------> $H_3O^+(aq) + CN^-(aq)$ $K_a = 6.2 \times 10^{-10}$

The math is no worse than a quadratic, even if you don't approximate, but it should be ok to approximate in this problem.

a) 1.6 b) 4.3 c) 8.1 d) 9.7 e) 12.4

20. What is the $[H_3O^+]$ in a 3.00 M sodium acetate ($NaHC_2H_3O_2$) solution? Note that sodium acetate is a salt that undergoes hydrolysis after being dissolved in water. The salt is freely soluble, and dissolves without establishing an equilibrium:

$$NaHC_2H_3O_2(aq) \quad ==========> \quad Na^+(aq) \quad + \quad C_2H_3O_2^-(aq)$$

The Na^+, being the conjugate acid of a strong base (NaOH) is too weak an acid to react with water. The $C_2H_3O_2^-$, being the conjugate base of a weak acid ($HC_2H_3O_2$) has enough base strength to react with water:

$$C_2H_3O_2^-(aq) \ + \ H_2O(l) \quad <----------> \quad HC_2H_3O_2(aq) \quad + \quad OH^-(aq)$$

The numerical value of the equilibrium constant for the above reaction is normally not published in tables, because it can be obtained from the equilibrium constants of two other reactions that ARE published:

$$HC_2H_3O_2(aq) \quad + \quad H_2O(l) \quad <----------> \quad H_3O^+(aq) \quad + \quad C_2H_3O_2^-(aq) \qquad K_a = 1.8 \times 10^{-5}$$

$$2H_2O(l) \quad <----------> \quad H_3O^+(aq) \quad + \quad OH^-(aq) \qquad K_w = 1.0 \times 10^{-14}$$

By combining these two reactions in the appropriate way, you can produce the reaction for which the numerical value of the equilibrium constant is desired. Once you have that, you can do an ICE table calculation in the usual way. It should be possible to make an approximation in your solution to the ICE table calculation to avoid having to solve the quadratic formula.

a) 1.6×10^{-13} b) 2.4×10^{-10} c) 2.5×10^{-7}

d) 4.1×10^{-5} e) 1.8×10^{-3}