

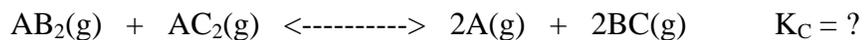
Representative Exam Questions
On The Topic of Equilibrium
(Includes Acid / Base Equilibria)

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
- when a reaction is elementary
 - when a reaction is non-elementary
 - when the reaction is exothermic in the forward direction
 - when you reverse the direction of a reaction that initially had a positive equilibrium constant
 - 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?
- None. A given reaction has a characteristic numerical value for its equilibrium constant that applies under all conditions.
 - Temperature
 - The choice of coefficients used to balance the equation describing the reaction.
 - Whether the reaction is elementary or non-elementary
 - Both b and c
7. Given the equilibrium reaction



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



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

8. Given the equilibrium reaction

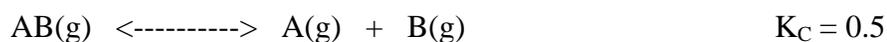


what is the numerical value of the equilibrium constant (K_C) for the reaction



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

9. Given the equilibrium reactions

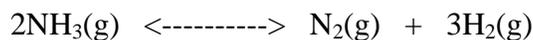


what is the equilibrium constant (K_C) for the following reaction?



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

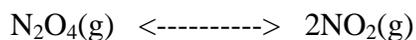
10. The reaction



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

- a) 2.62×10^{-4} b) 0.159 c) 0.304
d) 3.91 e) 14.3

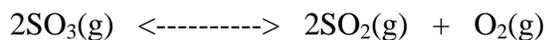
11. The reaction



has $K_P = 0.145$ at 25 °C. What is K_C for the reaction at this same temperature? Note that $R = 0.0820584 \text{ (L atm) / (K mol)}$. 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°C . 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



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

$$[\text{SO}_3]_{\text{eq}} = 1.14 \times 10^{-2} \text{ M}$$

$$[\text{SO}_2]_{\text{eq}} = 8.64 \times 10^{-3} \text{ M}$$

$$[\text{O}_2]_{\text{eq}} = 4.32 \times 10^{-3} \text{ M}$$

What is the numerical value of the equilibrium constant for this reaction at 700°C ?

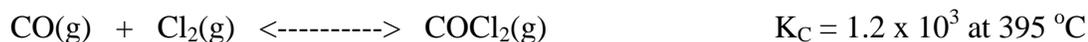
- a) 1.56×10^{-4} b) 2.48×10^{-3} c) 5.81×10^{-2}
d) 4.72×10^2 e) 6.38×10^3
13. At 395°C , an equilibrium mixture of CO , Cl_2 , and COCl_2 was found to have the following concentrations:

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

$$[\text{Cl}_2]_{\text{eq}} = 1.4 \times 10^{-3} \text{ M}$$

$$[\text{COCl}_2]_{\text{eq}} = \text{unspecified}$$

The equilibrium reaction for this chemical system is as follows:



What is the concentration of COCl_2 in this mixture at 395°C ?

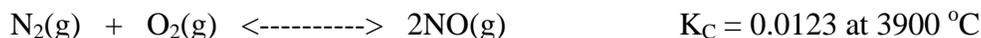
- a) $7.4 \times 10^{-9} \text{ M}$ b) $8.8 \times 10^{-6} \text{ M}$ c) $3.5 \times 10^{-3} \text{ M}$
d) $6.9 \times 10^{-3} \text{ M}$ e) $1.1 \times 10^{-2} \text{ M}$

14. Into a 10.00 L reaction vessel, a chemist placed 0.381 moles of HI, 0.492 moles of H₂, and 0.773 moles of I₂ at 425 °C. The chemical equation for the equilibrium of HI, H₂, and I₂ is as follows:



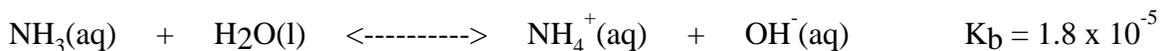
What can be said about this chemical system?

- a) This is an equilibrium mixture. No net reaction will occur.
 - b) This is not an equilibrium mixture. Some of the H₂ and I₂ will combine to form HI until equilibrium is reached.
 - c) This is not an equilibrium mixture. Some of the HI will decompose into H₂ and I₂ until equilibrium is reached.
15. A 5.00 L reaction vessel at 3900 °C initially contained 0.200 moles each of N₂ and O₂ gases. These reacted to form NO as described by the following equation:



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

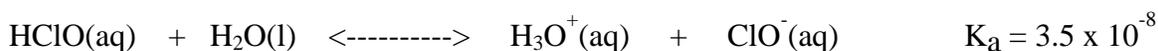
- a) 8.91×10^{-3} mol
 - b) 2.10×10^{-2} mol
 - c) 4.23×10^{-2} mol
 - d) 7.66×10^{-2} mol
 - e) 1.85×10^{-1} mol
16. What is the pH of a 3.88 M NH₃ solution? NH₃ is a weak base that establishes the following equilibrium when dissolved in water:



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

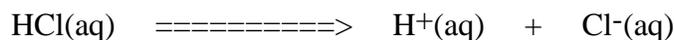
- a) 2.1
- b) 8.6
- c) 9.2
- d) 11.9
- e) 12.8

17. What is the $[\text{H}_3\text{O}^+]$ in a 2.50 M HClO solution? Hypochlorous acid, HClO, is a weak acid with the following equilibrium equation:



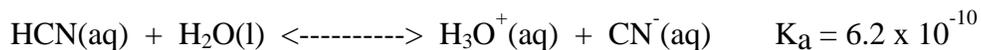
The math is no worse than a quadratic, even if you don't approximate, but it should be ok to approximate in this problem.

- 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 $[\text{OH}^-]$ in a 0.0100 M HCl solution? Note that HCl is a strong acid. It ionizes completely when dissolved in water:



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.

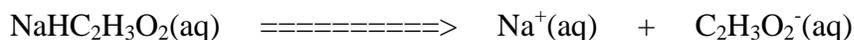
- a) 1.0×10^{-12} b) 1.0×10^{-10} c) 1.0×10^{-8}
d) 1.0×10^{-4} e) 1.0×10^{-2}
19. What is the pOH of a 4.20 M hydrocyanic acid (HCN) solution? Note that hydrocyanic acid is a weak acid that establishes the following equilibrium in water:



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

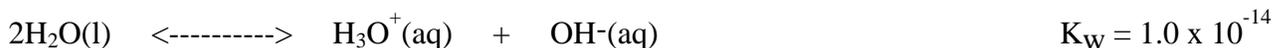
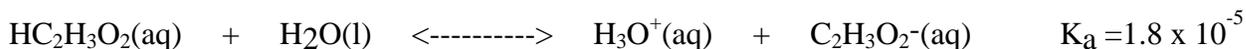
20. What is the $[H_3O^+]$ in a 3.00 M sodium acetate ($NaHC_2H_3O_2$) solution? Note that sodium acetate is a salt that undergoes hydrolysis after being dissolved in water. The salt is freely soluble, and dissolves without establishing an equilibrium:



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:



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:



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}