

Class: XI  
Subject: Chemistry  
Topic: Equilibrium  
No. of Questions: 27

Q1. Species acting as both bronsted acid and bronsted base are

- A.  $\text{HSO}_4^{-1}$
- B.  $\text{Na}_2\text{CO}_3$
- C.  $\text{NH}_3$
- D. None of these

Right Answer Explanation: A

$\text{HSO}_4^-$  can act as both a bronsted acid as well as a bronsted base. To act as bronsted acid, it will donate one proton and becomes sulphate ion, on the other hand to act as a bronsted base, it will accept one proton to become sulphuric acid.

Q2. The solubility of  $\text{Mg}(\text{OH})_2$  is S moles/ litre. The solubility product under the same condition is

- A.  $4S^3$
- B.  $3S^4$
- C.  $4S^2$
- D.  $S^3$

Right Answer Explanation: A

For different salts such as AB,  $\text{AB}_2$ ,  $\text{AB}_3$  etc.  $K_{sp} = s^2, 4s^3, 27s^4$  etc.

Q3. What is the pH of a solution, whose hydronium ion concentration is  $6.2 \times 10^{-9} \text{ mol L}^{-1}$

- A. 8.31
- B. 8.41
- C. 8.34
- D. 8.21

Right Answer Explanation: D

Use  $\text{pH} = -\log [\text{H}^+]$

Q4.  $\text{NH}_4\text{OH}$  is a weak base because

- A. it has low vapour pressure
- B. it is only slightly ionized
- C. it has low density
- D. none of these

Right Answer Explanation:

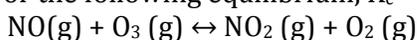
$\text{NH}_4\text{OH}$  is a weak base because it is only slightly ionized

Q5. Reaction between silver nitrate and sodium chloride goes to completion because

- A. the reaction is instantaneous
- B. silver nitrate is insoluble in water
- C. silver chloride is sparingly soluble in water
- D. solubility of silver nitrate increases with sodium chloride

Ans: silver chloride is sparingly soluble in water

6. For the following equilibrium,  $K_c = 6.3 \times 10^{14}$  at 1000K



Both the forward and reverse reactions in the equilibrium are elementary bimolecular reactions.

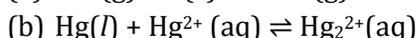
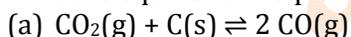
What is  $K_c$  for the reverse reaction?

Ans: It is given that  $K_c$  for the forward reaction is  $6.3 \times 10^{14}$ .

Then,  $K_c$  for the reverse reaction will be,

$$K'_c = \frac{1}{K_c}$$

7. Write the equilibrium equation for each of the following reactions:



Ans: (a)  $K_c = \frac{[\text{CO}]^2}{[\text{CO}_2]}$

Alternatively, because CO and  $\text{CO}_2$  are gases, the equilibrium equation can be written using partial pressures:

$$K_p = \frac{(P_{\text{CO}})^2}{P_{\text{CO}_2}}$$

The relationship between  $K_p$  and  $K_c$  is  $K_p = K_c (RT)^{\Delta n} = K_c (RT)$ , because  $\Delta n = 2 - 1 = 1$ .

$$B K_c = \frac{[Hg_2^{2+}]}{[Hg^{2+}]}$$

In this case, it's not appropriate to write an expression for  $K_p$  because none of the reactants and products is a gas.

8. In a reversible reaction, two substances are in equilibrium. If the concentration of each one is doubled, the equilibrium constant will be

- A. Reduced to half its original value
- B. Reduced to one fourth of its original value
- C. Doubled
- D. Constant.

Ans (d) Constant

9. Explain why pure liquids and solids can be ignored while writing the equilibrium constant expression?

Ans: For a pure substance (both solids and liquids),

$$[\text{Pure substance}] = \frac{\text{Number of moles}}{\text{Volume}}$$

$$= \frac{\text{Mass/molecular mass}}{\text{Volume}}$$

$$= \frac{\text{Mass}}{\text{Volume} \times \text{Molecular mass}}$$

$$= \frac{\text{Density}}{\text{Molecular mass}}$$

Now, the molecular mass and density (at a particular temperature) of a pure substance is always fixed and is accounted for in the equilibrium constant. Therefore, the values of pure substance are not mentioned in the equilibrium constant expression.

10. Does the number of moles of reaction products increase, decrease, or remain the same when each of the following equilibria is subjected to a decrease in pressure by increasing the volume?

- (a)  $\text{PCl}_5 (\text{g}) \rightleftharpoons \text{PCl}_3 (\text{g}) + \text{Cl}_2 (\text{g})$
- (b)  $\text{CaO} (\text{s}) + \text{CO}_2 (\text{g}) \rightleftharpoons \text{CaCO}_3 (\text{s})$
- (c)  $3 \text{Fe} (\text{s}) + 4 \text{H}_2\text{O} (\text{g}) \rightleftharpoons \text{Fe}_3\text{O}_4 (\text{s}) + 4 \text{H}_2 (\text{g})$

Ans: (a) Because the forward reaction converts 1 mol of gas to 2 mol of gas, net reaction will go from reactants to products, thus increasing the number of moles of  $\text{PCl}_3$  and  $\text{Cl}_2$ .

(b) Because there is 1 mol of gas on the reactant side of the balanced equation and none on the product side, the stress of a decrease in pressure is relieved by net reaction from products to reactants. The number of moles of  $\text{CaCO}_3$  therefore decreases.

(c) Because there are 4 mol of gas on both sides of the balanced equation, the composition of the equilibrium mixture is unaffected by a change in pressure. The number of moles of  $\text{Fe}_3\text{O}_4$  and  $\text{H}_2$  remains the same.

11. Which of the following statements is correct about the equilibrium constant?

- A. Its value increases by increase in temperature
- B. Its value decreases by decrease in temperature
- C. Its value may increase or decrease with increase in temperature
- D. Its value is constant at all temperature.

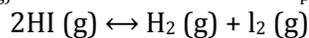
Ans : : Its value may increase or decrease with increase in temperature

12. Sulphanilic acid is a/an

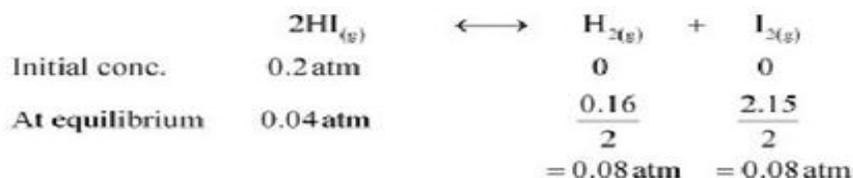
- A. Arrhenius acid
- B. Lewis base
- C. Neither (a) nor (b)
- D. Both (a) and (b).

Ans Both (a) and (b).

13. A sample of  $\text{HI}_{(g)}$  is placed in flask at a pressure of 0.2 atm. At equilibrium the partial pressure of  $\text{HI}_{(g)}$  is 0.04 atm. What is  $K_p$  for the given equilibrium?



Ans: The initial concentration of HI is 0.2 atm. At equilibrium, it has a partial pressure of 0.04 atm. Therefore, a decrease in the pressure of HI is  $0.2 - 0.04 = 0.16$ . The given reaction is:

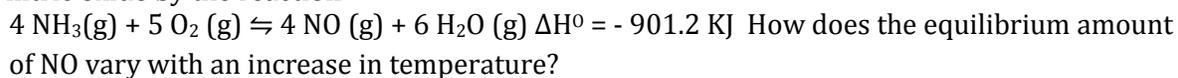


Therefore,

$$\begin{aligned}
 K_p &= \frac{P_{\text{H}_2} \times P_{\text{I}_2}}{P_{\text{HI}}^2} \\
 &= \frac{0.08 \times 0.08}{(0.04)^2} \\
 &= \frac{0.0064}{0.0016} \\
 &= 4.0
 \end{aligned}$$

Hence, the value of  $K_p$  for the given equilibrium is 4.0.

14. In the first step of the Ostwald process for the synthesis of nitric acid, ammonia is oxidized to nitric oxide by the reaction



Ans: Because the oxidation of ammonia is exothermic, we include the heat (901.2 kJ) on the product side :



The stress of added heat when the temperature is increased will be relieved by net reaction from products to reactants, which absorbs the added heat. The equilibrium will therefore shift to the reactant side ( $K_c$  will decrease) with an increase in temperature. Consequently, the equilibrium mixture will contain less NO at higher temperatures.

15. To a solution equimolar mixture of sodium acetate solution is added. The pH of mixture solution

- A. increase
- B. decreases
- C. remains unchanged
- D. unpredictable.

Ans (a) increase

16. The equilibrium constant expression for a gas reaction is,  $K_c = \frac{[\text{NH}_3]^4[\text{O}_2]^3}{[\text{NO}]^4[\text{H}_2\text{O}]^6}$   
Write the balanced chemical equation corresponding to this expression.

Ans: The balanced chemical equation corresponding to the given expression can be written as :  
 $4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g}) \leftrightarrow 4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g})$

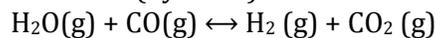
17. Equilibrium constant changes with

- A. time
- B. temperature
- C. pressure
- D. both temperature and concentration

Ans: (b) temperature

18. One mole of H<sub>2</sub>O and one mole of CO are taken in 10 L vessel and heated to 725 K. At equilibrium

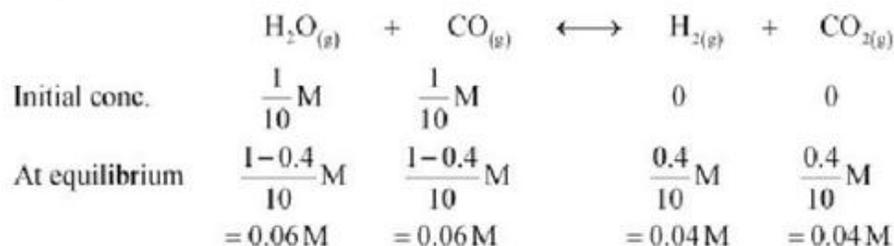
40% of water (by mass) reacts with CO according to the equation,



Calculate the equilibrium constant for the reaction.

Ans:

The given reaction is:



Therefore, the equilibrium constant for the reaction,

$$\begin{aligned}
 K_c &= \frac{[\text{H}_2][\text{CO}_2]}{[\text{H}_2\text{O}][\text{CO}]} \\
 &= \frac{0.04 \times 0.04}{0.06 \times 0.06} \\
 &= 0.444 \text{ (approximately)}
 \end{aligned}$$

19. Under what conditions of temperature and pressure the formation of atomic hydrogen from molecular hydrogen will be favoured most.

- A. High temperature and high pressure
- B. High temperature and low pressure
- C. Low temperature and low pressure
- D. Low temperature and high pressure

Ans: (b) High temperature and low pressure

Explanation: High temperature and low pressure

20. The chemical system in equilibrium is not affected by

- A. change in the concentration of products
- B. increase in the concentration of reactants
- C. addition of a catalyst
- D. changing the temperature

Ans: (c) addition of a catalyst

21. Does the number of moles of reaction products increase, decrease or remain same when each of the following equilibria is subjected to a decrease in pressure by increasing the volume?

- (a)  $\text{PCl}_5 (\text{g}) \leftrightarrow \text{PCl}_3 (\text{g}) + \text{Cl}_2 (\text{g})$
- (b)  $\text{CaO} (\text{s}) + \text{CO}_2 (\text{g}) \leftrightarrow \text{CaCO}_3 (\text{s})$
- (c)  $3\text{Fe} (\text{s}) + 4\text{H}_2\text{O} (\text{g}) \leftrightarrow \text{Fe}_3\text{O}_4 (\text{s}) + 4\text{H}_2 (\text{g})$

Ans: (a) The number of moles of reaction products will increase. According to Le Chatelier's principle, if pressure is decreased, then the equilibrium shifts in the direction in which the number of moles of gases is more. In the given reaction, the number of moles of gaseous products is more than that of gaseous reactants. Thus, the reaction will proceed in the forward direction. As a result, the number of moles of reaction products will increase.

(b) The number of moles of reaction products will decrease.

(c) The number of moles of reaction products remains the same.

22. Following gaseous reaction is undergoing in a vessel  $C_2H_4 + H_2 \rightleftharpoons C_2H_6$   $\Delta H = -32.7$  Kcal ;  
Which will increase the equilibrium concentration of  $C_2H_6$
- A. Increase of temperature
  - B. By removing some hydrogen
  - C. By reducing temperature
  - D. By adding some  $C_2H_6$

Ans: (c) By reducing temperature

Explanation: Exothermic reaction, favoured by low temperature.

23. A substance X dissolves in water with a decrease in volume and absorption of heat solubility of X will be favoured by
- A. low pressure high temp.
  - B. low temp. high pressure
  - C. low temp. low pressure
  - D. high temperature, high pressure

Ans (d) high temperature, high pressure

24. Write the conjugate acids for the following bronsted bases:  $NH_2^-$ ,  $NH_3$  and  $HCOO^-$ ,

Ans: The table below lists the conjugate acids for the given bronsted bases.

Bronsted base	Conjugate acid
$NH_2^-$	$NH_3$
$NH_3$	$NH_4^+$
$HCOO^-$	$HCOOH$

25. 3.2 moles of hydrogen iodide were heated in a sealed bulb at 444 °C till the equilibrium state was reached. Its degree of dissociation at this temperature was found to be 22%. The number of moles of hydrogen iodide present at equilibrium are . [BHU 1982]

- A. 2.496
- B. 2
- C. 1.87
- D. 4

Answer: 2.496

Explanation:  $(22/100) * 3.2 = 0.704$  ( $\therefore$  at equil. moles of HI =  $3.2 - 0.704 = 2.496$ )

26. Which of the following aqueous solutions will have highest pH?

- A. Sodium acetate
- B. Sodium chloride
- C. Ammonium phosphate
- D. Calcium chloride.

Ans (a) Sodium acetate

27. The pH of a sample of vinegar is 3.76. Calculate the concentration of hydrogen ion in it.

Ans: Given, pH = 3.76

it is known that,

$$\text{pH} = -\log[\text{H}^+]$$

$$\Rightarrow \log [\text{H}^+] = -\text{pH}$$

$$\Rightarrow [\text{H}^+] = \text{antilog} (-\text{pH})$$

$$= \text{antilog} (-3.76)$$

$$= 1.74 \times 10^{-4} \text{ M}$$

Hence, the concentratin of hydrogen ion in the given sample of vinegar is  $1.74 \times 10^{-4} \text{ M}$ .