

# Equilibrium JEE Main PYQ – 2

Total Time: 25 Minute

Total Marks: 40

## Instructions

### Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

### Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

## Equilibrium

1. The standard Gibbs energy change at  $300\text{ K}$  for the reaction  $2A \rightarrow B + C$  is  $2494.2\text{ J}$ . At a given time, the composition of the reaction mixture is  $[A] = \frac{1}{2}$ ,  $[B] = 2$  and  $[C] = \frac{1}{2}$ . The reaction proceeds in the :  $[R = 8.314\text{ J/K/mol}, e = 2.718]$  (+4, -1)
- forward direction because  $Q > K_c$
  - reverse direction because  $Q > K_c$
  - forward direction because  $Q < K_c$
  - reverse direction because  $Q < K_c$
- 
2.  $5.1\text{ g NH}_4\text{SH}$  is introduced in  $3.0\text{ L}$  evacuated flask at  $327^\circ\text{C}$ . 30% of the solid  $\text{NH}_4\text{SH}$  decomposed to  $\text{NH}_3$  and  $\text{H}_2\text{S}$  as gases. The  $K_p$  of the reaction at  $327^\circ\text{C}$  is  $\{(R = 0.082\text{ L atm mol}^{-1}\text{K}^{-1})\}$ , Molar mass of  $S = 32\text{ g mol}^{-1}$ , molar mass of  $N = 14\text{ g mol}^{-1}$  (+4, -1)
- $1 \times 10^{-4}\text{ atm}^2$
  - $4.9 \times 10^{-3}\text{ atm}^2$
  - $0.242\text{ atm}^2$
  - $0.242 \times 10^{-4}\text{ atm}^2$
- 
3. For the reaction,  $\text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g})$  if  $K_P = K_C (RT)^x$  where, the symbols have usual meaning, then the value of  $x$  is (assuming ideality) (+4, -1)
- 1
  - $-\frac{1}{2}$
  - $\frac{1}{2}$
  - 1
-

4. At 320 K, a gas  $A_2$  is 20% dissociated to  $A(g)$ . The standard free energy change at 320 K and 1 atm in  $J\ mol^{-1}$  is approximately : ( $R=8.314\ JK^{-1}\ mol^{-1}$ ;  $\ln 2=0.693$ ;  $\ln 3=1.098$ ) (+4, -1)
- a. 4763
- b. 2068
- c. 1844
- d. 4281
- 
5. A solid  $XY$  kept in an evacuated sealed container undergoes decomposition to form a mixture of gases  $X$  and  $Y$  at temperature  $T$ . The equilibrium pressure is 10 bar in this vessel.  $K_p$  for this reaction is : (+4, -1)
- a. 5
- b. 10
- c. 25
- d. 100
- 
6. Addition of sodium hydroxide solution to a weak acid ( $HA$ ) results in a buffer of pH 6. If ionisation constant of  $HA$  is  $10^{-5}$ , the ratio of salt to acid concentration in the buffer solution will be : (+4, -1)
- a. 4:05
- b. 1:10
- c. 10:01
- d. 5:04
- 
7. An aqueous solution contains an unknown concentration of  $Ba^{2+}$ . When 50 mL of a 1 M solution of  $Na_2SO_4$  is added,  $BaSO_4$  just begins to precipitate. (+4, -1)

The final volume is  $500\text{ mL}$ . The solubility product of  $BaSO_4$  is  $1 \times 10^{-10}$ . What is the original concentration of  $Ba^{2+}$  ?

- a.  $5 \times 10^{-9}M$
- b.  $2 \times 10^{-9}M$
- c.  $1.1 \times 10^{-9}M$
- d.  $1.0 \times 10^{-10}M$

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8. Assuming that the degree of hydrolysis is small, the pH of  $0.1\text{ M}$  solution of sodium acetate ( $K_a = 1.0 \times 10^{-5}$ ) will be : (+4, -1)

- a. 5
- b. 6
- c. 8
- d. 9

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9. Consider the following equation:  $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ ,  $\Delta H = -190\text{ kJ}$ . The number of factors which will increase the yield of  $SO_3$  at equilibrium from the following is \_\_\_\_\_ (+4, -1)

- A. Increasing temperature
- B. Increasing pressure
- C. Adding more  $SO_2$
- D. Adding more  $O_2$  E Addition of catalyst

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10. The dissociation constant of acetic acid is  $x \times 10^{-5}$  When  $25\text{ mL}$  of  $0.2\text{ M } CH_3COONa$  solution is mixed with  $25\text{ mL}$  of  $0.02\text{ M } CH_3COOH$  solution, the pH of the resultant solution is found to be equal to 5. The value of  $x$  is \_\_\_\_ (+4, -1)

## Answers

### 1. Answer: b

#### Explanation:

$$\Delta G^\circ \text{ at } 300 \text{ K} = 2494.2 \text{ J}$$

$$\Delta G^\circ = -RT \ln K$$

$$-2494.2 = -8.314 \times 300 \ln K$$

$$K = 10$$

$$Q = \frac{[B][C]}{[A]^2} = \frac{2 \times \frac{1}{2}}{\left(\frac{1}{2}\right)^2} = 4$$

$$Q > K_c \Rightarrow \text{reverse direction.}$$

#### Concepts:

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Read More: [Calculating Equilibrium Concentration](#)

# Types of Chemical Equilibrium

There are two types of chemical equilibrium:

- Homogeneous Equilibrium
- Heterogeneous Equilibrium

## Homogenous Chemical Equilibrium

In this type, the reactants and the products of chemical equilibrium are all in the same phase. **Homogenous equilibrium** can be further divided into two types: Reactions in which the number of molecules of the products is equal to the number of molecules of the reactants. For example,

- $\text{H}_2 (\text{g}) + \text{I}_2 (\text{g}) \rightleftharpoons 2\text{HI} (\text{g})$
- $\text{N}_2 (\text{g}) + \text{O}_2 (\text{g}) \rightleftharpoons 2\text{NO} (\text{g})$

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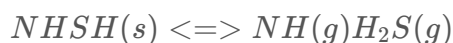
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Check Out: [Equilibrium Important Questions](#)

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2. Answer: c

Explanation:



$$n = \frac{5.1}{51} = .1 \text{mole} \quad 0 \quad 0$$

$$.1(-1 - \alpha) \quad .1\alpha \quad .1\alpha$$

$$\alpha = 30\% = .3$$

so number of moles at equilibrium

$$.1(1 - 3) \quad .1 \times .3 \quad .1 \times .3$$

$$= .07 \quad = .03 \quad = .03$$

Now use PV = nRT at equilibrium

$$P_{\text{total}} \times 3 \text{ lit} = (.03 + .03) \times .082 \times 600$$

$$P_{\text{total}} = .984 \text{atm}$$

At equilibrium

$$P_{NH_3} = P_{H_2} = \frac{P_{\text{total}}}{2} = .492$$

$$K_P = P_{NH_3} \cdot P_{H_2} = (.492) (.492)$$

$$K_p = .242 \text{atm}^2$$

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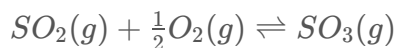
Check Out: [Equilibrium Important Questions](#)

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3. Answer: b

Explanation:





$$K_p = K_C(RT)^x$$

$x = \Delta n_g =$  no. of gaseous moles in product

- no. of gaseous moles in reactant

$$= 1 - \left(1 + \frac{1}{2}\right) = 1 - \frac{3}{2} = \frac{-1}{2}$$

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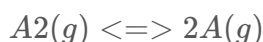
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### 4. Answer: d

#### Explanation:



1 0

$$1 - 1 \times \frac{20}{100} \quad 2 \times \frac{20}{100}$$

0.8 0.4

$$K_p = \frac{(p_A)^2}{(p_{A_2})} = \frac{0.4 \times 0.4}{0.8} = 0.2$$

$$\Delta G^\circ = -2.303 \times 8.314 \times 320 \log 0.2 = 4281 \text{ J/mole}$$

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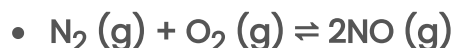
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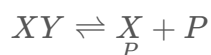
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Check Out: [Equilibrium Important Questions](#)

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### 5. Answer: c

#### Explanation:



$$\text{Total pressure } nP = 10\text{bar} \quad P = 5$$

$$K_P = (P_X)(P_Y) = P^2 = 25$$

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## 6. Answer: c

### Explanation:

$$K_a = 10^{-5}$$

$$pK_a = -\log K_a = -\log 10^{-5} = 5$$

$$pH = pK_a + \log \frac{[\text{salt}]}{[\text{acid}]}$$

$$6 = 5 + \log \frac{[\text{salt}]}{[\text{acid}]}$$

$$1 = \log \frac{[\text{salt}]}{[\text{acid}]}$$

$$\frac{[\text{salt}]}{[\text{acid}]} = \frac{10}{1}$$

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### 7. Answer: c

#### Explanation:

$$\text{Final concentration of } [SO_4^{2-}] = \frac{[50 \times 1]}{[500]} = 0.1 \text{ M}$$

$K_{sp}$  of  $BaSO_4$ ,

$$[Ba^{2+}] [SO_4^{2-}] = 1 \times 10^{-10}$$

$$[Ba^{2+}] [0.1] = \frac{10^{-10}}{0.1} = 10^{-9} \text{ M}$$

Concentration of  $Ba^{2+}$  in final solution =  $10^{-9} \text{ M}$

Concentration of  $Ba^{2+}$  in the original solution.

$$M_1 V_1 = M_2 V_2$$

$$M_1 (500 - 50) = 10^{-9} (500)$$

$$M_1 = 1.11 \times 10^{-9} \text{ M}$$

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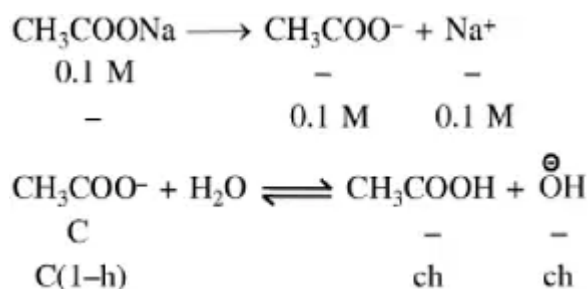
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## 8. Answer: d

### Explanation:



$$\Rightarrow K_h = \frac{[\text{CH}_3\text{COOH}][\overset{\ominus}{\text{O}}\text{H}]}{[\text{CH}_3\text{COO}^-]} = \frac{K_w}{K_a} = \frac{ch^2}{(1-h)}$$

$$\Rightarrow \frac{10^{-14}}{10^{-5}} = ch^2$$

{∵ h is very small ∴ 1 - h ≈ 1}

$$\Rightarrow h = \sqrt{\frac{10^{-9}}{0.1}} = 10^{-4}$$

$$\therefore [\overset{\ominus}{\text{O}}\text{H}] = ch = 0.1 \times 10^{-4} = 10^{-5}$$

$$\Rightarrow [\overset{\oplus}{\text{H}}] = 10^{-9}$$

$$\therefore p^{\overset{\oplus}{\text{H}}} = -\log[\overset{\oplus}{\text{H}}] = 9$$

### Concepts:

#### 1. Equilibrium:

An **equilibrium** represents a state in a process when the observable properties such as color, temperature, pressure, concentration etc do not show any change.

The word equilibrium means 'balance' which indicates that a **chemical reaction** represents a balance between the reactants and products taking part in the reaction. The equilibrium state is also noticed in certain physical processes such as the **melting point** of ice at 0°C, both ice and water are present at equilibrium.

In the case of physical processes such as the melting of solid, dissolution of salt in water etc., the equilibrium is called **physical equilibrium** while the equilibrium associated with chemical reaction is known as **chemical equilibrium**.

## Equilibrium in Chemical changes

The chemical equilibrium in a reversible reaction is the state at which both forward and backward reactions occur at the same speed.

The stage of the reversible reaction at which the concentration of the reactants and products do not change with time is called the equilibrium state.

Read More: [Calculating Equilibrium Concentration](#)

## Types of Chemical Equilibrium

There are two types of chemical equilibrium:

- Homogeneous Equilibrium
- Heterogeneous Equilibrium

### Homogenous Chemical Equilibrium

In this type, the reactants and the products of chemical equilibrium are all in the same phase. [Homogenous equilibrium](#) can be further divided into two types: Reactions in which the number of molecules of the products is equal to the number of molecules of the reactants. For example,

- $\text{H}_2 (\text{g}) + \text{I}_2 (\text{g}) \rightleftharpoons 2\text{HI} (\text{g})$
- $\text{N}_2 (\text{g}) + \text{O}_2 (\text{g}) \rightleftharpoons 2\text{NO} (\text{g})$

Reactions in which the number of molecules of the products is not equal to the total number of reactant molecules. For example,

- $2\text{SO}_2 (\text{g}) + \text{O}_2 (\text{g}) \rightleftharpoons 2\text{SO}_3 (\text{g})$
- $\text{COCl}_2 (\text{g}) \rightleftharpoons \text{CO} (\text{g}) + \text{Cl}_2 (\text{g})$

### Heterogeneous Chemical Equilibrium

In this type, the reactants and the products of chemical equilibrium are present in different phases. A few examples of [heterogeneous equilibrium](#) are listed below.

- $\text{CO}_2 (\text{g}) + \text{C} (\text{s}) \rightleftharpoons 2\text{CO} (\text{g})$
- $\text{CaCO}_3 (\text{s}) \rightleftharpoons \text{CaO} (\text{s}) + \text{CO}_2 (\text{g})$

Thus, the different types of chemical equilibrium are based on the phase of the reactants and products.

Check Out: [Equilibrium Important Questions](#)

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## 9. Answer: 3 – 3

### Explanation:

The correct answer is 3.

The yield of  $SO_3$  at equilibrium will be due to :

- B. Increasing pressure
- C. Adding more  $SO_2$
- D. Adding more  $O_2$

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Thus, the different types of chemical equilibrium are based on the phase of the reactants and products.

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### 10. Answer: 10 – 10

#### Explanation:

The correct answer is 10  
Buffer of  $\text{HOAc}$  and  $\text{NaOAc}$

$$pH = pKa + \log \frac{0.1}{0.01}$$

$$5 = pKa + 1$$

$$pKa = 4$$

$$Ka = 10^{-4}$$

$$x = 10$$

## Concepts:

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