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 $300\,K$ for the reaction $2A \rightarrow B + C$ is $2494.2]$. 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 : $[R = 8.314\,J/\,K/\,mol, e = 2.718]$ (+4, -1)

a. forward direction because $Q > K_c$

b. reverse direction because $Q > K_c$

c. forward direction because $Q < K_c$

d. reverse direction because $Q < K_c$

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2. $5.1g\ NH_4SH$ is introduced in $3.0\,L$ evacuated flask at $327°C$. 30% of the solid $NH4SH$ decomposed to NH_3 and $H2S$ as gases. The Kp of the reaction at $327°C$ is ${(R = 0.082 \; L \; atm \; mol^{-1} K^{-1}}}$, Molar mass of $S = 32\ g\ mol/^{01}$, molar mass of $N = 14g\,mol^{-1}$) (+4, -1)

a. $1 \times 10^{-4}\ atm^2$

b. $4.9 \times 10^{-3}\ atm^2$

c. $0.242\ atm^2$

d. $0.242 \times 10^{-4}\ atm^2$

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3. For the reaction, $SO_2(g) + \frac{1}{2}O_2\,(g) \rightleftharpoons SO_3\,(g)$ if $K_P = K_C\,(RT)^x$ X where, the symbols have usual meaning, then the value of x is (assuming ideality) (+4, -1)

a. -1

b. - $\frac{1}{2}$

c. $\frac{1}{2}$

d. 1

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4. At 320 K, a gas A2 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}; In 2=0.693; In 3=1.098) **(+4, -1)**

a. 4763

b. 2068

c. 1844

d. 4281

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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

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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

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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 $500\,mL$. The solubility product of $BaSO_4$ is 1×10^{-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. $1.0 \times 10^{-10} M$

---

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

a. 5

b. 6

c. 8

d. 9

---

9. Consider the following equation: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g), \Delta H = -190\,kJ$. 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 $25\,mL$ of $0.2\,M\,CH_3COONa$ solution is mixed with $25\,mL$ of $0.02\,M\,CH_3COOH$ 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:

ΔG° at $300\,K = 2494.2\,J$
$\Delta G^0 = -RT\ell nK$
$-2494.2 = -8.314 \times 300\,\ell\,n\,K$
$K = 10$
$Q = \frac{[B][C]}{[A]^2} = \frac{2\times\frac{1}{2}}{\left(\frac{1}{2}\right)^2} = 4$
$Q > K_c \Rightarrow$ reverse direction.

Concepts:

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Equilibrium in Chemical changes

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Check Out: Equilibrium Important Questions

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2. Answer: c

Explanation:

$$NHSH(s) <=> NH(g)H_2S(g)$$
$$n = \frac{5.1}{51} = .1\text{mole} \quad 0 \quad 0$$
$$.1(-1-\alpha) \quad .1\alpha \quad .1\alpha$$
$$\alpha = 30\% = .3$$

so number of moles at equilibrium

$$\begin{array}{lccc} & .1(1-3) & .1 \times .3 & .1 \times .3 \\ = & .07 & = .03 & = .03 \end{array}$$

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

$$P_{NH_3} = P_{H_2S} = \frac{P_{\text{total}}}{2} = .492$$
$$k_P = P_{NH_3}.P_{H_2S} = (.492)(.492)$$
$$k_p = .242\text{atm}^2$$

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3. **Answer: b**

Explanation:

$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$
$K_p = K_C(RT)^x$
$x = \Delta n_g =$ no. of gaseous moles in product

- no. of gaseous moles in reactant

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

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Check Out: Equilibrium Important Questions

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4. Answer: d

Explanation:

$A2(g) <=> 2A(g)$

1 0

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

$0.8\, 0.4$

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

$\Delta G^\circ =$ -2.303 ? 8.314 ? 320 log 0.2 = 4281 J/mole

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Check Out: Equilibrium Important Questions

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5. **Answer: c**

Explanation:

$XY \rightleftharpoons \underset{P}{X} + P$

Total pressure $nP = 10bar\ \ P = 5$

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

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6. **Answer: c**

Explanation:

$$K_a = 10^{-5}$$
$$pK_a = -\log K_a = -\log 10^{-5} = 5$$
$$pH = pKa + \log \frac{[\text{salt}]}{[\text{acid}]}$$
$$6 = 5 + \log \frac{[\text{salt}]}{[\text{acid}]}$$
$$1 = \log \frac{[\text{salt}]}{[\text{acid}]}$$
$$\frac{[\text{ salt}]}{[\text{ acid}]} = \frac{10}{1}$$

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7. **Answer: c**

Explanation:

Final concentration of $[SO_4^{--}] = \frac{[50\times 1]}{[500]} = 0.1\,M$
K_{sp} of $BaSO_4$,
$[Ba^{2+}]\,[SO_4^{2-}] = 1\times 10^{-10}$
$[Ba^{2+}]\,[0.1] = \frac{10^{-10}}{0.1} = 10^{-9}\,M$

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

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

$M_1 V_1 = M_2 V_2$
$M_1(500-50) = 10^{-9}(500)$
$M_1 = 1.11\times 10^{-9}\,M$

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8. **Answer: d**

Explanation:

$$CH_3COONa \longrightarrow CH_3COO^- + Na^+$$
$$\begin{array}{ccc} 0.1\ M & - & - \\ - & 0.1\ M & 0.1\ M \end{array}$$

$$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + \overset{\ominus}{O}H$$
$$\begin{array}{ccc} C & - & - \\ C(1-h) & ch & ch \end{array}$$

$\Rightarrow K_h = \frac{[CH_3COOH][\overset{?}{H}]}{[CH_3COO]} = \frac{K_w}{K_a} = \frac{ch^2}{(1-h)}$

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

$\{\because$ h is very small $\therefore 1 - h \approx 1\}$

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

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

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

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

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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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10. Answer: 10 - 10

Explanation:

The correct answer is 10
Buffer of $HOAc$ and $NaOAc$

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

$5 = pKa + 1$

$pKa = 4$

$Ka = 10^{-4}$

$x = 10$

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℃, 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,

- H_2 (g) + I_2 (g) ⇌ 2HI (g)
- N_2 (g) + O_2 (g) ⇌ 2NO (g)

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

- $2SO_2$ (g) + O_2 (g) ⇌ $2SO_3$ (g)
- $COCl_2$ (g) ⇌ CO (g) + Cl_2 (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.

- CO_2 (g) + C (s) ⇌ 2CO (g)
- $CaCO_3$ (s) ⇌ CaO (s) + CO_2 (g)

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

Check Out: Equilibrium Important Questions