Equilibrium JEE Main PYQ - 1

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. What will be the equilibrium constant of the given reaction carried out in a $5\,L$ vessel and having equilibrium amounts of A_2 and A as 0.5 mole and 2×10^{-6} mole respectively? **(+4, -1)**

The reaction : $A_2 \rightleftharpoons 2A$

a. 0.16×10^{-11}

b. 0.25×10^{5}

c. 0.4×10^{-5}

d. 0.2×10^{-11}

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2. For a reaction, $A \rightleftharpoons P$, the plots of [A] and [P] with time at temperatures T_1 and T_2 are given below. If $T_2 > T_1$, the correct statement(s) is (are) (Assume $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ are independent of temperature and ratio of lnK at T_1 to lnK at T_2 is greater than $\frac{T_2}{T_1}$. Here H, S, G and K are enthalpy, entropy, Gibbs energy and equilibrium constant, respectively.) **(+4, -1)**

a. $\Delta H^{\ominus} < 0, \Delta S^{\ominus} < 0$

b. $\Delta G^{\ominus} < 0, \Delta H^{\ominus} > 0$

c. $\Delta G^{\ominus} < 0, \Delta S^{\ominus} < 0$

d. $\Delta G^{\ominus} < 0, \Delta S^{\ominus} > 0$

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3. At a certain temperature in a 5 L vessel, 2 moles of carbon monoxide and 3 moles of chlorine were allowed to reach equilibrium according to the reaction,$CO + Cl_2 <=> COCl_2$ At equilibrium, if one mole of CO is present then equilibrium constant (K_c) for the reaction is : **(+4, -1)**

a. 2

b. 2.5

c. 3

d. 4

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4. An aqueous solution contains $0.10\,M\,H_2S$ and $0.20\,M\,HCl$. If the equilibrium constants for the formation of HS^- from H_2S is 1.0×10^{-7} and that of S^{2-} from HS^- ions is 1.2×10^{-13} then the concentration of S^{2-} ions in aqueous solution is - **(+4, -1)**

[2018]

a. 5×10^{-8}

b. 3×10^{-20}

c. 6×10^{-21}

d. 5×10^{-19}

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5. Predict expression from α in terms of K_{eq} and concentration C : **(+4, -1)**

$A_2B_3(aq) \leftrightharpoons 2A_3(aq) + 3B_{2-}(aq)$

a. $\left(\frac{K_{eq}}{108C^4}\right)^{\frac{1}{5}}$

b. $(\frac{K_{eq}}{5C^4})^{\frac{1}{5}}$

c. $(\frac{4K_{eq}}{5C^4})^{\frac{1}{5}}$

d. $(\frac{9K_{eq}}{108C^4})^{\frac{1}{5}}$

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6. Which of the following is a Lewis acid? **(+4, -1)**

a. PH_3

b. $B(CH_3)_3$

c. NaH

d. NF_3

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7. In which of the following reactions, an increase in the volume of the container will favour the formation of products ? **(+4, -1)**

a. $2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$

b. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

c. $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(l)$

d. $3O_2(g) \rightleftharpoons 2O_3(g)$

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8. $(1)\ N_2(g) + 3H_2(g) <=> 2NH_3(g), K_1$ **(+4, -1)**
$(2)\ N_2(g) + O_2(g) <=> 2NHO(g), K_2$
$(3)\ H_2(g) + \frac{1}{2}O_2(g) <=> H_2O(g), K_3$
The equation for the equilibrium constant of the reaction
$2NH_3(g) + \frac{5}{2}O_2(g) <=> 2NO(g), 3H_2O(g)$, (K_4) in terms of K_1 and K_3 is:

a. $\frac{K_1.K_2}{K_3}$

b. $\frac{K_1.K_3^2}{K_2}$

c. $K_1K_2K_3$

d. $\frac{K_2.K_3^3}{K_1}$

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9. For reaction : $SO_2(g) + \frac{1}{2}O_2(g) = SO_3(g)\, K_p = 2 \times 10^{12}$ at $27°C$ and 1 atm pressure The K_c for the same reaction is ____ $\times 10^{13}$ (Nearest integer)(Given $R = 0.082\, L\, atm\, K^{-1}\, mol^{-1}$) **(+4, -1)**

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10. At $298\, K$, the solubility of silver chloride in water is $1434 \times 10^{-3}\, g\, L^{-1}$. The value of $-\log K_{sp}$ for silver chloride is ____. **(+4, -1)**
(Given: Mass of Ag is $1079\, g\, mol^{-1}$ and mass of Cl is $355\, g\, mol^{-1}$)

[31-Jan-2023-Shift-2]

Answers

1. **Answer: a**

Explanation:

The correct option is(A) : 0.16×10^{-11}
$A_2 \rightleftharpoons 2A$
Concentration of A_2 at equilibrium $= \frac{0.5}{5}$
Concentration of A at equilibrium $= \frac{2\times10^{-6}}{5}$
Equilibrium constant, $K_c = \frac{[A]^2}{[A_2]} = \frac{\left(\frac{2\times10^{-6}}{5}\right)^2}{\frac{0.5}{5}}$
$= \frac{4\times5}{25\times0.5} \times 10^{-12}$
$= 0.16 \times 10^{-11}$

Concepts:

1. **Laws of Chemical Combination:**

Basic Laws of Chemical Combinations:

The five basic laws of chemical combination for elements and compounds are given below.

Law of Conservation of Mass:

The Law of conservation of mass or the principle of mass conservation states that for any system closed to all transfers of matter and energy, the mass of the system must remain constant over time, as the system's mass cannot change, so the quantity can neither be added nor be removed.

Law of Definite Proportions:

The Law of definite proportions, sometimes called Proust's law, or the law of constant composition states that a given chemical compound always contains its component elements in a fixed ratio and does not depend on its source and method of preparation

Law of Multiple proportions:

The Law of multiple proportions states that if two elements form more than one compound, then the ratios of the masses of the second element which combine with a fixed mass of the first element will always be ratios of small whole numbers.

Gay Lussac's Law of Gaseous Volumes:

Gay Lusaacc's law of gaseous volume states that the pressure of a given mass of gas varies directly with the absolute temperature when the volume is kept constant.

Avogadro's Law:

Avogadro-Ampère's hypothesis is an experimental gas law relating the volume of a gas to the amount of substance of gas present.

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2. Answer: c

Explanation:

The correct answer is option (C) : $\Delta G^{\ominus} < 0, \Delta S^{\ominus} < 0$

$A \rightleftharpoons P$

given $T_2 > T_1$

$\frac{InK_1}{InK_2} > \frac{T_2}{T_1}$

$\Rightarrow T_1 Ink_1 > T_2 Ink_2$

$\Rightarrow -\Delta G_1^{\circ} > -\Delta G_2^{\circ}$

$\Rightarrow (-\Delta H^{\circ} + T_1 \Delta S^{\circ}) > (-\Delta H^{\circ} + T_2 \Delta S^{\circ})$

$\Rightarrow T_1 \Delta S^{\circ} > T_2 \Delta S^{\circ}$

$\Rightarrow \Delta S^{\circ} < 0$

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3. Answer: b

Explanation:

We have

	CO	+	Cl_2	$\rightleftharpoons$	$COCl_2$
Initial conc.	2 mol		3 mol		
Final conc.	1 mol		(3 − 1) = 2 mol		

Equilibrium constant can be calculated as $K_c = \frac{[COCl_2]}{[CO][Cl_2]}$

$K_c = \frac{(1mol/5L)}{(1mol/5L)\times(2mol/5L)} = 2.5$

Concepts:

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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

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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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4. **Answer: b**

Explanation:

In presence of external H^+,

$$H_2S \rightleftharpoons 2H^+ + S^{2-}, K_{a_1} \cdot K_{a_2} = K_{eq}$$
$$\therefore \frac{[H^+]^2[S^{2-}]}{[H_2S]} = 1 \times 10^{-7} \times 1.2 \times 10^{-13}$$

$$\frac{[0.2]^2[S^{2-}]}{[0.1]} = 1.2 \times 10^{-20}$$
$$[S^{2-}] = 3 \times 10^{-20}$$

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Check Out: Equilibrium Important Questions

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5. **Answer: a**

Explanation:

The expression in terms of α (degree of dissociation), K_{eq} (equilibrium constant), and concentration C for the given reaction $A_2B_3(aq) \leftrightharpoons 2A_3(aq) + 3B_{2-}(aq)$ can be derived as follows:

Let's assume the initial concentration of A_2B_3 is 'C'. At equilibrium, if α is the degree of dissociation, then the concentration of A_2B_3 will be $(1-\alpha)$ C, and the concentrations of A_3 and B_{2-} will be $2\alpha C$ and $3\alpha C$, respectively.

The equilibrium constant (K_{eq}) for the reaction is given by:

$$K_{eq} = \frac{([A_3]^2[B_{2-}]^3)}{[A_2B_3]}$$

Substituting the concentrations:

$$K_{eq} = \frac{[(2\alpha C)^2 \times (3\alpha C)^3]}{[(1-\alpha)C]}$$

Simplifying:

$$K_{eq} = \frac{(4\alpha^2 \times 27\alpha^3)}{(1-\alpha)}$$

$$K_{eq} = \frac{(108\alpha^5)}{(1-\alpha)}$$

To express this equation in terms of α, K_{eq}, and concentration C, we can rearrange it as:

$$\left(\frac{K_{eq}}{108C^4}\right)^{\frac{1}{5}} = \alpha$$

Therefore, the expression in terms of α is:

$$\left(\frac{K_{eq}}{108C^4}\right)^{\frac{1}{5}}$$

Hence, the correct answer is option (A): $\left(\frac{K_{eq}}{108C^4}\right)^{\frac{1}{5}}$

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Check Out: Equilibrium Important Questions

6. **Answer: b**

Explanation:

The Lewis acid is a compound that can accept an electron pair.
Among the options provided:
PH_3 is a Lewis base because it can donate its lone pair of electrons.
$B(CH_3)_3$ is a Lewis acid as it can accept a pair of electrons from a Lewis base.
NaH is a Lewis base as it can donate a pair of electrons to form a bond.
NF_3 is a Lewis base because it can donate a lone pair of electrons.

So, the correct option is (B): $B(CH_3)_3$

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Check Out: Equilibrium Important Questions

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7. **Answer: a**

Explanation:

For reaction $2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g); \Delta n_g > 0$

So, if volume increases, pressure decreases and n decreases, therefore, the reaction will move in the direction where n increases, that is in the forward direction which in turn will favour the formation of products.

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Check Out: Equilibrium Important Questions

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8. Answer: d

Explanation:

To calculate the value of K_4 in the given equation we should apply:
$eqn.(2) + eqn.(3)x3 - eqn.(1)$
hence $K_4 = \frac{K_2 K_3^3}{K_1}$

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Check Out: Equilibrium Important Questions

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9. **Answer: 1 - 1**

Explanation:

The correct answer is 1.

$SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons SO_{3(g)}$
$K_p = 2 \times 10^{12}$ at $300K$
$K_p = K_C \times (RT)^{\Delta n_g}$
$2 \times 10^{12} = K_c \times (0.082 \times 300)^{-1/2}$
$K_C = 9.92 \times 10^{12}$
$K_C = 0.992 \times 10^{13}$
$= 1$

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10. **Answer: 10 - 10**

Explanation:

$$AgCl(s) \rightarrow \underset{S}{Ag^+}\text{(aq.)} + \underset{S}{Cl^-}\text{(aq.)}$$
$$K_{sp} = S^2 = \left(\frac{1.43}{143.4} \times 10^{-3}\right)^2 = 10^{-10}$$
$$-\log K_{sp} = 10$$

So, the correct answer is 10.

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

- $2SO_2 (g) + O_2 (g) \rightleftharpoons 2SO_3 (g)$
- $COCl_2 (g) \rightleftharpoons CO (g) + Cl_2 (g)$

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.

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

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

Check Out: Equilibrium Important Questions