Chemical Equilibrium

Question1

Which of the following statements is/are true about equilibrium?

(a) Equilibrium is possible only in a closed system of at a given temperature

(b) All the measurable properties of the system remain constant at equilibrium

(c) Equilibrium constant for the reverse reaction is the inverse of the equilibrium constant for the reaction in the forward direction.

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Options:

A. Only b

B. Only c

C. a, b and c

D. Only a

Answer: C

Solution:

The correct choice is Option C: all three statements are true.

Here's why:

Equilibrium requires a closed system at constant temperature

If the system isn't closed, reactants or products can escape and you never reach a true dynamic balance.

And since the equilibrium constant depends on temperature, “at a given temperature” ensures K stays fixed.

All macroscopic (measurable) properties remain constant at equilibrium

Even though the forward and reverse reactions continue at the molecular level, their rates are equal, so pressure, concentration, temperature, etc., no longer change.

The equilibrium constant for the reverse reaction is the reciprocal of that for the forward reaction

If for

$A \rightleftharpoons B$

we have

$K_{\text{fwd}} = \frac{[B]}{[A]},$

then for the reverse

$B \rightleftharpoons A,$

$K_{\text{rev}} = \frac{[A]}{[B]} = \frac{1}{K_{\text{fwd}}}.$

Question2

According to Le Chatelier's principle, in the reaction $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$, the formation of methane is favoured by

(a) Increasing the concentration of CO

(b) Increasing the concentration of H_2O

(c) Decreasing the concentration of CH_4

(d) Decreasing the concentration of H_2

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Options:

A. a and c

B. b and d

C. a and d

D. a and b

Answer: A

Solution:

Here's how Le Chatelier's principle applies to

$CO(g) + 3\,H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$:

Adding a reactant shifts equilibrium toward products.

• Increasing [CO] (option a) drives the forward reaction.

Removing a product also shifts equilibrium toward products.

• Decreasing [CH_4] (option c) removes a product and pulls the reaction to the right.

Options b (adding H_2O) and d (removing H_2) work against methane formation.

Answer: Option A (a and c).

Question3

The equilibrium constant at 298 K for the reaction $A + B \rightleftharpoons C + D$ is 100 . If the initial concentrations of all the four species were 1 M each, then equilibrium concentration of D (in $\text{mol} L^{-1}$) will be

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Options:

A. 0.182

B. 1.818

C. 1.182

D. 0.818

Answer: B

Solution:

$$A + B \rightleftharpoons C + D$$
$$1-x \quad 1-x \quad 1+x \quad 1+x$$
$$100 = \frac{(1+x)(1+x)}{(1-x)(1-x)}$$
$$\Rightarrow \frac{1+x}{1-x} = 10$$
$$\Rightarrow 1+x = 10 - 10x$$
$$\Rightarrow 11x = 9$$
$$x = \frac{9}{11} = 0.818$$
(D) $1 + x = 1 + 0.818 = 1.818$

Question4

At 500 K, for a reversible reaction $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$ in a closed container, $K_C = 2 \times 10^{-5}$. In the presence of catalyst, the equilibrium is attaining 10 times faster. The equilibrium constant K_C in the presence of catalyst at the same temperature is

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Options:

A. 2×10^{-4}

B. 2×10^{-6}

C. 2×10^{-10}

D. 2×10^{-5}

Answer: D

Solution:

The value of the K_C remains same as catalyst does not affects the K_C. Only temperature can alter the value of the K_C of a given reaction. Thus, the equilibrium constant K_C in the presence of catalyst at the same temperature is 2×10^{-5}.

Question5

1 mole of HI is heated in a closed container of capacity of 2 L. At equilibrium half a mole of HI is dissociated.The equilibrium constant of the reaction is

KCET 2022

Options:

A. 0.5

B. 0.25

C. 0.35

D. 1

Answer: B

Solution:

$$2HI \rightleftharpoons H_2 + I_2$$

	$2HI$	H_2	I_2
Initial mole :	1	x	x
Final mole :	$(1-x)$	$x/2$	$x/2$

$K_C = \frac{x^2}{4(1-x)^2}$

By putting the value of $x = 1/2$, we get,

$K_C = \frac{1/4}{4(1-1/2)^2} = 0.25$

Question6

For the reaction,

$$A(g) + B(g) \rightleftharpoons C(g) + D(g); \Delta H = Q \text{ kJ}$$

The equilibrium constant cannot be disturbed by

KCET 2021

Options:

A. addition of A

B. addition of D

C. increasing of pressure

D. increasing of temperature

Answer: C

Solution:

For the given hypothetical reaction,

$A(g) + B(g) \rightleftharpoons C(g) + D(g); \Delta H = -Q$ kJ

$\Delta n = 0$, because number of molecules of gaseous molecule on both side are equal. Thus, the equilibrium constant cannot be disturbed by increasing of pressure.

Question7

The relationship between K_p and K_c is $K_p = K_c(RT)^{\Delta n}$. What would be the value of Δn for the reaction
$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$?

KCET 2018

Options:

A. 1

B. 0.5

C. 1.5

D. 2

Answer: D

Solution:

The relationship between K_p and K_c is expressed as:

$K_p = K_c(RT)^{\Delta n}$

Here, Δn represents the change in moles of gaseous species, calculated using the formula:

$\Delta n = (\text{moles of gaseous products}) - (\text{moles of gaseous reactants})$

Consider the reaction:

$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$

In this reaction, there are 2 moles of gaseous products (NH_3 and HCl) and 0 moles of gaseous reactants. Therefore, the calculation of Δn is:

$\Delta n = 2 - 0 = 2$

Thus, for this reaction, Δn is 2.

Question8

The reaction quotient ' Q ' is useful inpredicting the direction of the reaction. Which of the following is incorrect?

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Options:

A. If $Q_c < K_c$, the forward reaction is favoured

B. If $Q_c > K_c$, the reverse reaction is favoured

C. If $Q_c > K_c$, the forward reaction is favoured

D. If $Q_c = K_c$, no reaction occur

Answer: C

Solution:

Let's review each statement by considering the reaction quotient, Q_c, and how it compares to the equilibrium constant, K_c.

When $Q_c < K_c$:

The system has a deficiency of products relative to the equilibrium state.

The forward reaction is favored to produce more products.

Thus, Option A is correct.

When $Q_c > K_c$:

The system has an excess of products relative to equilibrium.

The reverse reaction is favored to consume some of the products.

Therefore, Option B is correct.

Option C states: "If $Q_c > K_c$, the forward reaction is favoured."

This is incorrect because, as mentioned, when $Q_c > K_c$, the reverse reaction is favored, not the forward reaction.

When $Q_c = K_c$:

The system is at equilibrium.

There is no net change in the concentrations of reactants and products, though reactions continue to occur at the molecular level.

Option D, while it simplifies by saying "no reaction occur," generally implies that the system is at equilibrium, which is acceptable in many basic contexts.

Thus, the incorrect statement is:

Option C: If $Q_c > K_c$, the forward reaction is favoured.

Question9

The equilibrium constant for the reaction $\mathrm{N_2}(g) + \mathrm{O_2}(g) \rightleftharpoons 2\mathrm{NO(g)}$ is 4×10^{-4} at 2000 K . In presence of a catalyst the equilibrium is attained ten times faster. Therefore the equilibrium constant in presence of catalyst 2000 K is

KCET 2017

Options:

A. 4×10^{-3}

B. 4×10^{-2}

C. 40×10^{-4}

D. 4×10^{-4}

Answer: D

Solution:

The equilibrium constant K for the reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ at 2000 K is expressed as:

$$K = \frac{[\text{concentration of products}]}{[\text{concentration of reactants}]} = 4 \times 10^{-4}$$

When a catalyst is introduced, the system reaches equilibrium ten times faster. However, it's important to note that while the presence of a catalyst affects the rate at which equilibrium is reached, it does not alter the equilibrium constant. The equilibrium constant is solely dependent on temperature and not on the rate at which equilibrium is established.

Thus, the equilibrium constant in the presence of a catalyst at 2000 K remains:

$$K_{(\text{new})} = K_{(\text{previous})} = 4 \times 10^{-4}$$
