Chemical Equilibrium

Question1

At 1000 K , the equilibrium constant for the reaction, $\mathrm{CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)}$ is 0.53 . In a one litre vessel, at equilibrium the mixture contains 0.25 mole of CO, 0.5 mole of $\mathrm{CO_2}$, 0.6 mole of $\mathrm{H_2}$ and x moles of $\mathrm{H_2O}$. The value of x is

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Options:

A.

0.563

B.

0.363

C.

0.636

D.

0.736

Answer: C

Solution:

Given reaction,

$\mathrm{CO_2}(g) + \mathrm{H_2}(g) \rightleftharpoons \mathrm{CO}(g) + \mathrm{H_2O}(g); K = 0.53$

At equilibrium, $[\mathrm{CO}] = 0.25 \mathrm{~mol/L}$,

$[CO_2] = 0.5$ mol/L
$[H_2] = 0.6$ mol/L, $[H_2O] = x$

Rate reaction; $K = \frac{[CO][H_2O]}{[CO_2][H_2]} = \frac{0.25 \times x}{0.5 \times 0.6}$

$x = 0.636$

Question2

For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, the correct relation between degree of dissociation (α) of $N_2O_4(g)$ and equilibrium constant, K_p is ($p =$ total pressure of mixture)

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Options:

A.

$\alpha = \frac{K_p/p}{4+\frac{K_p}{p}}$

B.

$\alpha = \frac{K_p}{4+K_p}$

C.

$\alpha = \left(\frac{K_p/p}{4+\frac{K_p}{p}}\right)^{\frac{1}{2}}$

D.

$\alpha = \left(\frac{K_p}{4+K_p}\right)^{\frac{1}{2}}$

Answer: C

Solution:

Given, reaction is

	$N_2O_4(g) \rightleftharpoons$	$2NO_2(g)$
Initial moles	1	0
Degree of dissociation=	α	
At equilibrium	1-α	2α

Partial pressure is given by

$$p_{N_2O_4} = \left(\frac{1-\alpha}{1+\alpha}\right)p; \quad p_{NO_2} = \frac{2\alpha}{1+\alpha} \cdot p$$

$$K_p = \frac{(p_{NO_2})^2}{p_{N_2O_4}}$$

Substituting the values,

$$\alpha = \left(\frac{\frac{K_p}{p}}{4+\frac{K_p}{p}}\right)^{1/2}.$$

Question3

At $T(K)$ the equilibrium constants for the following two reactions are given below

$2A(g) \rightleftharpoons B(g) + C(g); K_1 = 16$

$2B(g) + C(g) \rightleftharpoons 2D(g); K_2 = 25$

What is the value of equilibrium constant (K) for the reaction given below at $T(K)$?

$A(g) + \frac{1}{2}B(g) \rightleftharpoons D(g)$

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Options:

A. 100

B. 50

C. 20

D. 75

Answer: C

Solution:

Given the equilibrium constants for the reactions:

$2A(g) \rightleftharpoons B(g) + C(g)$ with $K_1 = 16$

$2B(g) + C(g) \rightleftharpoons 2D(g)$ with $K_2 = 25$

We need to find the equilibrium constant K for the reaction:

$A(g) + \frac{1}{2}B(g) \rightleftharpoons D(g)$

To determine this, we first manipulate the given reactions as follows:

Divide both sides of the first reaction by 2:

$A(g) \rightleftharpoons \frac{1}{2}B(g) + \frac{1}{2}C(g)$

When you perform this division, the equilibrium constant becomes the square root of the original. Therefore, the equilibrium constant for this modified reaction is $\sqrt{K_1} = \sqrt{16} = 4$.

Next, divide both sides of the second reaction by 2:

$B(g) + \frac{1}{2}C(g) \rightleftharpoons D(g)$

Similarly, the equilibrium constant for this modified reaction is $\sqrt{K_2} = \sqrt{25} = 5$.

By adding these two modified reactions, we obtain the target reaction:

$A(g) + \frac{1}{2}B(g) \rightleftharpoons D(g)$

The equilibrium constant for the resulting reaction is the product of the equilibrium constants of the individual modified reactions:

$K = \sqrt{K_1} \cdot \sqrt{K_2} = 4 \cdot 5 = 20$

Thus, the equilibrium constant K for the reaction $A(g) + \frac{1}{2}B(g) \rightleftharpoons D(g)$ at temperature $T(K)$ is 20.

Question4

At $T(\mathrm{~K}), K_C$ for the dissociation of PCl_5 is $2 \times 10^{-2} \mathrm{~mol~L}^{-1}$. The number of moles of PCl_5 that must be taken in 1.0 L flask at the same temperature to get 0.2 mol of chlorine at equilibrium is

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Options:

A. 2.2

B. 1.1

C. 1.8

D. 4.4

Answer: A

Solution:

The given reaction is,

	PCl_5	$\rightleftharpoons PCl_3(g)$	$+Cl_2(g)$
Moles at initial	x	0	0
Moles at equilibrium	$x-0.2$	0.2	0.2

Equilibrium constant of above reaction is,

$$K_C = \frac{[PCl_3][Cl_2]}{[PCl_5]}$$

$$2 \times 10^{-2} = \frac{[0.2][0.2]}{[x-0.2]}$$

$$\Rightarrow \quad x = 2.2 \text{ mol}$$

Question5

At $T(\mathrm{~K}), K_c$ for the reaction, $AO_2(g) + BO_2(g) \rightleftharpoons AO_3(g) + BO(g)$ is 16 . One mole each of reactants and products are taken in a IL flask and heated to $T(\mathrm{~K})$, and equilibrium is established. What is the equilibrium concentration of BO (in $\mathrm{mol L}^{-1}$)?

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Options:

A. 1.6

B. 0.4

C. 1.2

D. 0.8

Answer: A

Solution:

To determine the equilibrium concentration of $BO(g)$, we need to consider the reaction and the given equilibrium constant:

$AO_2(g) + BO_2(g) \rightleftharpoons AO_3(g) + BO(g)$

The reaction quotient, Q_c, is given by:

$Q_c = \frac{[AO_3][BO]}{[AO_2][BO_2]}$

Given $K_c = 16$ at equilibrium, the system satisfies:

$K_c = \frac{[AO_3][BO]}{[AO_2][BO_2]} = 16$

Let x be the change in concentration of products and reactants at equilibrium. The initial concentration for all species is 1 mol/L, thus:

Initial concentrations: $[AO_2] = [BO_2] = [AO_3] = [BO] = 1\,\text{mol/L}$

Change in concentrations:

$[AO_2] = [BO_2] = 1 - x$

$[AO_3] = [BO] = 1 + x$

At equilibrium:

$K_c = \frac{(1+x)(1+x)}{(1-x)(1-x)} = 16$

$\frac{(1+x)^2}{(1-x)^2} = 16$

Taking the square root of both sides:

$\frac{1+x}{1-x} = 4$

Solving for x:

$1 + x = 4 - 4x$

$1 + 5x = 4$

$5x = 3$

$x = 0.6$

Thus, the equilibrium concentration of BO is:

$[BO] = 1 + x = 1 + 0.6 = 1.6 \, \text{mol/L}$

Therefore, the correct option is:

Option A: 1.6

Question6

At 780 K and 10 atmosphere pressure the equilibrium constant for the reaction $2A(g) \rightleftharpoons B(g) + C(g)$ is 3.52 . At the same temperature and 7.04 atmosphere pressure, the equilibrium constant for the same reaction is

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Options:

A. 7.04

B. 3.52

C. 10.56

D. 5.23

Answer: B

Solution:

At 750 K and 10 atm , the equilibrium constant of reaction $2A(g) \rightleftharpoons B(g) + C(g)$ is 3.52 . It will be same at 750 K and 7.04 atm pressure as equilibrium constant doesn't depend on pressure, catalyst and concentration. It just depends on absolute temperature.
