

Chemical Equilibrium

Question1

At 1000 K , the equilibrium constant for the reaction, $\text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$ is 0.53 . In a one litre vessel, at equilibrium the mixture contains 0.25 mole of CO, 0.5 mole of CO_2 , 0.6 mole of H_2 and x moles of H_2O . The value of x is

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Options:

A.

0.563

B.

0.363

C.

0.636

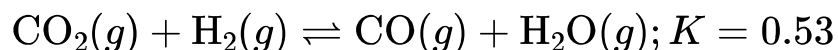
D.

0.736

Answer: C

Solution:

Given reaction,



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



$$[\text{CO}_2] = 0.5 \text{ mol/L}$$

$$[\text{H}_2] = 0.6 \text{ mol/L}, [\text{H}_2\text{O}] = x$$

$$\text{Rate reaction; } K = \frac{[\text{CO}][\text{H}_2\text{O}]}{[\text{CO}_2][\text{H}_2]} = \frac{0.25 \times x}{0.5 \times 0.6}$$

$$x = 0.636$$

Question2

For the reaction $\text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g)$, the correct relation between degree of dissociation (α) of $\text{N}_2\text{O}_4(g)$ 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.

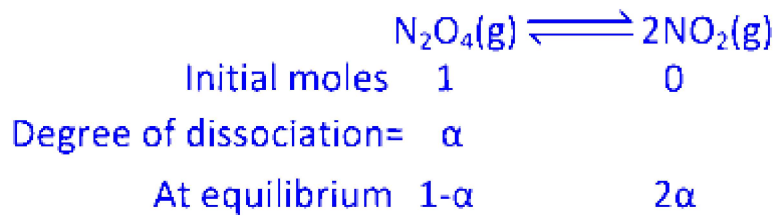
$$\alpha = \left(\frac{K_p}{4 + K_p} \right)^{\frac{1}{2}}$$

Answer: C

Solution:

Given, reaction is





Partial pressure is given by

$$p_{\text{N}_2\text{O}_4} = \left(\frac{1-\alpha}{1+\alpha} \right) p; \quad p_{\text{NO}_2} = \frac{2\alpha}{1+\alpha} \cdot p$$

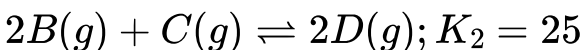
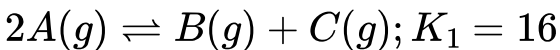
$$K_p = \frac{(p_{\text{NO}_2})^2}{p_{\text{N}_2\text{O}_4}}$$

Substituting the values,

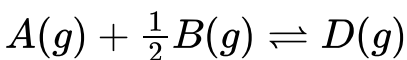
$$\alpha = \left(\frac{\frac{K_p}{p}}{4 + \frac{K_p}{p}} \right)^{1/2}$$

Question3

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



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



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Options:

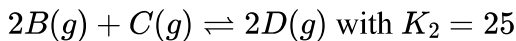
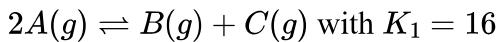
- A. 100
- B. 50
- C. 20

D. 75

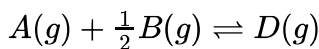
Answer: C

Solution:

Given the equilibrium constants for the reactions:

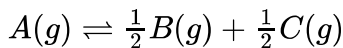


We need to find the equilibrium constant K for the reaction:



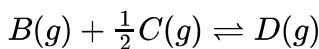
To determine this, we first manipulate the given reactions as follows:

Divide both sides of the first reaction by 2:



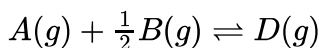
When you perform this division, the equilibrium constant becomes the square root of the original. Therefore, the equilibrium constant for this modified reaction is $\sqrt{K_1} = \sqrt{16} = 4$.

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



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:



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 $T(K)$, K_C for the dissociation of PCl_5 is $2 \times 10^{-2} \text{ mol L}^{-1}$. 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

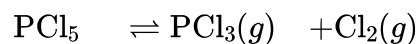
C. 1.8

D. 4.4

Answer: A

Solution:

The given reaction is,



Moles at initial x 0 0

Moles at equilibrium $x - 0.2$ 0.2 0.2

Equilibrium constant of above reaction is,

$$K_C = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]}$$

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

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

Question5

At T (K), K_c for the reaction, $\text{AO}_2(g) + \text{BO}_2(g) \rightleftharpoons \text{AO}_3(g) + \text{BO}(g)$ is 16 . One mole each of reactants and products are taken in a 1L flask and heated to T (K), and equilibrium is established. What is the equilibrium concentration of BO (in molL^{-1})?

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Options:

A. 1.6



B. 0.4

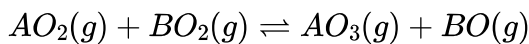
C. 1.2

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:



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:

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

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.
