

# Equilibrium

## Check Point - 1

1. (a) :  $K_p = \frac{P_C}{P_A \times P_B} = \frac{1}{P} = \text{atm}^{-2}$

2. (a) : (b) is correct because concentrations of  $H_2$  and  $N_2$  decrease while that of  $NO_2$  increases with time and after equilibrium, all of them remain constant.

3. (b) :  $K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(2 \times 10^{-3})^2}{(0.2/2)} = \frac{10^{-6}}{0.1} = 10^{-5}$

4. (b) :  $A(Y) \rightleftharpoons XY + Y$

initial  $1000 \text{ mm Hg}$   $0$   $0$

at eqn.  $1000 - x$   $x$   $x$

total pressure =  $1000 - x$

$x = 1000 - 1000 = 0$

equilibrium  $1000 - 0$   $0$   $0$

or  $P = 1000 \text{ mm Hg}$

$K = \frac{1000 \times 1000}{1000} = 100$

5. (c) : Partial pressure of 1 atoms ( $P_1$ )

$= \frac{40}{100} \times 10^5 \text{ Pa} = 0.40 \times 10^5 \text{ Pa}$

Partial pressure of  $I_2(P_2)$

$= \frac{60}{100} \times 10^5 \text{ Pa} = 0.60 \times 10^5 \text{ Pa}$

$K_p = \frac{P_2^2}{P_1} = \frac{0.60 \times 10^5}{{0.40 \times 10^5}} = 2.66 \times 10^4$

6. (d) :  $A_1 + 3B_1 \rightleftharpoons 2AB_3$ ;  $K_1 = x \text{ mol}^{-2} \text{ L}^2$

$AB_3 \rightleftharpoons \frac{1}{2}A_2 + \frac{3}{2}B_2$ ;  $K_2 = y \text{ mol L}^{-1}$

Equation (ii) is obtained by reversing equation (i) and then dividing by 2.

∴  $K_2 = \frac{1}{\sqrt{K_1}} \Rightarrow y = \frac{1}{\sqrt{x}} = x^{-1/2}$

7. (b) : For reaction (i),

$K_1 = \frac{1}{2} \times 10^{-3}$  (given)

For reaction (ii),

$K_2 = \frac{P^2 CO}{P_{CO_2}} = 2$  (given)

∴  $2 = \frac{P^2 CO}{2 \times 10^{-3}} \Rightarrow P_{CO} = 0.4$

8. (c) :  $K_p = \frac{[PCl_3][Cl_2]}{[PCl_5]} \text{ i.e., } 0.5 = \frac{0.2 \times [Cl_2]}{0.4}$

9.  $[Cl_2] = 1.0 \text{ mol L}^{-1}$

10. (a) : Active mass = molar concentration =  $n/V$

From  $PV = nRT$ ,  $\frac{n}{V} = \frac{P}{RT}$

11. (a)

## Check Point - 2

1. (b)

2. (a) : Equilibrium shifts backward.

3. (d) : At constant volume, there is no change in concentrations.

4. (c) :  $n_p = n_v$ . Pressure has no effect.

5. (c) : As  $n_p < n_v$  higher the pressure, greater will be yield of  $Z$ . As reaction is exothermic in the forward direction, lower the temperature, greater is the yield of  $Z$ .

6. (c) : The given reaction is endothermic. So, on increasing temperature, it will shift in the forward direction.

7. (c) :  $\text{Ice} \rightleftharpoons \text{Water}$   
More vol. less vol.

On applying pressure, equilibrium shifts to the side in which volume is less.

8. (c) : The reaction proceeds from right to left when  $Q_c > K_c$ , so, that  $Q_c$  tends to decrease to become equal to  $K_c$ .

9. (a) : Change in volume, changes the molar concentration. In (a),  $n_p = n_v$ . Change in volume will not alter the number of moles in this case.

10. (b) : For a hypothetical reaction



$$Q_c = \frac{[C][D]}{[A][B]} \text{, } Q_c \text{ increases}$$

## Check Point - 3

1. (b) :  $\text{pH} = \frac{\text{p}K_1 + \text{p}K_2}{2} = \frac{2.15 + 7.80}{2} = 4.975$

2. (c) :  $\text{pOH} = 14 - \text{pH} = 14 - 8.26 = 5.74$

$$5.74 = \text{p}K_{2a} + \log \frac{[\text{NH}_3^+]}{[\text{NH}_2]}$$

$$[\text{NH}_2] = 1 \text{ mol L}^{-1}$$

$$[(\text{NH}_4)_2\text{SO}_4] = \frac{1}{2} = 0.5 \text{ mol L}^{-1}$$

3. (c) :  $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$

$$x = 0 \quad 1 \quad 0$$

$$4x \quad 1 - x \quad 2x$$

Total number of moles at equilibrium =  $1 - x + 2x = 1 + x$

$$K_p = \frac{P_{NO_2}^2}{P_{N_2O_4}} = \frac{\left( \frac{2x}{1+x} P \right)^2}{\left( \frac{1-x}{1+x} P \right)}$$

$$K_p = \frac{4x^2 P}{(1+x)(1-x)} = \frac{4x^2 P}{1-x^2}$$

$$4x^2 P = K_p = x^2 K_p$$

$$4x^2 P + x^2 K_p = K_p$$

# 19 Chemical Equilibrium Answer Key

**Judd E. Hollander**

## 19 Chemical Equilibrium Answer Key:

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