JEE Main Chemistry Previous Year Questions With Solutions on Equilibrium

1. Which of the following are Lewis acids?

(a) PH_3 and BCl_3
(b) $AlCl_3$ and $SiCl_4$
(c) PH_3 and $SiCl_4$
(d) BCl_3 and $AlCl_3$

Solution:

The compound which can accept a pair of electrons is known as Lewis acid. BCl_3 and $AlCl_3$ have vacant orbitals and their octet is not complete. Hence these can accept electron pairs and behave as Lewis acids.
Hence option (d) is the answer.

2. Species acting as both Bronsted acid and base is

(a) $(HSO_4)^-$
(b) Na2CO3
(c) NH3
(d) OH-

Solution:

A Bronsted acid is a substance that can donate a proton to any other substance and a Bronsted base is a substance that can accept a proton from any other substance. $(HSO_4)^-$ can donate and accept a proton.
Hence option (a) is the answer.

3. What is the conjugate base of OH^-?

(a) O_2
(b) H_2O
(c) O^-
(d) O^{-2}

Solution:

When acid gives H^+ then the remaining of its part is called the conjugate base.
The conjugate base of OH^- is O^{2-}.
Hence option (d) is the answer.

4. Which one of the following substances has the highest proton affinity?

(a) H_2S
(b) NH_3
(c) PH_3
(d) H_2O

Solution:
The stability of the conjugate acid will give us the compound with the highest proton affinity.
Here ammonia has the highest proton affinity.
Hence option (b) is the answer.

5. When rain is accompanied by a thunderstorm, the collected rainwater will have a pH value
(a) slightly lower than that of rainwater without a thunderstorm
(b) slightly higher than that when the thunderstorm is not there
(c) uninfluenced by the occurrence of a thunderstorm
(d) which depends on the amount of dust in the air.

Solution:
The temperature increases due to the thunderstorm. As temperature increases, $[H^+]$ also increases, and thus pH decreases.
Hence option (a) is the answer.

6. For the reaction, $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$, $\Delta H = -57.2$ kJ mol^{-1} and $K_c = 1.7 \times 10^{16}$ Which of the following statements is incorrect?
(a) The equilibrium will shift in the forward direction as the pressure increases.
(b) The addition of inert gas at constant volume will not affect the equilibrium constant.
(c) The equilibrium constant is large, suggestive of reaction going to completion and so no catalyst is required.
(d) The equilibrium constant decreases as the temperature increases.

Solution:
The large value of Kc suggests that the reaction should go almost to completion. The oxidation of SO_2 to SO_3 is very slow. So the rate of reaction is increased by adding a catalyst. Statement c is wrong.
Hence option (c) is the answer.

7. 20 mL of 0.1 M H_2SO_4 solution is added to 30 mL of 0.2 M NH_4OH solution. The pH of the resultant mixture is [pK_b of $NH_4OH = 4.7$]
(a) 9.4
(b) 9.0
(c) 5.0
(d) 5.2

Solution:
Given pK_b of $NH_4OH = 4.7$
20 mL of 0.1 M $H_2SO_4 \Rightarrow n_{H^+} = 4$
30 ml 0.2 M $NH_4OH \Rightarrow n_{NH4OH} = 6$

$$NH_4OH + H^+ \rightleftharpoons NH_4^+ + H_2O$$
$$6 \quad 4 \quad 0 \quad 0$$
$$2 \quad 0 \quad 4 \quad 4$$

Solution is basic buffer.

$pOH = pK_b + \log [NH_4^+]/[NH_4OH] = 4.7 + \log (4/2)$

$= 4.7 + \log 2$

$= 4.7+0.3$

$= 5$

$pH = 14-pOH$

$= 14-5 = 9$

Hence option (b) is the answer.

8. The increase of pressure on ice water system at constant temperature will lead to

(a) no effect on that equilibrium

(b) a decrease in the entropy of the system

(c) a shift of the equilibrium in the forward direction

(d) an increase in the Gibbs energy of the system.

Solution:

On increasing the pressure on this system in equilibrium, the equilibrium tends to shift in a direction in which volume decreases, i.e., in the forward direction.

Hence option (c) is the answer.

9. The pH of rain water is approximately

(a) 7.5

(b) 6.5

(c) 7.0

(d) 5.6

Solution:

The pH of rainwater is approximately 5.6.

Hence option (d) is the answer.

10. A vessel at 1000 K contains CO_2 with a pressure of 0.5 atm. Some of the CO_2 is converted into CO on the addition of graphite. If the total pressure at equilibrium is 0.8 atm, the value of K is

(a) 1.8 atm

(b) 3 atm

(c) 0.3 atm

(d) 0.18 atm

Solution:
Given total pressure = 0.8 atm
$CO_{2(g)} + C_{(s)} \rightleftharpoons 2CO_{(g)}$
Total pressure = 0.5-P +2P = 0.8
P = 0.8-0.5 = 0.3
$K_P = P^2_{CO}/P_{CO2} = (2P)^2/(0.5-P)$
$= (0.6)^2/0.2$
= 0.36/0.2
= 1.8 atm
Hence option (a) is the answer.

11. Which of the following is a Lewis acid?
(a) NaH
(b) NF_3
(c) PH_3
(d) $B(CH_3)_3$

Solution:
The compound which can accept a pair of electrons is known as Lewis acid. $B(CH_3)_3$
Is a Lewis acid.
Hence option (d) is the answer.

12. The exothermic formation of ClF3 is represented by the equation:
$Cl_{2(g)} + 3F_{2(g)} \rightleftharpoons 2ClF_{3(g)}$; ΔH = –329 kJ Which of the following will increase the quantity of ClF_3 in an equilibrium mixture of Cl_2, F_2 and ClF_3?
(a) Increasing the temperature
(b) Removing Cl_2
(c) Increasing the volume of the container
(d) Adding F_2

Solution:
The addition of reactants or removal of the product will favour the forward reaction.
So adding F_2 will increase the quantity of ClF_3.
Hence option (d) is the answer.

13. Among the following acids which have the lowest pKa value?
(a) CH_3COOH
(b) $(CH_3)_2CH\text{-}COOH$
(c) HCOOH
(d) CH_3CH_2COOH

Solution:
Higher the pKa value, weaker is the acid. So the strongest acid has the lowest pKa value.
Hence option (b) is the answer.

14. The correct relationship between free energy change in a reaction and the corresponding equilibrium constant K_c is
(a) $\Delta G = RT \ln K_c$
(b) $-\Delta G = RT \ln K_c$
(c) $\Delta G^\circ = RT \ln K_c$
(d) $-\Delta G^\circ = RT \ln K_c$

Solution:
$\Delta G = \Delta G^\circ + 2.303\ RT \log Kc$
At equilibrium, $\Delta G = 0$
So $\Delta G^\circ = -2.303\ RT \log Kc$
Hence option (d) is the answer.

15. The molar solubility of $Cd(OH)_2$ is 1.84×10^{-5} M in water. The expected solubility of $Cd(OH)_2$ in a buffer solution of pH = 12 is
(a) 1.84×10^{-9} M
(b) 2.49×10^{-10} M
(c) $(2.49/ 1.84) \times 10^{-9}$ M
(d) 6.23×10^{-11} M

Solution:
Given molar solubility, $s = 1.84 \times 10^{-5}$
$K_{sp} = 4s^3$
$= 4(1.84 \times 10^{-5})^3$
$Cd(OH_2) \rightleftharpoons Cd^{2+} + 2OH^-$
s' represents the solubility in buffer solution
pH = 12
pOH = 2
$[OH^-] = 10^{-2}$
$s' \times (10^{-2})^2 = 4(1.84 \times 10^{-5})^3$
So, $s' = 2.492 \times 10^{-10}$ moles L^{-1}
Hence option (b) is the answer.