

**1. Which of the following are Lewis acids?**

- (a)  $\text{PH}_3$  and  $\text{BCl}_3$
- (b)  $\text{AlCl}_3$  and  $\text{SiCl}_4$
- (c)  $\text{PH}_3$  and  $\text{SiCl}_4$
- (d)  $\text{BCl}_3$  and  $\text{AlCl}_3$

**Solution:**

The compound which can accept a pair of electrons is known as Lewis acid.  $\text{BCl}_3$  and  $\text{AlCl}_3$  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)  $(\text{HSO}_4)^-$
- (b)  $\text{Na}_2\text{CO}_3$
- (c)  $\text{NH}_3$
- (d)  $\text{OH}^-$

**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.  $(\text{HSO}_4)^-$  can donate and accept a proton.

Hence option (a) is the answer.

**3. What is the conjugate base of  $\text{OH}^-$ ?**

- (a)  $\text{O}_2$
- (b)  $\text{H}_2\text{O}$
- (c)  $\text{O}^-$
- (d)  $\text{O}^{2-}$

**Solution:**

When acid gives  $\text{H}^+$  then the remaining of its part is called the conjugate base.

The conjugate base of  $\text{OH}^-$  is  $\text{O}^{2-}$ .

Hence option (d) is the answer.

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

- (a)  $\text{H}_2\text{S}$
- (b)  $\text{NH}_3$
- (c)  $\text{PH}_3$
- (d)  $\text{H}_2\text{O}$

**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,  $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ ,  $\Delta H = -57.2 \text{ kJ mol}^{-1}$  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  $K_c$  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  $NH_4OH = 4.7$ ]**

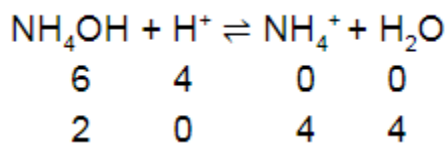
- (a) 9.4
- (b) 9.0
- (c) 5.0
- (d) 5.2

**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  $NH_4OH \Rightarrow n_{NH_4OH} = 6$



Solution is basic buffer.

$$\text{pOH} = \text{pK}_b + \log \frac{[\text{NH}_4^+]}{[\text{NH}_4\text{OH}]} = 4.7 + \log (4/2)$$

$$= 4.7 + \log 2$$

$$= 4.7 + 0.3$$

$$= 5$$

$$\text{pH} = 14 - \text{pOH}$$

$$= 14 - 5 = 9$$

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.

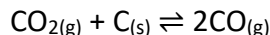
Hence option (d) is the answer.

**10. A vessel at 1000 K contains  $\text{CO}_2$  with a pressure of 0.5 atm. Some of the  $\text{CO}_2$  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



Total pressure =  $0.5 - P + 2P = 0.8$

$$P = 0.8 - 0.5 = 0.3$$

$$K_P = \frac{P_{\text{CO}}^2}{P_{\text{CO}_2}} = \frac{(2P)^2}{(0.5 - P)}$$

$$= \frac{(0.6)^2}{0.2}$$

$$= 0.36/0.2$$

$$= 1.8 \text{ atm}$$

Hence option (a) is the answer.

**11. Which of the following is a Lewis acid?**

- (a) NaH
- (b)  $\text{NF}_3$
- (c)  $\text{PH}_3$
- (d)  $\text{B}(\text{CH}_3)_3$

**Solution:**

The compound which can accept a pair of electrons is known as Lewis acid.  $\text{B}(\text{CH}_3)_3$  is a Lewis acid.

Hence option (d) is the answer.

**12. The exothermic formation of  $\text{ClF}_3$  is represented by the equation:**

$\text{Cl}_{2(g)} + 3\text{F}_{2(g)} \rightleftharpoons 2\text{ClF}_{3(g)}$ ;  $\Delta H = -329 \text{ kJ}$  Which of the following will increase the quantity of  $\text{ClF}_3$  in an equilibrium mixture of  $\text{Cl}_2$ ,  $\text{F}_2$  and  $\text{ClF}_3$ ?

- (a) Increasing the temperature
- (b) Removing  $\text{Cl}_2$
- (c) Increasing the volume of the container
- (d) Adding  $\text{F}_2$

**Solution:**

The addition of reactants or removal of the product will favour the forward reaction.

So adding  $\text{F}_2$  will increase the quantity of  $\text{ClF}_3$ .

Hence option (d) is the answer.

**13. Among the following acids which have the lowest  $\text{pK}_a$  value?**

- (a)  $\text{CH}_3\text{COOH}$
- (b)  $(\text{CH}_3)_2\text{CH-COOH}$
- (c)  $\text{HCOOH}$
- (d)  $\text{CH}_3\text{CH}_2\text{COOH}$

**Solution:**

Higher the  $pK_a$  value, weaker is the acid. So the strongest acid has the lowest  $pK_a$  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:**

$$\Delta G = \Delta G^\circ + 2.303 RT \log K_c$$

At equilibrium,  $\Delta G = 0$

$$\text{So } \Delta G^\circ = -2.303 RT \log K_c$$

Hence option (d) is the answer.

**15. The molar solubility of  $\text{Cd}(\text{OH})_2$  is  $1.84 \times 10^{-5}$  M in water. The expected solubility of  $\text{Cd}(\text{OH})_2$  in a buffer solution of  $\text{pH} = 12$  is**

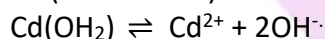
- (a)  $1.84 \times 10^{-9}$  M
- (b)  $2.49 \times 10^{-10}$  M
- (c)  $(2.49/1.84) \times 10^{-9}$  M
- (d)  $6.23 \times 10^{-11}$  M

**Solution:**

Given molar solubility,  $s = 1.84 \times 10^{-5}$

$$K_{sp} = 4s^3$$

$$= 4(1.84 \times 10^{-5})^3$$



$s'$  represents the solubility in buffer solution

$$\text{pH} = 12$$

$$\text{pOH} = 2$$

$$[\text{OH}^-] = 10^{-2}$$

$$s' \times (10^{-2})^2 = 4(1.84 \times 10^{-5})^3$$

$$\text{So, } s' = 2.492 \times 10^{-10} \text{ moles L}^{-1}$$

Hence option (b) is the answer.