10.IONIC EQUILIBRIUM

CONCEPT OF NEUTRALISATION & PH CALCULATIONS

TEACHING TASK

JEE MAIN LEVEL

1. P^H of $NaOH$ solution is 13. The amount of $NaOH$ present in 100ml of the solution is

   A) 0.2gm B) 0.3gm C) 0.4gm D) 0.1gm

Answer:C

Solution:

Step 1: Relate pH to pOH

$$p^H + p^{OH} = 14 \Rightarrow p^{OH} = 14 - 13 = 1$$

Step 2: Find OH^- concentration

$$[OH^-] = 10^{-pOH} = 10^{-1} = 0.1M$$

Step 3: Find moles of NaOH in 100 ml

$$\text{Moles in } 100\,mL = 0.1M \times 0.1L = 0.01 mol$$

Step 4: Convert moles to grams

$$\text{Mass of NaOH} = 0.01 \times 40 = 0.4 g$$

2. When 50ml of 0.1M $NaOH$ is mixed with 50ml of 0.1M H_2SO_4 the resultant solution is **(FA & SA- 2 Marks)**

   A) acidic B) basic C) Neutral D) Cannot be predicted

Answer:A

Solution:Step 1: Moles of NaOH

0.1 M × 0.050 L = 0.005 mol

Step 2: Moles of H_2SO_4

0.1 M × 0.050 L = 0.005 mol

Step 3: Reaction

H_2SO_4 needs 2 NaOH for full neutralization:

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Step 4: Check limiting reagent

0.005 mol NaOH can neutralize only 0.0025 mol H_2SO_4

But we have 0.005 mol H_2SO_4 $\rightarrow$ 0.0025 mol H_2SO_4 remains

Step 5: Result

Excess strong acid $\rightarrow$ Acidic solution

3. At 25° C, $[H_3O^+]$ is 4×10^{-5} M, the value of kw at that temperature is _____

A) 2.5×10^{-15} moles²/litre²　　B) 1.5×10^{-13} moles²/litre²

C) 1×10^{-14} moles²/litre²　　D) 11.35×10^{-12} moles²/litre²

Answer:C

Solution:The value of the ion product of water, (K_w), is a constant at a given temperature. At 25°C, its value is universally accepted as: K_w = 1×10^{-14} moles²/litre²

4. Which of the following solution will have a pH exactly equal to 8 ?

A) 10^{-8} M HCl solution at 25°C　　B) 10^{-8} M H^+ solution at 25°C

C) 2×10^{-6} M $Ba(OH)_2$ solution at 25°C　D) 10^{-5} M NaOH solution at 25°C

Answer:B

Solution:The pH scale is a measure of the acidity or basicity of a solution. It is defined as: $pH = -\log(H^+)$

The first option is a solution of 10^{-8} M HCl.

However, the concentration of HCl is 10^{-8} M,

which means the concentration of (H^+) ions would also be 10^{-8} M.

In pure water at 25°C, the concentration of (H^+) is 10^{-7} M due

to the autoionization of water. Therefore, the total (H^+) in this solution would be:

$(H^+) = 10^{-8} + 10^{-7} = 1.1\times10^{-7}$ M

Now, calculating the pH: $pH = -\log(1.1\times10^{-7}) \approx 6.96$

The second option is a solution with a concentration of 10^{-8} M (H^+)

Here, we can directly use the concentration of (H^+) to find the pH:

$$pH = -\log(10^{-8}) = 8$$

$C)2\times10^{-6}$ M $Ba(OH)_2$ *solution*

$Ba(OH)_2$ *isastrongbasethatproducestwo* OH^- *ionspermolecule.*

$$[OH^-] = 2\times[Ba(OH)_2] = 2\times(2\times10^{-6}\ M) = 4\times10^{-6}\ M$$

$$pOH = -\log(4\times10^{-6}) \approx 5.40$$

$$pH = 14 - 5.40 = \mathbf{8.60}(Incorrect)$$

$D)10^{-5}$ M NaOH *solution*

NaOH *isastrongbasethatproducesone* OH^- *ionpermolecule.*

$$[OH^-] = [NaOH] = 10^{-5}\ M$$

$$pOH = -\log(10^{-5}) = 5$$

$$pH = 14 - 5 = \mathbf{9}(Incorrect)$$

5. 100ml of 0.1M H_2SO_4 is diluted to 250ml, then change in P^H value is

(FA & SA- 5 Marks / 8 Marks)

A) 1.2010 B) 1.6990 C) 0.3979 D) 6.6990

Answer:C

Solution:Step 1: Initial $[H^+]$

H_2SO_4 is diprotic and strong acid:

$$[H^+]_{initial} = 2\times0.1 = 0.2\,M$$

$$pH_{initial} = -\log(0.2) \approx 0.69897$$

Step 2: After dilution

Moles of H^+ =0.2 M×0.100 L=0.02 mol

Final volume = 250 ml = 0.250 L

$$[H^+]_{final} = \frac{0.02}{0.250} = 0.08\,M$$

$$pH_{final} = -\log(0.08) \approx 1.09691$$

Step 3: Change in pH

$$\Delta pH = 1.09691 - 0.69897 \approx 0.39794$$

6. P^H of decimolar solution of NH_4OH is ________ (K_b for NH_4OH is 10^{-5})

A) 3 B) 11 C) 5 D) 12

Answer:B

Solution:We are given:

$C = 0.1 M NH_4OH (Weak base)$

$K_b = 10^{-5}$

Step 1: Find $[OH^-]$

For a weak base:

$$[OH^-] = \sqrt{K_b C} = \sqrt{10^{-5} \times 0.1}$$

$$[OH^-] = \sqrt{10^{-6}} = 10^{-3} M$$

Step 2: Find p^{OH}

$$p^{OH} = -\log(10^{-3}) = 3$$

Step 3: Find pH

$$p^{H} = 14 - p^{OH} = 14 - 3 = 11$$

7. Number of $[H_3O^+]$ ions present in 20 ml of water at 25° is

A) 6.023×10^{24} B) 12.046×10^{14} C) 12.046×10^{12} D) 9.0345×10^{22}

Answer:B

Solution:In pure water at 25°C, $[H_3O^+] = 1.0 \times 10^{-7} M$

Moles in 20 mL: $1.0 \times 10^{-7} \times 0.020 = 2.0 \times 10^{-9} mol.$

Number of ions = moles × N_A = $2.0 \times 10^{-9} \times 6.022 \times 10^{23} = 1.2044 \times 10^{15} = 12.044 \times 10^{14}$

8. Equal volumes of two HCl solutions with P^H values 3 & 4 are mixed. molarity of the resulting solution is __________

A) 5.5×10^{-4} B) 5.5×10^{-7} C) 2.75×10^{-6} D) 6.25×10^{-6}

Answer:A

Solution:

$pH_1 = 3 \Rightarrow [H^+]_1 = 10^{-3}$ M

$pH_2 = 4 \Rightarrow [H^+]_2 = 10^{-4}$ M

$\text{Moles}_{\text{total}} = (M_1 \times V_1) + (M_2 \times V_2)$

$\text{Moles}_{\text{total}} = (10^{-3} \cdot V) + (10^{-4} \cdot V)$

$\text{Moles}_{\text{total}} = V(10^{-3} + 10^{-4}) = V(0.001 + 0.0001) = \mathbf{V(0.0011)}$ mol

$M_{\text{final}} = \dfrac{\text{Moles}_{\text{total}}}{\text{Total Volume}} = \dfrac{V(0.0011)}{2V} M_{\text{final}} = \dfrac{0.0011}{2} = 0.00055\text{ M} = \mathbf{5.5 \times 10^{-4}}$ M

9. K_W of water at a cartain temperature is 9×10^{-14} moler^2 / litre^2. P^H of H_2O at that temperature is ________ **(FA & SA- 3 Marks / 4 Marks)**

A) 7 B) 6.5229 C) 5.4771 D) 3.9216

Answer:B

Solution:We are given: $K_w = 9 \times 10^{-14}\ M^2$

Step 1: Find [H $^+$] in pure water

In pure water:

$[H^+] = \sqrt{K_w} = \sqrt{9 \times 10^{-14}}$

$[H^+] = 3 \times 10^{-7} M$

Step 2: Find pH

$pH = -\log(3 \times 10^{-7})$

$pH = -\log 3 - \log 10^{-7}$

$pH = -0.4771 + 7 = 6.5229$

10. Pure water ionise as

$2H_2O\ (l) \rightleftharpoons H_3O^+(aq) + OH^-\ (aq)$

At 25°C the pH of pure water is approximately 7.0 At 37°C its pH is :

A) More than 7.0 B) Less than 7.0 C) Equal to 7.0 D) None of these

Answer:B

Solution:When temperature increases (from 25°C $\rightarrow$ 37°C):

The equilibrium shifts to the right (since the process absorbs heat).

So both [H$^+$] and [OH$^-$] increase.Hence, K_w increases

At 25°C $\rightarrow K_w = 1 \times 10^{-14}$, so pH = 7.0

At 37°C $\rightarrow K_w > 1 \times 10^{-14}$

$[H^+] > 1\times10^{-7}$

pH < 7.0

11. Which of the following solution will have pH close to 1.0 ?

A) 100 ml of M/10 HCl + 100 ml of M/10 NaOH

B) 55 ml of M/10 HCl + 45 ml of M/10 NaOH

C) 10 ml of M/10 HCl + 90 ml of M/10 NaOH

D) 75 ml of M/5 HCl + 25 ml of M/5 NaOH.

Answer:D

Solution:

Option A:100 mL of M/10 HCl + 100 mL of M/10 NaOH

Both have same moles of acid and base.

Complete neutralization $\rightarrow$ solution is neutral $\rightarrow$ pH = 7

Option B:55 mL of M/10 HCl + 45 mL of M/10 NaOH

Moles of HCl = $0.055\times\frac{1}{10}=0.0055$ mol

Moles of NaOH = $0.045\times\frac{1}{10}=0.0045$ mol

Excess H^+ = 0.0055-0.0045=0.0010 mol

Total volume = 55+45=100 mL = 0.1 L

$$[H^+]=\frac{0.001}{0.1}=0.01M$$

$$pH=-\log(0.01)=2$$

Option C:

10 mL of M/10 HCl + 90 mL of M/10 NaOH

Moles HCl = 0.01 × 0.01 = 0.0001 mol

Moles NaOH = 0.01 × 0.09 = 0.0009 mol

Excess OH^- = 0.0008 mol $\rightarrow$ basic solution

Option D:75 mL of M/5 HCl + 25 mL of M/5 NaOH

Moles HCl = 0.075 × 0.2 = 0.015 mol

Moles NaOH = 0.025 × 0.2 = 0.005 mol

Excess H^+ = 0.015 – 0.005 = 0.010 mol

Total volume = 0.075 + 0.025 = 0.100L

pH=-log(0.1)=1

12. 10 mL of 10^{-6} M HCI solution is mixed with 90 mL H_2O. pH will change approximately:

A) By one unit B) By 0.3 unit C) By 0.7 unit D) By 0.1 unit

Answer:C

Solution:

$$\textit{The initial concentration of } \mathrm{HCl} \textit{ is } 10^{-6}\ \mathrm{M}. \textit{Since } 10^{-6}\ \mathrm{M} \gg 10^{-7}\ \mathrm{M}(\mathrm{H}^{+} \textit{ from water}),$$

$$\textit{we can approximate the initial } \mathrm{pH} \textit{ by ignoring water's contribution}:$$

$$\mathrm{pH}_1 = -\log_{10}[\mathrm{H}^+]_{\text{initial}} = -\log_{10}(10^{-6}) = \mathbf{6.0}$$

$$\textit{Final } \mathrm{H}^+ \textit{ Concentration } (\mathrm{C}_2)$$

$$\textit{The acid is diluted from } V_1 = 10\ \mathrm{mL} \textit{ to a total volume of } V_2 = 10\ \mathrm{mL} + 90\ \mathrm{mL} = 100\ \mathrm{mL}$$

$$\textit{Using the dilution formula } \mathrm{C}_1\mathrm{V}_1 = \mathrm{C}_2\mathrm{V}_2:$$

$$[\mathrm{H}^+]_{\text{diluted}} = 10^{-6}\ \mathrm{M} \times \frac{10\ \mathrm{mL}}{100\ \mathrm{mL}} = 10^{-7}\ \mathrm{M}$$

Since the diluted concentration of the acid (10^{-7}M) is equal to the concentration of H^+ from pure water (10^{-7}M), we must consider the contribution from water's autoionization.The exact total H^+ concentration $[H^+]_2$ is found by solving:

$$[\mathrm{H}^+]_2 = [\mathrm{H}^+]_{\text{acid}} + [\mathrm{H}^+]_{\text{water}} \Rightarrow [\mathrm{H}^+]_2 = 10^{-7} + x$$

Where x is the $[OH^-]$ from water. The final H^+ concentration is approximately:

$$[\mathrm{H}^+]_2 \approx 2\times10^{-7}\ \mathrm{M}$$

$$\mathrm{pH}_2 = -\log_{10}(2\times10^{-7}) \approx \mathbf{6.70}$$

$$\Delta\mathrm{pH} = \mathrm{pH}_2 - \mathrm{pH}_1 = 6.70 - 6.0 = \mathbf{0.70}$$

13. Number of H^+ ions present in 10 mL of solution of pH = 3 are:

A) 10^{13} B) 6.02×10^{18} C) 6.02×10^{13} D) 6.02×10^{10}

Answer:B

Solution:

$Given\,\mathrm{pH} = 3$

$[H^+] = 10^{-pH} = 10^{-3}$ M

Moles = Molarity × Volume (L)

Moles of $H^+ = (10^{-3}$ mol/L$) \times (0.010$ L$)$

Moles of $H^+ = 10^{-5}$ mol

Number of ions = Moles × N_A

Number of H^+ ions $= (10^{-5}$ mol$) \times (6.02 \times 10^{23}$ ions/mol$)$

Number of H^+ ions $= \mathbf{6.02 \times 10^{18}}$

JEE ADVANCED LEVEL

Multicorrect Answer Type

14. Which of the following statements are correct

A) heat liberated during the neutralisation reaction

B) When one mole of H^+ ions react with one mole of OH^- ions the heat liberated is 13.7 kcal/mole

C) $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ ΔH= +0.3 k cal/mole

D) The number of equivalents of a solute present in one litre of solution is called Molarity

Answer:A,B,C

Solution:

A) Heat liberated during the neutralisation reaction

True — Neutralisation is always exothermic.

B) When one mole of H^+ reacts with one mole of OH^- ions, the heat liberated is 13.7 kcal/mol

True — Enthalpy of neutralisation for a strong acid–strong base = 13.7 kcal/mol (˜ 57 kJ/mol).

C) $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$, ΔH = +0.3 kcal/mol

True — Ionisation of a weak acid (acetic acid) is endothermic (ΔH positive, small value).

D) The number of equivalents of solute present in one litre of solution is called Molarity

False — That defines Normality, not molarity

15. Which of the following statement is incorrect

A) At 25°C ionic product of water $\simeq 1 \times 10^{-14}$ moles^2 / lit ^{2}

B) Molarity × Number of litres of solution = Number of moles of solute

C) The unit of molarity is mol L or mol dm.

D) On adding an acid $[H^+]$ increases, as the ionic product of water decreases.

Answer:C,D

Solution:A) At 25°C, ionic product of water ˜ 1 × 10?¹4 mol²/L² → Correct

B) Molarity × Litres of solution = Moles of solute → Correct

C) Unit of molarity = mol L^{-1} or mol dm^{-1}

D)On adding an acid $[H^+]$ increases, as the ionic product of water is constant the $[OH^-]$ decreases.

Statement Type

16 Assertion A: P^H of a solution changes from 6 to 7 when diluted by 10 times

Reason R: If $[H^+]$ decreases 10 times, P^H increases by one unit .

Answer: A

Solution:When a solution is diluted 10 times, the concentration of $[H^+]$ decreases to one-tenth of its original value.

Since pH=-log$[H^+]$ a tenfold decrease in $[H^+]$ causes pH to increase by log(10)=1unit.

Hence, if pH was initially 6, it becomes 7 after dilution

17. Assertion A: P^H of a solution of CH_3COOH decreases on dilution.

Reason R: On dilution, degree of ionization of CH_3COOH increases.

Answer: D

Solution:Assertion (A) is false, and Reason (R) is true. When a solution of CH_3COOH is diluted, the degree of ionization increases, which means more CH_3COOH molecules dissociate into H^+ and CH_3COO^- ions, but the overall concentration of H^+ ions decreases because the volume of the solution increases by a greater factor. Since pH is calculated as -log$[H^+]$, a decrease in $[H^+]$ leads to an increase in pH.

Comprehension Type

When a mixture of strong acids are present in the aqueous solutions, the normality N of the mixture = $\dfrac{V_1N_1 + V_2N_2}{V_1 + V_2}$.

Where V_1 and N_1 are the volume and normality of first acid; V_2 and N_2 are the volume and normlaity of second acid.

$$pH = -\log [N] = -\log \left[\frac{V_1N_1 + V_2N_2}{V_1 + V_2}\right]$$

When a mixture of strong bases are present in the aqueous solutions, the normalty N of the mixture.

$$= \frac{V_1N_1 + V_2N_2}{V_1 + V_2}$$

The $[OH^-]$ in the mixture = Normality of the mixture.

$$pOH = -\log [N] = -\log \frac{V_1N_1 + V_2N_2}{V_1 + V_2}$$

18. 75ml of 0.2M HCl is mixed with 25ml of 1M HCl. To this solution 300ml of distilled water is added. What is the pH of the resultant solution?

A) 1 B) 2 C) 4 D) 0.2

Answer:A

Solution:We have:

75 mL of 0.2 M HCl $\rightarrow$ moles = $0.075 \times 0.2 = 0.015 mol$

25 mL of 1 M HCl $\rightarrow$ moles = $0.025 \times 1 = 0.025$ mol

Total moles of HCl = 0.015+0.025=0.04 mol

Total volume after adding 300 mL water:75+25+300=400 mL = 0.4 L

Molarity = $\frac{0.04}{0.4} = 0.1$ M

For strong acid, $[H^+] = 0.1M \Rightarrow pH = -\log_{10}(0.1) = 1$

19. Equal volumes of two solutions with P^H =3 and P^H =11 are mixed. Then the P^H of resulting solution is

A) 8 B) 7 C) 6 D) 0

Answer:B

Solution:One solution has pH = 3 $\rightarrow$ $[H^+] = 10^{-3}$ M.

The other has pH = 11 $\rightarrow$ pOH = 3 $\rightarrow$ $[OH^-] = 10^{-3}$ M (so $[H^+] = 10^{-11}$ M).

Equal volumes $\rightarrow$ equal moles of H^+ and OH^-, so they neutralize completely $\rightarrow$ resulting solution is essentially neutral (only the very diluted salt + water) $\rightarrow$ pH ˜ 7

Integer Type

20. The highest acidic solution has a pH of _____

Answer:0

Solution:The highest acidic solution has a pH of 0. While pH values can theoretically go below 0 for very strong, concentrated acids, on the standard 0-14 scale, 0 represents the highest acidity.

21 At 50^0C, pH + pOH is equal to _______

Answer:13.3

Solution:At 50^0C, $K_w = 5.5\times10^{-14}$

pH + pOH = $-\log(K_w) = -\log(5.5\times10^{-14}) = 13.3$

Matrix Matching Type

22 K_w under conditions of high temperature and pressure is 1.0×10^{-10}. Match the following

Column-I	Column-II
A. Solution of pH 5.5	p.Neutral
B. Solution of pH 5	q. Acidic
C. Solution of pH 4	r. $[OH^-] = 10^{-3}M$
D. Solution of pH 7	s. Basic

Answer:A-s,B-p,C-q,D-s,r

Solution:

$$K_w = 1.0\times10^{-10}$$

$$pK_w = 10 \Rightarrow pH + pOH = 10$$

Neutral solution: pH=pOH=5

So,pH>5 are basic

pH<5 are acidic

A. Solution of pH 5.5	s. Basic
B. Solution of pH 5	p.Neutral
C. Solution of pH 4	q. Acidic
D. Solution of pH 7	s. Basic, r. $[OH^-] = 10^{-3}M$

LEARNERS TASK

Conceptual Understanding Questions (CUQ's)

1. Ionic product of water at 80° C is _____

A) $>10^{-14}$ moles^2/litre^2 B) $<10^{-14}$ moles^2/litre^2 C)10^{-14} moles^2/litre^2 D) none

Answer:A

Solution:K_w increases with temperature. At 25°C, $K_w = 10^{-14}$. At 80°C, $K_w > 10^{-14}$

2. P^H of 10^{-2} M HCl solution is _______

A) 2 B) 3 C) 8 D) 12

Answer:A

Solution:1. Identify $[H^+]$

HCl is a strong acid, so it dissociates completely: $[H+] = 10^{-2}$ M

Calculate pH

$p^H = -\log(10^{-2}) = 2$

3. P^H of 10^{-3} M NaOH solution is ________

A) 3 B) 13 C) 11 D) 10

Answer:C

Solution:1. Identify $[OH^-]$

NaOH is a strong base, so it dissociates completely:

$[OH^-] = 10^{-3}$ M

2. Calculate p^{OH}

$p^{OH} = -\log(10^{-3}) = 3$

3. Calculate pH

$p^H = 14 - p^{OH} = 14 - 3 = 11$

4. Conjugate base of NH_3 is _________

A) NH_4^+ B) NH_4OH C) NH_2^- D) OH^-

Answer:C

Solution:When NH_3 loses a proton: $NH_3 \rightarrow NH_2^- + H^+$

5. At 75^0C $P^H + P^{OH}$

A) 14 B) than 14 C) less than 14 D) Can not be preidicted

Answer:C

Solution: 1. Relationship between pH and pOH

We know:

$p^H + p^{OH} = pK_w$

$At 25^0 C, k_w = 1\times10^{-14}$

So $pK_w = 14$

2. Effect of temperature

K_w increases with temperature.

$At\, 75^0 C > 10^{-14}$

So $pK_w < 14$

Thus: $p_H + p_{OH} < 14$

6. P^H of 0.0015 M H_2SO_4 is ______

A) 3.5×10^{-2} B) 0.35 C) 4.25 D) 2.5229

Answer:D

Solution:1. Find $[H^+]$

H_2SO_4 is a strong diprotic acid: $[H^+] = 2 \times 0.0015 = 0.0030\,M$

2. Calculate pH

$$pH = -\log(0.0030)$$
$$pH = -\log(3.0 \times 10^{-3})$$
$$pH = -[\log 3 + \log 10^{-3}]$$
$$pH = -[\log 3 - 3]$$
$$pH = -[0.4771 - 3] = -0.4771 + 3 = 2.5229$$

7. The solution which has the lowest P^H value is

A) 1M $NaOH$ B) $1M\, K_2SO_4$ C) $1M\, HCl$ D) $1N\, CH_3COOH$

Answer:C

Solution:1 M HCl $\rightarrow$ $[H^+]$ = 1 M $\rightarrow$ pH = 0 (lowest)

1 M NaOH $\rightarrow$ pH = 14

1 M K_2SO_4 $\rightarrow$ neutral $\rightarrow$ pH = 7

1 N CH_3COOH $\rightarrow$ weak acid, pH > 0

8. P^H of HCl solution is 4.6990 then $\left[H^+\right]$ concetration is

A) 5×10^{-3} B) 3×10^{-5} C) 2×10^{-5} D) 1×10^{-4}

Answer:C

Solution: 1. Relationship between pH and $[H^+]$

$$pH = -\log[H^+]$$
$$[H^+] = 10^{-pH}$$

2. Substitute given pH

$[H^+] = 10^{-4.6990}$

$[H^+] = 0.0000199986 = 1.999 \times 10^{-5} \approx 2 \times 10^{-5}$

9. p^H of H_2SO_4 is 2, then molarity of the acid is ________

A) 0.01 B) 0.02 C) 0.005 D) 0.03

Answer:B

Solution:pH of H_2SO_4=2

$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

$[H^+]=10^{-2}$

$2[H^+]=2 \times 10^{-2}=0.02$

10. pH of 10 $MHCl(aq)$ on Sorenson's scale is:

A) -1 B) 0 C) 10 D) 5

Answer:B

Solution:

1. Identify $[H^+]$

HCl is a strong acid, so: $[H^+] = 10\,M$

2. Calculate pH: $pH = -\log(10) = -1$

Sorenson's scale ,pH=0 to 14,there is no -1

So, pH=0

JEE MAIN LEVEL

11. For pure water : **(FA & SA- 2 Marks)**

A) pH increases and pOH decreases with rise in temperature

B) pH decreases and pOH increases with rise in temperature

C) Both pH and pOH increase with rise in temperature

D) Both pH and pOH decrease with rise in temperature

Answer:D

Solution:Step 1: Recall what happens to K_W with temperature

$H_2O \rightleftharpoons H^+ + OH^-$

This reaction is endothermic, so when temperature increases,K_W increases

Step 2: Effect on $[H^+]$ and $[OH^-]$ in pure water

$[H^+] = [OH^-] = \sqrt{K_w}$

So as K_W increases, both $[H^+]$ and $[OH^-]$ increase.

Step 3: Effect on pH and pOH

$$pH = -\log[H^+], pOH = -\log[OH^-]$$

If $[H^+]$ and $[OH^-]$ increase, both pH and pOH decrease

12. An acid solution with pH = 6 at 25°C is diluted by 10^2 times. The pH of solution will:

A) Decrease by 2
B) Increase by 2
C) Decrease by 0.95 approximately
D) Increase by 0.95 approximately

Answer:D

Solution:

Given: Initial pH = 6

So, $[H^+] = 10^{-6}$ M

After dilution by (10^2) times (i.e., 100 times),

$$[H^+]_{new} = \frac{10^{-6}}{100} = 10^{-8}\ M$$

But we must consider auto-ionization of water:

$[H^+]_{total} = [H^+]_{acid} + [H^+]_{water}$

$[H^+]_{water} = 10^{-7}M$

$[H^+]_{total} = 10^{-8} + 10^{-7} = 1.1 \times 10^{-7}M$

pH = $-\log(1.1 \times 10^{-7}) \approx 6.96$

Hence, the pH increases from 6 to ˜ 6.95,

Increase by ~0.95**

13. 10 mL, of a strong acid solution of pH = 2.000 are mixed with 990 mL of another strong acid solution of pH = 4.000. The pH of the resulting solution will be:

A) 4.002
B) 4.000
C) 4.200
D) 3.7

Answer:D

Solution:Solution 1: pH = 2.000 $\rightarrow [H^+] = 1.00 \times 10^{-2}\ M$

Volume = 10 mL $\rightarrow$ moles of H^+ = $(1.00 \times 10^{-2}) \times 0.010 = 1.00 \times 10^{-4}\ mol$

Solution 2: pH = 4.000 $\rightarrow [H^+] = 1.00 \times 10^{-4}\ M$

Volume = 990 mL $\rightarrow$ moles of H^+ = $(1.00 \times 10^{-4}) \times 0.990 = 9.90 \times 10^{-5}\ mol$

2. Total moles of H^+

Total moles H^+ = $1.00 \times 10^{-4} + 9.90 \times 10^{-5} = 1.99 \times 10^{-4}$ mol

3. Total volume

$$V_{total} = 10 + 990 = 1000\,mL = 1.000\,L$$

4. Final [H⁺]

$$[H^+]_{final} = \frac{1.99 \times 10^{-4}}{1.000} = 1.99 \times 10^{-4}\,M$$

5. Final pH

$$pH = -\log(1.99 \times 10^{-4}) \approx -\log(2.00 \times 10^{-4}) = 4 - \log 2.00$$
$$\log 2.00 \approx 0.3010 \Rightarrow pH \approx 3.699$$

14. At 25°C K_b for BOH = 1.0×10^{-12} . 0.01 M solution of BOH has $[OH^-]$:

A) 1.0×10^{-6} M B) 1.0×10^{-7} M C) 1.0×10^{-5} M D) 2.0×10^{-6} M

Answer:B

Solution:The reaction takes place as, $BOH \rightleftharpoons B^+ + OH^-$

The given values are,K_b=1.0×10^{-12}

[BOH] =0.01M

$$K_b = \frac{[B^+][OH^-]}{[BOH]}$$

For the equilibrium condition, $[B^+] = [OH^-]$

$$K_b = \frac{[OH^-]^2}{[BOH]}$$

$$1.0 \times 10^{-12} = \frac{\left[OH^-\right]^2}{0.01}$$
$$[OH]^{-2} = 1 \times 10^{-14}$$
$$OH^- = 1.0 \times 10^{-7}\,mol$$

15. Hydrogen ion concentration in mol/L in a solution of pH = 5.4 will be **[AIEEE-2005]** **(FA & SA- 3 Marks / 4 Marks)**

A) 3.98×10^{8} B) 3.88×10^{6} C) 3.68×10^{-6} D) 3.98×10^{-6}

Answer:D

Solution:1. Formula

$$pH = -\log[H^+]$$
$$[H^+] = 10^{-pH}$$

2. Substitute pH = 5.4

$[H^+] = 10^{-5.4} = 0.0000039811 = 3.98 \times 10^{-6} M$

16. How many litres of water must be added to 1 litre an aqueous solution of HCl with a pH of 1 to create an aqueous solution with pH of 2 ?
[JEE(Main) 2013]

A) 0.1 L B) 0.9 L C) 2.0 L D) 9.0 L

Answer:D

Solution:Given:

Initial pH = 1 $\rightarrow [H^+]_1 = 10^{-1} = 0.1M$

Final pH = 2 $\rightarrow [H^+]_2 = 10^{-2} = 0.01M$

Initial volume = 1 L

Final volume = ?

Step 1: Apply dilution formula

$$M_1V_1 = M_2V_2$$
$$0.1 \times 1 = 0.01 \times V_2$$
$$V_2 = \frac{0.1}{0.01} = 10\,L$$

Step 2: Water added

$Water\ added = V_2 - V_1 = 10 - 1 = 9\,L$

17. P^H of $NaOH$ solution is 12. The amount of NaOH present in 2 litres of the solution is

A) 0.8gm B) 0.4gm C) 1.2gm D) 3.45gm

Answer:A

Solution:Given:pH = 12

pOH = 14 - 12 = 2

$[OH^-] = 10^{-pOH} = 10^{-2} = 0.01M$

That means the NaOH concentration = 0.01 M, because each NaOH gives one OH^-.

Now,Moles of NaOH = M x V = 0.01 x 2 = 0.02 ,mol

Molecular weight of NaOH = 40 g/mol

Mass = 0.02 x 40 = 0.8 g

18. pH of a sample of KOH and another of NaOH are 10 and 12 respectively. Their normalities are related as $N_{NaOH} = xN_{KOH}$. What is the value of x?

(FA & SA- 5 Marks / 8 Marks)

A) 5/6 B) 6/5 C) 10^2 D) 10^{-2}

Answer:C

Solution: Given: pH of KOH = 10 , pH of NaOH = 12

For bases,[pOH = 14 - pH]

So,For KOH, pOH = 14 - 10 = 4

For NaOH, pOH = 14 - 12 = 2

Now,$OH^- = 10^{-pOH}$

$[OH^-]_{KOH} = 10^{-4}M$

$[OH^-]_{NaOH} = 10^{-2}M$

Normality (N) = concentration of OH^- (since both are monobasic bases):

$N_{NaOH} = 10^{-2}M$, $N_{KOH} = 10^{-4}M$

Now,$N_{NaOH} = x\, N_{KOH}$

$10^{-2} = x\, 10^{-4}$

$x = 10^2 = 100$

19. 100 mL of 0.2 N NaOH is mixed with 100 mL 0.1 NHCl and the solution is made 1L. The pH of the solution is:

A) 4 B) 8 C) 10 D) 12

Answer:D

Solution:

NaOH: 0.2 N = 0.2 M. Moles in 100 mL = $0.2\times0.1 = 0.02$ mol.

HCl: 0.1 N = 0.1 M. Moles in 100 mL = 0.1×0.1=0.01 mol.

Neutralization: 0.02-0.01=0.01 mol OH^- remains (excess base).

Final volume = 1.00 L $\rightarrow [OH^-]$=0.01 M.

pOH = -log0.01=2.

pH = 14-2=12

20. At 90^0 C, pure water has $[H_3O]^+ = 10^{-6}$ mole lts^{-1}. Value of Kw at 90^0 C

A) 10^{-14} B) 10^{-8} C) 10^{-6} D) 10^{-12}

Answer:D

Solution:At 90°C, pure water has $[H_3O^+] = 10^{-6}$M

In pure water, $[H_3O^+] = [OH^-]$

So: $K_w = [H_3O^+][OH^-] = (10^{-6})(10^{-6}) = 10^{-12}$

JEE ADVANCED LEVEL

Multicorrect Answer Type

21. The correct statements

A) P^H of water decreases with increase in temperature

B) P^H of water remains same with increase in temperature

C)P^H of water decreases with the addition of acid

D)Degree of dissociation of water is independent of temperature

Answer:A,C

Solution:

A is correct: When water is heated, the dissociation of water molecules into H+ and OH- ions increases, leading to a decrease in pH.

C is correct: Adding an acid to water increases the concentration of H+ ions, which directly lowers the pH.

B is incorrect: The pH of water does not stay constant with temperature increase; it actually decreases.

D is incorrect: The degree of dissociation of water is temperature-dependent, meaning more water molecules dissociate into ions as the temperature rises.

Statement/Reason & Assertion Type

22. **Assertion A:** P^H of pure water increases with increase in temperature.

Reason R: Degree of dissociation of water increases with increase in temperature considerable.

Answer:D

Solution:Actually, pH of pure water decreases with temperature because K_w increases $[H^+]$ increases.

Assertion is false.

Reason: Degree of dissociation of water increases with increase in temperature considerably.This is true

23. **Assertion A:** P^H of 10^{-8} HCl is not equal to 8.

Reason R: HCl does not ionize completely in very dilute aqueous solution

Answer:C

Solution:

Assertion: pH of 10^{-8} M HCl is not equal to 8.

True, because at such low concentration, contribution from water's $H^+ \sim 10^{-7} M$ is significant.

Actual $[H^+] \approx 10^{-8} + 10^{-7} = 1.1 \times 10^{-7}$ M $\Rightarrow$ pH $\approx$ 6.96, not 8.

Reason: HCl does not ionize completely in very dilute aqueous solution.

False — HCl is a strong acid and ionizes completely at all dilutions.

The real reason is the H^+ from water autoionization.

Comprehension Type

Phosphoric acid is used as a fertiliser for agriculture and an aqueous soil digesting. 1.00 × 10^{-3} M phosphoric acid is found to have pH = 7. Zinc is an essential micronutrient for plant growth. Plants can absorb zinc in water soluble from only. In the given soil, zinc phosphate is only the source of zinc and phosphate ions

24. Molar concentration of phosphate ion in the soil with pH 7 is :

A) 1.2 × 10^{-4} M B) 2.2 × 10^{-4} M C) 1 × 10^{-3} M D) 1.1 × 10^{-10} M

Answer:B

Solution: $H_3PO_4 \rightleftharpoons 3H^+ + PO_4^{3-}$

overall dissociation constant $K = K_{a1}K_{a2}K_{a3}$

$$K_{a1} = 7.59\times10^{-3}, K_{a2} = 6.17\times10^{-8}, K_{a3} = 4.79\times10^{-13}$$

$$K = K_{a1}K_{a2}K_{a3} = (7.59\times10^{-3})(6.17\times10^{-8})(4.79\times10^{-13}) \approx 2.25\times10^{-22}$$

$$At pH = 7, [H^+] = 10^{-7} M$$

$$H_3PO_4 \rightleftharpoons 3H^+ + PO_4^{3-}$$

$$K = \frac{[H^+]^3[PO_4^{3-}]}{[H_3PO_4]}$$

$$\Rightarrow [PO_4^{3-}] = \frac{K[H_3PO_4]}{[H^+]^3}$$

$$[PO_4^{3-}] = \frac{[2.25\times10^{-22}][(1\times10^{-3}]}{[10^{-7}]^3} = 2.2\times10^{-4}$$

25. Concentration of [Zn^{2+}] in the soil is :

A) 9.1 × 10^{-5} M B) 5.7 × 10^{-9} M C) 4.0 × 10^{-10} M D) 3.0 × 10^{-6} M

Answer:B

Solution:

$$Zn_3(PO_4)_2(s) \rightleftharpoons 3Zn^{2+} + 2PO_4^{3-}$$
$$K_{sp} = [Zn^{2+}]^3[PO_4^{3-}]^2$$

For $Zn_3(PO_4)_2, K_{sp} = 9.0\times10^{-33}$

$$K_{sp} = [Zn^{2+}]^3[PO_4^{3-}]^2$$
$$9.0\times10^{-33} = [Zn^{2+}]^3[2.2\times10^{-4}]^2$$
$$[Zn^{2+}]^3 = \frac{9.0\times10^{-33}}{[2.2\times10^{-4}]^2}$$
$$[Zn^{2+}]^3 = 0.185\times10^{-24}$$
$$Zn^{2+} = 5.7\times10^{-9}$$

Integer Type

26 If pH of solution of NaOH is 12.0 the pH of H_2SO_4 solution of same molarity will be

Answer:1.7

Solution:Step 1: For NaOH solution,pH = 12

$$pOH = 14-12 = 2$$
$$[OH-] = 10^{-2} = 0.01M$$

So, NaOH molarity = 0.01 M

Step 2: For H_2SO_4 solution of same molarity = 0.01 M

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

Strong acid — gives 2 H^+ per molecule

$$[H^+] = 2\times0.01 = 0.02M$$
$$pH = -\log(0.02) = 1.7$$

27 10ml of 0.1 N HCl is added to 990ml solution of NaCl the P^H of resulting solution

Answer:3

Solution:Step 1: Moles of H^+ from HCl

$$N = 0.1, V = 10mL = 0.01L$$

$\text{Moles of } H^{+} = 0.1 \times 0.01 = 0.001$

Step 2: Total volume = 10 + 990 = 1000 mL = 1L

$[H^{+}] = \frac{0.001}{1} = 0.001M = 10^{-3}$

$pH = -\log(10^{-3}) = 3$

Matrix Matching Type

28	**SET -1 (ConC)**	**SET-2 (pH)**
	I) 10^{-1} M HCl	A) 0.6990
	II) 10^{-1} M H_2SO_4	B) Between 1&2
	III) 10^{-1} M CH_3COOH	C) Between 6&7
	IV) 10^{-8} M HCl solution	D) 1

Answer:I-D,II-A,III-B,IV-C

Solution:

I) 10^{-1} M HCl pH = –log(0.1) = 1

II) 10^{-1} M H_2SO_4 $[H^+] = 2\times10^{-1} = 0.2$

pH = –log(0.2) = 0.699

III) 10^{-1} M CH_3COOH (Weak acid) Partially ionized

pH between 1 and 2

IV) 10^{-8} M HCl

Very dilute acid, affected by water autoionization

pH slightly below 7 (˜6.96)

KEY

				TEACHING TASK					
1	2	3	4	5	6	7	8	9	10
C	A	C	B	C	B	B	A	B	B
11	12	13	14	15	16	17	18	19	20
D	C	B	A,B,C	C,D	A	D	A	B	0
21	22								
13.3	A-s,B-p,C-q,D-s,r								
				LEARNERS TASK					
			CONCEPTUAL UNDERSTANDING QUESTIONS (CUQ'S)						
1	2	3	4	5	6	7	8	9	10
A	A	C	C	C	D	C	C	B	B
			JEE MAINS LEVEL QUESTIONS						
11	12	13	14	15	16	17	18	19	20
D	D	D	B	D	D	A	C	D	D
			JEE ADVANCED LEVEL QUESTIONS						
21	22	23	24	25	26	27	28		
A,C	D	C	B	B	1.7	3	I-D,II-A,III-B,IV-C		