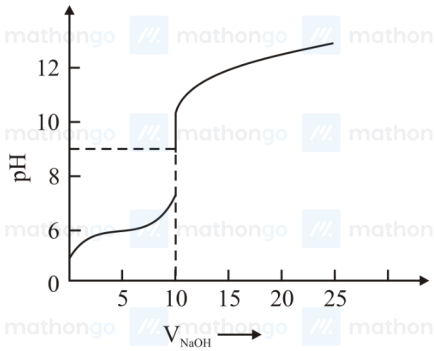
1. The titration curve of weak acid vs. strong base with phenolphthalein as indicator is shown below. The $K_{phenolphthalein} = 4 \times 10^{-10}$
Given: $\log\ 2 = 0.3$



The number of following statement/s which is/are correct about phenolphthalein is _____
A. It can be used as an indicator for the titration of weak acid with weak base.
B. It begins to change colour at $pH = 8.4$
C. It is a weak organic base
D. It is colourless in acidic medium

[2023 (08 Apr Shift 1)]

2. Given below are two statements:
Statement-I : Methyl orange is a weak acid.
Statement-II : The benzenoid form of methyl orange is more intense/deeply coloured than the quinonoid form.
In the light of the above statement, choose the most appropriate answer from the options given below:
[2023 (08 Apr Shift 2)]
(1) Both **Statement-I** and **Statement-II** are incorrect
(2) **Statement-I** is incorrect but **Statement-II** is correct
(3) Both **Statement-I** and **Statement-II** are correct
(4) **Statement-**I is correct but **Statement-II** is incorrect

3. The solubility product of $BaSO_4$ is 1×10^{-10} at 298 K. The solubility of $BaSO_4$ in $0.1M\ K_2SO_4(aq)$ solution is ------$\times 10^{-9}$ g L^{-1}(nearest integer).
Given: Molar mass of $BaSO_4$ is 233 g mol^{-1}
[2023 (08 Apr Shift 2)]

4. An analyst wants to convert 1 L HCl of pH = 1 to a solution of HCl of pH = 2. The volume of water needed to do this dilution is _____ mL. (Nearest integer)
[2023 (12 Apr Shift 1)]

5. 25.0 mL of 0.050 M $Ba(NO_3)_2$ is mixed with 25.0 mL of 0.020 M NaF. K_{sp} of BaF_2 is $0.5 \times 10-6$ at 298K. The ratio of $\left[Ba^{2+}\right]\left[F^{-}\right]^2$ and K_{sp} is _____.
[2023 (13 Apr Shift 1)]

6. 20 mL of 0.1 MNaOH is added to 50 mL of 0.1M acetic acid solution. The pH of the resulting solution is $\times 10^{-2}$. (Nearest integer) Given :
$pK_a(CH_3COOH) = 4.76$
$\log\ 2 = 0.30$
$\log\ 3 = 0.48$
[2023 (13 Apr Shift 2)]

7. Which of the following statement(s) is/are correct?
(A) The pH of 1×10^{-8} M HCl solution is 8.
(B) The conjugate base of H_2PO^{4-} is HPO_4^{2-}.
(C) K_w increases with increase in temperature.
(D) When a solution of a weak monoprotic acid is titrated against a strong base at half neutralisation point, $pH = \frac{1}{2}pK_a$. Choose the correct answer from the options given below:
[2023 (15 Apr Shift 1)]
(1) (B), (C)
(2) (A), (D)
(3) (A), (B), (C)
(4) (B), (C), (D)

ANSWER KEYS

1. (2) **2.** (4) **3.** (233) **4.** (9000) **5.** (5) **6.** (458) **7.** (1)

1. (2)

Phenolphthalein is an organic acid and can be represented as HPh.

$$\underset{\text{(colourless)}}{\text{HPh}} \rightleftharpoons \text{H}^+ + \underset{\text{(Pink)}}{\text{Ph}^-}$$

Using Henderson equation for phenolphthalein

$$\text{pH} = \text{pK}_{\text{In}} + \log\left[\frac{[\text{Ph}^-]}{[\text{HPh}]}\right]$$

At equivalence point $[\text{Ph}^-] = [\text{HPh}]$

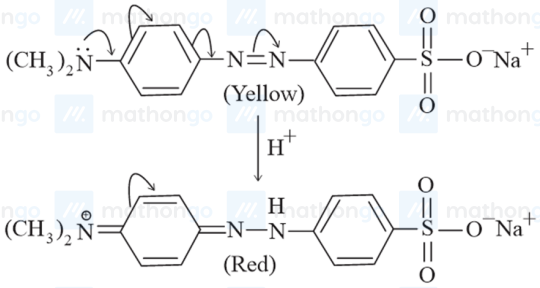
$\therefore \text{pH}_2 = \text{pK}_{\text{In}} = -\log[4] + 10 = -0.6 + 10 = 9.4$

Hence at (9.4 ± 1) PH , phenolphthalein starts changing colour. Phenolphthalein is colourless in acidic medium and pink in basic medium.

Phenolphthalein indicator distinguish the pH change between 8 to 10. Therefore, it is used for strong acid and strong base titration or weak acid and strong base titration. Hence, A and C are incorrect statements.

2. (4)

Methyl orange is a weak acid. Additionally, in acidic conditions, methyl orange exists in the quinonoid form, which is red in color. In alkaline conditions, it exists in the benzenoid form, which is yellow in color. Since red is more deeply coloured than yellow, Statement-2 is wrong.



3. (233)

For the insoluble salt barium sulphate, sulphate ion added is the common ion. Due to the common ion effect the solubility of barium sulphate decreases. Let us assume solubility of barium sulphate is S.

$$\underset{S}{\text{BaSO}_4(s)} \rightleftharpoons \underset{S}{\text{Ba}^{2+}(aq)} + \underset{S+0.1}{\text{SO}_4^{2-}(aq)}$$

$$\underset{0.1-0.1}{\text{K}_2\text{SO}_4} \longrightarrow \underset{0.1}{\text{K}^+(aq)} + \underset{0.1}{\text{SO}_4^{2-}(aq)}$$

$$\text{K}_{\text{SP}} = \left[\text{Ba}^{2+}\right]\left[\text{SO}_4^{2-}\right]$$

$$1 \times 10^{-10} = \text{S}(\text{S} + 0.1)$$

$$\simeq 0.1\ \text{S}$$

$$\text{S} = 10^{-9}\text{M} = 233 \times 10^{-9}\ \text{gL}^{-1}$$

4. (9000)

The concentration of H^+ or say HCl in both the given solution is 10^{-1} and 10^{-2} mole L^{-1} respectively.

For the given amount of HCl the concentration depends over dilution hence

$$\text{M}_1\text{V}_1 = \text{M}_2\text{V}_2$$

$$\frac{\text{M}_1}{\text{M}_2} = \frac{\text{V}_2}{\text{V}_1}$$

$$\frac{10^{-1}}{10^{-2}} = \frac{\text{V}_2}{1\text{L}}$$

$$\text{V}_2 = 10\ \text{L} = 10000\ \text{mL}$$

$$\Delta\text{V} = 10000 - 1000\ \text{mL} = 9000\ \text{mL}$$

5. (5)

Given:

Volume of $Ba(NO_3)_2$ solution = $25.0mL$ Concentration of $Ba(NO_3)_2$ solution = $0.050M$ Volume of NaF solution = $25.0\ mL$ Concentration of NaF solution = $0.020M$

$\left[Ba^{+2}\right]=\left(\frac{25\times0.05}{50}\right)=0.025M$

$[F^-]=\left(\frac{25\times0.02}{50}\right)=0.01M$

$\left[Ba^{+2}\right]\ [F^-]=25\times10^{-7}$

$K_{sp}=0.5\times10^{-6}=5\times10^{-7}$

Ratio$=\frac{\left[Ba^{+2}\right]\ [F^-]}{K_{sp}}=\frac{25\times10^{-7}}{5\times10^{-7}}=5$

6. (458)

When a strong base is added to a weak acid solution, it results in the formation of a salt. Here, acid is present in a limiting reagent and base is present in excess amounts. So, by using the pH formula:

$pH = pKa+\log\frac{[salt]}{[acid]}$

$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

$5 \quad 2 \quad — \quad —$

$3 \quad 0 \quad 2$

$pH=pK_a+\log\left(\frac{2}{3}\right)$

$pH=4.76+0.30-0.48$

$=4.76-.18$

$=4.58$

7. (1)

When concentration of H^+ ion is more than $10^{-7}M$, the proton concentration from water must be considered. Hence, the pH of $10^{-8}M$ HCl solution is not equal to 8.

$\underset{\text{Acid}}{H_2PO_4^-} \rightleftharpoons \underset{\text{Conjugate base}}{HPO_4^{2-}} + H^+$

K_w increase with increase in temperature as dissociation of water increases with increase in temperature.

When weak monoprotic acid is titrated against strong base, at half neutralization point, the solution becomes acidic buffer and its pH is given by

$pH=pK_a+\log\frac{[Salt]}{[Acid]}$

$\Rightarrow pH=pK_a+0$ as [salt]=[acid]