Weird Chemist

DPP–1 [Acid–Base Titration] — SOLUTIONS

Chapter: Practical Physical Chemistry

"Bas ek question uthao… Perfect hone ki zarurat nahi… Shuru karo—baaki sab khud ho jayega."

TYPE-1 : Indicator

Q.1. The color of phenolphthalein indicator in acid solution is

Phenolphthalein is a weak acid indicator. In acidic medium, excess H^+ ions suppress its ionisation, keeping it in its un-ionised (HIn) form. This form does not absorb visible light and therefore appears colourless.

Approach

Phenolphthalein exists in two forms: colourless HIn (acid form) and pink In^- (base form). In acidic solution, the equilibrium: $HIn \rightleftharpoons H^+ + In^-$ shifts to the left. So: **acid medium = HIn = colourless**.

Answer

(3) Colourless

Q.2. Phenolphthalein color in basic medium is

In basic medium, OH^- ions remove the proton from HIn, converting it to the In^- (ionised) form. This In^- ion has an extended quinonoid conjugated structure that absorbs visible light and appears pink.

Approach

Basic medium deprotonates phenolphthalein: $HIn + OH^- \rightarrow In^- + H_2O$. The In^- form is pink due to its quinonoid structure. So: **basic medium = In^- = pink**.

Answer

(1) Pink

Q.3. Methyl orange is

Methyl orange is a weak acid indicator. In acidic medium it is in the protonated quinonoid form which appears **red**. In basic medium it loses a proton and converts to the benzenoid (azo) form which appears **yellow**. Its effective pH range is 3.1–4.4.

Approach

Key rule: Methyl orange is **red in acid, yellow in base**. Below pH 3.1 = red; above pH 4.4 = yellow; between 3.1–4.4 = orange (transition zone).

Answer

(1) Red in acidic medium, yellow in basic medium

Q.4. The pink colour of phenolphthalein in alkaline medium is due to –

In alkaline medium, OH^- ions deprotonate phenolphthalein to form the In^- anion (negatively charged ion). This negative ion has a quinonoid structure with extended conjugation, which absorbs visible light in the green region, giving the solution a **pink** appearance.

Approach

The colour change in phenolphthalein is a direct result of the formation of the **negative ion** (In^-) in basic medium. The anion's quinonoid structure is responsible for the pink colour. The neutral HIn form (in acid) is colourless.

Answer

(1) Negative ion

Q.5. Which indicator works in the pH range 8–9.8

Indicator working pH ranges:

- Methyl orange: 3.1–4.4
- Methyl red: 4.4–6.2
- Litmus: 6.0–8.0
- Phenolphthalein: 8.3–10.0

The range 8–9.8 falls within phenolphthalein's working range (8.3–10.0).

Approach

Match the given range (8–9.8) with indicator pH ranges. Phenolphthalein (8.3–10.0) is the only indicator whose range overlaps with 8–9.8.

Answer

(1) Phenolphthalein

Q.6. Phenolphthalein is not a good indicator for titrating

Phenolphthalein is an acid–base indicator and works only where the equivalence point pH is in the range 8.3–10.0. The titration of ferrous sulphate against $KMnO_4$ is a **redox titration** (electron transfer reaction), not an acid–base titration. Phenolphthalein cannot detect redox equivalence points. Additionally, $KMnO_4$ itself acts as a self-indicator in this titration (the pink colour of $KMnO_4$ disappears at the end point).

Approach

Phenolphthalein = acid–base indicator only. $FeSO_4$ vs $KMnO_4$ = **redox titration**. Since there is no acid–base reaction and $KMnO_4$ is a self-indicator, phenolphthalein has no role here.

Answer

(4) Ferrous sulphate against $KMnO_4$

Q.7. Phenolphthalein is most suitable indicator for the titration of

Phenolphthalein is suitable when the equivalence point pH falls in its working range (8.3–10.0). This happens in **weak acid–strong base** titrations. For CH_3COOH + NaOH: the salt formed (sodium acetate) undergoes anionic hydrolysis, making the equivalence point basic (pH $\approx$ 8–9). This falls squarely in phenolphthalein's range.

Approach

Rule: Phenolphthalein is ideal for **weak acid + strong base**. CH_3COOH (weak acid) + NaOH (strong base) gives an alkaline equivalence point (pH 8–9) $\Rightarrow$ phenolphthalein works perfectly.

Answer

(2) CH_3COOH and NaOH

Q.8. When basic solution is titrated against HCl in the burette with Methyl orange indicator, the end point is the color change from

The conical flask contains the basic solution. Methyl orange in basic medium is **yellow**. HCl is added from the burette. As acid is added, the solution becomes progressively more acidic. At the end point, the pH drops into methyl orange's acidic range, converting it from the benzenoid (yellow) form to the quinonoid (orange/red) form. Colour change: **yellow to orange**.

Approach

Methyl orange in base (flask) = yellow. Add HCl (acid) from burette. End point: solution turns acidic. Methyl orange shifts from benzenoid (yellow) to quinonoid (orange). Colour change = **yellow** $\rightarrow$ **orange**.

Answer

(4) Yellow to orange

Q.9. In Base vs. Acid titration, at the end point methyl orange is present as

Methyl orange exists in two structural forms:

- **Benzenoid (azo) form**: yellow, stable in neutral/basic medium
- **Quinonoid form**: red/orange, stable in acidic medium

In a base vs acid titration (base in flask, acid added from burette), at the end point the solution is just at the boundary of the transition zone. The yellow benzenoid form just begins to convert. The end point in base vs acid titration with methyl orange is when the colour shifts from yellow to orange – the **benzenoid** form is present at this transition.

Approach

At end point of base vs acid: methyl orange is at the yellow-to-orange transition. The yellow form = **benzenoid** form. This is the form present at the end point of base vs acid (base in flask, acid added).

Answer

(4) Benzenoid form

Q.10. Which of the following is used as an indicator in the titration of a strong acid and a weak base?

For strong acid–weak base titration (e.g., HCl + NH_4OH), the salt formed (NH_4Cl) undergoes cationic hydrolysis, making the equivalence point **acidic** (pH $\approx$ 4–5). The indicator must change colour in this acidic pH range. **Methyl orange** (pH range 3.1–4.4) is suitable for this purpose. Phenolphthalein (8.3–10.0) would show no colour change at the actual equivalence point.

Approach

Strong acid + Weak base $\Rightarrow$ equivalence point pH < 7 (acidic) $\Rightarrow$ need an indicator working in acidic range $\Rightarrow$ **Methyl orange** (3.1–4.4).

Answer

(1) Methyl orange

Q.11. The ideal indicator for the titration of strong acid and weak base should have a pH range between …

For strong acid–weak base titration, the equivalence point lies on the acidic side (pH $\approx$ 5). The sharp pH change near the equivalence point in such titrations occurs in the acidic region. The indicator's transition range must overlap with this steep pH change. The range **4–6** covers the acidic equivalence point of strong acid–weak base titrations.

Approach

Strong acid + Weak base $\Rightarrow$ equivalence point pH $\approx$ 4–6 (acidic). The ideal indicator must work in this range. Answer: **4–6**.

Answer

(2) 4–6

Q.12. In the volumetric estimation of HCl, if we make use of phenolphthalein as an indicator, which base is unsuitable for the titration?

Phenolphthalein works when the equivalence point is basic (pH > 8). For strong bases (NaOH, KOH, RbOH) reacting with HCl, equivalence point is at pH = 7, and the pH jump (from $\approx$4 to $\approx$10) passes through phenolphthalein's range, so it works. However, NH_4OH is a **weak base**. Strong acid (HCl) + Weak base (NH_4OH) gives an **acidic** equivalence point (pH $\approx$ 4–5). Phenolphthalein (working range 8.3–10.0) will not undergo a colour change at this acidic equivalence point. Hence NH_4OH is unsuitable.

Approach

Phenolphthalein needs equivalence point pH > 8. NH_4OH is a weak base $\Rightarrow$ HCl + NH_4OH equivalence point pH < 7 (acidic) $\Rightarrow$ phenolphthalein fails $\Rightarrow$ **NH_4OH is unsuitable**.

Answer

(4) NH_4OH

Q.13. What is the suitable indicator for titration of NaOH and oxalic acid?

NaOH is a strong base and oxalic acid ($H_2C_2O_4$) is a weak diprotic acid. This is a **strong base–weak acid** titration. The salt formed (sodium oxalate) undergoes anionic hydrolysis, making the equivalence point **basic** (pH > 7). Phenolphthalein (pH range 8.3–10.0) is ideal for this type of titration.

Approach

Strong base (NaOH) + Weak acid (oxalic) $\Rightarrow$ equivalence point pH > 7 (basic) $\Rightarrow$ use **phenolphthalein**.

Answer

(3) Phenolphthalein

Q.14. Phenolphthalein does not act as an indicator for the titration between:

Phenolphthalein is an acid–base indicator. The titration of **oxalic acid with $KMnO_4$** is a **redox titration** (oxidation–reduction), not an acid–base reaction. $KMnO_4$ acts as a self-indicator (it is purple; decolouration marks the end point). Phenolphthalein has no role in redox titrations and will not indicate the correct end point.

Approach

Only option (3) involves a **redox** reaction (oxalic acid is oxidised by $KMnO_4$). Phenolphthalein cannot work in redox titrations. All other options are acid–base titrations where phenolphthalein can function.

Answer

(3) Oxalic acid and $KMnO_4$

Q.15. For weak acid strong base titration, the indicator used is:

Weak acid–strong base titration (e.g., CH_3COOH + NaOH) gives an equivalence point at pH $>$ 7 (basic side, pH $\approx$ 8–9). The sharp pH change at the equivalence point covers the range 7–11 approximately. Phenolphthalein (range 8.3–10.0) has its transition within this sharp region, making it the ideal indicator.

Approach

Weak acid + Strong base $\Rightarrow$ equivalence point pH $\approx$ 8–9 (basic) $\Rightarrow$ use **phenolphthalein** (8.3–10.0). Methyl orange (3.1–4.4) would change colour far from the equivalence point and give wrong results.

Answer

(4) Phenolphthalein

Q.16. From the following in which titration methyl orange is a best indicator:

Evaluating each option:

- CH_3COOH + NaOH: weak acid–strong base $\Rightarrow$ equivalence pH $>$ 7 $\Rightarrow$ phenolphthalein preferred
- $H_2C_2O_4$ + NaOH: weak acid–strong base $\Rightarrow$ equivalence pH $>$ 7 $\Rightarrow$ phenolphthalein preferred
- **HCl + NaOH**: strong acid–strong base $\Rightarrow$ sharp pH jump from $\approx$4 to $\approx$10, passing through methyl orange's range (3.1–4.4). Methyl orange works here.
- CH_3COOH + NH_4OH: weak acid–weak base $\Rightarrow$ no sharp equivalence point, no indicator works reliably

Approach

Methyl orange is best for **strong acid** titrations. Among the options, HCl is the only strong acid. HCl + NaOH (strong–strong) has a pH jump that passes through methyl orange's range ⇒ best fit.

Answer

(3) HCl + NaOH

Q.17. When 20 mL of $\frac{\mathbf{M}}{20}$ NaOH are added to 10 mL of $\frac{\mathbf{M}}{10}$ HCl, the resulting solution will:

Calculate millimoles of each reactant:

$$n_{\text{NaOH}} = M \times V = \frac{1}{20} \times 20 = 1 \text{ mmol}$$

$$n_{\text{HCl}} = \frac{1}{10} \times 10 = 1 \text{ mmol}$$

Both are equal. They completely neutralise each other to give NaCl + H_2O. The resulting solution is **neutral** (pH = 7). A neutral solution has no effect on either red litmus or blue litmus.

Approach

$n_{\text{NaOH}} = \frac{1}{20} \times 20 = 1$ mmol. $n_{\text{HCl}} = \frac{1}{10} \times 10 = 1$ mmol. Equal moles ⇒ complete neutralisation ⇒ neutral solution ⇒ **no effect on litmus**.

Answer

(4) Will have no effect on either red or blue litmus

Q.18. Which is the best choice for weak base–strong acid titration?

Weak base–strong acid titration (e.g., NH_4OH + HCl) gives an equivalence point on the **acidic side** (pH $\approx$ 4–5). The indicator must change colour in this pH range. **Methyl red** (pH range 4.4–6.2) fits best among the given options, as its transition range overlaps with the acidic equivalence point of weak base–strong acid titrations.

Approach

Weak base + Strong acid ⇒ equivalence point pH $\approx$ 4–5 (acidic). Best indicator for this range = **Methyl red** (4.4–6.2). Phenolphthalein (8.3–10.0) is completely in the wrong range.

Answer

(1) Methyl red

Q.19. Incorrect statement for the use of indicators in acid-base titration is

Evaluating each statement:

- **(1) Methyl orange for weak acid vs weak base**: **Incorrect statement**. Weak acid–weak base titrations do not produce a sharp pH change near the equivalence point. Therefore, **no indicator** is suitable for such titrations, including methyl orange.
- (2) Methyl orange for strong acid vs weak base: Correct. Acidic equivalence point suits methyl orange.
- (3) Phenolphthalein for weak acid vs strong base: Correct. Basic equivalence point suits phenolphthalein.
- (4) Phenolphthalein for strong acid vs strong base: Correct. The large pH jump passes through phenolphthalein's range.

Approach

Weak–weak titration = no sharp pH jump = no reliable indicator. So saying "methyl orange may be used" for weak–weak is **incorrect**.

Answer

(1) Methyl orange may be used for a weak acid vs weak base titration

Q.20. An alkali is titrated against an acid with methyl orange as indicator, which of the following is a correct combination?

Methyl orange is yellow in basic/neutral medium and pinkish-red in acidic medium. For methyl orange to work reliably, the acid must be a **strong acid** (so the equivalence point is in the acidic pH range). If a **weak base** (e.g., NH_4OH) is in the flask (indicator is yellow initially) and a **strong acid** (HCl) is added from the burette, the end point is reached when pH drops to the acidic range. Colour change: **yellow to pinkish red**. This is option (2).

Approach

Methyl orange works when the acid is strong (acidic equivalence point). Base (weak) in flask = yellow indicator. Add strong acid = pinkish red at end point. $\Rightarrow$ Weak base + Strong acid + Yellow to pinkish red = **option (2)**.

Answer

(2) Weak base, Strong acid, Yellow to pinkish red

Q.21. The indicator which is not added in titration flask but kept on a spot plate is

An **external indicator** is one that cannot be added to the titration flask directly (because it may react with the solution or get destroyed). Instead, after each addition of titrant, a small drop of the reaction mixture is taken out and placed on a spot plate (white tile) to test for the end point with the external indicator. A classic example is starch solution used externally in iodometric titrations.

Approach

Indicator used **outside** the flask on a spot plate = **External indicator**. Indicator added directly into the flask = Internal indicator. Self-indicator = the reactant itself acts as indicator (e.g., $KMnO_4$).

Answer

(2) External indicator

Q.22. The rapid change of pH near the stoichiometric point of an acid-base titration is the basis of indicator detection. pH of the solution is related to ratio of the concentrations of the conjugate acid (HIn) and base (In^-) forms of the indicator by the expression:

For an indicator acting as a weak acid:

$$\mathrm{HIn} \rightleftharpoons \mathrm{H}^+ + \mathrm{In}^-$$

$$K_{\mathrm{In}} = \frac{[\mathrm{H}^+][\mathrm{In}^-]}{[\mathrm{HIn}]}$$

Rearranging:

$$[\mathrm{H}^+] = K_{\mathrm{In}} \cdot \frac{[\mathrm{HIn}]}{[\mathrm{In}^-]}$$

Taking negative logarithm of both sides:

$$\mathrm{pH} = \mathrm{p}K_{\mathrm{In}} + \log \frac{[\mathrm{In}^-]}{[\mathrm{HIn}]}$$

Rearranging to get $[\mathrm{HIn}]/[\mathrm{In}^-]$:

$$\log \frac{[\mathrm{HIn}]}{[\mathrm{In}^-]} = \mathrm{p}K_{\mathrm{In}} - \mathrm{pH}$$

Approach

Apply Henderson–Hasselbalch to the indicator (HIn as the weak acid):

$$\mathrm{pH} = \mathrm{p}K_{\mathrm{In}} + \log \frac{[\mathrm{In}^-]}{[\mathrm{HIn}]} \implies \log \frac{[\mathrm{HIn}]}{[\mathrm{In}^-]} = \mathrm{p}K_{\mathrm{In}} - \mathrm{pH}$$

Answer

(1) $\log \frac{[\mathbf{HIn}]}{[\mathbf{In}^-]} = \mathbf{p}K_{\mathbf{In}} - \mathbf{pH}$

TYPE-2 : Numerical / Calculation Based

Q.23. The number of gms of solute per 100 ml of solution is known as

Concentration expressions:

- Molarity: moles of solute per litre of solution
- Normality: gram equivalents of solute per litre of solution
- Mole fraction: moles of component / total moles in solution
- **% w/v**: grams of solute per 100 mL of solution

The definition “grams per 100 mL” exactly matches **% weight by volume**.

Approach

% w/v $= \dfrac{\text{mass of solute (g)}}{\text{volume of solution (mL)}} \times 100$. This gives grams per 100 mL. Direct match.

Answer

(3) % weight by volume

Q.24. The pH of titration mixture for strong acid–strong base titration at equivalence point is

In strong acid–strong base titration (e.g., HCl + NaOH), the salt formed (NaCl) does not undergo hydrolysis because both constituent ions (Na^+ from strong base, Cl^- from strong acid) are spectator ions that do not react with water. Therefore, the solution at equivalence point is **neutral**, with pH = **7**.

Approach

Strong acid + Strong base ⇒ neutral salt (no hydrolysis) ⇒ pH at equivalence = **7**.

Answer

(3) 7

Q.25. The equivalent weight of sodium carbonate [Na_2CO_3] is

$$\text{Equivalent weight} = \frac{\text{Molar mass}}{\text{n-factor}}$$

Molar mass of $Na_2CO_3 = 2(23) + 12 + 3(16) = 106$ g/mol
Na_2CO_3 reacts with acids by accepting 2 protons (dibasic nature):

$$Na_2CO_3 + {}_2HCl \longrightarrow {}_2NaCl + H_2O + CO_2$$

So n-factor = 2.

$$\text{Equivalent weight} = \frac{106}{2} = \mathbf{53}$$

Approach

Na_2CO_3: molar mass = 106, n-factor = 2 (accepts 2 H^+). Equivalent weight = 106/2 = **53**.

Answer

(2) 53

Q.26. Find the concentration of HCl, if 10 ml of 0.5 M $Ca(OH)_2$ is required to titrate 50 ml of HCl.

$Ca(OH)_2$ is dibasic (n-factor = 2), HCl is monobasic (n-factor = 1).
Using milliequivalent principle (meq of acid = meq of base at equivalence):

$$\text{meq of Ca(OH)}_2 = M \times V \times n = 0.5 \times 10 \times 2 = 10 \text{ meq}$$

$$\text{meq of HCl} = M_{\text{HCl}} \times 50 \times 1 = 10$$

$$M_{\text{HCl}} = \frac{10}{50} = 0.2 = \frac{1}{5} \text{ M}$$

Approach

$M_1V_1n_1 = M_2V_2n_2$
$0.5 \times 10 \times 2 = M_{\text{HCl}} \times 50 \times 1 \Rightarrow M_{\text{HCl}} = \frac{10}{50} = \frac{1}{5}$ M

Answer

(2) 1/5 M

Q.27. If 20 ml of 0.25 N strong acid and 30 ml of 0.2 N of strong base are mixed, then the resulting solution is

$$\text{meq of acid} = N \times V = 0.25 \times 20 = 5 \text{ meq}$$

$$\text{meq of base} = 0.2 \times 30 = 6 \text{ meq}$$

Base is in excess: $6 - 5 = 1$ meq. Total volume $= 20 + 30 = 50$ mL.

$$N_{\text{excess base}} = \frac{1}{50} = 0.02 \text{ N basic}$$

Approach

meq acid = 5, meq base = 6. Excess base = 1 meq in 50 mL $\Rightarrow N_{\text{base}} = \frac{1}{50} =$ **0.02 N basic**.

Answer

(4) 0.02 N basic

Q.28. 10 ml of 10 M H_2SO_4 is mixed to 100 ml 1M NaOH solution. The resultant solution will be

H_2SO_4 is dibasic (n-factor = 2):

$$\text{meq of } H_2SO_4 = 10 \times 10 \times 2 = 200 \text{ meq}$$

$$\text{meq of NaOH} = 100 \times 1 \times 1 = 100 \text{ meq}$$

Acid is in large excess: $200 - 100 = 100$ meq. The resulting solution is strongly **acidic**.

Approach

meq of H_2SO_4 = $10 \times 10 \times 2 = 200$. meq of NaOH = $100 \times 1 = 100$. Acid excess = 100 meq $\Rightarrow$ **acidic**.

Answer

(1) Acidic

Q.29. Phosphoric acid (H_3PO_4) is tribasic acid and one of its salt is sodium dihydrogen phosphate (NaH_2PO_4). What volume of 1 M NaOH solution should be added to 12 g of sodium dihydrogen phosphate (mol. wt. 120) to exactly convert it into trisodium phosphate Na_3PO_4?

Moles of $NaH_2PO_4 = \dfrac{12}{120} = 0.1$ mol
The conversion reaction:

$$NaH_2PO_4 + {}_2NaOH \longrightarrow Na_3PO_4 + {}_2H_2O$$

NaH_2PO_4 has 2 replaceable H^+ ions. Moles of NaOH required $= 2 \times 0.1 = 0.2$ mol.
Volume of 1 M NaOH $= \dfrac{0.2 \text{ mol}}{1 \text{ mol/L}} = 0.2 \text{ L} = \mathbf{200\ mL}$

Approach

$NaH_2PO_4 \xrightarrow{+2NaOH} Na_3PO_4$. Moles of NaH_2PO_4 = 0.1. Moles NaOH needed = 0.2. Volume of 1 M NaOH = 0.2 L = **200 mL**.

Answer

(3) 200 ml

Q.30. 10 ml of concentrated HCl were diluted to 1 litre. 20 ml of this diluted solution required 25 ml of 0.1 N sodium hydroxide solution for complete neutralization, the normality of the concentrated hydrochloric acid will be

Step 1: Find normality of diluted HCl:

$$N_{\text{dil}} \times 20 = 0.1 \times 25 \implies N_{\text{dil}} = \frac{2.5}{20} = 0.125\ \text{N}$$

Step 2: Apply dilution formula (original 10 mL diluted to 1000 mL):

$$N_{\text{conc}} \times 10 = 0.125 \times 1000 \implies N_{\text{conc}} = \frac{125}{10} = \mathbf{12.5}\ \text{N}$$

Approach

Step 1: $N_{\text{dil}} = \frac{0.1 \times 25}{20} = 0.125$ N.

Step 2: $N_{\text{conc}} = \frac{0.125 \times 1000}{10} =$ **12.5 N**.

Answer

(3) 12.5

Q.31. 25 ml of the given HCl solution requires 30 mL of 0.1 M sodium carbonate solution. What is the volume of this HCl solution required to titrate 30 mL of 0.2 M aqueous NaOH solution?

Step 1: Find molarity of HCl. Na_2CO_3 is dibasic (n-factor = 2), HCl is monobasic (n-factor = 1):

$$M_{\text{HCl}} \times 25 \times 1 = 0.1 \times 30 \times 2 \implies M_{\text{HCl}} = \frac{6}{25} = 0.24\ \text{M}$$

Step 2: HCl vs NaOH, both n-factor = 1:

$$0.24 \times V = 0.2 \times 30 \implies V = \frac{6}{0.24} = \mathbf{25}\ \text{mL}$$

Approach

Step 1: $M_{\text{HCl}} = \frac{0.1 \times 30 \times 2}{25} = 0.24$ M.

Step 2: $0.24 \times V = 0.2 \times 30 \Rightarrow V =$ **25 mL**.

Answer

(1) 25 mL

Q.32. 50 mL of 0.5 M oxalic acid is needed to neutralize 25 mL of sodium hydroxide solution. The amount of NaOH in 50 mL of the given sodium hydroxide solution is

Oxalic acid ($H_2C_2O_4$) is diprotic (n-factor = 2):

$$\text{meq of oxalic acid} = 0.5 \times 50 \times 2 = 50\ \text{meq}$$

At equivalence: meq of NaOH in 25 mL = 50 meq.

$$N_{\text{NaOH}} = \frac{50}{25} = 2\text{ N} = 2\text{ M}$$

Mass of NaOH in **50 mL** of 2 M NaOH:

$$n = 2 \times \frac{50}{1000} = 0.1\text{ mol} \implies m = 0.1 \times 40 = \mathbf{4}\text{ g}$$

Approach

meq oxalic acid = $0.5 \times 50 \times 2 = 50$.
$N_{\text{NaOH}} = 50/25 = 2$ M.
Mass in 50 mL = $2 \times 0.05 \times 40 = \mathbf{4}$ **g**.

Answer

(1) 4 g

TYPE-3 : Graph Based

Q.33. In an acid-base titration, 0.1 M HCl solution was added to the NaOH solution of unknown strength. Which of the following correctly shows the change of pH of the titration mixture in this experiment?

HCl (acid) is being **added to NaOH** (base). Initially, the flask contains base ⇒ **high pH**. As HCl is added, pH decreases gradually (buffer region), then drops sharply near the equivalence point, and finally levels off at a low pH (excess acid). This produces a **decreasing S-shaped (sigmoid) curve**:

- Starts at high pH (basic region)
- Sharp vertical drop near equivalence point
- Ends at low pH (acidic region)

Graph (A) shows exactly this: starts high, has a steep drop, then flattens at low pH.

Approach

Acid added to base ⇒ pH starts **high** and ends **low**. Curve shape: decreasing S-curve. Among the options, **Graph (A)** shows this correctly.

Answer

(1) Graph (A)

Q.34. 100 mL of 0.1 M HCl is taken in a beaker and to it 100 mL of 0.1M NaOH is added in steps of 2 mL and the pH is continuously measured. Which of the following graphs correctly depicts the change in pH?

HCl is in the beaker (acidic) and NaOH is added from outside. pH starts **low** (acidic) and increases as base is added. Near the equivalence point (when moles of NaOH = moles of HCl), there is a **sharp rise** in pH at pH = 7 (since it is a strong–strong titration). After equivalence, excess NaOH makes the solution strongly basic and pH levels off at a high value.
This produces an **increasing S-shaped curve** with:

- Low initial pH (acidic)
- Sharp vertical rise near equivalence at pH = 7
- High final pH (basic)

Graph (3) shows this correct shape with the dotted line at pH = 7.

Approach

Base added to acid ⇒ pH starts **low**, ends **high**. Strong–strong ⇒ equivalence at pH = 7. Increasing S-curve with steep jump at pH 7 ⇒ **Graph (3)**.

Answer

(3) Graph (3)

Q.35. The Plot of pH-metric titration of weak base NH_4OH vs strong acid HCl looks like

NH_4OH is a weak base. Initially pH is **moderately basic** (not very high, around 9–10, since it is a weak base with limited ionisation). As HCl (strong acid) is added:

- Buffer region: pH decreases gradually (NH_4OH/NH_4^+ buffer)
- Equivalence point: pH drops sharply but to the **acidic side** (pH $<$ 7) since NH_4Cl is an acidic salt
- After equivalence: slight further decrease as excess HCl is added

Key feature: The curve starts **above 7** (moderately basic, not extremely high), has a steep region, and equivalence is **below 7**. Graph (1) correctly shows this with the initial pH above 7 and the steep portion ending below 7.

Approach

Weak base + Strong acid:

- Start: pH moderately above 7 (weak base, not strongly basic)
- End: pH below 7 (acidic equivalence point)
- Steep drop is smaller/shorter than strong–strong

⇒ **Graph (1)**.

Answer

(1) Graph (1)

TYPE-4 : Assertion–Reason / Statement Based

Instructions: (1) Both A and R true, R is correct explanation of A. (2) Both true, R is NOT correct explanation. (3) A true, R false. (4) A false, R true.

Q.36. Assertion (A): IInd flask is more suitable than first for titration.
Reason (R): It is difficult to add titrant in first.

Looking at the four flask types shown in the assignment (conical/Erlenmeyer flask is typically the IInd):
Assertion: The conical (Erlenmeyer) flask is preferred over a round-bottomed flask for titrations because it can be swirled easily and has a narrow neck that prevents splashing. However, as a general assertion about "IInd flask being more suitable," the reasoning must be evaluated.
Reason: The reason given — "it is difficult to add titrant in first" — is not the correct or standard reason for preferring a conical flask. The actual reason is ease of swirling and preventing spills.
As per the answer key, **both (A) and (R) are false**, indicating the assertion itself about the IInd flask is also incorrect in this context.

Approach

Assertion is debatable/incorrect as stated. Reason gives a wrong justification. As per answer key: **Both (A) and (R) are false**.

Answer

(4) Both (A) and (R) are false

Q.37. Assertion (A): Phenolphthalein is a pH dependent indicator, remains colourless in acidic solution and gives pink colour in basic medium.
Reason (R): Phenolphthalein is a weak acid. It doesn't dissociate in basic medium.

Assertion is **TRUE**: Phenolphthalein is indeed a pH-dependent indicator. It is colourless in acidic medium and pink in basic medium – this is a well-established fact.
Reason is **FALSE**: The reason contains a logical error. Phenolphthalein **does dissociate** in basic medium (the OH^- ions remove the proton from HIn to form In^-). It is in **acidic** medium that it does not dissociate (remains as HIn). The reason statement is exactly the reverse of what actually happens.

Approach

A = True (correct colour behaviour). R = False (phenolphthalein dissociates IN basic medium, not "doesn't dissociate in basic medium"). ⇒ **Assertion true, Reason false**.

Answer

(3) Assertion is true but Reason is false

Q.38. Assertion (A): An aqueous solution of KOH when for volumetric analysis, its concentration should be checked before use.
Reason (R): On aging, KOH solution absorbs atmospheric CO_2.

Assertion is **TRUE**: KOH is not a primary standard. It absorbs moisture and CO_2 from air, causing its effective concentration to decrease over time. Hence its concentration must be standardised before use in volumetric analysis.
Reason is **TRUE** and directly explains the assertion:

$${}_2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$

This reaction reduces the KOH content, justifying why the concentration must be checked before use.
Both A and R are true, and R is the correct explanation of A.

Approach

A = True. R = True. R explains A directly (CO2 absorption reduces KOH concentration ⇒ must check before use). ⇒ **Both correct, R is correct explanation**.

Answer

(3) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion

Instructions (Statement based): (1) Both incorrect. (2) Both correct. (3) St. I incorrect, St. II correct. (4) St. I correct, St. II incorrect.

Q.39. 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.

Statement I is **TRUE**: Methyl orange is a weak organic acid (indicator of the azo dye family). In its acid form (HIn), it exists in the quinonoid structure (red). In its base form (In^-), it exists in the benzenoid (azo) structure (yellow).
Statement II is **FALSE**: The **quinonoid** form (present in acidic medium) is the more intensely coloured form (red/orange), not the benzenoid form. The benzenoid form (yellow) is less intensely coloured. Statement II has it reversed.

Approach

St. I: True (methyl orange is a weak acid indicator). St. II: False (quinonoid = red = more intense; benzenoid = yellow = less intense; statement says the opposite). ⇒ **Statement I correct, Statement II incorrect**.

Answer

(4) Statement I is correct but Statement II is incorrect

Q.40. Statement I: In the titration between strong acid and weak base methyl orange is suitable as an indicator.
Statement II: For titration of acetic acid with NaOH phenolphthalein is not a suitable indicator.

Statement I is **TRUE**: Strong acid–weak base titration gives an acidic equivalence point (pH ≈ 4–5). Methyl orange (pH range 3.1–4.4) is suitable for detecting this end point.
Statement II is **FALSE**: For acetic acid (CH_3COOH) + NaOH, this is a **weak acid–strong base** titration. The equivalence point is **basic** (pH ≈ 8–9). Phenolphthalein (8.3–10.0) is actually a **perfectly suitable** indicator for this titration. Saying it is "not suitable" is incorrect.

Approach

St. I: True (methyl orange works for strong acid + weak base). St. II: False (phenolphthalein IS suitable for CH_3COOH + NaOH – the equivalence point is basic, which is in phenolphthalein's range). ⇒ **Statement I true, Statement II false**.

Answer

(3) Statement I is true but statement II is false

TYPE-5 : Miscellaneous / Application Based

Q.41. A neutralization reaction is a ……… reaction taking place between the acids and the bases.

In a neutralisation reaction, acid and base exchange their respective ions:

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Here, H^+ from HCl and OH^- from NaOH exchange partners (Cl- stays with Na+ to form NaCl, H+ combines with OH- to form water). This exchange of ions between two compounds is the definition of a **double displacement** reaction.

Approach

Neutralisation = acid + base exchange ions to form salt + water. Ion exchange between two reactants = **double displacement**.

Answer

(1) double displacement

Q.42. A precipitation reaction is a double displacement reaction taking place between

In a precipitation reaction, two soluble ionic compounds dissolved in water react by exchanging ions. One of the newly formed combinations is insoluble in water and precipitates out. Both starting materials are **aqueous ionic compounds**.
Example: $AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)\downarrow} + NaNO_{3(aq)}$

Approach

Precipitation = two soluble ionic compounds in water exchange ions $\Rightarrow$ one insoluble product (precipitate) is formed. Both reactants are **aqueous ionic compounds**.

Answer

(2) two aqueous ionic compounds

Q.43. Which of the following is a general property of base

Analysing each option:

- (1) Taste sour: Property of **acids**, not bases. Bases taste bitter.
- (2) Turn litmus red: Property of **acids**. Bases turn litmus **blue**.
- **(3) Conduct electric current in solution**: Bases ionise in water to produce OH^- ions. These ions are charge carriers and conduct electric current. This is a property of bases.
- (4) Concentration of $H_3O^+ > OH^-$: This is a property of **acidic** solutions. In basic solutions, $[OH^-] > [H_3O^+]$.

Approach

Options (1), (2), (4) are properties of acids. Only option (3) applies to bases. Bases produce ions in solution $\Rightarrow$ **conduct electric current**.

Answer

(3) Conduct electric current in solution

Q.44. The reagent of known concentration which is taken in burette is

In titration terminology:

- **Titrant**: Standard solution of **known concentration** placed in the **burette**. Added to the titrand.
- **Titrand**: Solution of unknown concentration in the **conical flask**.
- Titration: The overall process.
- End point: The point at which indicator changes colour.

Approach

Burette contains the **known concentration** solution ⇒ **Titrant**.

Answer

(3) Titrant

Q.45. The unknown solution whose concentration is to be determined by titration is called

The **Titrand** (also called analyte) is the solution of unknown concentration placed in the conical flask. Its concentration is determined by titrating it against the titrant (standard solution of known concentration) until the equivalence point is reached.

Approach

Unknown concentration in conical flask = **Titrand**. Known concentration in burette = Titrant.

Answer

(1) Titrand

Q.46. Process in which addition of titrant from burette into titration flask till titrant react completely is called

The complete process of carefully adding the titrant from the burette into the conical flask containing the titrand, until the reaction is complete (equivalence point is reached, indicated by indicator colour change), is called **Titration**. It is a volumetric analysis technique.

Approach

The overall **process** of adding titrant until reaction completes = **Titration**.

Answer

(2) Titration

Q.47. In titration colourless solution will change into light pink colour that point is called –

The experimentally observed point where the indicator changes colour (here: colourless to light pink, as seen with phenolphthalein) is called the **End point**. The **Equivalence point** is the theoretical point where stoichiometrically exact quantities of acid and base have reacted. The end point is observed experimentally and approximates the equivalence point. They are not exactly the same (titration error exists between them).

Approach

Indicator colour change = experimentally observed **End point**. Equivalence point = theoretical completion. The question describes the colour change, so it refers to the **End point**.

Answer

(2) End point

Q.48. Which is the minimum volume of solution which can be measured with the help of burette?

A standard 50 mL burette has major graduations at every 1 mL and minor graduations (divisions) at every 0.1 mL. The **least count** of a standard burette is **0.1 mL**. This is the smallest volume that can be accurately read and dispensed. (With estimation, readings up to 0.05 mL are possible, but the minimum reliable graduation is 0.1 mL.)

Approach

Standard burette least count = **0.1 mL**. This is the minimum measurable volume.

Answer

(3) 0.1 ml

Q.49. The chemical reagent from which solution of required concentration can be prepared is

A **Primary standard** is a reagent that:

- Is of high purity and known composition
- Is chemically stable (does not absorb moisture, CO_2, etc.)
- Has a high molar mass (reduces weighing errors)
- Can be directly weighed and dissolved to prepare a solution of **exact known concentration**

Examples: Oxalic acid, Na_2CO_3, $K_2Cr_2O_7$, KIO_3.
A secondary standard (e.g., NaOH, HCl) cannot be used directly because its concentration is uncertain due to absorption of atmospheric gases.

Approach

Only a **Primary standard** can directly give a solution of exact required concentration by weighing and dissolving. Secondary standards need further standardisation.

Answer

(4) Primary standard

Q.50. Match the following: (Phosphoric acid, Calcium hydroxide, Nitric acid, Potassium hydroxide)

- **Phosphoric acid (H_3PO_4)**: Weak acid ⇒ R
- **Calcium hydroxide ($Ca(OH)_2$)**: Sparingly soluble; classified as weak base in Indian curriculum ⇒ S
- **Nitric acid (HNO_3)**: Strong acid ⇒ Q
- **Potassium hydroxide (KOH)**: Strong base ⇒ P

Matching: **1-R, 2-S, 3-Q, 4-P**

Approach

H_3PO_4 = Weak acid (R). $Ca(OH)_2$ = Weak/sparingly soluble base (S). HNO_3 = Strong acid (Q). KOH = Strong base (P). ⇒ **1-R, 2-S, 3-Q, 4-P**.

Answer

(2) 1-R, 2-S, 3-Q, 4-P

Q.51. Match the following: (Acetic acid, Sodium bicarbonate, Hydrochloric acid, Sodium hydroxide)

- **Acetic acid (CH_3COOH)**: Weak acid ⇒ R
- **Sodium bicarbonate ($NaHCO_3$)**: Weak base (hydrolyses to give a basic solution) ⇒ S
- **Hydrochloric acid (HCl)**: Strong acid ⇒ Q
- **Sodium hydroxide (NaOH)**: Strong base ⇒ P

Matching: **1-R, 2-S, 3-Q, 4-P**

Approach

CH_3COOH = Weak acid (R). $NaHCO_3$ = Weak base (S). HCl = Strong acid (Q). NaOH = Strong base (P). ⇒ **1-R, 2-S, 3-Q, 4-P**.

Answer

(4) 1-R, 2-S, 3-Q, 4-P

Q.52. Match the following: (Titration types vs examples)

- **Strong acid–Strong base**: NaOH Vs HCl ⇒ R
- **Strong base–Weak acid**: NaOH Vs CH_3COOH ⇒ S
- **Strong acid–Weak base**: NH_4OH Vs HCl ⇒ Q
- **Weak acid–Weak base**: Not performed practically (no sharp equivalence point, no suitable indicator) ⇒ P

Matching: **1-R, 2-S, 3-Q, 4-P**

Approach

Strong–Strong = NaOH/HCl (R). Strong base + Weak acid = NaOH/CH_3COOH (S). Strong acid + Weak base = HCl/NH_4OH (Q). Weak–Weak = not practical (P). ⇒ **1-R, 2-S, 3-Q, 4-P**.

Answer

(3) 1-R, 2-S, 3-Q, 4-P

Q.53. For standardising NaOH solution, which of the following is used as a primary standard?

NaOH is a **secondary standard** because:

- It absorbs moisture from air (becomes more dilute)
- It absorbs CO_2 from air: $_2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

Therefore its concentration must be determined by standardisation against a primary standard. **Oxalic acid** ($H_2C_2O_4 \cdot {}_2H_2O$) is the standard primary standard used for NaOH standardisation because it is pure, stable, has a high molar mass, and reacts cleanly with NaOH.

Approach

NaOH = secondary standard (absorbs CO_2 and moisture). Must be standardised against a primary standard. **Oxalic acid** is the standard choice for standardising NaOH.

Answer

(1) Oxalic acid

Q.54. The strength of an aqueous NaOH solution is most accurately determined by titrating: (Note: Consider that an appropriate indicator is used)

For accurate titration to determine NaOH concentration:

- The **primary standard** (oxalic acid of exact known concentration) should be measured accurately using a **pipette** and placed in the conical flask.
- NaOH (whose concentration is to be found) should be in the **burette** so that its volume dispensed can be accurately measured.
- Concentrated H_2SO_4 cannot serve as a primary standard (fumes, hygroscopic, difficult to handle).
- Aqueous oxalic acid can be prepared as a primary standard of exact concentration.

Option (4): NaOH in burette + aqueous oxalic acid in conical flask. This is the most accurate setup.

Approach

Primary standard (oxalic acid, known concentration) → conical flask. NaOH (unknown concentration) → burette. Most accurate method: **Aq. NaOH in burette + aqueous oxalic acid in conical flask**.

Answer

(4) Aq. NaOH in a burette and aqueous oxalic acid in a conical flask