

Finding concentration by titration

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer shows moles of the known solution first, then the mole ratio, then the concentration of the unknown. Check the volume units and the dilution factor in every problem.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE C4 RP

Problem 1 Name the apparatus

1. A is the **burette**; it holds the solution that is added drop by drop, usually the acid.
2. B is the **tap**, which controls the flow.
3. The white background makes the **colour change at the end point easier to see**.

Problem 2 Reading burette results

1. The bottom of the meniscus is at **23.85 cm³** (to the nearest 0.05).
2. $23.85 - 0.40 = \mathbf{23.45\text{ cm}^3}$.
3. Looking from above or below gives a **parallax error** that changes the reading.

Problem 3 Which indicator?

1. **Pink**.
2. Pink to **colourless**.
3. The indicator is itself a weak acid and would react with some of the alkali, so too much would **alter the volume of acid needed**.

Problem 4 Moles from c and V

1. $0.200 \times 0.0250 = \mathbf{0.00500\text{ mol}}$.
2. $0.100 \times 0.0150 = \mathbf{0.00150\text{ mol}}$.
3. $0.0500 \times 0.0225 = \mathbf{0.001125\text{ mol}}$.

Problem 5 Choosing the mean

1. The rough titration was done quickly, so its value is **less accurate**; it only shows where to slow down.
2. The largest minus the smallest is $22.50 - 22.40 = 0.10\text{ cm}^3$, so they are **concordant**.
3. $(22.40 + 22.50 + 22.45) \div 3 = \mathbf{22.45\text{ cm}^3}$.

Problem 6 Technique steps

1. Water left inside would **dilute the acid**, so a larger volume would be needed.

2. A bubble leaves during the run and the reading would show **too large a volume** of acid.
3. Swirling mixes the solutions so the acid reacts at once and the end point is sharp.

Problem 7 Alkali in the flask

1. $0.100 \times 0.02000 = \mathbf{0.00200 \text{ mol}}$.
2. Ratio 1 : 1, so $c = 0.00200 \div 0.0250 = \mathbf{0.0800 \text{ mol/dm}^3}$.
3. $0.0800 \times 40 = \mathbf{3.20 \text{ g/dm}^3}$.

Problem 8 How strong is the vinegar?

1. $n(\text{NaOH}) = 0.100 \times 0.02150 = 0.002150 \text{ mol} = n(\text{acid})$. $c = 0.002150 \div 0.0250 = \mathbf{0.0860 \text{ mol/dm}^3}$.
2. The dilution was $250 \div 25 = 10$ times, so $c = \mathbf{0.860 \text{ mol/dm}^3}$.
3. $M(\text{CH}_3\text{COOH}) = 60 \text{ g/mol}$; $0.860 \times 60 = \mathbf{51.6 \text{ g/dm}^3}$.

Problem 9 Testing limewater

1. $n(\text{HCl}) = 0.0200 \times 0.01550 = \mathbf{0.000310 \text{ mol}}$.
2. Ratio 1 : 2, so $n(\text{Ca}(\text{OH})_2) = 0.000155 \text{ mol}$ and $c = 0.000155 \div 0.0250 = \mathbf{0.00620 \text{ mol/dm}^3}$.
3. $M = 74$; $0.00620 \times 74 = \mathbf{0.459 \text{ g/dm}^3}$.

Problem 10 Drain cleaner

1. $n(\text{HCl}) = 0.100 \times 0.02000 = 0.00200 \text{ mol} = n(\text{NaOH})$. $c = 0.00200 \div 0.0250 = \mathbf{0.0800 \text{ mol/dm}^3}$.
2. $500 \div 10.0 = \mathbf{50}$.
3. $0.0800 \times 50 = \mathbf{4.00 \text{ mol/dm}^3}$, and $4.00 \times 40 = \mathbf{160 \text{ g/dm}^3}$.

Problem 11 Sodium carbonate and acid

1. $0.100 \times 0.02200 = \mathbf{0.00220 \text{ mol}}$.
2. Ratio $\text{Na}_2\text{CO}_3 : \text{HCl}$ is 1 : 2, so $n = 0.00110 \text{ mol}$ and $c = 0.00110 \div 0.0250 = \mathbf{0.0440 \text{ mol/dm}^3}$.
3. $M = 106$; $0.0440 \times 106 = \mathbf{4.66 \text{ g/dm}^3}$.

Problem 12 Analyse the results table

1. Rough **25.40**; run 1 **24.30**; run 2 $48.50 - 24.30 = \mathbf{24.20}$; run 3 $24.45 - 0.20 = \mathbf{24.25}$.
2. Runs 1, 2 and 3 lie within 0.10 cm^3 ($24.30 - 24.20$), so the mean is $(24.30 + 24.20 + 24.25) \div 3 = \mathbf{24.25 \text{ cm}^3}$.
3. $n(\text{acid}) = 0.100 \times 0.02425 = 0.002425 \text{ mol}$; $c(\text{alkali}) = 0.002425 \div 0.0250 = \mathbf{0.0970 \text{ mol/dm}^3}$.

Problem 13 Read the pH curve

1. The steep part is at **24 cm³**.
2. The curve passes through **pH 7**.
3. $n(\text{NaOH}) = 0.150 \times 0.0200 = 0.00300 \text{ mol}$; the ratio is 1 : 1; $c(\text{acid}) = 0.00300 \div 0.0240 = \mathbf{0.125 \text{ mol/dm}^3}$.

Problem 14 Household ammonia

1. $n(\text{HCl}) = 0.100 \times 0.02300 = 0.00230 \text{ mol} = n(\text{NH}_3)$; $c = 0.00230 \div 0.0250 = \mathbf{0.0920 \text{ mol/dm}^3}$.
2. Dilution is $250 \div 10.0 = 25$ times: $0.0920 \times 25 = \mathbf{2.30 \text{ mol/dm}^3}$; $\times 17 = \mathbf{39.1 \text{ g/dm}^3}$.
3. The salt NH_4Cl makes the end point **slightly acidic** (about pH 5), where methyl orange changes; phenolphthalein changes in alkaline solution and would change colour too early.

Problem 15 Purity of sodium hydroxide

1. $n(\text{HCl}) = 0.200 \times 0.02250 = 0.00450 \text{ mol}$, so $n(\text{NaOH}) = \mathbf{0.00450 \text{ mol}}$.
2. In 250 cm³: $0.0450 \text{ mol} \times 40 = \mathbf{1.80 \text{ g}}$.
3. $1.80 \div 2.00 \times 100 = \mathbf{90.0\%}$.

Problem 16 Making a standard solution

1. $n = 0.0500 \times 0.250 = 0.0125 \text{ mol}$; $M = 106$; $m = \mathbf{1.325 \text{ g}}$ (1.33 g).
2. $\mathbf{\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2}$; ratio 1 : 2.
3. $n(\text{Na}_2\text{CO}_3) = 0.0500 \times 0.0250 = 0.00125 \text{ mol}$; $n(\text{HCl}) = 0.00250 \text{ mol}$; $c = 0.00250 \div 0.02080 = \mathbf{0.120 \text{ mol/dm}^3}$.

Problem 17 Acid in lemon juice

1. $0.100 \times 0.02400 = \mathbf{0.00240 \text{ mol}}$.
2. Ratio acid : NaOH is 1 : 3, so $n(\text{acid}) = 0.000800 \text{ mol}$ and $c = 0.000800 \div 0.0250 = \mathbf{0.0320 \text{ mol/dm}^3}$.
3. The dilution factor is 10: $\mathbf{0.320 \text{ mol/dm}^3}$. $M(\text{C}_6\text{H}_8\text{O}_7) = 192$, so $0.320 \times 192 = \mathbf{61.4 \text{ g/dm}^3}$.

Problem 18 Which errors matter?

1. **Too high**: the acid is diluted, so a larger titre is needed.
2. **Unaffected**: water does not change the moles of alkali placed in the flask.
3. **Too high**: the volume read from the burette includes the volume of the bubble.
4. **Too high**: excess acid was added, so the titre is larger than the true value.

Problem 19 Checking a label

1. $n(\text{NaOH}) = 0.0500 \times 0.02050 = 0.001025 \text{ mol} = n(\text{HCl})$; $c = 0.001025 \div 0.0250 =$
0.0410 mol/dm³.
2. Dilution is $250 \div 10.0 = 25$: $0.0410 \times 25 =$ **1.025 mol/dm³.**
3. $(1.025 - 1.00) \div 1.00 \times 100 =$ **2.5%**, so the label is **within $\pm 5\%$.**

Problem 20 An unknown acid

1. $n(\text{NaOH}) = 0.100 \times 0.02000 = 0.00200 \text{ mol} = n(\text{HX})$ in 25.0 cm^3 : **0.00200 mol.**
2. $0.00200 \times 4 =$ **0.00800 mol.**
3. $M = 0.600 \div 0.00800 =$ **75.0 g/mol.**
4. A diprotic acid would use 2 mol of NaOH per mole, so the moles of acid would be half and the molar mass would be **twice as large (150 g/mol).**