# Unit 1 · Volumetric Analysis

**ANSWER KEY · FOR TEACHERS**

Full marks 33

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

## 1 Key words

1. analyte
2. titrant
3. equivalence point
4. end point
5. primary standard
6. molality
7. normality
8. self-indicator

Each carries 0.5 mark. **K · 4**

## 2 Label the diagram

1. burette
2. stopcock
3. conical flask: acid + phenolphthalein
4. white tile

Each carries 0.5 mark. **K · 2**

## 3 Multiple choice

**i.** **c.** 3 **K · 1**

$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$: manganese goes from +7 to +4, gaining **3** electrons. It is 5 in acid (to $Mn^{2+}$) and 1 in strong alkali (to $MnO_4^{2-}$).

**ii.** **d.** molality **U · 1**

Molality is moles of solute per kilogram of solvent: it uses only masses, which don't change when the solution warms. Molarity, normality and % w/v divide by a volume, which grows as a liquid expands.

**iii.** **b.** 69 **A · 1**

$M = 2 \times 39 + 12 + 3 \times 16 = 138$. The total positive charge ($2K^+$) is 2, so $E = 138/2 =$ **69**.

**iv.** **b.** 15 mL **A · 1**

0.10 M $H_2SO_4$ is 0.20 N (basicity 2). $N_1V_1 = N_2V_2$: $0.20 \times 15 = 0.20 \times V$, so V = **15 mL**. 7.5 mL forgets the factor of 2.

**v.** **c.** starch **K · 1**

Starch gives a blue-black color with iodine, which disappears when all the iodine has been used up by the thiosulphate.

## 4 Short answers

**a.** **MARKING SCHEME** **U · 2**

- ✓ Equivalence point: the reaction exactly complete; end point: the indicator changes color.
- ✓ The titration error is the difference between the two.

**b.** **MARKING SCHEME** **U · 2**

- ✓ It absorbs moisture and carbon dioxide from the air, so its weighed mass is not exact.
- ✓ Its solution is standardized by titration against a primary standard (oxalic acid).

**c.** **MARKING SCHEME** **A · 3**

- ✓ 26.
- ✓ 54.7.
- ✓ 95.



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## 5 Long answer

**ANSWER** U · 4

**Permanganometry** is a redox titration with potassium permanganate as the titrant, used to measure reducing agents such as iron(II) salts and oxalates.

The permanganate ion is deep purple and is reduced in acid to the almost colorless $Mn^{2+}$ ion, so each drop loses its color as it reacts; once the reducing agent is used up, the next drop stays and the solution turns pale pink. It is its own indicator.

$KMnO_4$ is not a primary standard: its solution slowly decomposes, faster in light and with dust or organic matter, depositing $MnO_2$, so its strength changes. Hydrochloric acid can't be used because permanganate oxidizes chloride ions to chlorine, using up some permanganate.

$MnO_4^- + 8\,H^+ + 5\,Fe^{2+} \rightarrow Mn^{2+} + 5\,Fe^{3+} + 4\,H_2O$

**MARKING SCHEME**

- ✓ Permanganometry: a redox titration with $KMnO_4$ as the titrant.
- ✓ Self-indicator: purple $MnO_4^-$ becomes nearly colorless $Mn^{2+}$; the first drop left over turns the solution pale pink.
- ✓ Standardized because it decomposes; not HCl because $Cl^-$ is oxidized to $Cl_2$.
- ✓ The balanced ionic equation.

## 6 Numerical problems

**a.** **ANSWER** A · 4

i. $E(Na_2CO_3) = 106/2 = 53$. Gram equivalents $= 2.65/53 = 0.0500$ in 0.250 L: N = **0.200 N**.

ii. $M = N/n = 0.200/2 =$ **0.100 M** (2.65/106 = 0.0250 mol in 0.250 L).

iii. $N_1V_1 = N_2V_2$: $0.200 \times 20.0 = N \times 16.0$, so N = **0.250 N**.

iv. HCl has n = 1: g/L $= 0.250 \times 36.5 =$ **9.13 g/L**.

**MARKING SCHEME**

- ✓ 0.200 N.
- ✓ 0.100 M.
- ✓ 0.250 N HCl by the normality equation.
- ✓ 9.13 g/L.

**b.** **ANSWER** A · 4

i. Moles of $Cr_2O_7^{2-} = 0.0150 \times 0.0150 =$ **$2.25 \times 10^{-4}$ mol**.

ii. Moles of $Fe^{2+} = 6 \times 2.25 \times 10^{-4} = 1.35 \times 10^{-3}$ mol in 0.0200 L: **0.0675 M**.

iii. $0.0675 \times 56 =$ **3.78 g/L**.

iv. Each Cr goes from +6 to +3, so n = 6 for $K_2Cr_2O_7$: N $= 0.0150 \times 6 =$ **0.0900 N**. (Check: $0.0900 \times 15.0 = 0.0675 \times 20.0$.)

**MARKING SCHEME**

- ✓ $2.25 \times 10^{-4}$ mol of dichromate.
- ✓ 0.0675 M iron(II), using the 1 : 6 ratio.
- ✓ 3.78 g/L.
- ✓ 0.0900 N.

## 7 Think

**ANSWER** HA · 3

Sita's result will be **too high**. The water left in her burette dilutes the sodium hydroxide, so more of it is needed to reach the end point; she works out the acid's concentration from this larger volume and the alkali's known (undiluted) concentration.

Manish's result will be **right**. The extra water in the flask changes the volume of the solution, but not the amount of acid pipetted into it, and it is the amount that reacts with the alkali.

**MARKING SCHEME**

- ✓ Sita's alkali is diluted, so a larger volume is used.
- ✓ Her result for the acid is too high.
- ✓ Manish's water doesn't change the amount of acid, so his result is right.



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## 8 Activity: Concordant readings

(not marked)

### WHAT STUDENTS SHOULD FIND

The flask stays colorless until one drop turns it a pale pink that stays. The rough titration usually overshoots by a few tenths of a milliliter. The careful titrations are repeated until two agree within 0.10 mL (concordant readings), and only those are averaged. The normality of the acid is then $N(\text{acid}) = N(\text{NaOH}) \times V(\text{NaOH}) \div 25.0$.

| Marks by level | Knowledge | Understanding | Application | Higher ability | Total |
|---|---|---|---|---|---|
| **Marks** | 8 | 9 | 13 | 3 | **33** |



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