Question 1

(a) EXPLAIN: **can be dissolved (used) to make up a solution of exact (known) concentration / no need to standardise by titration (can be made up directly) //**

pure / stable / anhydrous (not hydrated) / no water loss (no efflorescence) / not deliquescent (not hygroscopic) / does not sublime / high formula (molecular, molar) mass (M_r)

ANY TWO: (3 + 2)

(b) DESCR: **rinse (wash) from clock glass into beaker and dissolve //**
pour (add) using funnel (glass rod) into 500 cm^3 volumetric flask and add rinsings of beaker //
add deionised* water until bottom of meniscus on (level with) mark / read at eye level //
stopper and **invert** (not "shake") **several times** ANY FOUR: (4 × 3)
******[Accept if "deionised water" appears elsewhere in candidate's description.]*

CALC: **2.65 g** (6)

$$\frac{500 \times 0.05 \times 106^*}{1000} \quad (3) \quad = \quad 2.65 \quad (3)$$

** Addition must be shown for error to be treated as a slip.*

(c) *(i)* **fill above mark and adjust with tap / fill to below mark and add dropwise** (3)

(ii) **safety / avoid solution getting into mouth / hygiene** (3)

(d) NAME: **indicator** (3)

CHANGE: **colour before // colour after** (2 × 3)

Indicator	Colour before	Colour after
Methyl orange	Orange (yellow)	Red (pink)
Methyl red	Yellow	Red (pink)
Methyl yellow	Yellow	Red (pink)
Bromophenol blue	Blue (purple, violet)	Yellow
Bromocresol green	Blue	Yellow

[Linked marks - suitable indicator is a requirement for award of marks for matched colours]

(e) CALC: *(i)* **0.12 M** (9)

$$\frac{20.8 \times M_{HCl}}{2} = \frac{25 \times 0.05}{1} \quad (6)$$

$$M_{HCl} = 0.12 \quad (3)$$

(ii) **4.38 / 4.39 g l^{-1}** (3)

$$0.12 \times 36.5^* = 4.38 \quad (3)$$

** Addition must be shown for error to be treated as a slip.*

NOTE: Treat answers not given to two decimal places as slips.

Question 2

(*a*) MEASURE: use 25 cm³ **pipette (burette)** //
previously rinsed with deionised (distilled, pure) water //
and previously rinsed with vinegar (solution it will contain, sample) //
pipette: **read at eye-level / read bottom of meniscus / bottom of meniscus on the mark /**
allow drainage time / last drop to remain (not to be shaken out, blown out) /
drain under gravity / touch (tip, tap) pipette **against** wall of **flask**
burette: **read at eye-level / jet (part below tap) full / vertical / read bottom of meniscus**
ANY THREE: (3 × 3)

DILUTE: transfer to 250 cm³ **volumetric flask** //
previously rinsed with deionised (distilled, pure) water //
fill with deionised water until **bottom of meniscus is on mark** //
stopper and **invert flask a number of times** / stopper and **mix contents thoroughly**
ANY TWO: (2 × 3)

[Award marks for reference to '*bottom of meniscus*' once only in (*a*).]

(*b*) NAME: **phenolphthalein** (3)

WHAT: from **pink (purple)** (3)
to **colourless** (3)
[Colours reversed unacceptable.] ['*Clear*' unacceptable for '*colourless*'.]

(*c*) CALCULATE: (*i*) **0.0015 (1.5 × 10⁻³) moles** (6)

$= \frac{1.20 \times 2}{40^*} = 0.06^{**}$ M (3)
$\frac{25 \times 0.06}{1000} = 0.0015$ moles/25 cm³ (3)

/

$\frac{1.20}{20} = 0.06$ g in 25 cm³ (3)
$\frac{0.06}{40^*} = 0.0015$ moles/25 cm³ (3)

/

$\frac{1.20}{40^*} = 0.03$ moles/500 cm³ (3)
$\frac{0.03}{20} = 0.0015$ moles/25 cm³ (3)

[**Addition must be shown for error to be treated as slip.*]

(*ii*) **0.00008 (8 × 10⁻⁵) moles per cm³** (6)

0.0015 moles CH_3COOH (3)
0.0015 18.75 =
0.00008 (8 × 10⁻⁵) moles per cm³ (3)

/

$\frac{18.75 \times M}{1} = \frac{25 \times 0.06}{1}$ / $\frac{18.75 \times M}{1} = \frac{25 \times Molarity^{**}}{1}$
$M = 0.08^{***}$ M (3)
$\frac{0.08}{1000} = 0.00008$ (8 × 10⁻⁵) moles per cm³ (3)

(*d*) FIND: (*i*) **0.8 M** (3)

0.00008 × 1000 × 10 = 0.8 moles/L (3)

/

0.08 (Molarity***) × 10 = 0.8 moles/L (3)

(*ii*) **4.8 % (w/v)** (6)

0.8 × 60* = 48 g/L (3)
$\frac{48}{10}$ = 4.8 g/100 cm³ = 4.8 % (w/v) (3)

/

0.8 ÷ 10 = 0.08 moles/100 cm³ (3)
0.08 × 60* = 4.8 g/100 cm³ = 4.8 % (w/v) (3)

[**Addition must be shown for error to be treated as slip*]

(*e*) WHAT: anhydrous sodium carbonate titrated **with a strong acid {hydrochloric acid (HCl), sulfuric acid (H_2SO_4), nitric acid (HNO_3)}** //
acid titrated **with sodium hydroxide (NaOH)** solution (3 + **2**)
[Award (3) for correct titrations in reverse order.]

Question 3

(*a*) EXPLAIN: **concentration (molarity) known (found, got, etc.) by another titration (colorimetry, u.v. spectroscopy)** **(5)**
[Allow 4 for **concentration (molarity) known (found, got, etc).**]

(*b*) DISSOLVED AND MADE-UP: wash (rinse) into beaker **of deionised (distilled, pure) water** //
stir to dissolve //
pour through **funnel (down glass rod) into volumetric flask adding rinsings** of beaker //
add last few drops of deionised water **drop by drop (using dropper) to bring bottom of meniscus level with (up to, on, at) mark** reading at eye level (6 + 3 + 3)
[Stopper and invert does not ensure solution made up to exactly 250 cm^3.][‘Deionised’ mentioned anywhere in (*b*) is acceptable for first point.]

(*c*) STATE: **add drop by drop (slowly) / wash down inner sides of conical flask / swirl (shake)** flask contents //

EXPLAIN: add dropwise so that **end point will be precisely (accurately) detected (correct end point not passed) / one drop** of solution **would change colour near end point /** wash sides **so that all reagent(s) (acid) in the reaction mixture /** swirl **to ensure thorough mixing** of reactants (2 × 3)
[‘State’ & ‘Explain’ to be linked.]

(*d*) NAME: **methyl orange / methyl red / bromophenol blue / bromocresol green** (3)

CHANGE: **before // after** (2 × 3)

Name (3)	**Colour before (3)**	//	**Colour after (3)**
methyl orange	orange (yellow)	//	red (pink, peach)
methyl red	orange (yellow)	//	red (pink)
bromophenol blue	blue (purple, violet)	//	yellow
bromocresol green	blue	//	yellow

[Colour change must be matched with named indicator.]

(*e*) CALCULATE: (i) **0.0432 M** (6)
[Molarity divided by 4 to get 0.0108 - deduct 3 marks.]

$\frac{25 \times M}{1} = \frac{21.6 \times 0.1}{2}$ (3)

$M = 0.0432$ (3)

[*M* = 0.04 or 0.043, deduct 1 mark for inappropriate rounding off in (i) or for use of 0.04 or 0.043 in (ii) but deduction to made once only.]

(ii) **4.6 g l^{-1}** (3)

$0.0432 \times 106 = 4.5792 / 4.58 / 4.6$ (3)

(*f*) % WATER: **54 – 54.4%** (3)

Hydrated = 2.50 g/250 cm^3 / 10 g l^{-1}

Anhydrous = 1.14 – 1.15 g/250 cm^3 / 4.58 – 4.6 g l^{-1}

Water = 1.35 – 1.36 g/250 cm^3 / 5.4 – 5.44 g l^{-1}

$\Rightarrow \frac{1.35/1.36}{2.5} \times 100 \; / \; \frac{5.4/5.44}{10} \times 100 = 54\%$ (3)

Question 4

(a) IDENTIFY: **anhydrous sodium carbonate (Na_2CO_3)** [Allow (3) for *sodium carbonate*.] (5)

[*OTHER POSSIBILITY*: sodium tetraborate (disodium tetraborate, $Na_2B_4O_7$)]

(b) NAME: **indicator** (3)

colour change (2 × 3)

methyl orange	orange (yellow)	//	to red (pink)
methyl red	yellow	//	to red (pink)
methyl yellow	yellow	//	to red (pink)
bromophenol blue	blue (purple, violet)	//	to yellow
bromocresol green	blue	//	to yellow

[*Colour change must be matched with chosen indicator*]

EXPLAIN: **indicator is a weak acid / indicator is a weak base** (3)

(c) (i) DESCRIBE: **rinse with deionised (distilled) water** //

rinse with reagent (solution) (2 × 3)

(ii) WHY: **air will be displaced by the solution (reagent) / some of measured volume replaces air / some of measured volume not delivered / some of measured volume goes to fill space / causes (gives) wrong (inaccurate, too high, too low) reading (result, titre) / air will be displaced (removed, got rid of)** during the titration / **will be filled during the titration / affects result** / burette **only works properly when it** (part below tap) **is full** / burette **designed to work properly when it** (part below tap) **is full / distorts result (reading)** [Accept 'air bubbles' for 'air'] (6)

(d) (i) MOL/LITRE: **0.05731 / 0.0573 / 0.057 M** **[0.06 (-1)*]** (6)

$\frac{25 \times X}{1} = \frac{26.05 \times 0.11}{2}$ (3)

X = 0.05731 / 0.0573 / 0.057 M (3)

*Not deducted if more accurate value also given. However, lost later if 0.06 used in later calculations.

(ii) g/LITRE: **6.042 to 6.075 g l^{-1}** (3)

0.0573 × 106* = 6.075 (3)

[* *Addition must be shown for error to be treated as a slip.*]

Question 5

(a) WHY: **vinegar (it) too concentrated / would require very concentrated (corrosive) NaOH solution / to suit concentration of NaOH solution / very large volume* of NaOH needed to be get a reasonable titration / small acid titration volume lowers accuracy / small acid titration volume increases percentage error** *[*Allow "value", "figure", "amount"]* (5)
[In the absence of adequate qualification, allow 3 marks for "for accuracy", "large volume of NaOH needed", "small titration figure(s) / titration figure(s) too small / end point(s) too low"]

(b) DESCRIBE: **rinse pipette (burette) with water //**
and then with vinegar //
fill with **pipette filler / have bottom of meniscus on mark / read** pipette (burette) **at eye level (vertically) //**
deliver (add, let flow) 25 cm^3 **to** 250 cm^3 **volumetric flask //** *available from diagram*
add deionised (distilled, pure) water until level of water near mark //
add **dropwise (by dropper / by pipette / by wash bottle)** //
bring **bottom of meniscus to (on, at) mark** / vol. flask **at eye-level (vertical)** //
stopper and **invert** several times / **mix** thoroughly / solution **homogeneous (even concentration, same concentration throughout)** ANY FIVE: (5 × 3)

(c) NAME: **phenolphthalein / thymolphthalein / thymol blue / cresol purple / neutral red / phenol red / bromothymol blue** (3)

JUSTIFY: **pH change (drop, jump** down) at end point **c11 – c6 (c6 – c11)* / specify indicator range /** titration of **weak acid-strong base / pH at end point passes through indicator range** (3)
**Change of three to five units of pH required. [Allow "passes through midpoint of range".]*
Name and Justify are not linked.

STATE: **colour before (in base, in NaOH) // colour after (in acid)** (2 × 3)

phenolphthalein	pink (purple, violet, red) // colourless
thymolphthalein	blue // colourless
thymol blue	blue // yellow
cresol purple	purple (pink, violet) // yellow
neutral red	yellow-brown (yellow, brown) // red
phenol red	red // yellow
bromothymol blue	blue // yellow

[Colour change must be matched with chosen indicator. Allow 3 for reversed colour change.]

(d) CALC: (i) **0.11 mol l^{-1}** *[Multiplied (or divided) by 4:loses 3 marks.]* (6)

Mean titre = $\frac{(22.6 + 22.7)}{2}$ = 22.65 *[Loses 3 if incorrect]*
$22.65 \times M = 25.0 \times 0.10$ (3) $M = 0.11$ (3)

(ii) **6.6 g l^{-1}** (3)

$0.11 \times 60^* = 6.6$ (3)
** Addition must be shown for error to be treated as a slip.*

STATE: **66 g l^{-1}** (3)

$6.6 \times 10 = 66$ (3)

EXPRESS: **6.6 %** (w/v) (3)

$66 \div 10 = 6.6$ (3)

(e) IDENTIFY: **methanoic (formic) acid / HCOOH / CH_2O_2** (3)
[If name & formula are given and one is incorrect, award marks on basis of first answer given.]