Course 3 -Acid/Base Titrations

Marking scheme

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)

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

* *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)

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

M_{HCl} = **0.12** (3)

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

0.12 × 36.5* = **4.38** (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) 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*.]

(e) CALCULATE: (i) **62.9 to 63.2%** (3)

$$\frac{10.325 \times 100}{16.4} = 62.9 \quad (3)$$

(ii) **10** [*Accept answers giving 10 when rounded off to nearest integer*] (9)

M_r of Na_2CO_3 = 106	M_r of H_2O = 18

hydrated form = 8.20×2 = 16.4 g l^{-1}
water content = 16.4 – 6.075 = 10.325 (3)

$^{6.075}/_{106}$: $^{10.325}/_{18}$ (3)

0.0573 : 0.573

1 : 10 (3)

OR

anhydrous form = 6.075 ÷ 2 = 3.0375 g/500cm^3
water content = 8.20 – 3.0375 = 5.1625 (3)

$^{3.0375}/_{106}$: $^{5.1625}/_{18}$ (3)

0.0287 : 0.287

1 : 10 (3)

OR

hydrated form = 16.4 g l^{-1} => $M_r = {}^{16.4}/_{0.05731} = 286$ (3)
water content = 286 – 106 = 180 / 286 = 106 + 18x (3)
=> x = 180 ÷ 18 = 10 (3)

OR

hydrated form = 16.4 g l^{-1} $^{Mr}/_{106} = {}^{16.4}/_{6.075}$ => M_r = 286 (3)
water content = 286 – 106 = 180 / 286 = 106 + 18x (3)
=> x = 180 ÷ 18 = 10 (3)

OR

hydrated form = 16.4 g l^{-1} => water = 16.4 – 6.075 = 10.325 g (3)
$^{water}/_{106} = {}^{10.325}/_{6.075}$ => water = 180 (3)
=> x = 180 ÷ 18 = 10 (3)

OR

anhydrous form = 3.0375 g/500cm^3 water = 8.2 – 3.0375 = 5.1625 g (3)
$^{water}/_{106} = {}^{5.1625}/_{3.0375}$ => water = 180 (3)
=> x = 180 ÷ 18 = 10 (3)

[Note: If no marks have been got in (e) (ii), 3 marks to be awarded if M_r of Na_2CO_3 (106) appears in the candidate's calculations.]

Question 3

QUESTION 1

(*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.]

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

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 × 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}

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

QUESTION 1

(*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.]

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

VALUE OF x: **6.9 – 7** (6)

Formula mass of Na_2CO_3 = 106		**Formula mass of H_2O = 18**
Na_2CO_3 content = 4.6 g l^{-1} [4.5792 – 4.6] H_2O content = 10 – 4.6 = = 5.4 g l^{-1} [5.4 – 5.4208] $\frac{\mathbf{5.4}}{\mathbf{4.6}} = \frac{\mathbf{18}x}{\mathbf{106}}$ (3) x = **6.9 – 7** (3)	OR	Na_2CO_3 content = 1.15 g /250 cm^3 [1.14 - 1.15] H_2O content = 2.5 – 1.15 = 1.35 g /250 cm^3 [1.35 - 1.36] $\frac{\mathbf{1.35}}{\mathbf{1.15}} = \frac{\mathbf{18}x}{\mathbf{106}}$ (3) x = **6.9 – 7** (3)
Na_2CO_3 content = 4.6 g l^{-1} [4.5792 – 4.6] H_2O content = 10 – 4.6 = = 5.4 g l^{-1} [5.4 – 5.4208] $\frac{\mathbf{4.6}}{\mathbf{106}} : \frac{\mathbf{5.4}}{\mathbf{18}}$ / **0.043 : 0.3** (3) = 1 : **6.9 – 7** (3)	OR	Na_2CO_3 content = 1.15 g /250 cm^3 [1.14 -1.15] H_2O content = 2.5 – 1.15 = 1.35 g /250 cm^3 [1.35 - 1.36] $\frac{\mathbf{1.15}}{\mathbf{106}} : \frac{\mathbf{1.35}}{\mathbf{18}}$ / **0.0109 : 0.075** (3) = 1 : **6.9 – 7** (3)
Hydrated form: 10 g l^{-1} = 0.0432 M Formula mass = $\frac{\mathbf{10}}{\mathbf{0.0432}}$ / **231.5** (3) $x = \frac{231.5-106}{18}$ = **6.9 – 7** (3)	OR	Hydrated form: 2.5 g /250 cm^3 = 0.0108 mol Formula mass = $\frac{\mathbf{2.5}}{\mathbf{0.0108}}$ / **231.5** (3) $x = \frac{231.5-106}{18}$ = **6.9 – 7** (3)
$\frac{\boldsymbol{M}_{\mathbf{r(hyd)}}}{\mathbf{106}} = \frac{\mathbf{10}}{\mathbf{4.6}^*}$ / $M_{r(hyd)}$ = **230.4**[230.4 -231.5] [*4.5792 – 4.6] (3) $x = \frac{230.4-106}{18}$ = **6.9 – 7** (3)	OR	$\frac{\boldsymbol{M}_{\mathbf{r(hyd)}}}{\mathbf{106}} = \frac{\mathbf{2.5}}{\mathbf{1.15}^*}$ / $M_{r(hyd)}$ = **230.4** [230.4 - 232.5] [*1.14 – 1.15] (3) $x = \frac{230.4-106}{18}$ = **6.9 – 7** (3)
$\frac{\mathbf{mass_{water}}}{\mathbf{106}} = \frac{\mathbf{5.4}}{\mathbf{4.6}}$ [5.4 – 5.4208][4.5792 –4.6]/ $\mathbf{mass_{water}}$ = **124.4** [124.4 – 125.5] (3) $x = \frac{124.4}{18}$ = **6.9 – 7** (3)	OR	$\frac{\mathbf{mass_{water}}}{\mathbf{106}} = \frac{\mathbf{1.35}}{\mathbf{1.15}}$ [1.35 - 1.36][1.14 - 1.15] / $\mathbf{mass_{water}}$ = **124.4** [124.4 – 125.5] (3) $x = \frac{124.4}{18}$ = **6.9 – 7** (3)

[*Reminder: second 3 may be awarded consequentially.]*

VALUE OF x: **6.9 – 7** (6)

Formula mass of Na_2CO_3 = 106		**Formula mass of H_2O = 18**
Na_2CO_3 content = 4.6 g l^{-1} [4.5792 – 4.6] H_2O content = 10 – 4.6 = = 5.4 g l^{-1} [5.4 – 5.4208] $\frac{\mathbf{5.4}}{\mathbf{4.6}} = \frac{\mathbf{18}x}{\mathbf{106}}$ (3) x = **6.9 – 7** (3)	OR	Na_2CO_3 content = 1.15 g /250 cm^3 [1.14 - 1.15] H_2O content = 2.5 – 1.15 = 1.35 g /250 cm^3 [1.35 - 1.36] $\frac{\mathbf{1.35}}{\mathbf{1.15}} = \frac{\mathbf{18}x}{\mathbf{106}}$ (3) x = **6.9 – 7** (3)
Na_2CO_3 content = 4.6 g l^{-1} [4.5792 – 4.6] H_2O content = 10 – 4.6 = = 5.4 g l^{-1} [5.4 – 5.4208] $\frac{\mathbf{4.6}}{\mathbf{106}} : \frac{\mathbf{5.4}}{\mathbf{18}}$ / **0.043 : 0.3** (3) = 1 : **6.9 – 7** (3)	OR	Na_2CO_3 content = 1.15 g /250 cm^3 [1.14 -1.15] H_2O content = 2.5 – 1.15 = 1.35 g /250 cm^3 [1.35 - 1.36] $\frac{\mathbf{1.15}}{\mathbf{106}} : \frac{\mathbf{1.35}}{\mathbf{18}}$ / **0.0109 : 0.075** (3) = 1 : **6.9 – 7** (3)
Hydrated form: 10 g l^{-1} = 0.0432 M Formula mass = $\frac{\mathbf{10}}{\mathbf{0.0432}}$ / **231.5** (3) $x = \frac{231.5-106}{18}$ = **6.9 – 7** (3)	OR	Hydrated form: 2.5 g /250 cm^3 = 0.0108 mol Formula mass = $\frac{\mathbf{2.5}}{\mathbf{0.0108}}$ / **231.5** (3) $x = \frac{231.5-106}{18}$ = **6.9 – 7** (3)
$\frac{\boldsymbol{M}_{\mathbf{r(hyd)}}}{\mathbf{106}} = \frac{\mathbf{10}}{\mathbf{4.6}^*}$ / $M_{r(hyd)}$ = **230.4**[230.4 -231.5] [*4.5792 – 4.6] (3) $x = \frac{230.4-106}{18}$ = **6.9 – 7** (3)	OR	$\frac{\boldsymbol{M}_{\mathbf{r(hyd)}}}{\mathbf{106}} = \frac{\mathbf{2.5}}{\mathbf{1.15}^*}$ / $M_{r(hyd)}$ = **230.4** [230.4 - 232.5] [*1.14 – 1.15] (3) $x = \frac{230.4-106}{18}$ = **6.9 – 7** (3)
$\frac{\mathbf{mass_{water}}}{\mathbf{106}} = \frac{\mathbf{5.4}}{\mathbf{4.6}}$ [5.4 – 5.4208][4.5792 –4.6]/ **$mass_{water}$ = 124.4** [124.4 – 125.5] (3) $x = \frac{124.4}{18}$ = **6.9 – 7** (3)	OR	$\frac{\mathbf{mass_{water}}}{\mathbf{106}} = \frac{\mathbf{1.35}}{\mathbf{1.15}}$ [1.35 - 1.36][1.14 - 1.15] / **$mass_{water}$ = 124.4** [124.4 – 125.5] (3) $x = \frac{124.4}{18}$ = **6.9 – 7** (3)

[*Reminder: second 3 may be awarded consequentially.]*

Question 4

QUESTION 1

a	b	c	d
5	**12**	**12**	**21**

(*a*) IDENTIFY: **anhydrous sodium carbonate / Na_2CO_3** (5)
[Anhydrous omitted (3).]

(*b*) DESCRIBE: washing soda **transferred to a beaker** and **dissolved in (added to)** deionised **water /**
washing soda **rinsed into beaker with** deionised **water //**

use **funnel //**

transfer solution (contents of beaker) **to** correctly prepared **volumetric flask //**

rinse beaker and glass rod **into** volumetric **flask //**

make up (top up, fill, add deionised **water)** to 250 cm^3 with **bottom of meniscus on mark //**

stopper and invert several times

(4 × 3)

(*c*) NAME: (*i*) **methyl orange / methyl red** (3)

JUSTIFY: (*ii*) **strong acid weak base** titration **/**
end point (indicator **range**) **below pH** of **7 (at pH < 7, between pH 3 and** pH **5) /**
diagram showing (description of) end point occurring within sharp rise in pH (steep vertical part of pH curve, in acidic range) /
indicator (methyl orange) **changes colour coinciding with (at) end point (below pH** of **7, at pH < 7, between pH 3 and** pH **5)** (3)

WHAT: (*iii*) from **orange (yellow) //**
to **red (pink, peach)** (2 × 3)
[Allow (3) for colours in reverse]

(*d*) FIND: (*i*) **0.00258** (**2.58 × 10^{-3}, 129/50000**) moles HCl (3)

$\frac{21.5 \times 0.12}{1000}$ = **0.00258** (**2.58 × 10^{-3}, 129/50000**) moles HCl (3)

(*ii*) **0.00129** (**1.29 × 10^{-3}, 129/100000**) moles of Na_2CO_3 in 25.0 cm^3 (3)

Na_2CO_3 : HCl = 1 : 2 ⇒ 0.00258 (2.58 × 10^{-3}, 129/50000) ÷ 2
= **0.00129** (**1.29 × 10^{-3}, 129/100000**) moles of Na_2CO_3 in 25.0 cm^3 (3)
[Divide by 2 essential.]

or

$\frac{25.0 \times M}{1} = \frac{21.5 \times 0.12}{2}$ ⇒ M = 0.0516 (5.16 × 10^{-2}, 129/2500) moles /l (M) of Na_2CO_3

0.0516 (5.16 × 10^{-2}, 129/2500) ÷ 40 / [0.0516 (5.16 × 10^{-2}, 129/2500)] × (25 ÷ 1000)
= **0.00129** (**1.29 × 10^{-3}, 129/100000**) moles of Na_2CO_3 in 25.0 cm^3 (3)
[Divide by 40 or multiply by (25 ÷ 1000) essential.]

(*iii*) **0.0129** (**1.29 × 10^{-2}, 129/10000**) moles of Na_2CO_3 in 250 cm^3 (3)

0.00129 (1.29 × 10^{-3}, 129/100000) × 10
= **0.0129 (1.29 × 10^{-2}, 129/10000)** moles Na_2CO_3 in 250 cm^3 (3)
[Multiply answer in (*ii*) by 10 essential.]

or

0.0516 ÷ 4 / 0.0516 × (250 ÷ 1000)
= **0.0129 (1.29 × 10^{-2}, 129/10000)** moles Na_2CO_3 in 250 cm^3 (3)
[Only from molarity Na_2CO_3 obtained in (*ii*).]

(*iv*) **1.36**74 g Na_2CO_3 in 250 cm^3 (3)

0.0129 (1.29 × 10^{-2}, 129/10000) × 106* = **1.36**74 g Na_2CO_3 in 250 cm^3 (3)
[Multiply answer in (*iii*) by 106 essential.]

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

(*v*) **2.09**26 g water and 0.**116**256 moles water (6)

3.46 − 1.3674 = **2.09**26 g water (3)

2.0926 ÷ 18** = 0.**116**256 moles water (3)
[Divide by 18 essential.]

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

(*vi*) **9** (3)

$\frac{0.116256}{0.0129}$ = **9** = *x* (3)

[Allow ratio 9:1 for 3 marks]
[*1 mark to be deducted for incorrect or inappropriate **rounding**; deduction to be made once only in (d).*]

[*1 mark to be deducted for **each** of any other mathematical slips, e.g. transposing numbers, addition error in M_r where atomic masses **shown** but added incorrectly, final answer not a whole number, etc.*

Question 5

QUESTION 1

(a) COMPOUND: **ethanol / ethyl alcohol / C_2H_5OH** (4)

PROCESS: **oxidation** (4) *can be got from reaction scheme but only if oxidation is shown by symbol or otherwise.*

(b) DESCRIBE: **pipette (burette)** vinegar (3) *can be shown on diagram*

into **volumetric flask** (3) *can be shown with diagram provided line on neck present*

add deionised **water** (3)

when near mark, add **dropwise (using dropper/pipette/wash bottle)** / **until bottom of meniscus on (at) mark / read bottom of meniscus** (3)

(c) NAME: **burette** (3)

WASHING & FILLING: with **deionised water / then solution (ethanoic acid, diluted vinegar)** / use of **funnel (pour in at top)** / **ensure that the area below (jet, tip, nozzle) the tap is filled** *(not 'the tap is filled')* (3 x 3)

Note: if pipette is named the marks for rinsing with deionised water, then solution, can be given.

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

Cancelling applies to INDICATOR

(d) CONC DIL VIN: **0.15** (6) [20.5 x M = 25 x 0.12 (3) M = 0.15 (3)]

ORIG VIN: **1.5** (3) [0.15 x 10 (3)] [Accept 0.075 moles per 50 cm^3 or 90 g / l for 3 marks]

Note: if a value has not been worked out for the concentration of the original vinegar, (3) consequential marks can be given for the percentage calculation but only if a number (e.g. the answer to conc dil vin) is multiplied by 60 and the product obtained is divided by 10 – the (3) is given for the result of the division by 10; marks for the fully correct answer can of course be given.

PERCENTAGE: **9** (6) [1.5 x 60 = 90 g l^{-1} (3) 90 ÷ 10 = 9 % (3)]

Note: answers can be given to more decimal places.

Question 6

QUESTION 1

(*a*) MEASURE: use 25 cm^3 **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 cm^3 **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)

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

/

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

/

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

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

(*ii*) **0.00008 (8 × 10^{-5})** moles per cm^3 (6)

0.0015 moles CH_3COOH (3)
0.0015 ÷ 18.75 =
0.00008 (8 × 10^{-5}) moles per cm^3 (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 cm^3 (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 cm^3 = **4.8** % (w/v) (3)

/

0.8 ÷ 10 = **0.08** moles/100 cm^3 (3)
0.08 × 60* = 4.8 g/100 cm^3 = **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 7

(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 = $(22.6 + 22.7)/2$ = 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.]