Mark schemes

Q1.

(a) % uncertainty = (2 × 0.005 / 2.14) × 100

= 0.467%

2 sf or more

1

(b) Moles = 25.0 × 10^{-3} × 2.00

= <u>0.0500</u> mol

Answer must be to 3 sf

1

(c) M1: n(NaOH used in titration) = 0.0900 × 0.02038 = 0.0018342 (mol)

n(HCl in excess in 25cm^3) = 0.0018342 (mol)

M1: Moles NaOH

M2: n(HCl in excess in 250cm^3) = 0.0018342 × 10 = 0.018342 (mol)

M2: M1 × 10

M3: n(HCl that reacted) = 0.0500 - 0.018342 = 0.031658 (mol)

M3: (b) - M2

M4: n(MgO in 6 tablets using equation stoichiometry) = 0.031658/2

= 0.015829 (mol)

M4: M3 / 2

M5: Mass of MgO in 6 tablets = 0.015829 × 40.3 = 0.6379 g

M5: M4 × 40.3

M6: % by Mass of MgO = (0.6379 / 2.14) × 100= 29.8 %

M6: (M5 / 2.14) ×100

6

[8]

Q2.

(a) **M1** amount of Mg = $\frac{0.400}{24.3}$ = 0.016(5) (mol)

M2 amount of HCl = 1.50 × $\frac{20.0}{1000}$ = 0.03(00) (mol)

M3 justification that HCl is the limiting reagent (e.g. 0.0165 mol of Mg requires 0.0330 mol of HCl or only 0.0150 mol of Mg reacts with 0.030 mol of HCl or mols of HCl is less than double the moles of Mg or mols of Mg is more than half the moles of HCl)

M4 amount of H_2 formed = 0.0150 (or $\frac{M2}{2}$)

M5 converting T to 288, P to 101000

M6 $V = \frac{M4 \times 8.31 \times 288}{101000}$

M7 V = 3.55×10^{-4} (m^3)

M7 to at least 2 sf (3.554376... x 10^{-4})

3.6 x 10^{-4} to 2sf

M2 Penalise 0.015 mol shown as amount of HCl but ignore 0.015 in working out of limiting reagent

Allow ECF at each stage, but note:

- *M3 should be based on their values for M1/2*
- *M4 should be based on their values of M1/2 independent of M3*
- *Note that answer based on 0.0165 mol Mg as limiting reagent gives 3.79-3.91 × 10^{-4} m^3 which scores M5,6,7 and possibly M3,4*

If candidates use 1 mol has volume of 24 dm^3 rather than use ideal gas equation - cannot score M5/6/7

7

(b) **M1** $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

M1 Allow multiples/fractions

M2 250 (cm^3)

ECF from M1 to M2 (i.e. 50 x mol O_2 in equation)

2

[9]

Q3.

(a) (To make sure that) as much as possible/maximum amount (of solid) dissolves
OR
(To ensure that) the solution/it is saturated

Do not accept reacted

Ignore references to right/correct concentration

1

(b) otherwise, the titre would be larger
OR
would need a larger volume of acid/HCl
OR
because undissolved strontium hydroxide will react (with the acid/HCl).

Allow (solid) could block pipette

Ignore references to changes in concentration and pH

1

(c) To prevent reaction with carbon dioxide (in the air)

Allow so flask can inverted/shaken (to ensure homogeneous mixture)

OR
To prevent evaporation (of water/from solution)

Ignore contamination

1

(d) Answer **C**

1

(e) **M1** $Sr(OH)_2 + 2\ HCl \rightarrow SrCl_2 + 2\ H_2O$

M1 Equation

M2 32.43 (cm^3)

M2 Allow 32.425

M3 n HCl in mean titre = $3.24(3) \times 10^{-3}$ mol

M3 Allow 0.1 x M2 ÷ 1000

M4 n $Sr(OH)_2$ in 25 cm^3 = 1.62×10^{-3} mol

M4 Allow M3 ÷ 2

M5 n $Sr(OH)_2$ in 100 cm^3 of solution = 6.48×10^{-3} mol

M5 Allow M4 × 4

M6 mass = (6.48×10^{-3} mol x 121.6) = 0.788 (g per 100 cm^3 solution)

M6 Allow = M5 × 121.6
M6 Allow 0.79

Allow M5 and M6 in either order

6

[10]

Q4.

(a) **M1** mol P = 0.0145 + (2 × 0.0115) = 0.0375

M2 $[P] = \frac{M1}{0.025}$ = 1.50 mol dm^{-3}

ECF from incorrect M1

2

(b)

M1 $K_c = \frac{[R][S]^3}{[P]^2\,[Q]}$

M1 Must be square brackets in expression

M2 $K_c = \frac{\left(\frac{0.0115}{0.045}\right)\left(\frac{0.0345}{0.045}\right)^3}{\left(\frac{0.0145}{0.045}\right)^2\left(\frac{0.0275}{0.045}\right)}$ or $= \frac{(0.256)(0.767)^3}{(0.322)^2(0.611)}$

M2 Inserts values and divides by volume in dm^3

M3 = 1.81 to 1.82

M3 Evaluates expression
If no use of volume lose M2 but can score M3 for 0.0817

M4 units mol dm^{-3}

M4 Allow consequential to their expression

4

(c) **M1** <u>equilibrium</u> shifts to side with most moles

M2 to oppose decrease in concentration of all reactants and products / dilution of everything

Allow
M2 oppose the decrease in concentration of S

OR

M1 K_c is expressed as a function of concentrations and concentration equals amount over volume.

$K_c = RS^3/P^2Q \times 1/V$ (where R,S etc are amounts)
So, if V increases R and S must increase relative to P and Q to keep K_c constant

M2 If Volume increases the amount of **R** and **S** must increase in order to keep K_c constant.

2

[8]

Q5.

M1 $\frac{2.62 \times 10^{-3}}{6.56 \times 10^{-4}} = 4$ or $\frac{6.56 \times 10^{-4}}{2.62 \times 10^{-3}} = 0.25$

M2 Hence $4CO_2 + 4H_2O$

M3 So 4C and 8H in L

M4 Hence 2O so $C_4H_8O_2$

$C_3H_4O_3$ scores 1 if no other mark scored

Alternative method

M1
nH in L = 5.24×10^{-3}
Hence mass H = 5.24×10^{-3} g

M2
n C in L = 2.62×10^{-3}
Hence mass C = $2.62 \times 10^{-3} \times 12$
= 3.144×10^{-2} g

M3
Mass L = $6.56 \times 10^{-4} \times 88$
= 0.057728 g
Mass O = 0.057728 - ($5.24 \times 10^{-3} + 3.144 \times 10^{-2}$)
= 0.021048 g

M4
nO = 0.021048 / 16
= 1.3155×10^{-3}

EF	C	H	O
	2.62×10^{-3}	5.24×10^{-3}	1.3155×10^{-3}
	2	4	1

MF = (88/44) x C_2H_4O
= $C_4H_8O_2$

$C_3H_4O_3$ scores 1 if no other mark scored

[4]

Q6.

(a) **M1** (giant) lattice of (Mg^{2+}) cations / (giant) lattice of (Mg) atoms

Incorrect structure type loses M1

M2 (Electrostatic) attractions between cations / Mg^{2+} ions / nuclei **and** delocalised electrons

2

(b) **M1** Trend: increases

M2 Reason: the number of electron energy levels increases

Allow: the number of electron shells increases

Ignore increase in shielding

2

(c) $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

State symbols essential

Bright/white flame/light

White/grey ash/powder (allow smoke)

Do not allow ppt

Ignore black solid

Ignore fumes.

3

(d) **M1** $BaSO_4$

M2 X-rays (of internal organs) / barium meal

2

(e) **M1** Abundance of ^{87}Sr = X

and Abundance of ^{86}Sr = 1 - 0.83 - X

= 0.17 - X

Allow M1 for

Abundance of ^{87}Sr = X and Abundance of ^{86}Sr = Y ***if*** *also states that X + Y = 17*

M2 87.73 = (88 × 0.83) + (87 × X) + (86 × (0.17 - X))

87.73 = (88 × 0.83) + (87 × X) + (86 × Y)

87.73 = 73.04 + 87X + 14.62 - 86X

87.73 = 87.66 + X

M3 ^{87}Sr = 0.07 = 7 %

M4 Abundance of ^{86}Sr = 1 - 0.83 - 0.07 = 0.1 = 10 %

M4 = 17 - M3

4

(f) **M1** Amount of HCl added = 0.200 × 0.040 = 0.00800 mol

M2 Amount of NaOH = 0.100 × 0.02925 = 0.002925 mol

(Amount of HCl = 0.002925 mol)

M3 Amount of HCl reacted with $Mg(OH)_2$ = 0.00800 - 0.002925 = 0.005075 mol

M3 = M1 - M2

M4 Amount of $Mg(OH)_2$ = 0.005075 ÷ 2 = 0.0025375 mol

M4 = M3 ÷ 2

M5 Mass of $Mg(OH)_2$ = 58.3 × 0.0025375 = 0.148 g

M5 = M4 × 58.3

M6 % by mass = $\frac{0.148}{0.200}$ × 100 = 74.0 %

M6 = $\frac{M5}{0.200}$ *× 100*

Do not allow M6 if >100%

6

[19]

Q7.

(a) ANY THREE

Ignore apparatus changes

Record all masses (accurately to 2 decimal places)

Weigh by difference / wash the solid from weighing container into the beaker / add solid directly to volumetric flask (via a funnel) and dissolve in approximately 100 cm^3 of distilled water.

Wash the beaker into the flask after the solution is transferred to the volumetric flask / wash the stirring rod into the flask after use / wash beaker and transfer washings to the volumetric flask.

(Use a dropper when adding close to the graduation mark to) ensure the <u>bottom of the meniscus</u> is on the graduation mark

Mix thoroughly the final solution in the volumetric flask / invert the flask several times (after making the solution up to the graduation mark).

3

(b) $\frac{0.20}{250} \times 100 = 0.080\ \%$

1

[4]

Q8.

M1 $V = 225\times10^{-6}$ m^3 ; $T = 723$ K

M1 converts units of V and T

M2

$n = \frac{pV}{RT} = \frac{101\,000 \times 225 \times 10^{-6}}{8.31 \times 723}$ = 3.78×10^{-3} mol

***M2** calculates the amount, in moles, of gas produced*

M3

n = M2 × $\frac{2}{5}$ = 1.51×10^{-3} mol

***M3** calculates the amount, in moles, of $M(NO_3)_2$*

$n = (M2 \times \frac{2}{5})$

M4

$Mr = \frac{\text{mass}}{\text{mol}} = \frac{0.320}{(\text{M3})}$ = 211.9

***M4** calculation of Mr*

(allow 211.5 to 212)

M5

Ar (M) = 211.9 - 124.0 = 87.9, so

M is **Sr**

***M5** determination of Metal, M using M4*

Consequential to M_r value on answer line: must be a Group 2 metal

[5]

Q9.

(a) $\frac{0.100 \times 250 \times 171.3}{1000}$ = 4.28 g

Allow 4.3 g

1

(b) M1 Transfers the solution to a volumetric/graduated flask

M2 Add washings using distilled water and make up to the graduation mark/250 cm^3

M3 Invert many times / shake to mix

3

(c) So that the titration is done with known concentration of $Ba(OH)_2$

Allow so that water does not dilute the solution

Allow remove water/prevent contamination

1

(d) Drops of acid could fall into the burette (so no longer know how much has been added from burette)

OR

Decreases titre

Ignore changes the titre

Do not accept increases titre

1

(e) **M1** n $Ba(OH)_2$ in 25 cm^3 = $\frac{0.952}{171.3 \times 10}$ = 5.56×10^{-4} mol

M2 n HCl in 24.5 cm^3 = **2 x** 5.56×10^{-4} = 0.00111 mol

M2 = M1 x 2

M3 Concentration of HCl = $\frac{0.00111 \times 1000}{24.50}$ = 0.045 mol dm^{-3}

M3 = $\frac{M2 \times 1000}{24.50}$

3

(f) $\left(\frac{0.15}{24.50} + \frac{0.05}{25.00}\right)$ x 100% = 0.8(1)%

1

[10]

Q10.

(a) M1 n(propanone) = $\frac{0.146}{58}$ (= 2.52×10^{-3})

M2 Conversion of T and P (T = 368K and P = 103000Pa)

M3 V = $\frac{nRT}{P}$ rearranged for V as subject (in algebraic or numbers)

V = $\frac{M1 \times 8.31 \times 368}{103000}$ *scores M2 and M3*

M4 their evaluated M3 × 1 × 10^6 = 75 cm^3

Allow 74-75

4

(b) M1 V = $\frac{348}{368}$ × M4 = 71 cm^3

Marked with (a)

Using alternate answer

M1 V = $\frac{348}{368}$ *× 89 = 84* cm^3

M2 Decrease = M4 - M1 = 4 cm^3

M2 89 - 84 = 5 cm^3

Allow answer for M1 calculated as 70.8 cm^3 *after substitution of values into pV = nRT. Could then lead to a difference of 18.2* cm^3 *if compared to the alternate value for M4 of 89* cm^3

2

(c) M1 % uncertainty = $\frac{0.001}{0.146}$ × 100 = 0.685%

Marked with (a)

M2 Vol uncertainty = $\frac{M1}{100}$ × M4 = 0.5 cm^3

Allow 0.6 cm^3 *if 89* cm^3 *used*

2

(d) M1 Vol CO_2 formed = 3 × 600 = 1800 cm^3

If PV = nRT method used

M1 n(CO_2 *) = 0.0651*

M2 Total Vol left = 1800 + 400 = 2200 cm^3

2

[10]

Q11.

(a) **M1** measure the mass of the weighing boat (or similar) and solid

1

M2 Add the solid to a beaker (or other suitable container) and then reweigh the weighing boat (and subtract to find the mass of solid added.)

1

OR

M1 Place weighing boat on a balance and zero the balance

M2 Add the solid to a beaker (or other suitable container), wash out weighing boat and transfer washing to the beaker.

M1 place (an empty) beaker on balance and zero
M2 add the solid to the beaker and record the mass

OR

M1 place (an empty) beaker on balance and measure its mass
M2 add the solid to the beaker and subtract mass of empty beaker from the total mass

(b) **M1** M_r citric acid = 192.0

1

M2 Amount of citric acid = Mass / M_r
= 0.834 / 192
= 0.0043438 (mol)

M2 conseq on M1

1

M3 Concentration = moles / volume
= 0.0043438 / 0.5
= 0.00869 (mol dm^{-3})

M3 conseq on M2

1

Alternative Method

M1 Concentration (g/dm^3) = 0.834 / 0.50 = 1.668

M2 M_r citric acid = 192.0

M3 Concentration (mol/dm^3) = M1/M2 = 0.00869

(c) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3 Three stages are covered and the explanation of each stage is generally correct and virtually complete Answer is well structured with no repetition or irrelevant points. Accurate and clear expression of ideas with no errors in use of technical terms.	5-6 marks
Level 2 Three stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete Answer shows some attempt at structure. Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. Some minor errors in use of technical terms.	3-4 marks
Level 1 Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete. Answer includes isolated statements but these are not presented in a logical order or show some confusion. Answer may contain valid points which are not clearly linked to an argument structure. Errors in the use of technical terms.	1-2 marks
Level 0 Insufficient correct chemistry to gain a mark.	0 marks

Use best three of these four stages

Stage 1

a. Problem – using a measuring cylinder
b. Explanation – large uncertainty / not accurate enough
c. Improvement – use a (volumetric) pipette (Not dropping pipette)

Stage 2

a. Problem – too much indicator
b. Explanation – may react and affect the endpoint reading
c. Improvement – use a smaller volume (2-6 drops)

Stage 3

a. Problem – rinsing the burette with distilled or deionised water
b. Explanation – will slightly dilute the alkali solution
c. Improvement – rinse the burette with alkali solution

Stage 4

a. Problem – adding alkali solution until the indicator "just" changes colour
b. Explanation – acid may not have fully reacted (as mixture not swirled)
c. Improvement – add alkali solution until a permanent colour change is seen.

6

(d) Calculates the titres for each of 1,2,3 as

1	2	3
22.95	23.10	22.90

1

Averages concordant titres:
(22.95 + 22.90) ÷ 2 = 22.93 cm^3

Allow 22.9(25) cm^3

1

(e) (0.15 / 22.95) × 100 = 0.65%

0.15 / (Their Run 1) × 100

1

[14]

Q12.

(a) **M1** amount of TNT = $\frac{1000}{227.0}$ (= 4.41 mol)

1

M2 amount of gases formed = 10 × **M1** (= 44.1 mol)

1

M3 **V** = $\frac{nRT}{P}$

1

M4 **V** = converting T to 1523 (K) (or 273 + 1250)

1

M5 **V** = $\frac{M2 \times 8.31 \times 1523}{101000}$ = 5.52 (m^3) range 5.5(1) tp 5.53 (m^3)

1

Final answer should be at least 2sf

Correct final answer scores 5 marks

*Allow ECF from **M1** to **M2**, **M2** to **M5**, **M4** to **M5** and **M3** to **M5***

*0.552 (m^3) for using 4.41 mol in **M5** scores 4 marks (loses **M2**)*

*4.54 (m^3) for using 1250 K scores 4 marks (loses **M4**)*

*3.54 (m^3) for using (1250 − 273) K scores 4 marks (loses **M4**)*

*0.18 (m^3) for inverted expression scores 4 marks (loses **M3** or **M5**)*

***M3** can score from a substituted expression*

(b) 1200 (cm^3)

200 × $\frac{3n}{2}$ where n = 4 200 × $\frac{12}{2}$

1

(c) $\frac{3n+1}{2}$

1.5n + 0.5

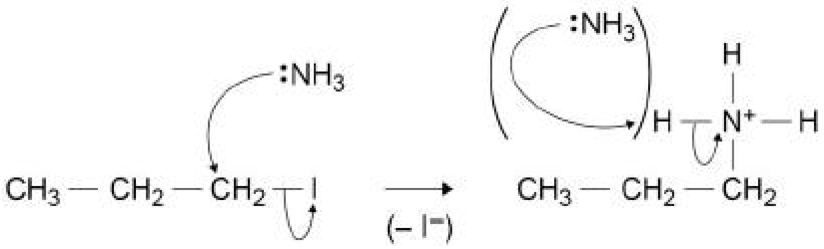
allow other correct expressions (e.g. $n + \frac{(n+1)}{2}$)

1

[7]

Q13.

(a) **M1** nucleophilic substitution



1

M2 attack by NH_3: arrow from lone pair on N of NH_3 towards C of
C-I bond

1

M3 breaking of C-I bond: arrow from C-I bond to I

1

M4 structure of intermediate

1

M5 loss of H^+: arrow from N-H bond to N

1

*Penalise **M3** for formal charge on C and / or I of C-I or incorrect partial charges on C-I; ignore other partial charges on uncharged atoms*

***M4** is independent*

*For **M5** there is no need to show attack by a second NH_3 molecule, but if it is shown, it must be correct (but, if the NH_3 is charged and has been penalised in **M2** (or **M3** for SN1), then do not penalise the same error again in **M5**); penalise removal of H^+ by attack with I^-*

For SN2:

*penalise **M2** for any additional arrow or charge on NH_3;*

*penalise **M3** for any additional arrow(s) to / from the I to / from anything else*

If SN1 mechanism given (loss of I first followed by attack by NH_3):
***M2** curly arrow from C-I bond to the I*
***M3** curly arrow from lone pair on N of NH_3 to positive C atom of correct carbocation*
*penalise **M2** for any additional arrow(s) to / from the I to / from anything else*
*penalise **M3** for any additional arrow or charge on NH_3*

(b) **M1** amount of 1-iodopropane = $\frac{5.0 \times 1.75}{169.9}$ (= 0.0515 mol)

*Allow ECF from **M1** to **M2** based on an attempt to find the amount of 1-iodopropane in moles using the M_r*

1

M2 number of molecules = **M1** × 6.022 × 10^{23}

= 3.1(0) − 3.13(144) × 10^{22}

***M2** Answer should be standard form (and be at least 2sf)*

1

(c) **M1** amount of propylamine = $\frac{2.3}{59.0}$(= 0.0390 mol)

AND amount of 1-iodopropane = $\frac{10.3}{169.9}$(= 0.0606 mol)

*Allow ECF from **M1** to **M2***

1

M2 % yield = $\frac{0.0390}{0.0606} x\ 100$ = 63.9 to 64(.4 %)

Alternative method

***M1** mass of 1-iodopropane =* $\frac{10.3 \times 59.0}{169.9}$ *(= 3.58 g)*

***M2** % yield =* $\frac{2.3}{M1} x\ 100$ *= 63.9 to 64(.4 %)*

1

Correct answer scores 2 marks

[9]

Q14.

(a) **M1** $2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

ignore state symbols

1

M2 n (MnO_4^-) = $\frac{0.020 \times 35.85}{1000}$ = $\underline{7.17 \times 10^{-4}}$ (mol)

1

M3 n (H_2O_2) = $7.17 \times 10^{-4} \times 5/2 = 1.793 \times 10^{-3}$ (mol)

M3 = M2 × 5/2

1

M4 conc (H_2O_2 in sample) = $\frac{1.793 \times 10^{-3}}{25 \times 10^{-3}}$ = 0.0717 (mol dm^{-3})

M4 = $\frac{M3 \times 100}{25}$

1

M5 original conc of H_2O_2 (= 0.0717 × $\underline{20}$ = 1.43 (mol dm^{-3})

M5 = $\frac{M4 \times 100}{5}$

allow 1.43−1.44

1

alternative answer using 3:4 ratio given on question paper

M3 = $7.17 \times 10^{-4} \times 4/3 = 9.56 \times 10^{-4}$

M4 = 0.0382 (mol dm^{-3}*)*

M5 = 0.765 (mol dm^{-3}*)*

(b) $KMnO_4$ is self-indicating

or

$KMnO_4$ is no longer decolourised at end point

or

(solution) changes (from colourless) to (pale) pink/purple at end point

1

(c) –1

1

(d) **M1** $2H_2O_2 \rightarrow 2H_2O + O_2$

allow multiples

ignore state symbols

1

M2 $V = 185 \times 10^{-6}$ (m^3) <u>and</u> $P = 100\ 000$(Pa)

unit conversions

1

M3 $n = \frac{PV}{RT} = \frac{100\,000 \times 185 \times 10^{-6}}{8.31 \times 298}$

rearrangement of ideal gas equation

1

M4 $n(O_2) = 7.47 \times 10^{-3}$ (mol)

calculation

1

M5 $n(H_2O_2) = (7.47 \times 10^{-3} \times 2) = 0.0149$ mol

allow M4 × 2 to 2 sig fig or more

1

if incorrect rearrangement in M3 can score M1, M2 and M5

[12]

Q15.

(a) Smaller titre will increase (%) uncertainty / error

1

amount $Br_2 = 0.025 \times \frac{30}{1000} = 7.5 \times 10^{-4}$ mol

Or 0.00075

1

(b) Ratio Y :bromine

M1 1 : 5

Alternative calc using supplied answer

M1

M2 n Y in 25 cm^3 oil = $\frac{7.5 \times 10^{-4}}{5} = 1.5 \times 10^{-4}$

n Y in 25 cm^3 oil = $\frac{6.25 \times 10^{-4}}{5} = 1.25 \times 10^{-4}$

If no ratio must state n Y for M2

M2

M3 n Y in 250 cm^3 = M2 × 10 = (1.5×10^{-3})

n Y in 250 cm^3 = $1.25 \times 10^{-4} \times 10 = (1.25 \times 10^{-3})$

M3

M4 Mass = M3 × 880 = (1.32 g)

Mass = $1.25 \times 10^{-3} \times 880 = (1.1\ g)$

M4

M5 Total mass oil needed = M4 × $\frac{100}{85}$ = 1.55 g

Total mass oil needed = $1.1 \times \frac{100}{85} = 1.29g$

M5

If wrong ratio used treat as AE and mark ECF

(c) Extra step: Weigh the bottle after oil transfer (and record the mass)

OR Rinse the bottle with solvent after transfer and add the washings (to the volumetric flask)

M1

Justification: Not all of the oil is transferred
Or so that the mass of oil left in the bottle is accounted for Or find the exact mass of oil used

To ensure all the oil is transferred

M2 is dependent on M1

M2

(d) To ensure the solution is homogeneous

Allow evenly mixed/ distributed OWTTE

Uniform solution

1

(e) $M_r = 345 - 1$

Must show workings in both M1 and M2

M1

M_r ($C_5H_{10}O$) = 86

$\frac{M1}{86}$ = 4 Hence $C_{20}H_{40}O_4$

M2

[12]