

The Mole and Simple Calculations

Q1. (2018)

A)

2(a)(i)	A description including any two from : <ul style="list-style-type: none"> • use a pipette filler (1) • wash pipette with sodium hydroxide solution (1) • draw the liquid up so (the bottom of the meniscus) touches the line (1) 	(2) AO 1 2
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B)

2(a)(ii)	An explanation linking any two from : <ul style="list-style-type: none"> • to remove water from the burette (1) • because this would dilute the original acid (1) • this will give an inaccurate result / ORA (1) 	ignore to avoid contamination ignore to kill bacteria (2) AO 1 2
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Q2. (2018) – 2c

2(c)	23.65 with or without working scores 2 OR $\frac{23.60 + 23.70}{2} (1)$ $= 23.65 (1)$	(2) AO 3 2a AO 3 2b allow 1 mark for all 3 averaged (24.35)
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Q3. (2018) – 4b

4(b)	56 with or without working (2) OR $(4 \times 12) + (8 \times 1) = (1)$ $= 56 (1)$	(2) AO 2 1 allow for ONE mark correctly evaluated expression of form: $(4 \times 12) + (Y \times 1) = \dots$ $(X \times 12) + (8 \times 1) = \dots$ OR $(8 \times 12) + (4 \times 1) = 100$ [In each case working and correctly evaluated answer required]
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Q4. (2018) – 5d

5(d)(i)	25.7 (g)	do not allow 25 answer may be written on the lower diagram (1) AO 2 1
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Q5. (2018) – 8d

8(d)	final answer of 94 (g dm ⁻³) with or without working (2)	allow ECF (error carried forward) throughout	(2)
	OR $\frac{23.5}{250}$ (1) (= 0.094)	other final answers: 0.094 / 9.4 (1) 0.000094 or 9.4×10^{-5} (1)	AO 2 1
	0.094 x 1000 (1)		
	OR $\frac{250}{1000}$ (dm ³) (1) (= 0.25 (dm ³))	0.25 (dm ³) (1)	
	$\frac{23.5}{0.25}$ (1)		
	OR $\frac{1000}{250}$ (1) = 4		
	4 x 23.5 (1)	allow $\frac{250}{23.5} \times 1000$ or 10638(.3) (1)	

Q6. (2018) – 9a (ii)

9(a)(ii)	final answer of 168 (tonnes) with or without working (3)	allow ECF throughout	(3)
	OR relative formula mass Fe ₂ O ₃ = 2x56 + 3x16 (= 160) (1)	M _r [Fe ₂ O ₃] = 160 seen without working (1)	AO 2 1
	160 tonnes Fe ₂ O ₃ produces {2x56 / 112} tonnes Fe (1)	allow 320 tonnes : 224 tonnes (1)	
	240 tonnes Fe ₂ O ₃ produces $\frac{2 \times 56}{160} \times 240$ (1) = 168 (tonnes)	final answer 84 (tonnes) with or without working (2)	
	OR relative formula mass Fe ₂ O ₃ = 2x56 + 3x16 (= 160) (1)		
	$\frac{240}{160}$ (1) = 1.5		
	1.5 x 112 (1) = 168 (tonnes)		
	OR relative formula mass Fe ₂ O ₃ = 2x56 + 3x16 (= 160) (1)	Note : final answer 1.5 scores 2 overall	
	$\frac{112}{160}$ (1) = 0.7		
	0.7 x 240 (1) = 168 (tonnes)		

Q7. (2018) – 10c (i)

10(c)(i)	final answer of 65(%) with or without working (2)		(2)
	OR $\frac{7.67}{11.80}$ (= 0.65) (1)		AO 2 1
	$\frac{7.67}{11.80} \times 100$ (=65(%)) (1)	allow any fraction x 100 (1)	
		153.84.... scores 1	

Q8. (2019) – 2c (ii)

2(c)(ii)	5.0 with or without working scores 2	allow any sig fig	(2)
	$\frac{3.15}{63.0} (1) \times 100 (1)$ $= 5.0$	if fraction inverted then $\times 100 = 2000$ allow (1) for 20 allow (1) allow any fraction using data $\times 100 (1)$	

Q9. (2019) – 3c (iii)

3(c)(iii)	0.68 x 100 (1) (= 136 (g))		(1)
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Q10. (2019)

5(a)(i)	A a balance The only correct answer is A .	(1)
	B is incorrect because a pipette is used to measure out a volume of liquid and is not used to find the mass of a metal. C is incorrect because a stopwatch is used to measure time and is not used to find the mass of a metal. D is incorrect because a thermometer is used to measure temperature and is not used to find the mass of a metal.	

Q11. (2019) – 5b (ii)

5(b)(ii)	5.22 with or without working scores 2		(2)
	$\frac{5.22 + 5.24 + 5.21}{3} (= 5.2233) (1)$ $= 5.22 (1)$	5.22 + 5.24 + 5.21 = 15.67 (MP1 does not score) allow 15.67 (1) (ie not divided by 3 but MP2 scores as answer to 2dp)	

Q12. (2019) – 8d

8(d)	MP1 for dividing by atomic mass $\frac{3.5}{7} : \frac{4.0}{16} (1)$ MP2 for deriving ratio from MP1 0.5 : 0.25 OR 2 : 1 (1) MP3 for ratio in MP2 to formula empirical formula A₂G (1)	A ₂ G with no relevant working (1) ONLY AG ₂ (0) For MP2: If they go on to calculate a different ratio in addition to 0.5:0.25 or 2:1 do not award MP2 ecf on step 1: if inverted, $\frac{7}{3.5} : \frac{16}{4.0} (0)$ $= 2 : 4$ or 1 : 2 (1) AG ₂ (1) allow 1 in empirical formula allow Li for A and O for G do not penalise incorrect case in formula	(3)
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Q13. (2019)

10(a)	8.000 - 6.213 = (1.787) (g)	allow 1.8, 1.79	(1)
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Q14. (2019) – 10b

10(b)(i)	97.3 (%) with or without working scores 2		(2)
	$\frac{5.450}{5.600} (1) \times 100$ $= 97.3214...$ $= 97.3 (%) (1)$	if fraction inverted then $\times 100 = 102.75...$ (3 or more sig fig) allow (1) for 0.973 allow (1) MP2 only for correctly $\times 100$ some figure derived from the data given eg 5.600 - 5.450 = 15 (%) allow any sig fig except 1	

Q15. (2019) – 10c

10(c)(i)	An explanation linking		(2)
	<ul style="list-style-type: none"> {rate/ mass loss} is slowing down (1) as amount of reactant falls (1) 		
	OR		
	<ul style="list-style-type: none"> mass decreases (1) as further decomposition occurs/ reaction continues / {gas/CO₂} {is produced/ escapes/ lost} (1) 	allow amount of calcium carbonate decreases do not allow 'as time goes on' for MP2; must explain in terms of a reaction	

Q16. (2019) – 10d

10(d)(i)	100 with or without working scores 2	ignore any units	(2)
	40 + 12 + 3 x 16 (1) =100 (1)	ecf for MP2 if using 12,16 and 40, using addition and multiplication only	

Q17. (2020) – 5a

5(a)	100 – 65 – 7 – 3 (1) (= 25)	25 alone scores 1	(1)
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Q18. (2020) – 5c (ii)

5(c)(ii)	$\frac{0.40 \times 30}{100} (1) (= 12)$ $\frac{12}{100} (1) (= 0.12)(g)$	0.12 (g) without working (2)	(2)
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Q19. (2020) – 6d

6(d)	$\frac{42.5}{5000} (1) \times 100 (1) (= 0.85)$	0.85 alone scores 2	(2)
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Q20. (2020) – 6f

6(f)	Ti $\frac{12}{48} = 0.25$ and O $\frac{8.0}{16} = 0.5$ (1) simplest ratio 1:2 (1) empirical formula TiO ₂ (1)	working must be shown to gain full marks allow TE Ti $\frac{48}{12} = 4$ and O $\frac{16}{8.0} = 2$ (0) simplest ratio 2:1 (1) empirical formula Ti ₂ O (1) allow (1) for formula with numbers obtained from 1 st step with no simplest ratio	(3)
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Q21. (2020) – 8b

8(b)	final answer of 114 (g dm ⁻³) with or without working (3)	allow ECF throughout	(3)
	OR 28.4 (1) (= 0.1136) 250 0.1136 x 1000 (1) (= 113.6)	250 (dm ³) (1) (= 0.250 (dm ³)) 1000 28.4 (1) (= 113.6) 0.250	
	= 114 (g dm ⁻³) (1)	OR 1000 (1) = 4 250 4 x 28.4 (1) (= 113.6) Must have 3sf for MP3 0.114 scores 2 Lose MP1 if rounded incorrectly e.g, to 0.11 or 0.113 but mark on	

Q22. (2020) – 9a (ii)

9(a)(ii)	63.5 + 12 + 3x16 (1)	(2)
	= 123.5 (1)	

Q23. (2020)

A)

10(a)(i)	K, L, J, N, M	(1)
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B)

10(a)(ii)	(volumetric) pipette	allow burette reject dropping pipette ignore balance	(1)
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Q24. (2020) – 10b (ii)

10(b)(ii)	final answer of 120% with or without working (2)	(2)
	OR 0.84 (=1.2) (1) 0.70 0.84 x 100 (=120(%)) (1) 0.70	allow any fraction x100 (1)

Q25. (2021) – 2b (iii)

2(b)(iii)	15 mg with or without working scores 2	(2) AO2
	<ul style="list-style-type: none"> 250/1000 (1) (=0.250) 60 x 250/1000 (1) (=15) 	
	OR <ul style="list-style-type: none"> 1000/250 (1) = 4 60/4 (1) (=15) 	

Q26. (2021) – 4a (iii)

4(a)(iii)	152 with or without working scores 2.	(2) AO2
	(52 x 2) + (16 x 3) (1) = 152 (1)	

Q27. (2021) – 7b

7(b)	1560 with or without working scores 3	(3) AO2
	$78 / 100$ (1) $78 / 100 \times 2.00$ (1) (= 1.56 kg) 1.56×1000 (1) (= 1560 g)	

Q28. (2021) – 10b

10(b)	$\frac{2.00 \times 695.0}{100}$ (1) (= 13.9) $695.0 - 13.9$ (1) (= 681.1 (g)) OR $\frac{98.00}{100} \times 695.0$ (1) (= 681.1 (g))	award full marks for correct final answer without working allow 2 or more sig.fig.	(2) AO2
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Q29. (2021) – 10c (ii)

10(c)(ii)	(from graph) percentage by mass of magnesium = 3.0 % (1) percentage aluminium in alloy = 100 - 3 (1) (= 97 %)	credit MP1 if written on graph ecf	(2) AO3
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Q30. (2022)

A)

4(a)	so the student knows where to slow the flow (of acid) on the second and third attempt / so that the student has an {estimate / idea} of the volume (of acid needed)	ignore to make it more accurate / to see if method works ignore to make it a fair test ignore as a practice run allow {how much / amount} for volume	(1) AO1-2
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B)

4(b)	B 27.60 is the only correct answer A is incorrect as this is the initial reading on the burette C is incorrect as this is the final reading on the burette D is incorrect as the values have been added rather than subtracted		(1) AO2-1
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C)

4(c)	a description including any four from: <ul style="list-style-type: none"> read the (initial) volume on the burette (1) open the tap / add acid to {alkali/flask} (1) swirl the mixture (1) until end point / until indicator changes colour (1) (close tap then) read (final) volume of acid in burette (1) 	allow initial burette reading allow add HCl to LiOH allow open tap ignore dropwise / drop by drop allow any change of colour given allow final burette reading	(4) AO1-1
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Q31. (2022) – 5b

5(b)	fractions $\frac{1.35}{27}$ and $\frac{12.00}{80}$ (1) ratios derived from two fractions into simplest whole number ratio $\frac{0.05}{1}$ $\frac{0.15}{3}$ (1) whole number ratio to formula AlBr_3 (1)	answer with no working scores 0 MP2 depends fractions being shown to give ratio allow ECF for MP2 and MP3 inverted fractions correctly followed through to Al_3Br scores 2 allow Al_3Br_3 allow errors in case or using superscript e.g. albr^3	(3) AO2-1
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Q32. (2022)

6(a)	12.56 with or without working scores 2		(2) AO2-1
	$\frac{3.14}{250}$ (1) (= 0.01256)	0.01256 / 0.0126 / 0.013 scores 1	
	0.01256 x 1000 (1) (= 12.56)	ECF for MP2	
	OR		
	$\frac{250}{1000}$ (1) (= 0.250)		
	$\frac{3.14}{0.250}$ (1) (= 12.56)	final answer of: 12.6 scores 2 13 with working scores 2 200.96 scores 1 0.0796 scores 1 2.0096 x 10 ⁻⁴ scores 1 2.0096 x 10 ⁻⁷ scores 0	

Q33. (2022) – 7b (ii)

7(b)(ii)	10(%) scores 3 with or without working	allow ECF from (b)(i)	(3) AO3 2a-1 2b-2
	50 – 45 (1) (= 5)		
	$\frac{5}{50}$ (1) (= 0.1)		
	0.1 x 100 (1) (= 10%)	90% gains 2 marks	

Q34. (2022) – 8b (i, iv)

A)

8(b)(i)	burette / (volumetric/graduated) pipette	allow syringe ignore any form of measuring cylinder / volumetric flask / dropping pipette	(1) AO3-3b
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B)

8(b)(iv)	<ul style="list-style-type: none"> linear scales on both axes (1) {plotted points / best fit line} must cover at least half graph paper in both directions (1) 7 or more points plotted correctly ($\pm$ half a square) (1) 	axes must be numbered (pH can start at 1) allow MP2 and MP3 if axes reversed must have numbered scale to score MP3 allow MP1 only for bar chart / histogram reject plotting on scale that uses the values from the table on Y axis (1, 1, 1, 1, 2, 7, 12, 13, 13)	(3) AO2-1
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Q35. (2022) – 9b

9(b)	MP1 – relative formula mass MgCO ₃ 24.0 + 12.0 + 3x16.0 (1) (= 84.0) MP2 – division $\frac{24.0}{84.0}$ (1) (= 0.28571429) 84(.0) MP3 – conversion to percentage (0.28571429) x 100 (= 28.57 / 28.6 / 29) (1)	28.57 / 28.6 / 29 with or without working gains 3 marks. allow ECF for MP2 and MP3 must have 2 or more sig figs for MP2 e.g Mr = 52 (0) $\frac{24}{52} = 0.4615$ (1) x 100 = 46.2 (1) MP3 – x 100 mark only if using all 3 pieces of data in calculation allow any number of sig figs except 1 correctly rounded allow $\frac{84.0}{24.0} \times 100 = 350$ (2)	(3) AO2-1
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Q36. (2022) – 10a (ii)

10(a)(ii)	$\frac{8.07}{53.80}$ (1) (= 0.15) 0.15 x 100 (1) (= 15)	award correct answer of 15(%) with or without working (2) allow $\frac{53.80}{8.07} \times 100 / 666.7/667/666.6$ for 1 mark	(2) AO3-1a
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Q37. (2023) – 1b (iv)

1(b)(iv)	answers between 49 and 51 score 1 mark with or without working. 75 – 25 = 50 (1)	allow readings between 74 and 76	AO3-1 (1)
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Q38. (2023) – 4b

4(b)
Group B

162.5 with or without working scores 2 marks

$$56 + 35.5 + 35.5 + 35.5 \quad (1)$$

$$= 162.5 \quad (1)$$

allow

91.5 scores 1 mark

AO1-1
(2)

Q39. (2023) – 5b (ii)

5(b)(ii)
Group A

2.4 + 2.4 + 2.7 = 7.5 (1)

$$\frac{7.5}{3} = 2.5 \quad (1)$$

2.5 with or without working scores 2 marks

allow ECF for an incorrect evaluation divided by 3

allow

$$2.4 + 2.4 = 4.8, 4.8/2 = 2.4 \quad (1)$$

$$2.4 + 2.4 + 2.7 \div 3 = 5.7 \quad (1)$$

$$2.4 + 2.7 + 2.4 \div 3 = 5.9 \quad (1)$$
AO2-2
(2)

Q40. (2023) – 6c

6(c)
Group B**MP1 for dividing by atomic mass**

$$\begin{array}{rcl} \text{Mg} & : & \text{Cl} \\ 1.20 & : & 3.55 \quad (1) \\ 24.0 & & 35.5 \end{array}$$

MP2 for deriving ratio from MP1

$$0.05 : 0.1$$

OR

$$1 : 2 \quad (1)$$

MP3 for formula using ratio in MP2MgCl₂ without working scores 0

Allow ECF

allow

$$\begin{array}{rcl} \text{Mg} & 24.0 & : \text{Cl} \quad 35.5 \quad (0) \\ 1.20 & & 3.55 \\ 20 & : & 10 \end{array}$$

OR

$$2 : 1 \quad (1)$$

empirical formula Mg₂Cl (1)

reject superscript numbers for MP3 only

AO2-1
(3)

Q41. (2023) – 8d (ii)

8(d)(ii)

0.74 (g)

AO3-2
(1)

Q42. (2023) – 10c

A)

10(c)(i)
Group A

final answer of 490 with or without working scores 2

$$\frac{400}{80} = 5 \quad (1)$$

$$5 \times 98 = 490 \quad (1)$$

OR

$$\frac{98}{80} = 1.225 \quad (1)$$

$$1.225 \times 400 = 490 \quad (1)$$

80/ 400 x 98 = 19.6 scores 1

allow ecf for MP2 only if MP1 uses 80 and 98

80/98 x 400 = 326.5 scores 1

allow ecf for MP2 only if MP1 uses 80 and 98

allow 490000 **kg** only if unit given

allow 490000000 **g** only if unit given

AO2-1
(2)

B)

10(c)(ii)
Group B

final answer of 96% with or without working scores 2

$$\frac{672}{700} = 0.96 \quad (1)$$

$$\times 100 = 96 \quad (1)$$

allow 24/25

no ecf for MP2

4 scores 1

104 scores 1 mark

AO2-1
(2)

Q43. (2024)

A)

4(a)(i)**B** burette is the only correct answer**A, C** and **D** are not correct as X is a burette**(1)**
AO1-2

B)

4(a)(ii)	A description to include		(2) AO1-2
	<ul style="list-style-type: none"> use a pipette (1) <p>then any one from</p> <ul style="list-style-type: none"> rinse (pipette) with dilute hydrochloric acid (1) draw solution up to line (of pipette) (1) touch tip (of pipette) on side of conical flask (1) 	<p>allow use of syringe - max 1 allow burette (1) and any one from then any one from</p> <ul style="list-style-type: none"> rinse with dilute hydrochloric acid (1) fill burette with acid using a funnel (1) fill jet below tap with acid (1) manipulation of tap to deliver exact volume (of acid) (1) adding acid slowly (to the flask) (1) read burette volumes from bottom of meniscus (1) <p>ignore use of measuring cylinder</p>	

C)

4(b)(i)	$29.15 - 1.50 = 27.65 \text{ (cm}^3\text{)}$		(1) AO1-2
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D)

4(b)(ii)	24.7(0) with or without working scores 2		(2) AO3-1
	$24.70 + 24.80 + 24.60 = 74.1 \text{ (1)}$	allow $27.65 + 24.70 + 24.80 + 24.60 = 101.75 \text{ (0)}$	
	$\frac{74.1}{3} = 24.7(0) \text{ (1)}$	then $\frac{101.75}{4} = 25.4375 \text{ (1)}$ / or correctly rounded to a min of 3 sig figs	

Q44. (2024) – 5b

5(b)	empirical formula alone without working scores 0	allow ecf throughout	(3) AO2-1
	<p>silicon: $\frac{1.4}{28}$ and chlorine $\frac{7.1}{35.5}$ (1)</p> <p>or 0.05 and 0.2</p> <p>simplest whole number ratio: 1 4 (1)</p> <p>empirical formula SiCl_4 / Cl_4Si (1)</p>	<p><u>inverted division:</u> silicon: $\frac{28}{1.4}$ and chlorine $\frac{35.5}{7.1}$ (0)</p> <p>or 20 5</p> <p>simplest whole number ratio: 4 1 (1)</p> <p>empirical formula Si_4Cl / ClSi_4 (1)</p> <p><u>error in step 2:</u> MP1 still scores, MP2 (0), allow ecf for MP3</p> <p><u>division other relative atomic mass:</u> silicon: $\frac{1.4}{35.5}$ and chlorine $\frac{7.1}{28}$ (0)</p> <p>0.0394 / 0.04 and 0.254 / 0.25 or 1 6.43 / 6.25</p> <p>simplest whole number ratio: 5 / 4 32 / 25 (1)</p> <p>empirical formula $\text{Si}_5\text{Cl}_{32}$ / $\text{Si}_4\text{Cl}_{25}$ (1)</p> <p><u>division by atomic number:</u> MP1 – 0, correctly calculated, can still score MP2 and MP3</p>	

Q45. (2024)

6(a)	26.08 with or without working scores 2 marks	allow ecf on all methods ignore 0.03	(2) AO2-1
	$\frac{6.52}{250} = 0.02608 / 0.026 / 0.0261 \text{ (1) [MP1]}$	OR $\frac{1000}{250} = 4 \text{ (1)}$	
	$\text{MP1} \times 1000 = 26.08 / 26(.0) / 26.1 \text{ (1)}$	$4 \times 6.52 = 26.08 \text{ (1)}$	
		OR $\frac{250}{1000} = 0.25 \text{ (1)}$	
		$\frac{6.52}{0.25} = 26.08 \text{ (1)}$	

Q46. (2024)

7(a)(i)	8 (%) with or without working (3) change in mass = $7.56 - 7.00 = 0.56$ (1) $\frac{0.56}{7.00} = 0.08$ (1) 0.08×100 (1) (= 8%)	ecf throughout	(3) AO3-2
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Q47. (2024) – 8b (iii, iv)

A)

8(b)(iii)	all points plotted correctly ($\pm$ half a small square) (2) OR 7/8 points plotted correctly (1) S-shaped line of best fit (1)	line of best fit must go through 7 points if the points are not visible a line going through all correct values scores 3 reject dot-to-dot line / line starting from origin tramlines allowed here but rejected in 8(b)(iv) bar chart scores 0	(3) AO2-1
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B)

8(b)(iv)	pH reading at 4.5 spatula measures from their line on graph	allow $\pm$ half a small square on y -axis ignore any candidate working allow ECF from 8(b)(iii) but if no graph line or multiple lines, cannot score. if bar chart has been drawn for 8biii, then mark for 8biv cannot be awarded	(1) AO3-2
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Q48. (2024) – 9b

9(b)	43(.4) with or without working scores 3 $2 \times 23 + 12 + 3 \times 16 = 106$ (1) $\frac{46}{106} = 0.4339622642$ (1) $0.4339622642 \times 100 = 43.4$ (1)	43.39622642 rounded correctly to 2 or more sig. fig. scores 3 if M_r incorrect, must show working to allow ecf on MP2 and MP3 $\frac{46}{106}$ attempt of $M_r \text{ Na}_2\text{CO}_3$ $\frac{23 \text{ or } 46}{106} \times 100$ attempt of $M_r \text{ Na}_2\text{CO}_3$ the following common answers with working are awarded 21.69811321 rounded correctly to 2 or more sig. fig. scores 2 76.6666667 rounded correctly to 2 or more sig. fig. scores 2 48.11320755 rounded correctly to 2 or more sig. fig. scores 1	(3) AO2-1
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Q49. (2024)

10(a)(i)	75.4 with or without working scores 3 marks $\frac{45.26}{60.00} = 0.7543$ (1) $(0.7543) \times 100 = 75.43$ (1) $= 75.4$ (1 dp) (1)	75.43 / 75.40 with or without working scores 2 marks allow ecf using numbers from the question allow 1 mark for correct rounding to 1 dp of an incorrectly calculated value only if using numbers from the question 91.2 with working scores 2 marks	(3) AO3-1
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