

**MARK SCHEME for the October/November 2009 question paper
for the guidance of teachers**

9701 CHEMISTRY

9701/51

Paper 51 (Planning, Analysis and Evaluation),
maximum raw mark 30

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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Question	Sections	Indicative material	Mark
1	(a)	Treat section (a) as one answer. From preliminary expt – predicts that rate of reaction will be proportional to [persulfate] / accept 'doubling the concentration doubles the rate'/increasing concentration increases rate. Explains that doubling the concentration doubles the number of collisions/increasing the concentration increases the number of collisions. The use of frequency alone is incorrect but if used with other correct comments regard it as neutral.	[1] [1]
	(b)	(i) [Persulfate] as independent variable. Accept the correct ion instead of the correct name. Do not accept volume or amount. (ii) Elapsed time identified as dependent variable / rate (of reaction) or equivalent. Time alone scores zero but rate alone is OK.	[1] [1]
	(c)	Explains that [iodide] remains constant – (controlled variable)/so that the iodide does not run out/continuous supply of iodide ions (for reaction with persulfate). NOT allowed are reformed/regenerated alone – rubric.	[1]
	(d)	(i) Has at least 3 more appropriate experiments of lower concentration. (inappropriate experiments negate this mark) (ii) At least one of the diluted (varying water or persulphate) solutions half or less of original <u>correct</u> concentration / uses 20 cm ³ or less of persulphate at least once. (if concentration is used alone it must be correct but if used in conjunction with volumes regard the concentration as neutral). (iii) Total volume, volumes of potassium iodide, thiosulfate and starch all constant. (allow drops of starch) (use of the exemplar experiment is not mandatory) If all volumes stated, then the same procedure (with different persulfate concentrations) repeated could suffice. (iv) Burette or measuring cylinder used to measure volumes of persulfate and distilled water. (v) 'Minimum' is persulfate and iodide kept apart until reaction stated as started. (vi) Clock stopped when blue colour appears / elapsed time to blue colour is noted / measure time to the appearance of the blue colour. Not in a (timed) titration procedure. <u>Also look at the table in (f) for possible answers to the first three marks.</u>	[1] [1] [1] [1] [1] [1]
(e)	PLAN Methods	<u>Explains</u> that the volume / amount of thiosulfate defines the extent of the reaction ("finishing line") to enable comparison – or equivalent statement. Relate the constant volume of thiosulphate to the end / finishing point. Any reference to 'accuracy' should be regarded as neutral'.	[1]

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(f)	PLAN Methods	Tabulates volumes or concentrations of persulfate. (<i>Accept concentration if volumes used in text to show diluted solution</i>) and elapsed time. Include unit	[1]
		Includes a column for rate or V_t and unit (cm^3s), or concentration $\times t$ and unit. (<i>Penalise error or omission in units once only across the three relevant columns</i>) Units for rate (or $1/t$) should be s^{-1} or $\text{mol dm}^{-3}\text{s}^{-1}$. allow 'brackets instead of /'. (NOT M seconds minutes)	[1]
(g)	PLAN Methods	Must have the first mark in (a). Mark "justification" consequently. 'If the rate increases/time decreases/ V_t is constant as the concentration of persulfate increases then the rate is proportional to the concentration of the persulfate'. Check the trend in (f) from time/rate and conc/vol data that may be provided. Accept a plot of rate against concentration having a line of positive slope/or going through the origin, OR a plot of time against concentration having a line of negative slope.	[1]
Qn 1	Total		[15]

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2	(a)	ACE Data	Mass of zinc used , B-D, / g and full column.	[1]
			Mass of iodine, C-B, / g and full column.	[1]
			Check first 3 subtractions correct in the column labelled iodine. These must also be to 2dp. All 3 must be totally correct. ECF incorrect equation in calculation only.	[1]
(b)	ACE Data ACE Data		Correctly converts the first three masses of zinc to moles of zinc. (to 2 s.f.)	[1]
			Correctly converts the first three masses of iodine to moles of iodine. (to 2 s.f.)	[1]
			For these two marks, allow ecf from incorrect masses in (a). This ecf refers to the masses the candidate believes to be Zn and/or I. (Allow 1 computational/s.f error for the first 3 values in each column.) So 1 error is allowed in these 6 values. If an incorrect A_r has been used to calculate moles in all 3 values in one column then count this as just 1 computational error, not 3. For example 254 being used for iodine. A similar error in the Zn column would also count as 1 error only.	[1]
			Has calculated the ratio of I:Zn (to 2 dp.) (do not allow the inverse) (this can be done by simple visual checking) (e.g. 2.08 or 2.08:1). No ecf for calculations that have used < 2 sf in moles. Experiments 3 and 8 calculations correct (to 2 dp.) No ecf for calculations that have used < 2sf in moles In the 3 rd and 4 th marks ecf can operate in the ratio calculation from incorrect values of moles but 2 dp required. If the calculations are evaluated to more than 2 s.f. they should approximate to the 2. s.f. answers. If a value is quoted to 3 sf then allow +/- 1 in the 3 rd figure.	[1]
(c)	ACE Evaluation		Both experiments 3 and 8 only. (other values are neutral if they are there as a consequence of errors in (b) or (a).) These must have some numerical justification in (b).	[1]
(d)	ACE Evaluation ACE Data		Suggests taking an average / plotting a graph.	[1]
			Leaving out the anomalies (when calculating an average) / calculate the gradient/measure the slope.	[1]
(e)	ACE Evaluation		(If experimental ratio of I: Zn is too high (Expt 3)) zinc has been oxidised during drying/ zinc not dried enough/ reaction is incomplete/ not all ZnI_2 washed away.	[1]
			If experimental ratio of I: Zn is too low (Expt 8) zinc has been blown out of the tube; or Zn lost on pouring out liquid. The reasoning must relate clearly to the correct anomaly. Allow correct reason for an anomaly (other than 3 or 8) stated in (c) provided evidenced in data in (b).	[1]

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(f)	ACE Conclusions	Must refer in some way to the general agreement of the calculated/stated ratio being approximately 2 or 1:2 (in (b) or (d)). May have something written below the table in (b) . OR The slope of the graph is approximately 2. OR The moles/atoms/ions of iodine is about double that of zinc. Not references to molecules/mass/weight/I ₂	[1]
(g)	ACE Conclusions	Identifies a single point of weakness in method. Possibly: Small masses weighed / large % error in mass. Not if large % error is related to balance dp or accuracy.	[1]
(h)	ACE Conclusion	Suggests titration of iodine with (sodium) thiosulfate.	[1]
Qn 2	Total		[15]

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Question	Sections	Indicative material	Mark
1 (a)	PLAN Problem	Predicts that all strong acids should have a constant ΔH_{neut} . Any attempt at 'grading' is incorrect.	[1]
		Explains that ΔH_{neut} for a weak acid should be less exothermic (ΔH is more positive or less negative) than a strong acid because some of the energy is absorbed in dissociation into ions.	[1]
(b)	PLAN Problem	(i) Nature of the acid as independent variable (not concentration).	[1]
		(ii) Temperature (ignore increase/decrease) / enthalpy change / heat exchange as dependent variable.	[1]
(c)	PLAN Methods	The diagram and/or the statements give (i) an insulated container or a lid used in an insulating context and the thermometer bulb in or touching the liquid	[1]
	PLAN Problem	(ii) constant volume/constant volume of acid mentioned/constant amount (ignore all the rest).	[1]
(d)	PLAN Methods	(i) Moles of all monobasic acids must be $< 6 \times 10^{-2}$ mol. (constant volume needed)	[1]
		(ii) [dibasic acids] = $\frac{1}{2}$ [monobasic acids] These marks should be treated as separate.	[1]
(e)	PLAN Methods	(i) Calculates the mass needed 31.5 g of $(\text{CO}_2\text{H})_2 \cdot 2\text{H}_2\text{O}$ for 1M solution or 63.0 g for 2M solution. (or in proportion to the tabled information)	[1]
		(ii) Solid dissolved in $< 250 \text{ cm}^3$ of distilled water (in beaker) and transferred to flask along with the rinsings.	[1]
		(iii) Volume made up to 250 cm^3 .	[1]
		(iv) Inversion/shaking/swirling of flask to mix the <u>solution</u> .	[1]
(f)	PLAN Methods	Shows the correct numerator <u>(vol of HCl + vol of NaOH) $\times$ temp rise $\times$ 4.3</u> moles of HCl	[1]
		shows the correct denominator <i>numbers should be given for the volumes and moles of HCl</i>	[1]
(h)	PLAN Methods	Use of gloves / protective clothing / eye or face protection / goggles suggested (anything relevant).	[1]
Qn 1	Total		[15]

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2 (a)	ACE Data	Correctly completes $(M_r)^2$ to 3 sig fig and $\sqrt{M_r}$ column to 4 sig. fig. except the square of 2 which should be accepted as 4. <i>See appendix</i>	[1]
(b)	ACE Data ACE Data	Selects horizontal scales for all three graphs such that the plotted points cover at least half the graph (the first two graphs need to be of an appropriate curved shape, any line negates this mark). Check 'visually' that the points for $\sqrt{M_r}$ graph are on a diagonal straight line (allow plotting errors up to one small square). Draws straight line through points and origin for $\sqrt{M_r}$ graph. If the line stops short of the origin do not award the third mark.	[1] [1] [1]
(c)	ACE Conclusions	Effusion time has a proportional relationship/is directly related to the M_r <i>(This is a soft mark – directly proportional not required) (give this mark even if subsequently the effusion time is stated as proportional to M_r rather than $\sqrt{M_r}$ or is stated as such initially.)</i> Reference to directly proportional or effusion time $\propto \sqrt{M_r}$ <u>gains both marks</u> .	[1] [1]
(d)	ACE Evaluation	Non-dry gas would also contain water vapour .	[1]
(e)	ACE Evaluation	Damp hydrogen would have a longer effusion time as M_r of H_2O greater than M_r of H_2 .	[1]
Qn 2	Total		[8]
3 (a)	ACE Data	Correctly calculates the mass of copper and the mass of oxygen in each sample. <i>Allow up to 2 computational/s.f. errors across both columns without penalty.</i> All masses must be shown to 2 decimal places. Correctly calculates the ratio: (ignore s.f. errors) $\frac{\text{mass of copper}}{\text{mass of oxygen}}$ for each sample. Allow one computational/s.f. error. Apply ecf if necessary. Calculations must be to 2 decimal places. See appendix	[1] [1]
(b)	ACE Evaluation	Explains <u>either</u> anomaly. Student 1 – (ratio of Cu/O is too <u>low</u>) – powder carried away in stream of hydrogen. Student 4 - (ratio of Cu/O is too <u>high</u>) – incomplete reduction/reoxidation. Only award this mark if students 1 and 4 are selected correctly.	[1]

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(c)	ACE Evaluation	Omits the results of students 1 and 4 (or the declared anomalies) from those used to obtain the mean/average.	[1]
	ACE Data	Calculates a mean for remaining values. <i>Mark ecf for any values selected by the candidate – see appendix.</i>	[1]
(d)	ACE Data	Uses answer to (c) to correctly calculate molar ratio/calculates combining moles. Accept any answer from (c) .	[1]
	ACE Conclusion	Calculates a formula compatible with calculation. <i>Must be integral values for Cu and O</i>	[1]
Qn 3	Total		[7]

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Appendix

2 (a)

		M_r	effusion time / s	$(M_r)^2$	$\sqrt{M_r}$
				3 sig fig	4 sig fig
hydrogen	H ₂	2	19	4.00	1.414
oxygen	O ₂	32	76	1020	5.657
carbon dioxide	CO ₂	44	89	1940	6.633
butane	C ₄ H ₁₀	58	102	3360	7.616
chlorine	Cl ₂	71	113	5040	8.426

Allow 3 dp here

3 (a)

student	mass of boat / g	mass of boat + oxide / g	mass of boat + copper / g	mass of copper / g	mass of oxygen / g	Mass ratio Cu/O / g	mass of oxide / g
1	5.55	7.71	7.11	<u>1.56</u>	0.60	2.600	2.16
2	5.18	8.07	7.49	<u>2.31</u>	0.58	3.983	2.89
3	5.17	10.05	9.07	<u>3.90</u>	0.98	3.980	4.88
4	5.39	10.91	10.06	<u>4.67</u>	0.85	5.494	5.52
5	5.46	11.64	10.40	<u>4.94</u>	1.24	3.984	6.18
6	4.99	12.02	10.61	<u>5.62</u>	1.41	3.986	7.03

Av 4.81.

3 (c) Mean/Average for ratio Cu/O – omitting the following results

	Mass ratio Cu/O	Mole Cu / 1 mol O
Student 1 <u>and</u> Student 4	3.983	1.004
Student 1 <u>only</u>	4.285	1.080
Student 4 <u>only</u>	3.707	0.934
None	4.005	1.009