

A-level Chemistry

Paper 3 (7405/3)

Mark scheme

7405

Specimen paper

Version 0.5

Section A

Question	Marking guidance	Mark	AO	Comments
01.1	A mixture of liquids is heated to boiling point for a prolonged time Vapour is formed which escapes from the liquid mixture, is changed back into liquid and returned to the liquid mixture Any ethanal and ethanol that initially evaporates can then be oxidised	1 1 1	AO1b AO1b AO2g	
01.2	$\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{O} \longrightarrow \text{CH}_3\text{COOH} + 4\text{H}^+ + 4\text{e}^-$	1	AO2d	
01.3	Mixture heated in a suitable flask / container With still head containing a thermometer Water cooled condenser connected to the still head and suitable <u>cooled</u> collecting vessel Collect sample at the boiling point of ethanal Cooled collection vessel necessary to reduce evaporation of ethanal	1 1 1 1 1	AO3 2a AO3 2a AO3 2a AO3 2a AO3 2a	A labelled sketch illustrating these points scores the marks
01.4	Hydrogen bonding in ethanol and ethanoic acid or no hydrogen bonding in ethanal Intermolecular forces / dipole-dipole are weaker than hydrogen bonding	1 1	AO1a AO1a	

01.5	Reagent to confirm the presence of ethanal: Add Tollens' reagent / ammoniacal silver nitrate / aqueous silver nitrate followed by 1 drop of aqueous sodium hydroxide, then enough aqueous ammonia to dissolve the precipitate formed OR Add Fehling's solution Warm Result with Tollen's reagent: Silver mirror / black precipitate OR Result with Fehling's solution: Red precipitate / orange-red precipitate Reagent to confirm the absence of ethanoic acid Add sodium hydrogencarbonate or sodium carbonate Result; no effervescence observed; hence no acid present OR Reagent; add ethanol and concentrated sulfuric acid and warm Result; no sweet smell / no oily drops on the surface of the liquid, hence no acid present	1	AO1b	M2 and M3 can only be awarded if M1 is given correctly
		1	AO1b	M2 and M3 can only be awarded if M1 is given correctly
		1	AO1b	
		1	AO1b	M5 can only be awarded if M4 is given correctly
		1	AO1b	

Question	Marking guidance	Mark	AO	Comments
02.1	Stage 1: Moles of acid at equilibrium Moles of sodium hydroxide in each titration = $(3.20 \times 2.00 \times 10^{-1}) / 1000 = 6.40 \times 10^{-4}$ Sample = 10 cm^3 so moles of acid in 250 cm^3 of equilibrium mixture = $25 \times 6.40 \times 10^{-4} = 1.60 \times 10^{-2}$ Stage 2: Moles of ester and water formed Moles of acid reacted = $8.00 \times 10^{-2} - 1.60 \times 10^{-2} = 6.40 \times 10^{-2}$ = moles ester and water formed Stage 3: Moles of ethanol at equilibrium Moles of ethanol remaining = $1.20 \times 10^{-1} - 6.40 \times 10^{-2} = 5.60 \times 10^{-2}$ Stage 4: Calculation of equilibrium constant $K_c = [\text{CH}_3\text{COOCH}_2\text{CH}_3] [\text{H}_2\text{O}] / [\text{CH}_3\text{COOH}] [\text{CH}_3\text{CH}_2\text{OH}]$ = $(6.40 \times 10^{-2})^2 / (1.60 \times 10^{-2})(5.60 \times 10^{-2})$ = 4.5714 = 4.57	1 1 1 1 1 1	AO2h AO2h AO2h AO2h AO1b AO2h	Extended response M2 can only be scored if = answer to M1 $\times$ 25 M3 is $8.00 \times 10^{-2} - \text{M2}$ M4 is $1.20 \times 10^{-1} - \text{M3}$ M6 is $\text{M3}^2 / \text{M2} \times \text{M4}$ Answer must be given to 3 significant figures

02.2	<table><tr><td></td><td>Rough</td><td>1</td><td>2</td><td>3</td></tr><tr><td>Final burette reading / cm³</td><td>4.60</td><td>8.65</td><td>12.85</td><td>16.80</td></tr><tr><td>Initial burette reading / cm³</td><td>0.10</td><td>4.65</td><td>8.65</td><td>12.85</td></tr><tr><td>Titre / cm³</td><td>4.50</td><td>4.00</td><td>4.20</td><td>3.95</td></tr></table>						Rough	1	2	3	Final burette reading / cm³	4.60	8.65	12.85	16.80	Initial burette reading / cm³	0.10	4.65	8.65	12.85	Titre / cm³	4.50	4.00	4.20	3.95	1	AO1b	
	Rough	1	2	3																								
Final burette reading / cm³	4.60	8.65	12.85	16.80																								
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Titre / cm³	4.50	4.00	4.20	3.95																								
02.3	Mean = 4.00 + 3.95 / 2 = 3.98 (cm ³) Titres 1 and 3 are concordant			1 1	AO3 1a AO3 1a	Allow 3.975 (cm ³) Allow titre 2 is not concordant																						
02.4	Thymol blue			1	AO1b																							
02.5	Percentage uncertainty: 0.15/3.98 × 100 = 3.77%			1	AO2h	Allow consequential marking on mean titre from 2.3																						
02.6	Use a lower concentration of NaOH So that a larger titre is required (reduces percentage uncertainty in titre)			1 1	AO3 2b AO3 2b																							

Question	Marking guidance	Mark	AO	Comments
03.1	Wear plastic gloves: Essential – to prevent contamination from the hands to the plate Add developing solvent to a depth of not more than 1 cm³: Essential – if the solvent is too deep it will dissolve the mixture from the plate Allow the solvent to rise up the plate to the top: Not essential – the R_f value can be calculated if the solvent front does not reach the top of the plate Allow the plate to dry in a fume cupboard: Essential – the solvent is toxic	1 1 1 1	AO3 1a AO3 1a AO3 1a AO3 1a	Allow hazardous
03.2	Spray with developing agent or use UV Measure distances from initial pencil line to the spots (x) Measure distance from initial pencil line to solvent front line (y) R_f value = x / y	1 1 1 1	AO1b AO2h AO2h AO1b	
03.3	Amino acids have different polarities Therefore, have different retention on the stationary phase or different solubility in the developing solvent	1 1	AO1b AO1b	

Question	Marking guidance	Mark	AO	Comments
04.1	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 5–6 marks All stages are covered and the explanation of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 and stage 2 to stage 3. Steps in stage 3 must be complete, ordered and include a comparison.	6	AO3 1a	Indicative Chemistry content Stage 1: difference in structure of the two acids - The acids are of the form RCOOH - but in ethanoic acid R = CH₃ - whilst in ethanedioic acid R = COOH Stage 2: the inductive effect - The unionised COOH group contains two very electronegative oxygen atoms - therefore has a negative inductive (electron withdrawing) effect - The CH₃ group has a positive inductive (electron pushing) effect Stage 3: how the polarity of OH affects acid strength - The O–H bond in the ethanedioic acid is more polarised / H becomes more δ+ - More dissociation into H⁺ ions - Ethanedioic acid is stronger than ethanoic acid
	Level 2 3–4 marks All 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 is mainly coherent and shows a progression from Stage 1 and stage 2 to stage 3.			
	Level 1 1–2 marks 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 some isolated statements, but these are not presented in a logical order or show confused reasoning.			
	Level 0 0 marks Insufficient correct Chemistry to warrant a mark.			

04.2	Moles of NaOH = Moles of HOCCOO^- formed = 6.00×10^{-2} Moles of HOCCOOH remaining = $1.00 \times 10^{-1} - 6.00 \times 10^{-2}$ $= 4.00 \times 10^{-2}$ $K_a = [\text{H}^+][\text{A}^-]/[\text{HA}]$ $[\text{H}^+] = K_a \times [\text{HA}]/[\text{A}^-]$ $[\text{H}^+] = 5.89 \times 10^{-2} \times (4.00 \times 10^{-2}/V)/(6.00 \times 10^{-2}/V) = 3.927 \times 10^{-2}$ $\text{pH} = -\log_{10}(3.927 \times 10^{-2}) = 1.406 = 1.41$	1 1 1 1 1	AO2h AO2h AO2h AO2h AO1b	Extended response Answer must be given to this precision
04.3	$5\text{H}_2\text{C}_2\text{O}_4 + 6\text{H}^+ + 2\text{MnO}_4^- \longrightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + 8\text{H}_2\text{O}$ OR $5\text{C}_2\text{O}_4^{2-} + 16\text{H}^+ + 2\text{MnO}_4^- \longrightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + 8\text{H}_2\text{O}$ Moles of $\text{KMnO}_4 = 20.2 \times 2.00 \times 10^{-2}/1000 = 4.04 \times 10^{-4}$ Moles of $\text{H}_2\text{C}_2\text{O}_4 = 5/2 \times 4.04 \times 10^{-4} = 1.01 \times 10^{-3}$ Concentration = moles/volume (in dm^3) $= 1.01 \times 10^{-3} \times 1000/25 = 4.04 \times 10^{-2} \text{ (mol dm}^{-3}\text{)}$	1 1 1 1	AO2d AO2h AO2h AO2h	If 1:1 ratio or incorrect ratio used, M2 and M4 can be scored

Question	Marking guidance	Mark	AO	Comments
05.1	$[\text{CH}_3\text{OCOCOOH}]^+$ $[\text{CH}_3\text{OCOCOOCH}_3]^+$	1 1	AO3 1a AO3 1a	Allow names Do not allow molecular formula
05.2	Positive ions are accelerated by an electric field To a constant kinetic energy The positive ions with m/z of 104 have the same kinetic energy as those with m/z of 118 and move faster Therefore, ions with m/z of 104 arrive at the detector first	1 1 1 1	AO1a AO1a AO2e AO2e	

Section B

In this section, each correct answer is awarded 1 mark.

Question	Key	AO
6	A	AO3 1b
7	B	AO2f
8	D	AO2d
9	D	AO2d
10	B	AO2b
11	A	AO2b
12	D	AO1b
13	B	AO2d
14	C	AO2h
15	B	AO1b
16	D	AO2c
17	D	AO2c
18	A	AO3 1b
19	B	AO3 1a
20	D	AO3 1a

Question	Key	AO
21	B	AO1a
22	B	AO1a
23	D	AO2h
24	B	AO1a
25	C	AO1a
26	C	AO1a
27	C	AO3 1a
28	D	AO1a
29	B	AO3 1a
30	D	AO3 1a
31	B	AO1a
32	C	AO3 1b
33	D	AO2a
34	C	AO3 1a
35	C	AO1a