Section A

Question	Marking guidance	Mark	AO	Comments
01.1	A mixture of liquids is heated to boiling point for a prolonged time	1	AO1b	
	Vapour is formed which escapes from the liquid mixture, is changed back into liquid and returned to the liquid mixture	1	AO1b	
	Any ethanal and ethanol that initially evaporates can then be oxidised	1	AO2g	
01.2	$CH_3CH_2OH + H_2O \longrightarrow CH_3COOH + 4H^+ + 4e^-$	1	AO2d	
01.3	Mixture heated in a suitable flask / container	1	AO3 2a	A labelled sketch illustrating these points scores the marks
	With still head containing a thermometer	1	AO3 2a	
	Water cooled condenser connected to the still head and suitable <u>cooled</u> collecting vessel	1	AO3 2a	
	Collect sample at the boiling point of ethanal	1	AO3 2a	
	Cooled collection vessel necessary to reduce evaporation of ethanal	1	AO3 2a	
01.4	Hydrogen bonding in ethanol and ethanoic acid or no hydrogen bonding in ethanal	1	AO1a	
	Intermolecular forces / dipole-dipole are weaker than hydrogen bonding	1	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	1	AO1b	
	OR			
	Add Fehling's solution			
	Warm	1	AO1b	M2 and M3 can only be awarded if M1 is given correctly
	Result with Tollen's reagent:			
	Silver mirror / black precipitate	1	AO1b	
	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	1	AO1b	
	Result; no effervescence observed; hence no acid present	1	AO1b	M5 can only be awarded if M4 is given correctly
	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			
				2

Question	Marking guidance	Mark	AO	Comments
02.1				Extended response
	Stage 1: Moles of acid at equilibrium			
	Moles of sodium hydroxide in each titration = $(3.20 \times 2.00 \times 10^{-1}) / 1000 = 6.40 \times 10^{-4}$	1	AO2h	
	Sample = 10 cm^3 so moles of acid in 250 cm^3 of equilibrium mixture			
	$= 25 \times 6.40 \times 10^{-4} = 1.60 \times 10^{-2}$	1	AO2h	M2 can only be scored if = answer to M1 × 25
	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	1	AO2h	M3 is 8.00×10^{-2} – M2
	Stage 3: Moles of ethanol at equilibrium			
	Moles of ethanol remaining $= 1.20 \times 10^{-1} – 6.40 \times 10^{-2} = 5.60 \times 10^{-2}$	1	AO2h	M4 is 1.20×10^{-1} – M3
	Stage 4: Calculation of equilibrium constant			
	$K_c = [CH_3COOCH_2CH_3]\,[H_2O] / [CH_3COOH]\,[CH_3CH_2OH]$	1	AO1b	
	$= (6.40 \times 10^{-2})^2 / (1.60 \times 10^{-2})(5.60 \times 10^{-2})$			
	= 4.5714 = 4.57	1	AO2h	M6 is $M3^2$ / M2 × M4 Answer must be given to 3 significant figures

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

Question	Marking guidance	Mark	AO	Comments
03.1	**Wear plastic gloves:**			
	Essential – to prevent contamination from the hands to the plate	1	AO3 1a	
	Add developing solvent to a depth of not more than 1 cm^3:			
	Essential – if the solvent is too deep it will dissolve the mixture from the plate	1	AO3 1a	
	Allow the solvent to rise up the plate to the top:			
	Not essential – the Rf value can be calculated if the solvent front does not reach the top of the plate	1	AO3 1a	
	Allow the plate to dry in a fume cupboard:			
	Essential – the solvent is toxic	1	AO3 1a	Allow hazardous
03.2	Spray with developing agent or use UV	1	AO1b	
	Measure distances from initial pencil line to the spots (*x*)	1	AO2h	
	Measure distance from initial pencil line to solvent front line (*y*)	1	AO2h	
	R_f value = *x* / *y*	1	AO1b	
03.3	Amino acids have different polarities	1	AO1b	
	Therefore, have different retention on the stationary phase or different solubility in the developing solvent	1	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.		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 = CH_3 • 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 CH_3 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 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.			
	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 aprogression 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				Extended response
	Moles of NaOH = Moles of $HOOCCOO^-$ formed = 6.00×10^{-2}	1	AO2h	
	Moles of HOOCCOOH remaining = $1.00 \times 10^{-1} - 6.00 \times 10^{-2}$			
	$= 4.00 \times 10^{-2}$	1	AO2h	
	$K_a = [H^+][A^-]/[HA]$			
	$[H^+] = K_a \times [HA]/[A^-]$	1	AO2h	
	$[H^+] = 5.89 \times 10^{-2} \times (4.00 \times 10^{-2}/V)/(6.00 \times 10^{-2}/V) = 3.927 \times 10^{-2}$	1	AO2h	
	$pH = -\log_{10}(3.927 \times 10^{-2}) = 1.406 = 1.41$	1	AO1b	Answer must be given to this precision
04.3	$5H_2C_2O_4 + 6H^+ + 2MnO_4^- \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$	1	AO2d	
	OR $5C_2O_4^{2-} + 16H^+ + 2MnO_4^- \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$			
	Moles of $KMnO_4 = 20.2 \times 2.00 \times 10^{-2}/1000 = 4.04 \times 10^{-4}$	1	AO2h	
	Moles of $H_2C_2O_4 = 5/2 \times 4.04 \times 10^{-4} = 1.01 \times 10^{-3}$	1	AO2h	
	Concentration = moles/volume (in dm^3)			
	$= 1.01 \times 10^{-3} \times 1000/25 = 4.04 \times 10^{-2}$ (mol dm^{-3})	1	AO2h	If 1:1 ratio or incorrect ratio used, M2 and M4 can be scored

Question	Marking guidance	Mark	AO	Comments
05.1	$[CH_3OCOCOOH]^+$	1	AO3 1a	Allow names
	$[CH_3OCOCOOCH_3]^+$	1	AO3 1a	Do not allow molecular formula
05.2	Positive ions are accelerated by an electric field	1	AO1a	
	To a constant kinetic energy	1	AO1a	
	The positive ions with m/z of 104 have the same kinetic energy as those with m/z of 118 and move faster	1	AO2e	
	Therefore, ions with m/z of 104 arrive at the detector first	1	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