Question Number	Correct Answer	Reject	Mark
1(a)(i)	Mass of ethanoic acid = 0.04 x 60.1 = (2.404 g) **(1)** Volume of ethanoic acid = 2.404 ÷ 1.049 = 2.2917 = 2.3 (cm^3) **(1)** Correct answer with no working **(2)** Ignore SF except only one ALLOW 60.0 for molar mass which gives mass 2.4 and volume 2.288 = 2.3 cm^3 **(2)** OR First step 1.049 ÷ 60/60.1 to find number of moles in 1 cm^3 = 0.017 **(1)** Then volume = 0.04 ÷ 0.017 = 2.3529 (cm^3) But note, if whole calculation done on calculator, 60 gives 2.2879 and 61 gives 2.2917. **(1)** If units given, they must be correct, but penalise wrong units only once here.		**2**

Question Number	Correct Answer	Reject	Mark
1 (a)(ii)	Syringe ALLOW Burette Graduated/adjustable pipette	Gas syringe Biuret Just 'pipette'	**1**

Question Number	Correct Answer	Reject	Mark
1 (a)(iii)	To prevent… evaporation/vapour escaping water vapour entering OR To maintain a closed system OR To maintain a closed environment ALLOW To prevent: air oxidizing the alcohol reaction with air OR Due to volatility (of chemicals) IGNORE …gas escaping …HCl escaping		**1**

Question Number	Correct Answer	Reject	Mark
1 (a)(iv)	**First and second mark** Phenolphthalein **(1)** From colourless to (pale) pink/red **(1)** ALLOW Other indicators with pK_{in} in range 7.5 – 10 Some examples are: Thymol blue ((base)) (yellow to blue) Phen**ol** red (yellow to red) Thymolphthalein (colourless to blue) Second mark depends on correct indicator except bromothymol blue, which is incorrect but very close to range so allow colour yellow to blue. **Third mark** Sodium ethanoate is (slightly) alkaline OR Ethanoic acid is a weak acid OR Phenolphthalein pH range coincides with vertical section of the pH/titration curve OR Titration of weak acid with strong base OR Neutralisation/equivalence point is at 8-10/ any number between 8 and 10. OR pK_{in} +/-1 lies within vertical region **(1)** Third mark is independent	Litmus/universal indicator Pink to colourless Thymol blue **(acid)** Phenyl red Methyl red	**3**

Question Number	Correct Answer	Reject	Mark
1 (b)(i)	$CH_3COOH + CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$ ALLOW Single arrow $-CO_2H$ $-C_2H_5$ Displayed formulae IGNORE state symbols even if incorrect		**1**

Question Number	Correct Answer	Reject	Mark
1 (b)(ii)	Volume of alkali reacting with ethanoic acid = 77.1-11.7 = 65.4 cm^3 **(1)** Moles of ethanoic acid = $\frac{65.4 \times 0.200}{1000}$ = $0.01308/1.308 \times 10^{-2}$ (mol) **(1)** Correct answer no working (2) Ignore SF except 1 Allow internal TE for use of Moles of ethanoic acid = $\frac{77.1 \times 0.200}{1000}$ = $0.01542/1.542 \times 10^{-2}$ (mol) max **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
1 (b)(iii)	Number of moles of ethanol = $0.01308/1.308 \times 10^{-2}$ (mol) TE same as (ii)		**1**

Question Number	Correct Answer	Reject	Mark
1 (b)(iv)	Number of moles of ethyl ethanoate =0.0400−0.01308 = 0.02692 (mol) Allow TE from (ii)/(iii) for example 0.01542 gives 0.02458		**1**

Question Number	Correct Answer	Reject	Mark
1 (b)(v)	$K_c = \frac{[CH_3CO_2CH_2CH_3][H_2O]}{[CH_3CO_2H][CH_3CH_2OH]}$ **(1)** $= \frac{0.02692 \times 0.02692}{0.01308 \times 0.01308}$ = 4.23579 = 4.24 **(1)** Ignore SF except one Allow TE from (ii), (iii) and (iv) for example 0.01542 etc gives 2.54 No TE for incorrect expression of K_c		**2**

Question Number	Correct Answer	Reject	Mark
1 (b)(vi)	The units cancel OR There are the same numbers of moles of reactants and products		**1**

Question Number	Correct Answer	Reject	Mark
1 (b)(vii)	(Concentrated) hydrochloric acid contains water		**1**

Question Number	Correct Answer	Reject	Mark
1 (c)(i)	First test tube esterification OR addition/elimination ALLOW Condensation **(1)** Second test tube (acid) hydrolysis **(1)** Two fully correct answers in wrong order **(1) ma**	Alkaline hydrolysis followed by acidification	**2**

Question Number	Correct Answer	Reject	Mark
1 (c)(ii)	The values are the same within experimental error OR The values are concordant ALLOW The values are similar **(1)** The equilibrium can be approached from either direction OR The reaction is reversible OR Any comment relating equilibrium to reversibility IGNORE Dynamic equilibrium OR Rate of reverse reaction = rate of forward reaction **(1)**	Just...the same	**2**

Question Number	Correct Answer	Reject	Mark
1 (c)(iii)	(Acid) catalyst (makes it faster) OR Provides H^+ (as a catalyst) OR Protonates... OR Protonating agent... OR Donates protons OR Increases H^+ concentration	Initiates Reacts with... Protates	**1**

Question Number	Acceptable Answers	Reject	Mark
***2(a)**	(A green solution) forms a yellow / orange / brown (solution) ALLOW reddish-brown **(1)** A grey / black precipitate ALLOW silver ppt ALLOW solid / crystals for precipitate **(1)**	Red 'Green(ish)' with any other colour Silver mirror silver compound	**2**

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	0.05(00) (mol dm^{-3})		**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	Amount of silver ion in 10 cm^3 = amount of thiocyanate = $\frac{5.6 \times 0.0200}{1000} = 0.000112/1.12 \times 10^{-4}$ (mol) **(1)** So concentration of silver ion = $0.000112 \times \frac{1000}{10} = 0.0112/1.12 \times 10^{-2}$ (mol dm^{-3}) **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
2(b)(iii)	$0.0112/1.12 \times 10^{-2}$ (mol dm^{-3}) Accept TE = answer to (ii)		**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)(iv)	$0.0500 - 0.0112 = 0.0388/3.88 \times 10^{-2}$ (mol dm^{-3}) Accept TE = 0.05 - answer to (iii) Accept answer to (i) – answer to (iii)		**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)(v)	$K_c = \frac{[Fe^{3+}(aq)]}{[Fe^{2+}(aq)]\,[Ag^{+}(aq)]}$ ALLOW $K_c = \frac{[Fe^{3+}]}{[Fe^{2+}]\,[Ag^{+}]}$ **(1)** $= \frac{0.0388}{0.0112^2}$ $= 309.311 = 309\ dm^3\ mol^{-1}$ Value **(1)** Unit (any order) **(1)** Three SF **(1)** Accept TE from (iii) and (iv): (use of 0.1 from (i) gives 708 $dm^3\ mol^{-1}$) If [Ag] is included in the numerator and taken as =$[Fe^{3+}(aq)]$, then allow unit and SF marks ONLY, but must either state 'no units' or show working	[Ag] in numerator	**4**

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	$\Delta S^{\ominus}_{total} = 8.31 \times \ln 309$ $= +47.6(4) / +47.6(5) J\ mol^{-1}\ K^{-1}$ OR $= 8.31 \times \ln 309.311 = +47.6(5)\ J\ mol^{-1}\ K^{-1}$ Accept TE : 8.31 x ln(answer from b(v)) Value **(1)** Sign **and** Unit (any order) **(1)** IGNORE sf except 1		**2**

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	First Mark: One of the products is a solid OR Two moles going to two moles but one of them is a solid OR Two moles of solution react to form one mole of solution / liquid and one mole of solid **(1)** **Second Mark** (Hence) RHS more ordered / LHS less ordered **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
2(c)(iii)	$\Delta S^{\ominus}_{surroundings} = \Delta S^{\ominus}_{total} - \Delta S^{\ominus}_{system}$ $= +47.6 - (-208.3) = (+)255.9$ (J mol^{-1} K^{-1}) Accept TE on c(i) IGNORE sf except 1		**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)(iv)	Because $\Delta S^{\ominus}_{surroundings} = \frac{-\Delta H^{\ominus}}{T}$ **(1)** $\Delta H = -298 \times 255.9 = -76258$ (J mol^{-1}) $= -76.258$ (kJ mol^{-1}) **(1)** Units if given must be correct Correct answer with or without working scores 2 marks IGNORE SF except 1 As T increases $\Delta S^{\ominus}_{surroundings}$ becomes less positive / decreases **therefore** ΔS_{total} becomes less positive / decreases ALLOW more negative for less positive **(1)**	$\Delta S^{\ominus}_{total} = \frac{-\Delta H^{\ominus}}{T}$	**3**

Question Number	Acceptable Answers	Reject	Mark
2*(d)	No change in the titre ALLOW No significant change Stand alone mark **(1)** (though silver solid was removed the equilibrium constant remains the same so) the equilibrium **concentration(s)** would remain the same **(1)** Second mark dependent on first IGNORE references to temperature		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	(K_p =) $\frac{pCH_3CO_2H}{pCH_3OH\ (x)\ pCO}$ Partial pressure symbol can be shown in various ways, eg pp, p_{CO}, (CO)p, etc *ALLOW* p in upper or lower case, round brackets *IGNORE* units	[ ] State symbols given as (l) + in botto line	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(ii)	P CH_3OH = 4.9 (atm) **(1)** P CO = 4.9 (atm) **(1)** 1 mark for recognition that pressures are equal *IGNORE* units		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iii)	$K_p = ((22.2)/(4.9)^2)$ = 0.925 **(1)** atm^{-1} **(1) stand alone mark but must match expression used in (a)(iii)** **OR** $9.25 \times 10^4\ Pa^{-1}$ / $92.5\ kPa^{-1}$ **(2)** *ALLOW* TE from (a)(i) if inverted and/or (a)(ii)	Answers to other than 3 significant figures	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(i)	CH_3OH: 3.2 CO : 3.2 **(1)** for both values CH_3CO_2H: 46.8 **(1)** *ALLOW* TE for moles of ethanoic acid based on numbers of methanol and carbon monoxide used, as long as moles of methanol and carbon monoxide are equal and moles ethanoic acid + moles methanol = 50		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(ii)	$\left(\frac{46.8 \times 32}{53.2}\right)$ = 28.2 / 28.1504 (atm) *IGNORE* sf except 1 Value = 28.16 if mol fraction rounded *ALLOW* TE from (b)(i)	28.1 $\frac{46.8 \times 32}{50}$ = 29.95 (atm)	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(iii)	exothermic as yield / pp of ethanoic acid / conversion of reactants/ K_p is higher at lower temperature / as equilibrium moves (right) at lower temperature *ALLOW* if partial pressure of ethanoic acid < 22.2 atm in (b)(ii), endothermic as yield / pp of ethanoic acid / conversion of reactants/ K_p is lower at lower temperature		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(i)	No effect **and** other concentrations change to keep K_p constant / K_p is only affected by temperature/ as equilibrium moves (right) to keep K_p constant / **change** in pressure does not change K_p	As K_p is a constant	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(ii)	Yield **increased** to restore fraction / quotient / partial pressure ratio back to K_p *ALLOW* (equilibrium moves) to use up the methanol /answers based on entropy or Le Chatelier Correct prediction in (c)(i) and (c)(ii) with inadequate explanations scores **1 mark** in (c)(ii)	Just 'equilibrium moves to the right'	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (d)	Mark independently Reaction can occur at lower temperature / has lower activation energy / requires less energy **(1)** less fuel needed / fewer emissions (from fuels) / fewer raw materials needed / less natural resources used **(1)** **OR** Enables use of an alternative process with higher atom economy **(1)** fewer raw materials needed / less natural resources used **(1)**	Answer based on car exhaust emissions	**2**