Question Number	Correct Answer	Reject	Mark
1(a)(i)	Purple gas/ gas turns colourless **(1)** to (silver/shiny) grey/black solid **(1)** **Just** gas to solid OR solid forming **(1)**	Purple liquid/solid	2

Question Number	Correct Answer	Reject	Mark
1 (a)(ii)	**First mark** Heat for different lengths of time OR After more time/specified time eg 2 days …. OR Use a colorimeter OR Set up reverse reaction **(1)** **Second mark** Measure the concentration of a reactant or product of two tubes, which should be the same OR Colour does not change /is same **(1)**		2

Question Number	Correct Answer	Reject	Mark
***1 (b)(i)**	Equilibrium moles HI $\frac{30 \times 0.00353}{1000}$ = 0.0001059 **(1)** H_2 and I_2 $\frac{30 \times 0.00048}{1000}$ = 0.0000144 **(1)** Initial amount of HI = 0.0001059 + 2 x 0.0000144 = 0.0001347 (mol) ALLOW TE from wrong moles of either or both entity **(1)** Mass of 1 mol of HI = 127.9 **(1)** Mass of HI = 0.0001347 x 127.9 = 0.0172 g **(1)** Correct answer with or without working **(5)** All marks stand alone Last two marks are available for **any** amount in moles x 127.9correctly calculated		5

Question Number	Correct Answer	Reject	Mark
1 (b)(ii)	$K_c = \frac{[H_2][I_2]}{[HI]^2}$ Ignore state symbols unless (aq) or (s) Ignore eq or eqm	p H_2 etc (K_p)	1

Question Number	Correct Answer	Reject	Mark
1 (b)(iii)	$K_c = \frac{0.00048 \times 0.00048}{0.00353^2}$ = 0.018489 = 0.0185 Allow all SF except 1		1

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

Question Number	Correct Answer	Reject	Mark
1 (c)(i)	$K_c' = \frac{[H_2]^{½}[I_2]^{½}}{[HI]}$ Ignore state symbols unless (aq) or (s) Ignore eq or eqm	p H_2 etc (K_p) but not if already penalised	1

Question Number	Correct Answer	Reject	Mark
1 (c)(ii)	$K_c' = \frac{[0.00048]^{½}[0.00048]^{½}}{[0.00353]}$ $= 0.136$ Allow all SF except 1 **(1)** Which is the square root of the previous value OR $K_c = (K_c')^2$ OR $0.136^2 = 0.0185$ **(1)**		2

Question Number	Correct Answer	Reject	Mark
1 (d)	**Frist mark** K_p remains unchanged/constant **(1)** **Second mark** (when pressure is increased) the quotient/ratio p_{H2}: $(p_{HI})^2$ becomes less than *K*p OR Ratio decreases OR Ratio proportional to 1/P (P is total pressure change) ALLOW K_p proportional to 1/P **(1)** **Third mark** To restore the value of the quotient/ratio to *K*p ALLOW To restore *K*p **And** EITHER p_{H2} increases / p_{HI} decreases **(1)** OR Equilibrium shifts to the right **(1)**	K_p decreases for this mark only	3

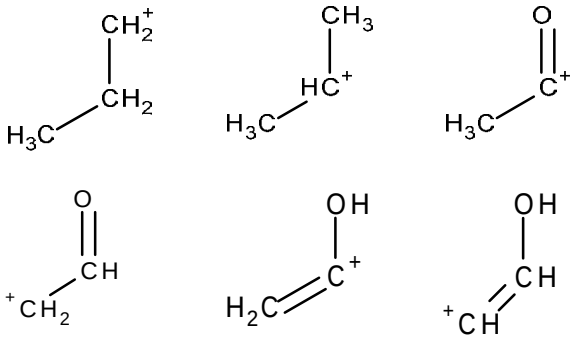
Question Number	Acceptable Answers	Reject	Mark
2 (a)(i)	So that only the water formed in the combustion is absorbed by X / measured. ALLOW 'reacts with X' for 'absorbed by X' OR Otherwise the mass / amount of the water measured will be too high	Reacts with A References to Y	**1**

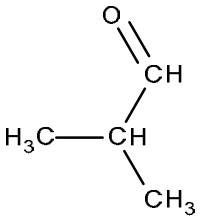
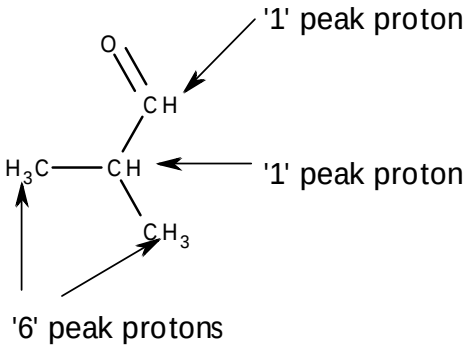
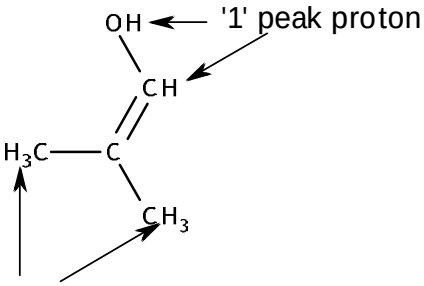
Question Number	Acceptable Answers	Reject	Mark
2 (a)(ii)	(Anhydrous) Calcium chloride / $CaCl_2$ / Magnesium sulphate / $MgSO_4$ / silica gel / sodium sulphate / Na_2SO_4 ALLOW Phosphorus(V) oxide / phosphorus pentoxide / P_4O_{10} / P_2O_5 / Silica beads	Sulfuric acid Calcium oxide Silica / SiO_2 anhydrous copper(II) sulfate	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(iii)	Soda lime OR calcium hydroxide / $Ca(OH)_2$ **and** sodium hydroxide / NaOH ALLOW sodium hydroxide / NaOH / potassium hydroxide / KOH / Calcium oxide / CaO	Limewater	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(iv)	The methods below illustrate the allocation of marks. But the first four marks may be scored by any correct method. **Method 1** mol CO_2 = 8.8/44 = 0.2 (= mol C) **(1)** mol H_2O = 3.6/18 = 0.2 mol H = 2 x mol H_2O = 0.4 **(1)** mass O = 3.6 – (12 x 0.2 + 1 x 0.4) = 0.8 (g) **(1)** mol O = 0.8/16 = 0.05 **(1)** **Method 2** Mass H = 3.60 x 2/18 = 0.40 (g) = 0.40 / 1 = 0.40 (mol) **(1)** Mass C = 8.80 x 12/44 = 2.4 (g) = 2.4 / 12 = 0.20 (mol) **(1)** Mass O = 3.60 – (0.40 + 2.4) = 0.80(g) **(1)** = 0.80 / 16 = 0.05 (mol) **(1)** Empirical formula = C_4H_8O **(1)** TE on incorrect moles but the ratio **must** be whole number IGNORE use of O_2 for O in the 'words' Correct empirical formula with some working at each stage scores full marks **but** Correct empirical formula with **no** working or **unclear and non-scoring** working scores final mark only		**5**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(i)	(Molecular ion is m/e =) 72 (= M_r of **A**) **(1)** Molecular formula = C_4H_8O **(1)** No TE on incorrect molecular ion	 Structural Or Displayed Or Molecular ion	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(ii)	Any three of (1 mark for each structure)  ALLOW structural formulae (eg CH_3CO^+) IGNORE Position of positive charge Penalise omission of charge or negative charge once $C_3H_7^+$ and /or $C_2H_3O^+$ scores 1 if no scoring structure		**3**

Question Number	Acceptable Answers		Reject	Mark
***2 (c)**	Structure of **A** (1)  Three (proton/H) environments (1) **Identify** the 6 protons in one environment and 1 each in the other two (1) No TE on incorrect structures except propan-2-ol : scores MP3 only	OR diagram (1)  6 proton label (1) **both** 1 proton labels (1) ALLOW enol structure  6 proton label (1) **both** 1 proton labels (1)		**3**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$ Ignore state symbols even if incorrect	Any answers with electrons even if balanced	**1**

Question Number	Acceptable Answers	Reject	Mark
3 **(a)(ii)**	Ignore SF except 1 SF – penalise this and/or rounding errors once only in (a)(ii) – (v) Moles of Fe^{2+} reacting in titration $= 23.85 \times 10^{-3} \times 0.255$ $= 6.08175 \times 10^{-3}$ mol * **(1)** Moles of $Cr_2O_7^{2-}$ that reacted in titration = answer * ÷ 6 $= 6.08175 \times 10^{-3} \div 6$ $= 1.013625 \times 10^{-3}$ mol **(1)** Correct answer with no working scores 2		**2**

Question Number	Acceptable Answers	Reject	Mark
3 **(a)(iii)**	Moles of $Cr_2O_7^{2-}$ at start $= 25 \times 10^{-3} \times 0.200$ $= 5 \times 10^{-3}$ mol** **(1)** Moles of $Cr_2O_7^{2-}$ that reacted with ethanol = answer ** – answer 21(a)(ii) $= 5 \times 10^{-3} - 1.013625 \times 10^{-3}$ $= 3.986375 \times 10^{-3}$ mol **(1)** Correct answer with no working scores 2		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iv)	$CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$ **(1)** 3 mol of ethanol needs 12 mol electrons supplied by 2 mol potassium dichromate(VI) ALLOW Use of oxidation numbers of C and Cr OR Use of ratio of electrons lost and gained OR Balanced equation: $3CH_3CH_2OH + 2Cr_2O_7^{2-} + 16H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O$ **(1)** IGNORE Uncancelled species including the 12 electrons in the last equation	Use of [O] **Just** 3 mol of ethanol reacts with 2 mol $Cr_2O_7^{2-}$	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(v)	Moles of ethanol that reacted with potassium dichromate(VI) = ans. 21(a)(iii) x 3 ÷ 2 = 5.9795625 x 10^{-3} mol **(1)** Concentration in **Q** = previous answer x 10 x 40 = 2.391825 mol dm^{-3} **(2)** (1 mark for x 10 or x 40 and 1 mark for completion of calculation Correct answer with no working scores 3		**3**

Question Number	Acceptable Answers	Reject	Mark
3(b)	Fe^{2+} / iron(II) **(1)** And any TWO of: Barium diphenylamine sulfonate is a **redox** indicator ALLOW reaction is **redox** **(1)** Barium diphenylamine sulfonate / indicator is reduced by iron(II) OR Iron(II) is oxidized by barium diphenylamine sulfonate / indicator OR Barium diphenylamine sulfonate / indicator oxidized by potassium dichromate(VI) OR Potassium dichromate(VI) is reduced by Barium diphenylamine sulfonate / indicator **(1)** The oxidized form / oxidation product of barium diphenylamine sulfonate is purple OR the reduced form is colourless ALLOW Oxidised and reduced form of the indicator have different colours **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
***3(c)**	**EITHER** **MP1** Difficult to know when reaction is complete OR Difficult to know when all the ethanol has been oxidized (to ethanoic acid) OR Some ethanol only oxidized to ethanal ALLOW Some ethanol is oxidized by air **(1)** **MP2** (depends on MP1 correct or 'ethanol evaporates') So less potassium dichromate(VI) will be used up **(1)** **MP3** (depends on MP1 or MP2 or 'ethanol evaporates') Ethanol concentration will appear low **(1)** **OR** Other compounds in the fermented solution (e.g. aldehydes) are oxidized also. **(1)** So more potassium dichromate(VI) will be used up **(1)** Ethanol concentration will appear high **(1)**	Ethanol evaporates Transfer losses / spillages Not all sugar fermented	**3**

Question Number	Acceptable Answers	Reject	Mark
4 (a)(i)	$Fe^{2+} \rightarrow Fe^{3+} + e^{(-)}$ $½O_2 + 2H^+ + 2e^{(-)} \rightarrow H_2O$ OR $O_2 + 4H^+ + 4e^{(-)} \rightarrow 2H_2O$ ALLOW Reversible arrows Equations in other direction Electrons subtracted on LHS of first equation Multiples Ignore state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
4 **(a)(ii)**	$½O_2 + 2H^+ + 2Fe^{2+} \rightarrow 2Fe^{3+} + H_2O$ OR $O_2 + 4H^+ + 4Fe^{2+} \rightarrow 4Fe^{3+} + 2H_2O$ ALLOW Multiples Reversible arrows Ignore state symbols even if incorrect No TE from 20(a)(i)	Equation in the wrong direction, even with reversible sign	1

Question Number	Acceptable Answers	Reject	Mark
4 (b)(i)	$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$ Ignore state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
4 (b)(ii)	(Pale) pink	Purple / mauve	1

Question Number	Acceptable Answers	Reject	Mark
***4** **(b)(iii)**	Amount of MnO_4^- = 24.90 x 0.0195 x 10^{-3} = 4.8555 x 10^{-4} (mol)* **(1)** Amount of Fe^{2+} = answer * x 5 in 25 cm^3 = 4.8555 x 10^{-4} x 5 = 2.42775 x 10^{-3} (mol) So in 250 cm^3 = 2.42775 x 10^{-2} (mol) **(1)** (M_r ($FeSO_4.7H_2O$) = 277.9) **ROUTE 1 (via moles)** Amount of Fe^{2+} used to prepare the solution = 6.90 / 277.9 = 2.4829 x 10^{-2} (mol) **(1)** EITHER % of Fe^{2+} remaining at titration = 100 x 2.42775 x 10^{-2} / 2.4829 x 10^{-2} = 97.7785 (%) **(1)** % Oxidized = 100 – 97.7785 = 2.221 (%) **(1)** OR Amount oxidized = 2.4829 x 10^{-2} – 2.42775 x 10^{-2} = 5.516 x 10^{-4} (mol) **(1)** % Oxidized = 5.516 x 10^{-4} x 100 / 2.4829 x 10^{-2} = 2.221 (%) **(1)** **ROUTE 2 (via mass)** mass from titration = 2.42775 x 10^{-2} x 277.9 = 6.7467 (g) **(1)** % of Fe^{2+} remaining at titration = 100 x 6.7467 / 6.9 = 97.7785 (%) **(1)** % Oxidized = 100 – 97.7785 = 2.221 (%) **(1)** Ignore SF except 1 SF unless justified in b(iv) Correct answer no working scores 5 marks 90.22% obtained from failure to multiply by 10 scores 4 marks		5

Question Number	Acceptable Answers	Reject	Mark
4 (b)(iv)	3 (significant figures) because all the data (except A_r(H)) is given to 3 SF OR 2 (significant figures) because the least precise data (A_r(H)) is 2 SF OR 2 (significant figures) because the data is to three figures. After processing only two figures are certain. OR 1 (significant figure) because of the subtraction of two similar numbers.		1

Question Number	Acceptable Answers	Reject	Mark
4 (c)(i)	Alkali neutralizes the acid shifting the equilibrium to the left OR Alkali neutralizes the acid so E value for half cell becomes less (than +2.20 V) ALLOW 'Reacts with' and 'removes' for 'neutralizes' IGNORE Just "shifts equilibrium to the left"		1

Question Number	Acceptable Answers	Reject	Mark
4 (c)(ii)	$4Fe^{3+} + 4H_2O \rightarrow 3Fe^{2+} + FeO_4^{2-} + 8H^+$ OR Multiples Species **(1)** balance **(1)** Ignore state symbols even if incorrect		2

Question Number	Acceptable Answers	Reject	Mark
4 **(c)(iii)**	Required half cell value is $E^{\ominus}$ = (+)0.77 **(1)** $E^{\ominus}_{cell}$ = (0.77 – 2.20 =) −1.43 V ($E^{\ominus}_{cell}$ negative so disproportionation) not feasible **(1)** TE on calculated negative value of $E^{\ominus}_{cell}$ No TE on positive value for $E^{\ominus}_{cell}$ OR Correct application of anti-clockwise rule e.g. $Fe^{3+}(aq) + e^{-} \rightleftharpoons Fe^{2+}(aq)$ $E^{\ominus}$ = +0.77 V $FeO_4^{2-}(aq) + 8H^{+}(aq) + 3e^{-} \rightleftharpoons Fe^{3+}(aq) + 4H_2O(l)$ $E^{\ominus}$ = +2.20 V Equations in order of increasing $E^{\ominus}$ value **and** arrows shown **(1)** Anti-clockwise rule shows top reaction moves left and bottom reaction moves right so disproportionation not feasible **(1)**		2