1)

Correct Answer	Mark
A	**1**

2)

Correct Answer	Mark
A	**1**

3)

Correct Answer	Mark
C	**1**

4)

Correct Answer	Mark
B	**1**

5)

Correct Answer	Mark
B	**1**

6)

Correct Answer	Mark
B	**1**

7)

Correct Answer	Mark
B	**1**

8)

Correct Answer	Mark
A	**1**

9)

Correct Answer	Mark
D	**1**

10)

Correct Answer	Mark
C	**1**
D	**1**

11)

Correct Answer	Mark
D	**1**

12)

Question Number	Acceptable Answers	Reject	Mark
(a)(i)	Throughout 20 (a): IGNORE sf except 1 sf (penalise once) correct answer with no working scores full marks mark consequentially IGNORE units unless incorrect $0.109 \times 27.35 \times 10^{-3}$ **(1)** $= 2.98115 \times 10^{-3}$ (mol) $= 2.98 \times 10^{-3}$ / 0.00298(mol) **(1)** cq only on some concentration x some volume	0.003	**2**

Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	Moles I_2 = 0.5 x moles thiosulfate **= 0.5 x answer to (a)(i)** $= 1.490575 \times 10^{-3} = 1.49 \times 10^{-3}$ /0.00149(mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
(a)(iii)	Moles of Cl_2 = moles of I_2 = **answer to (a)(ii)** $= 1.49 \times 10^{-3}$ /0.00149(mol)		**1**

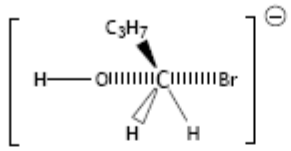
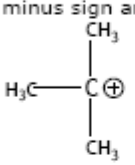
Question Number	Acceptable Answers	Reject	Mark
(a)(iv)	**Mark consequentially on answer in (a)(iii)** Amount in volumetric flask = 25 x answer to (a)(iii) (= $25 \times 1.490575 \times 10^{-3} = 3.72644 \times 10^{-2}$) OR ($25 \times 1.49 \times 10^{-3} = 3.725 \times 10^{-2}$) **(1)** (= amount in 10 cm^3 of disinfectant) Concentration = 100 x previous value (= $1000 \times 3.73 \times 10^{-2}/10 = 3.73$ (mol dm^{-3})) **(1)** Concentration = 100 x answer to (a)(iii) scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
b)	(Atoms of) the same element (in the same species) are oxidized and reduced **(1)** ALLOW chlorine for 'element' Chlorine ON 0 oxidized to (+)1 in ClO^- **(1)** and reduced to −1 in Cl^- **(1)** Only penalise once if oxidized and reduced omitted Just 'Chlorine ON 0 oxidized to (+)1 and reduced to −1' or 'Chlorine oxidized to chlorate(I) and reduced to chloride'(1 mark only) Only penalise once if oxidized and reduced reversed	Molecule/substance/ reactant /species Just Cl oxidized & reduced	**3**

Question Number	Acceptable Answers	Reject	Mark
(c)	Colour just before adding the starch: (very) pale yellow/straw coloured **(1)** Colour after adding the starch: Blue-black (ALLOW black or (dark) blue) Colour at the end point: colourless **(1)** **Both** colours required IGNORE 'Clear'	Just 'yellow', brown, gold purple	**2**

13)

(a)	Names OR Formulae A = NaOH/KOH in ethanol /alcohol **(1)** B = NaOH/KOH in water/ aqueous **(1)** IGNORE any reference to ethanol /alcohol /dilute C = NaBr/KBr & (50% or moderately conc) H_2SO_4 / P & Br_2 / PBr_3 /PBr_5 /NaBr /KBr & H_3PO_4 /HBr ALLOW phosphorus bromide **(1)** IGNORE red/white (phosphorus) D = NH_3 (in alcohol /in a sealed tube /at high pressure) **(1)** IGNORE aqueous	Water + ethanol /water + alcohol For A and B OH^-/alkali (penalise once) Dilute H_2SO_4 any mention of alkali any mention of acid	**4**
(b)(i)	A = elimination **(1)** IGNORE 'nucleophilic' D = (nucleophilic) substitution **(1)**	mention of dehydration in A mention of electrophilic in A or D	**2**

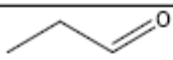
(b)(ii)	Mark the diagrams; then mark the explanation sections together Score **(1)** for intermediate/ transition state wrong way round		**4**
	 	Full O—C—Br bonds OH—C	
	IGNORE geometry and missing minus sign and δ+/ δ- **(1)**	+ sign	
	 **(1)**	δ+	
	Any two from		
	Tertiary carbocation more stable (than primary carbocation) ALLOW Tertiary carbocation very stable/fairly stable/stable **(1)** This mark can be awarded even if structures and other explanations are incorrect or missing	Just 'primary carbocation unstable'	
	Methyl groups stabilise charge (of carbocation) (through positive inductive effect)		
	Steric hindrance (by methyl groups) inhibits formation of (trigonal bipyramid) transition state/attack by nucleophile with tertiary compound		
	Steric hindrance is less with the primary halogenoalkane/more with tertiary halogenoalkane		
	ALLOW a description of steric hindrance e.g. blocking/less space		

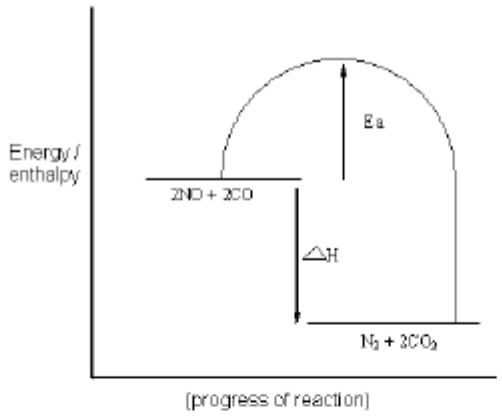
Number			
(b)(iii)	C–I bond weaker ALLOW C–I bond easier to break ALLOW iodine forms weaker bonds than bromine without mention of carbon ALLOW reverse arguments with C–Br bond stronger IGNORE Explanations in terms of electronegativity or bond polarity or activation energy or shielding even if incorrect	Just C–I bond longer	1

(c)(i)	(Boiling) absorbs heat (allow energy)/latent heat (of vaporization)/enthalpy of vaporization from the surroundings/endothermic. If bonds are mentioned they must be intermolecular		1

(c)(ii)	**Any two from** Not flammable Not toxic Unreactive/inert/non-corrosive (only one of these can score) (easily) compressible does not harm the ozone layer Boiling temperature below target temperature ALLOW low boiling temperature high heat of vaporization high gas density high critical temperature IGNORE Non-polluting/ environmentally friendly/ cheap/easily manufactured/ easy to store/easy to contain /take up little space/low melting point/endothermic/ harmful	 Does not produce CFCs Gas/solid stable	2

14)

(a)	$N_2 + O_2 \rightarrow 2NO$ or $\frac{1}{2}N_2 + \frac{1}{2}O_2 \rightarrow NO$ Or multiples ALLOW extra oxygen or nitrogen molecules provided equation is balanced IGNORE state symbols even if incorrect ALLOW = and 2NO•		**1**
(b)(i)	Free radical(s) ALLOW recognisable spellings e.g. radicle		**1**
(b)(ii)	Homolytic (fission) ALLOW recognisable spellings e.g. homolitic		**1**
(c)(i)	(unburnt) fuel/petrol/diesel/ kerosene (aviation fuel) ALLOW Car exhaust fumes/ fossil fuels/oil IGNORE burning/combustion except if stated as complete	Engines/factories/cattle/ methane/ethane/crude oil/ natural gas/coal/pollution	**1**
(c)(ii)	Oxidation ALLOW partial oxidation	Redox Addition oxidation	**1**
(c)(iii)	 IGNORE angles provided clearly 3 carbons	displayed or structural or molecular formulae or skeletal showing any H atoms	**1**
(c)(iv)	NO removed so less O_3 broken down/NO reacts with hydrocarbon rather than O_3 so less O_3 broken down IGNORE build up of ozone	Just 'less O_3 broken down'	**1**
(d)	(At high altitudes) intensity of UV (radiation/light) is greater **(1)** ALLOW more UV So conversion of NO_2 to NO will increase **(1)** ALLOW (At high altitudes) pressure is lower **(1)** So equilibrium $2NO(g) + O_2(g) = 2NO_2(g)$ shifts to the left **(1)**	NO_2 removed before it gets to high altitudes more sunlight less oxygen	**2**

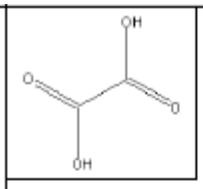
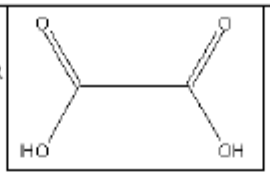
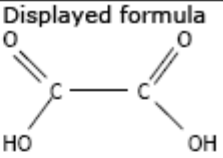
(e)	Ozone absorbs/blocks/filters/ protects against ALLOW removes (all) **UV** radiation **(1)** UV/sunlight is biologically harmful/causes genetic damage/causes (skin) cancer/causes eye cataracts **(1)** Reference to global warming max **(1)**	Sunlight; Infrared; reflects Just 'harmful' Effect of radiation without any mention of UV or sunlight	**2**
(f)(i)	$2NO + 2CO \rightarrow N_2 + 2CO_2$ OR $NO + CO \rightarrow \frac{1}{2}N_2 + CO_2$ Or multiples IGNORE state symbols even if incorrect ALLOW =		**1**
(f)(ii)	 ALLOW names or symbols in diagram ALLOW double headed arrows or headless arrows IGNORE Maxwell Boltzmann distributions **First mark** Labelled y axis and reactants and products ALLOW potential energy **(1)** IGNORE units IGNORE formula errors and x axis labels even if incorrect ALLOW 'reactants' and 'products' as labels **Second mark** **Exothermic** reaction **and** △H label **(1)** IGNORE negative sign on △H **Third mark** Activation energy line and label OR a double hump with higher first (smooth curve is not needed) **(1)**	Reversed arrows Energy change or enthalpy change or △H Any other humped diagram	**3**

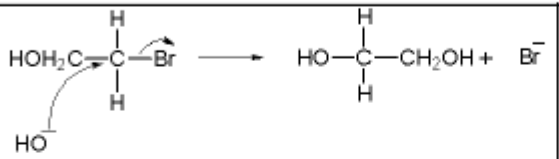
Number			
(f)(iii)	Catalyst provides an alternative route/mechanism **(1)** with lower activation energy ALLOW low activation energy **(1)** So a higher proportion (ALLOW more) molecules / collisions (ALLOW reactants) have energy equal to or greater than Ea ALLOW 'so more molecules react' **(1)**		**3**
(g)	Aircraft (release NO) closer to the ozone layer/(atmosphere) at high altitude/in the stratosphere **(1)** IGNORE greenhouse gases at this point So less NO is lost through competing / other reactions **(1)** ALLOW broken down ALLOW NO (released at ground level) dissipated (e.g. by reaction with oxygen or hydrocarbons or by reaction to form ozone (as in the passage))	Just 'atmosphere'	**2**

15) D (1)
16) D (1)
17) B (1)
18) A (1)
19) B (1)
20) D (1)
21) C (1)
22) D (1)
23) C (1)
24) A(1)

25)

(a)	$2Na + CH_2OHCH_2OH \rightarrow CH_2O^{(-)}Na^{(+)}CH_2O^{(-)}Na^{(+)} + H_2$ This equation scores **(2)** marks Accept multiples and $(CH_2OH)_2$ and $(CH_2O^{(-)}Na^{(+)})_2$ Organic product (Charges not needed) **(1)** Balancing and the rest **(1)** ALLOW for one mark: $Na + CH_2OHCH_2OH \rightarrow CH_2OHCH_2O^{(-)}Na^{(+)} + \frac{1}{2}H_2$ Accept multiples	$2\ CH_2O^{(-)}Na^{(+)}$ $CH_2Na^{(+)}O^{(-)}CH_2Na^{(+)}O^{(-)}$ Reject bond from C to Na	**2**
(b)	Remove thermometer / still-head / leave the top of condenser open **(1)** Place condenser directly on top of flask/in vertical position **(1)** ALLOW correct diagram for 2 marks IGNORE comments on use of electric heaters, changing concentration of reagents	Sealed apparatus, e.g. with thermometer in the top	**2**

(c)	 OR  ALLOW the OH bond to be displayed ALLOW displayed formula as 'working out' ALLOW any orientation IGNORE bonds of different lengths or incorrect bond angles	Displayed formula  Just 'Structural formula' Bond from carbon clearly to the H of the OH	**1**
(d)	Both have OH / hydroxyl groups OR Both would produce steamy / misty /white **and** fumes /gas (of HCl)	Hydroxide ions White smoke Just 'both produce HCl' Both give the same products'	**1**
(e)(i)	(Strong) Peak at 1750-1700 (cm^{-1}) **(1)** Peak(s) (either or both) at 2900-2700(cm^{-1}) **(1)** ALLOW these if merged	peak at 3300-2500 (cm^{-1}) peak at 3750-3200 (cm^{-1})	**2**
(e)(ii)	(Unreacted) ethanol C_2H_5OH /displayed /skeletal IGNORE references to O-H bonding	Molecular formula Just "O-H in alcohol" Ethane-1,2-diol	**1**

Number			
(e)(iii)	$COOH^+$ ALLOW CO_2H^+ ALLOW CH_3COO^+ ALLOW CH_2COOH^+ ALLOW the + sign wherever it is seen Also allow correct displayed, semi-displayed or structural formulae	$COOH^-$ or any other formula with – charge $CH_3CO_2H^+$ CH_3COOH^+ $C_2H_3O_2^+$	1
(f)(i)	 One mark for curly arrow from hydroxide ion; (This arrow can be drawn from anywhere on the hydroxide ion) **(1)** One mark for curly arrow from C-Br bond **(1)** Correct products; **(1)** If SN1 is shown, then intermediate with positive charge must be shown after loss of Br, followed by attack by hydroxide. This mechanism can score all 3 marks	Carbon with ∂- Bond to H of OH	3
(f)(ii)	Mechanism: Nucleophilic **(1)** Type: Substitution **(1)** ALLOW either way round Just S_N scores **(1)** ALLOW nucleophile and phonetic spelling IGNORE Heterolytic fission	Elimination SN with elimination or other type of reaction Homolytic fission	2
Number			
(g)	$Ag^+(aq) + Br^-(aq) \longrightarrow AgBr(s)$ Species **(1)** State symbols **(1)** ALLOW one mark for chemical equation with state symbols rather than ionic equation, e.g. $AgNO_3(aq) + NaBr(aq) \longrightarrow AgBr(s) + NaNO_3(aq)$	Spectator ions included	2
(h)	Both silver chloride and silver bromide dissolve /give colourless solution in conc. ammonia **(1)** If the solid doesn't dissolve in dilute ammonia then it is silver bromide OR Add conc. sulfuric acid to the (solid) silver bromide and get red-orange bromine gas **(1)**	Alternative tests which don't work eg displacement of bromine, use of organic solvent, leave in sunlight to see if bromine forms, add conc. sulfuric acid to halide solution.	2