Question	Answer	Marks
1(a)	1 $Na_2S_2O_3$ 2 H_2O 3 HCl **OR** 1 HCl 2 H_2O 3 $Na_2S_2O_3$ **OR** 1 H_2O 2 $Na_2S_2O_3$ 3 HCl **OR** 1 H_2O 2 HCl 3 $Na_2S_2O_3$;	**1**
(b)(i)	**M1** volumes 40 : 10 : 10; **M2** time = 14;	**2** 1 1
(b)(ii)	**M1** more particles per unit volume / particles are closer together; **M2** increases the rate of collisions / there are more collisions per unit time;	**2** 1 1
(c)	**M1** particles gain more energy **and** move fast**er**; **M2** increasing rate of collisions / more collisions per unit time; **M3** higher proportion of particles have sufficient energy to react / collisions have sufficient energy to react / are above the activation energy;	**3** 1 1 1

Question	Answer	Marks
2(a)	**M1** substance that speeds up a reaction / increases rate; **M2** unchanged (chemically) at the end / not used up / lowers activation energy / provides alternative pathway;	**2** 1 1
(b)	**M1** too slow / slower; **M2** lower yield / less product(s) / equilibrium shifts to left / equilibrium shifts in direction of reactants / backward reaction favoured / reverse reaction favoured;	**2** 1 1
(c)	fa / increase rate;	**1**
(d)	lo yield / less product(s) / equilibrium shifts to left / equilibrium shifts in direction of reactants / backward reaction favoured / reverse reaction favoured; **OR** higher cost / expensive; **OR** safety risks;	**1**
(e)(i)	**M1** breakdown of an ionic compound when molten or in aqueous solution; **M2** (using) electricity / electric current / electrical energy;	**2** 1 1
(e)(ii)	/ graphite / platinum;	**1**

Question	Answer	Marks
2(e)(iii)	$2H^+ + 2e(\ ) \rightarrow H_2$; **OR** $2H_3O^+ + 2e(\ ) \rightarrow H_2 + 2H_2O$;	**1**
(e)(iv)	cathode / negative electrode;	**1**
(e)(v)	 **M1** damp blue litmus paper; **M2** bleaches / loses colour / turns white / turns colourless;	**2** 1 1
(f)	$2NaCl + 2H_2O \rightarrow 2NaOH + H_2 + Cl_2$ all formulae correct; balancing;	**2**
(g)	 **M1** *chlorine*: treating (drinking) water / treating water in swimming pools / kill bacteria in water / chlorination of water / (manufacture of) paper products / plastics / PVC / dyes / textiles / medicines / antiseptics / insecticides / herbicides / fungicides / solvents / paints / disinfectant / bleach / hydrochloric acid; **M2** *sodium hydroxide*: drain cleaner / oven cleaner / extraction of aluminium / purification of bauxite / (manufacture of) biodiesel / paper / soap / detergents / washing powder / textiles / dyes; **M3** *hydrogen*: fuel / rocket fuel / fuel cells / in welding / (manufacture of) ammonia / NH_3 / margarine / methanol / hydrochloric acid / refrigerants;	**3** 1 1 1

Question	Answer	Marks
3(a)	**M1** (substance that) speeds up a reaction / increases the rate of a reaction; **M2** any one from: unchanged (chemically at the end) / not used up; lowers activation energy;	**2**
(b)(i)	at the start/initially / t = 0;	**1**
(b)(ii)	catalyst should be powdered / increase surface area (of catalyst) / decrease particle size (of catalyst); **or** increase temperature / heat / warm;	**1**
(c)(i)	(mol);	**1**
(c)(ii)	0.001 (mol);	**1**
(c)(iii)	(dm^3);	**1**
(c)(iv)	change / no effect;	**1**
(c)(v)	(dm^3);	**1**
(d)	s mass / amount of / moles / 1.0 g of catalyst; same temperature; same volume **and** concentration of hydrogen peroxide / 20 cm^3 of 0.1 mol / dm^3 of hydrogen peroxide or reactant;	**3**

Question	Answer	Marks	Guidance
4(a)(ii)	$^{+}$ or 'hydrogen ion(s)'; it accepts electrons or takes electrons (from zinc atoms);	**2**	**R** H_2 or 'hydrogen' **A** because it is reduced or because it decreases in oxidation number **A** it causes zinc to lose electrons
(b)(i)	zinc displaces copper or zinc more reactive than copper; $Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$ **OR** $Zn + Cu^{2+} \rightarrow Cu + Zn^{2+}$;	**2**	**A** copper less reactive than zinc **I** zinc reacts with copper ions or with Cu^{2+} or with copper chloride **I** zinc reacts with copper **I** Cu^{2+} ions are reduced **A** multiples **I** state symbols
(b)(ii)	steeper (line) or higher gradient; (means an) increased rate; but the same (final) volume;	**3**	**A** less time to complete the reaction / same amount of gas in less time / faster reaction / more gas in the same time period **A** same volume of hydrogen produced **A** 'amount' for volume **A** no extra gas is made
(c)	M1 less steep (line) or lower gradient; M2 (because of) decreased rate; M3 ethanoic is a weak(er) acid; M4 only partially ionised or dissociated **OR** lower concentration of hydrogen ions;	**4**	**A** alternative phrases e.g. 'shallower' **A** more time to complete the reaction **A** same amount of gas in more time **A** slower rate or slower reaction ORA **A** not fully dissociated or ionised **A** ionises less (than HCl) **I** less hydrogen ions

Question	Answer	Marks	Guidance
(d)	M1 moles of HCl = 0.1 (mol); M2 moles of Zn = 0.05 (mol); mass of zinc = 3.25 g;	3	**A** ECF for M1 × ½ **A** ECF for M2 × 65 Unit required for M3

5 **(a)** **(i)** rate decreases [1]
concentration of sodium chlorate ((I))/reactant decreases [1]

(ii) (initial) gradient greater/steeper (must start at origin) [1]
same final volume of oxygen [1]

(iii) (to prevent)photochemical reaction/(to prevent)reaction catalysed by light/light breaks down or decomposes sodium chlorate((I)) [

(iv) particles have more energy/particles move faster/ [1]
more collisions [1]
collisions more frequent or more often/greater chance of collision/collision rate increases/more particles have energy to react/more collisions are successful or effective [1]

(b) $2Cl \rightarrow Cl_2 + 2e( ) / 2Cl - 2e( ) \rightarrow Cl_2$ [1]

$2H^+ + 2e( ) \rightarrow H_2 / 2H^+ \rightarrow H_2 - 2e( )$ [1]

hydrogen formed at cathode/– and chlorine at anode/+ [1]

Na^+ and OH **or** sodium ions and hydroxide ions left in solution/form/become sodium hydroxide [1]

(ii) $Cl_2 + 2NaOH \rightarrow NaClO/NaOCl + NaCl + H_2O$ [2]
Species (1) Balancing (1)

[Total: 14]