PEARSON EDEXCEL IGCSE CHEMISTRY · 4CH1

CHEMISTRY



MARK SCHEME

SECTION 3: PHYSICAL CHEMISTRY (PACK 1)

SCORE	PERCENTAGE
/210	%

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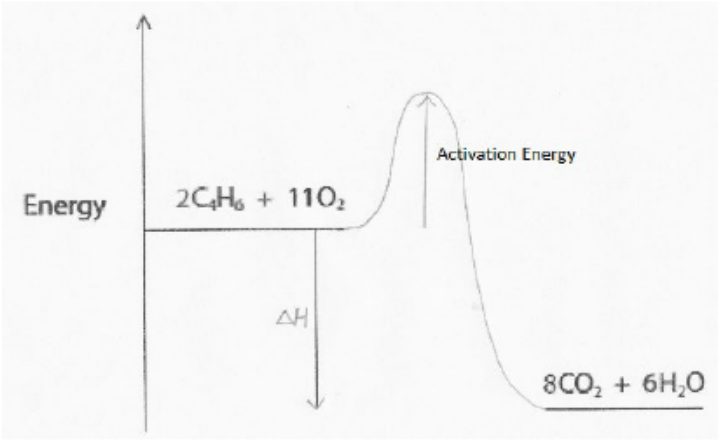
Mark Scheme

Q1.

Question number	Answer	Notes	Marks
(a)	Explanation including following points M1 (unsaturated because) contains (carbon to carbon) double bond(s) M2 (hydrocarbon because) contains (the elements/atoms) carbon and hydrogen M3 only	 ALLOW contains C=C REJECT molecules M3 DEP on carbon and hydrogen	3 grad

(b)	(i)	from orange to colourless	ALLOW yellow for orange or any combination of orange/yellow IGNORE clear	1 grad
	(ii)	calculation including following steps M1 calculation of energy involved in bond breaking in reactants M2 calculation of energy involved in bond making in products M3 evaluation of difference M4 correct answer and sign Example calculation M1 2(612) + 1(348) + 6(412) + 2(193) OR 4430 M2 3(348) + 6(412) + 4(276) OR 4620 M3 (4620 - 4430 =) 190 M4 -190	 ECF from M1 and M2 IGNORE signs in M1 and M2 ACCEPT 2(612) + 2(193) OR 1610 for M1 and 2(348) + 4(276) OR 1800 for M2 IGNORE sign ACCEPT (1800 - 1610 =) 190 M3 M4 ECF from M1 and M2 If M1 > M2 answer for M4 must be positive If M1 < M2 answer for M4 must be negative -190 with or without working scores 4 (+) 190 with or without working scores 3	4 Exp

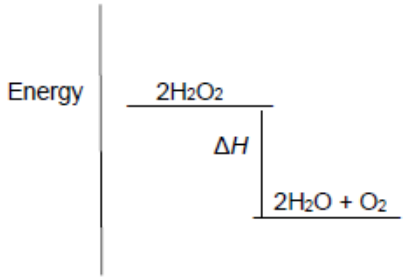
(c)	(i)	$2\,C_4H_6 + 7\,O_2 \rightarrow 2C + 4\,CO + 2\,CO_2 + 6H_2O$		1 Exp
	(ii)	Explanation including M1 CO/carbon monoxide M2 is poisonous/toxic/reduces capacity of blood to carry oxygen OWTTE **OR** M1 CO_2/carbon dioxide M2 is a greenhouse gas/contributes to global warming/ contributes to climate change OWTTE	M2 DEP M1 correct or missing **ACCEPT** prevents blood from carrying oxygen OWTTE ALLOW correct explanation in terms of haemoglobin eg prevents haemoglobin from carrying oxygen / forms carboxyhaemoglobin	2 Exp

(iii)	 M1 horizontal line below level of reactants with $8\,CO_2 + 6\,H_2O$ M2 profile curve rising from reactants level to form "hump" and then falling down to products level M3 activation energy correctly shown and labelled M4 $\triangle H$ correctly shown and labelled	ALLOW double headed arrow REJECT arrow pointing downwards ALLOW double headed arrow REJECT arrow pointing upwards ALLOW -3446 for $\triangle H$ label an endothermic reaction profile can score M2 M3 M4 ECF	4 Exp
		Total for Q = 15	

Q2.

Question number	Answer	Notes	Marks
(a)	**B** it relights a glowing splint A is incorrect as this is the test for hydrogen C is incorrect as oxygen is not an acidic gas D is incorrect as this is the test for carbon dioxide		1
(b)	An explanation that links the following two points **M1** provides an alternative pathway OWTTE **M2** with a lower activation energy OWTTE	**ACCEPT** more collisions with energy greater than the activation energy **ALLOW** lowers the energy needed to start the reaction	2

Question number	Answer	Notes	Marks
(c) (i)	• find energy needed to break bonds • find energy released when bonds form • correct subtraction to find ΔH Example calculation **M1** (4 x 463) + (2 x 143) **OR** 2138 (kJ) **M2** (4 x 463) + 498 **OR** 2350 (kJ) **M3** — 212 (kJ) **OR M1 – M2** correctly evaluated	**ACCEPT** (2 x 143)/286 for **M1** and 498 for **M2** **IGNORE** any signs in **M1** and **M2** — 212 with or without working scores 3 (+) 212 with or without working scores 2	3

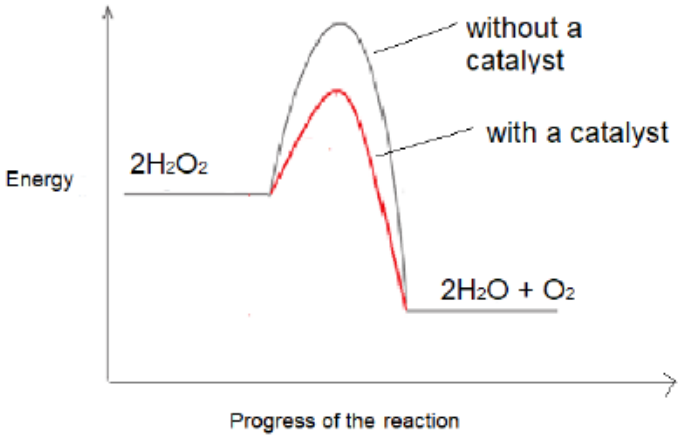
(ii)	 **M1** horizontal line to show products in correct position and correctly labelled **M2** vertical line in correct position and labelled ΔH	Mark CQ on sign in (i) **ACCEPT** double headed arrow or arrow pointing from reactants level to products level **REJECT** arrow pointing from products level to reactants level **IGNORE** any attempts at including activation energy	2 **Total 8**

Q3.

Question number	Answer	Notes	Marks
(a)	A description that refers to any five of the following points M1 add hydrogen peroxide to the conical flask and add catalyst M2 start the timer M3 record volume of gas produced in a given time/ record the time for certain volume of gas to be produced M4 repeat with same mass of a different catalyst M5 and with same volume of hydrogen peroxide M6 plot the results on a graph and calculate gradient (for each catalyst) M7 the most effective catalyst gives the fastest rate of reaction OWTTE		5
(b) (i)	M1 a vertical line from the level of the hydrogen peroxide to the top of the curve labelled activation energy or E_a M2 a vertical line from the level of the hydrogen peroxide to the level of the water and oxygen labelled enthalpy change or ΔH	the line does not need an arrow head ALLOW double headed arrow REJECT arrow pointing down ALLOW double headed arrow REJECT arrow pointing up	2
(ii)	curve starting from hydrogen peroxide level, below the peak of the original curve, and ending at water and oxygen level		1
			Total for question = 8

Q4.

Question number	Answer	Notes	Marks
(a)	a catalyst is chemically unchanged at the end of the reaction	ALLOW (provides alternative route for reaction of) lower activation energy ALLOW not used up in reaction	1
(b)	description including six of the following points: M1 do experiment using hydrogen peroxide solution only/without X/Y/Z M2 use known volume of hydrogen peroxide solution OWTTE M3 (and) measure time for certain volume of oxygen gas to be collected OR measure volume of gas collected in a certain time period OWTTE M4 repeat using same volume of hydrogen peroxide solution M5 with known mass/amount of solid X (then Y, then Z) M6 measure time for same volume of oxygen gas to be collected OR measure volume of gas collected in same time period (with solid/X/Y/Z present) M7 after reaction (remove solid/X/Y/Z by filtration and dry) find mass of solid/X/Y/Z /check if mass unchanged M8 reference to reduced time (for certain volume of oxygen gas to be collected) OR increased volume of gas (collected in a certain time period) means X/Y/Z (possible) catalyst (1)	ALLOW measure time until no more oxygen produced ALLOW amount ALLOW reference to increased rate	6

Question number	Answer	Notes	Marks
(c)	M1 labelled profile curve drawn for reaction without catalyst M2 labelled profile curve drawn with lower activation energy for reaction with catalyst  	must start from reactants energy level and end at products energy level	2

(d)	(i)	energy needed= [(4 x 463) + 2(146)] = 2144	Ignore sign	1
	(ii)	energy released = [(4 x 463)] = 1852	ignore sign	1
	(iii)	M1 for showing equation linking between (i), (ii), O=O bond energy and $\triangle H$ M2 correct calculation Example: M1 [1852+ (O=O)] - 2144 = 204 OR (O=O) = 2144 – 1852 + 204 M2 (O=O) = 496	Mark CSQ on (i) and (ii) -496 scores 1 mark	2
			(Total for Question = 13)	

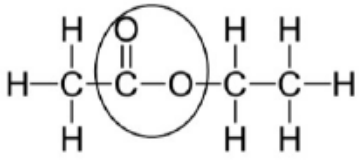
Q5.

Question number	Answer	Additional guidance	Marks
(a)	An explanation that links together the following two points: **M1** reaction is taking place in both directions (at same time) **M2** at equal rate	 **ACCEPT** both forward and backward reactions are taking place (at same time) **IGNORE** it is a reversible reaction **M2 DEP M1** rate of the forward reaction is equal to the rate of the backward reaction scores 2 marks **REJECT** both forward and backward reactions occur at constant rate for **M2** **ALLOW** the concentrations of the reactants and products remains constant scores 1 mark independently of **M1** but **REJECT** concentrations of the reactants and products are equal/the same	2

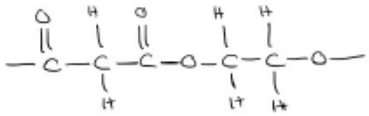
(b) (i)	An explanation that links together the following two points: **M1** (the position of) equilibrium has moved to the left	 **ALLOW** (position of) equilibrium has shifted in backwards direction **ALLOW** (position of) equilibrium has shifted towards the N_2O_4 /reactants (side) **ALLOW** increasing pressure shifts (position of) equilibrium in direction that produces fewer moles (of gas) **IGNORE** references to Le Chatelier's Principle eg increasing pressure favours the side that has fewer moles of gas / increasing pressure favours the backwards reaction	2
	M2 because there are fewer moles/molecules (of gas) on the left	**ALLOW** particles **REJECT** atoms **ALLOW** because there are fewer moles of N_2O_4 (than NO_2) **ALLOW** because there are fewer moles of reactant (than product) **ACCEPT** reverse argument	
(ii)	the concentration of NO_2 has increased	**ALLOW** molecules/particles of NO_2 are closer together **ALLOW** molecules/particles of NO_2 are in a smaller volume **REJECT** more NO_2 produced	1

Question number	Answer	Additional guidance	Marks
(c) (i)	nitrogen/N_2 reacts with oxygen/O_2 (both from the air)	**IGNORE** nitrogen burns/combusts in oxygen **IGNORE** nitrogen is oxidised	1
(ii)	(they form) acid rain	**ACCEPT** references to respiratory problems **ALLOW** a specified harmful effect of acid rain **ALLOW** references to smog **ALLOW** references to greenhouse gases/global warming/climate change	1
(iii)	$2NO + 2CO \rightarrow N_2 + 2CO_2$	**ACCEPT** multiples and fractions	1

Q6.

Question number	Answer	Notes	Marks
(a) (i)		REJECT any other atoms in the ring.	1
(ii)	ethyl ethanoate	ALLOW ethylethanoate ALLOW ethyl acetate	1
(iii)	M1 add a metal such as magnesium, aluminium, zinc or iron M2 effervescence/bubbles/fizzing **OR** M1 add a carbonate M2 effervescence/bubbles/fizzing	must be a named metal REJECT Group 1 metals ACCEPT test gas with lighted splint which pops M2 dep on reference to adding a metal ACCEPT any named carbonate ACCEPT test gas with limewater which goes cloudy/milky M2 dep on M1	2
(b)	M1 C-O and one / two O-H bonds are broken and formed M2 so the same amount of energy is needed to break the bonds in the reactants as is given off when the bonds in the products are formed	ALLOW the same bonds are broken and formed ALLOW energy of bonds formed equals energy of bonds broken	2

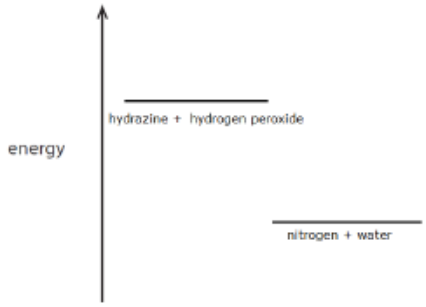
(c)	(i)	M1 the rate of the forward reaction equals the rate of the backward reaction M2 the concentrations of reactants and products remain constant	 REJECT concentration of the reactants and products are the same	2
	(ii)	M1 a catalyst increases the rate of forward and backward reactions M2 equally	 M2 dep on M1	2

Question number	Answer	Notes	Marks
(d)	example calculation M1 moles barium hydroxide = (0.150 × 22.75)÷ 1000 **OR** 0.0034125 M2 moles ethanoic acid = 0.006825 M3 moles ethanoic acid to 3 significant figures = 0.00683	 M1 needs to be given to at least 3 sig figs ALLOW M1 × 2 ALLOW answer to M2 to 3 significant figures. correct answer of 0.00683 moles with or without working scores 3 marks ACCEPT answer in standard form ACCEPT 0.00682 if M1 given to 3 sig figs 6.83 with or without working scores 2 marks	3
(e)	correct answer scores 2 marks  M1 three carbons from the dicarboxylic acid and two from the diol and the ester linkage M2 -OH lost from the dicarboxylic acid and -H lost from the diol	ALLOW structure without extension bonds IGNORE brackets and n and + H_2O ALLOW -OH lost from diol and -H lost from dicarboxylic acid	2
			Total for question = 15

Q7.

Question number	Answer	Additional guidance	Marks
(a) (i)	(bonds broken) 3861 (kJ)		1
(ii)	(bonds made) 4649 (kJ)		1
(iii)	**M1** subtraction of Σ(bonds made) made and Σ(bonds broken)	In (iii) ECF from (i) and (ii) must be applied Subtraction can be in any order	3
	M2 correct evaluation of the calculation shown in **M1**	**IGNORE** sign	
	M3 If Σ(bonds made) > Σ(bonds broken) final answer must be negative If Σ(bonds made) < Σ(bonds broken) final answer must be positive (and + sign given)	Expected final answer is −788 (kJ/mol) -788 with no working scores 3 (+) 788 scores 2	

(b)	An explanation that links together the following two points: **M1** more energy is given out when the bonds are made	If state/imply that energy required to make bonds OR If state/imply that energy released when bonds are broken scores 0/2	2
	M2 than is taken in when the bonds are broken	**ACCEPT** correct reverse argument	

Question number	Answer	Additional guidance	Marks
(c)	 **M1** right hand line below left hand line **M2** correct names/formulae of both reactants **M3** correct names/formulae of both products	**IGNORE** horizontal axis drawn **IGNORE** enthalpy change shown **IGNORE** activation energy shown If only use words *reactants* (on left) and *products* (on right) award 1 mark from M2 and M3	3

Q8.

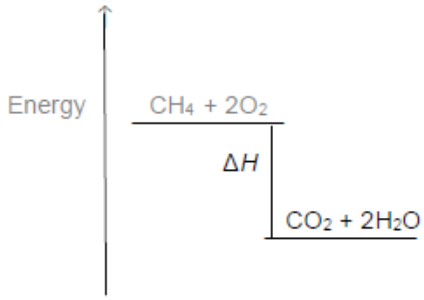
Question number	Answer	Notes	Marks
(a)	gives out thermal energy/heat (energy)		1
(b)	• M1 expression for Σ bond energies of reactants/bonds broken • M2 expression for Σ bond energies of products/bonds made or evaluation • M3 correct equation linking M1, M2 and value of ΔH • M4 evaluation of Cl-Cl bond energy		4
	Example calculation	Correct answer without working scores 4	
	M1 (Σ bond energies of reactants =) 436 + X	**ACCEPT** E(Cl– Cl) or any suitable symbol or expression for X	
	M2 (Σ bond energies of products =) 2 x 431 **OR** 862(kJ)		
	M3 – 184 = 436 + X – 862 **OR** X = – 184 + 862 – 436	**ALLOW M3** ECF if 431 for **M2** If not used (-)184 in **M3** can only score M1 M2 **M3** subsumes **M1 M2**	
	M4 X = 242 (kJ/mol)	**ALLOW M4** ECF on **M3** as long as **M3** involves 436, X, 862 (or 431) and (-)184	

Question number	Answer	Notes	Marks
(c)	An explanation that links the following three points		3
	M1 energy needed to break bonds / bond-breaking is endothermic	**ALLOW** energy is absorbed/taken in	
	M2 energy given out when bonds are formed / bond-forming is exothermic	**ALLOW** energy is released	
	M3 energy given out is greater than energy needed (so exothermic) OWTTE	**M3 DEP M1 M2** more energy released when new bonds are formed (in products) than is needed to break the bonds (in reactants) OWTTE scores **M1 M2 M3** If any contradictory statements max 1	
(d)	**M1** horizontal line to show products below reactants and to the right of reactants and labelled 2HCl	**ALLOW** products for 2HCl	4
	M2 vertical line from H_2 + Cl_2 level to 2HCl/products level and labelled enthalpy change/ΔH/ -184	**ACCEPT** double headed arrow or arrow pointing from H_2 + Cl_2 level to 2HCl/products level **REJECT** arrow pointing from 2HCl/products level to H_2 + Cl_2 level	
	M3 curve with hump/peak shown on diagram going up from H_2 + Cl_2 line and ending at 2HCl/products line		
	M4 vertical line from H_2 + Cl_2 level to top of hump level and labelled activation energy/E_a	**ACCEPT** double headed arrow or arrow pointing from H_2 + Cl_2 level to top of hump **REJECT** arrow pointing from top of hump to H_2 + Cl_2 level	
		If endothermic diagram shown, can score **M2 M3** (peak/hump must be above products line) and **M4**	**Total 12**

Q9.

Question number	Answer	Notes	Marks
(a)	carbon	**ALLOW** soot **ALLOW** copper(II) oxide /copper oxide/CuO **REJECT** copper(I) oxide	1
(b)	**M1** (amount of ethanol) = 0.92 ÷ 46 **OR** 0.02(0) (mol) **M2** (–)18.2 ÷ 0.02(0) = (–)910 (kJ/mol)	**ALLOW** alternative methods	2
(c)	Any 2 from **M1** heat (energy)/ thermal energy was lost (to the surroundings/apparatus) **M2** incomplete combustion (of ethanol) **M3** the ethanol was impure/ethanol evaporates		2

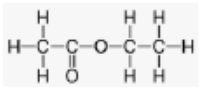
(d) (i)	**M1** Σ bonds broken = 4 x C–H + 2 x 498 **M2** Σ bonds formed = 2 x 805 + 4 x 463 **OR** 3462 **M3** 4 x C–H + 996 – 3462 = – 890 **M4** C–H = 1576 ÷ 4 = 394 (kJ/mol)	correct answer with or without working scores 4 **ALLOW** 2 x 498 **OR** 996 seen **ALLOW** ecf throughout 839 without working scores 3 616.5/617 without working scores 3	4

(ii)	 **M1** horizontal line to show products in correct position and correctly labelled **M2** vertical line in correct position and labelled ΔH / – 890 (kJ/mol)	**ACCEPT** double headed arrow or arrow pointing from reactants level to products level **REJECT** arrow pointing from products level to reactants level **IGNORE** any attempts at including activation energy If endothermic reaction shown **M2** can be awarded for correct arrow/line labelled ΔH / +890 (kJ/mol)	2
			Total 11

Q10.

Question number	Answer	Notes	Marks
(a) (i)	M1 no effect on yield	IGNORE comments about rate	2
	M2 because same number of moles (of gas) on both sides of equation	M2 dep on M1	
(ii)	M1 no effect on yield		2
	M2 because catalyst increases rate of both forward and backward reactions by same amount	M2 dep on M1	
(b)	M1 bonds broken = (436 + 158) OR 594 (ignore sign) M2 bonds made = (2 x 562) OR 1124 (ignore sign) M3 ΔH = -530 (kJ/mol)	-530 with no working scores 3 +530 or 530 with no working scores 2 +32 or 32 with no working scores 2	3
(c)	M1 right hand line below left hand line M2 correct names/formulae of reactants and products M3 enthalpy change, ΔH correctly shown and labelled with arrow pointing down If the answer to (b) is positive M1 right hand line above left hand line M2 correct names/formulae of reactants and products M3 enthalpy change, ΔH correctly shown and labelled with arrow pointing up	ALLOW reactants and products ACCEPT line with no arrow head / double arrow head if -ΔH or -530 is labelled REJECT arrow pointing upwards ALLOW reactants and products ACCEPT line with no arrow head / double arrow head if (+)ΔH or +530 is labelled REJECT arrow pointing downwards	3
		Total marks for Question = 10	

Q11.

Question number	Answer	Notes	Marks
(a) (i)	Any **two** from: M1 volume of acid M2 temperature M3 mass / moles of magnesium M4 surface area / size of pieces of magnesium		2
(ii)	so as little gas as possible escapes	**ALLOW** so no gas escapes **IGNORE** references to accuracy **REJECT** references to gas getting in	1
(b) (i)	M1 (69 + 70 + 71) ÷ 3 M2 70s	Answer of 70 with or without working scores 2 Answer of 76 or 75.8 or 75.75 with or without working scores 1	2
(ii)	as the (number of) carbons increases the time (to produce 10 cm^3 of hydrogen) increases ORA		1
(c)	M1 ester linkage as a displayed structure  M2 rest of molecule correct as a fully displayed structure 		2
			8 marks

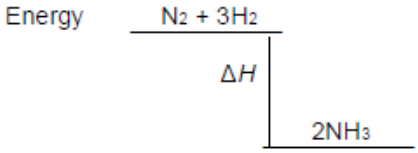
Q12.

Question number	Answer	Notes	Marks
(a) (i)	(produces) acid rain	**ALLOW** any detrimental effect of acid rain e.g. kills fish, damages limestone buildings	1
(ii)	• M1 find moles of sulfur • M2 multiply moles by 24 • M3 answer in standard form Example calculation **M1** $6.4 \times 10^6 \div 32$ **OR** $2.0 \times 10^5 / 200\,000$ **M2** $2.0 \times 10^5 \times 24$ / 200 000 x 24 / 4 800 000 **M3** 4.8×10^6	**ALLOW** ECF as long as an attempt has been made to calculate moles Correct answer without working scores 3 4 800 000 (dm^3) without working scores 2	3
(b) (i)	An explanation that links the following two points **M1** provides an alternative (reaction) pathway/route **M2** with a lower activation energy OWTTE	**ACCEPT so** more particles/collisions have energy greater than the activation energy **ALLOW** lowers the energy needed to start the reaction	2
(ii)	fewer moles (of gas) on RHS (than on (LHS)	**ALLOW** 3 moles (of gas) on LHS and 2 moles (of) gas on RHS **ALLOW** fewer moles of product/SO_3 (gas) (than of reactants/SO_2 and O_2 (gas)) **ALLOW** molecules in place of moles **IGNORE** references to rate	1
(iii)	as yield is approximately 98% /very high (it is not necessary to increase the pressure) OWTTE	**ALLOW** reference to reaction rate (already high enough) as catalyst used OWTTE	1

Question number	Answer	Notes	Marks
(c)	**M1** $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$ **M2** $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$	**ALLOW** multiples	2
(d)	**M1** (2 x 14 ÷ 132) x 100 **M2** 21.21 (%)	**ALLOW** any number of sig figs except 1 **ALLOW** ECF from **M1** as long as 132 used correctly Correct answer without working scores 2	2
			Total 12

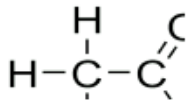
Q13.

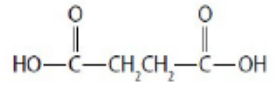
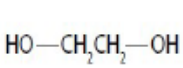
Question number	Answer	Notes	Marks
(a) (i)	reversible (reaction) / reaction that goes both ways OWTTE	IGNORE references to equilibrium	1
(ii)	increases the rate of reaction /speeds up the reaction	REJECT to increase yield ALLOW to reach equilibrium faster IGNORE provides an alternative pathway with lower activation energy	1
(b) (i)	**M1** yield decreases **M2** (forward) reaction is exothermic/ backward reaction is endothermic	IGNORE references to rate and Le Chatelier throughout ACCEPT (when temperature increased equilibrium shifts in) endothermic direction which is (from right) to left **M2** DEP **M1** correct or missing	2 2
(ii)	**M1** yield increases **M2** there are fewer moles (of gas) on the right-hand side/product side / there are more moles (of gas) on the left-hand side/there are 4 moles of reactants and 2 moles of product/ OWTTE	ALLOW molecules for moles **M2** DEP **M1** correct or missing	

(c)	 **M1** horizontal line labelled with $N_2 + 3H_2$ **M2** horizontal line showing $2NH_3$ in correct position **M3** vertical line in correct position and labelled ΔH /-92 (kJ/mol)	IGNORE any horizontal axis/labels IGNORE any attempts at including activation energy ALLOW nitrogen and hydrogen ALLOW ammonia If not balanced or words reactants and products on horizontal lines in correct position scores 1 out of 2 ACCEPT double headed arrow or arrow pointing from reactants level to products level REJECT arrow pointing from products level to reactants level If endothermic reaction can score M1 and M3	3

(d)	(i)	**M1** amount of nitrogen = (48 ÷ 24 =) 2 (mol) **M2** amount of hydrogen = (120 ÷ 24 =) 5 (mol) **M3** 2.5 mol of hydrogen to 1 mol of nitrogen (which is less than 3 so nitrogen is in excess) **OR** 2 mol of nitrogen needs 6 mol of hydrogen (so not enough hydrogen to react with the nitrogen)	ACCEPT alternative methods	3
	(ii)	**M1** 5 mol of hydrogen gives 3.33 mol of ammonia **M2** volume of ammonia (if 100% conversion) = 3.33 x 24 **OR** 80 (dm^3) **M3** (volume of ammonia if 20% conversion) = $\frac{(20 \times 80)}{100}$ = 16.0 (dm^3)	correct answer without working scores 3 ALLOW ECF from (i) ALLOW 3.3 use of 3.3 gives 79.2 use of 79.2 gives 15.84 ALLOW ECF from **M2** ACCEPT 120 dm^3 of hydrogen gives 2 x 120 ÷ 3 **OR** 80 (dm^3 of ammonia) for M1 and M2 ALLOW max 2 for use of 48 dm^3 of nitrogen giving 96 dm^3 of ammonia and final answer of 19.2 (dm^3)	3
				Total 15

Q14.

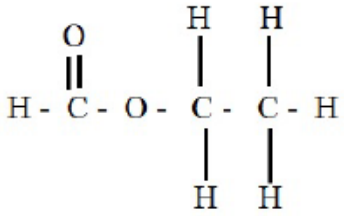
Question number	Answer	Notes	Marks
(a) (i)	**M1** $\frac{40.0}{12}$ $\frac{6.7}{1}$ $\frac{53.3}{16}$	0 marks for division by atomic numbers or upside-down calculation	2
	M2 3.33 6.7 3.33 **AND** 1 2 1	**ALLOW** any number of sig figs except 1 **ACCEPT** alternative methods	
(ii)	CH_3COOH **OR** 	**ACCEPT** $HCOOCH_3$ **OR** 	1
(b) (i)	$2HCOOH + Na_2CO_3 \rightarrow 2HCOONa + CO_2 + H_2O$		2
	M1 $CO_2 + H_2O$	**IGNORE** numbers in front of CO_2 and/or H_2O if only M1 scored	
	M2 HCOONa **and** equation correctly balanced	**REJECT** NaCOOH **ALLOW** NaHCOO	
(ii)	bubbles/ fizzing/ effervescence	**IGNORE** gas given off **ALLOW** sodium carbonate disappears/dissolves	1

(c)	(i)	propyl methanoate	spelling must be correct **ALLOW** propyl formate	1
	(ii)	reversible reaction	**ALLOW** reaction which goes both ways **IGNORE** equilibrium	1
	(iii)	forward and backward reactions occur at the same rate OWTTE **OR** concentrations of reactants and products remain constant/stay the same/do not change	 **ALLOW** amounts/moles/ratios of reactants and products remain constant **REJECT** concentrations of reactants and products are equal/the same	1
(d)	(i)	condensation (polymerisation)		1
	(ii)	**M1**  **M2** 	**ALLOW** $HOOCCH_2CH_2COOH$ for **M1** **ALLOW** $HOCH_2CH_2OH$ for **M2** **REJECT** OH—C once only	2
				Total 12

Q15.

Question number		Answer	Notes	Marks
(a)	(i)	sulfuric acid	**IGNORE** references to concentration **ALLOW** H_2SO_4 **REJECT** sulfurous acid	1 Grad
	(ii)	**D** orange to green A is incorrect as the solution is not colourless at the start of the reaction B is incorrect as the solution is not green at the start or orange at the end of the reaction C is incorrect as the solution is not colourless at the end of the reaction		1 Comp

(b)	(i)	• show the expression for the sum of the bond energies for the breaking of bonds • evaluation to give answer in kJ Example calculation **M1** ∑ C-C + 5C-H + C-O + O-H + 3O=O **OR** ∑ 346 + (5 x 412) + 358 + 463 + (3 x 496) **M2** 4715 (kJ)	correct answer without working scores 2 - 1 mark for each error	2 Exp
	(ii)	• show the expression for the sum of the bond energies for the forming of bonds • evaluation to give answer in kJ Example calculation **M1** ∑ 4C=O + 6O-H **OR** ∑ (4 x 743) + (6 x 463) **M2** 5750 (kJ)	correct answer without working scores 2 - 1 mark for each error **IGNORE** any signs in (i) and (ii)	2 Exp
	(iii)	(4715 – 5750 =) – 1035 (kJ/mol)	minus sign must be included **ACCEPT** – 1040 (kJ/mol) **ALLOW** ecf on answers to (i) and (ii) If answers to (i) and (ii) are reversed allow max 3 and ecf on (iii)	1 Exp

Question number	Answer	Notes	Marks
(c) (i)	ethyl methanoate	**ALLOW** ethyl formate **ALLOW** words written without gap	1 Grad
(ii)	**M1** ester linkage O || −C−O− **M2** rest of molecule correct  Structural formula of ethyl formate or ethyl methanoate	**M2** dep on **M1**	2 Exp
(iii)	**M1** forward and reverse reactions occur at the same rate OWTTE **M2** concentrations of reactants and products remain constant		2 Exp

(d)	• calculate amount in moles of HCOOH • use equation to find amount in moles of CO_2 • multiply amount in moles of CO_2 by molar volume • evaluation of answer in cm^3 Example calculation **M1** n(HCOOH) = 2.3 ÷ 46 **or** 0.05(0) **M2** $n(CO_2)$ = 0.05(0) ÷ 2 **or** 0.025 **M3** (volume of CO_2) = 0.025 x 24 **or** 0.025 x 24000 **M4** 600 (cm^3)	correct answer without working scores 4 No ecf from **M1** and **M2** if mass or M_r multiplied by 24 /24000 **ALLOW** ecf from **M3** 0.6, 1200 and 2400 score 3 1.2 and 2.4 score 2	4 Exp **Total 16**

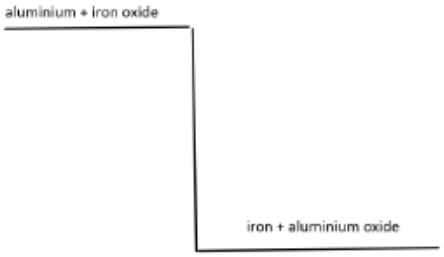
Q16.

Question number	Answer	Notes	Marks
(a) (i)	$NH_4Cl + NaOH \rightarrow NaCl + NH_3 + H_2O$		1
(ii)	M1 moist/damp red litmus paper M2 turns blue	ALLOW moist/damp universal indicator paper	2

(b)	an explanation linking following two points: M1 forward and backward/reverse reactions are taking place at same rate M2 the concentrations of reactants and products remain constant	 ACCEPT reaction is taking place in both directions at same rate REJECT concentrations of the reactants and products are equal/the same	2
(c)	an explanation linking following two points: M1 as temperature decreases yield of ammonia (formed in forward reaction) increases M2 so forward reaction is exothermic	 ALLOW as temperature decreases equilibrium position shifts in forward direction/(from left) to right (producing more ammonia) IGNORE references to pressure ALLOW reverse arguments IGNORE references to Le Chatelier's Principle M2 DEP M1	2
		(Total for Question	**= 7)**

Q17.

Question number	Answer	Notes	Marks
(a) (i)	M1 layers / rows (of atoms / ions) M2 can slide over one another	 M2 is dependent on mention of layers / rows in M1	2
(ii)	M1 delocalised electrons M2 can move / can flow / are free to move (throughout the structure)	 **IGNORE** references to charge or current **IGNORE** free electrons M2 dependent on mention of electrons in M1	2
(b)	aluminium is more reactive than carbon	**ALLOW** references to position in reactivity series e.g. aluminium is higher in reactivity series than carbon. **ALLOW** carbon is less reactive than aluminium	1
(c) (i)	M1 aluminium / Al^{3+} ions are attracted to the negative electrode / cathode (because they are positively charged) M2 where they gain electrons (forming aluminium)	 **ALLOW** $Al^{3+} + 3e^- \rightarrow Al$ **IGNORE** references to reduction	2
(ii)	$2O^{2-} \rightarrow O_2 + 4e^-$	**ALLOW** $2O^{2-} - 4e^- \rightarrow O_2$	1
(iii)	M1 electrodes are made of carbon M2 which reacts with / burns in oxygen		2

(d)	(i)	iron oxide loses oxygen	**IGNORE** references to electrons	1
	(ii)	 M1 right hand line below left hand line M2 correct name / formula of **both** reactants M3 correct name / formula of **both** products	**IGNORE** horizontal axis drawn **IGNORE** activation energy if shown If only use words *reactants* (on left) and *products* (on right) award 1 mark from M2 and M3 M2 and M3 can be scored from an endothermic diagram	3
				14 marks

Q18.

Question number	Answer	Notes	Marks
(a)	calculation with following steps M1 calculation of $n(K_2CO_3)$ M2 deduction of $n(CO_2)$ and $vol(CO_2)$ by multiplying by 24 (dm^3) M3 correct evaluation of volume in cm^3 Example calculation M1 $n(K_2CO_3) = 6.9 \div 138$ OR 0.05 M2 $vol(CO_2) = 0.05 \times 24$ (dm^3) M3 1200 (cm^3)	 Mark ECF from M1 correct answer with no working scores 3 1.2 scores 2 marks	3 Exp
(b) (i)	M1 higher yield of CO M2 because (equilibrium shifts to the right as the forward) reaction is endothermic	ACCEPT more CO is produced IGNORE references to Le Chatelier's Principle eg increasing temperature favours the forward reaction M2 DEP M1 correct or missing	2 Exp
(ii)	M1 no effect (on yield) OWTTE M2 because equal numbers of moles/molecules (of gas) on both sides	 M2 DEP M1 correct or missing	2 Exp
			Total for Q = 7

Q19.

Question number	Answer	Additional guidance	Mark
(a)(i)	Graph A An explanation that links the following two points: • the backward/reverse reaction is endothermic (1) • so an increase in temperature shifts the equilibrium to the left (hence the percentage of NO decreases) (1) Graph B An explanation that links the following two points: • there are fewer molecules/moles of gas on the left (1) • so an increase in pressure shifts the equilibrium to the left (hence the percentage of NO decreases) (1)	ignore any references to or arguments based on Le Chatelier's principle accept the (forward) reaction is exothermic	4

Question number	Answer	Additional guidance	Mark
(a)(ii)	• (The catalyst/it) increases the rate of both the forward and reverse reactions (1) • To the same extent (1)	second mark is dependent on the first	2

Question number	Answer	Mark
(b)(i)	Because a proton is transferred from HNO_3 to NH_3	1

Question number	Answer	Mark
(b)(ii)	• Calculate the amount of nitric acid • Calculate the volume of aqueous ammonia Example calculation: $n(HNO_3) = 15.8 \times 150$ mol (= 2370 mol) (1) vol(NH_3) required = (2370 ÷ 14.8) = 160(dm^3) (1)	2

(Total for question = 9 marks)