PEARSON EDEXCEL IGCSE CHEMISTRY · 4CH1

CHEMISTRY



MARK SCHEME

SECTION 4: ORGANIC CHEMISTRY (PACK 1)

SCORE	PERCENTAGE
/295	%

STEMUP

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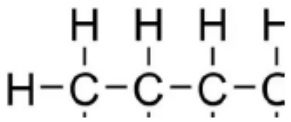
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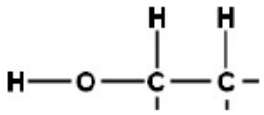
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Mark Scheme

Q1.

Question number	Answer	Notes	Marks
(a)	C is the only correct answer as temperature used is 300°C and pressure is 65 atm (60-70 atm) A is incorrect because 35°C and 300 atm are not the correct conditions B is incorrect because 65°C and 300 atm are not the correct conditions D is incorrect because 300°C and 35 atm are not the correct conditions		1
(b)		formula must be fully displayed ALLOW fully displayed formula for butan-2-ol	1
(c)(i)	M1 $\text{mol(KOH)} = \frac{45.00 \times 0.40}{1000}$ $= 0.018$		2
	M2 $\text{conc}(CH_3COOH) = \frac{0.018 \times 1000}{25}$ $= 0.72\ (\text{mol/dm}^3)$	ALLOW ecf from M1 0.72 (mol/dm^3) without working scores 2	
(ii)	M1 $\text{mol}(CO_2) = (0.0030 \div 2) = 0.0015$		
	M2 $\text{vol}(CO_2) = 0.0015 \times 24000 = 36\ (\text{cm}^3)$	ALLOW ecf from M1 36 (cm^3) without working scores 2 72 (cm^3) without working scores 1	2

(d)	**B** C_2H_5OH is the only correct answer A is not correct because CH_3OH could not form the ester ethyl propanoate C is not correct because C_3H_7OH could not form the ester ethyl propanoate D is not correct because C_4H_9OH could not form the ester ethyl propanoate		1

(e)	(i)	(in condensation polymerisation) two different monomers used / water is produced	ALLOW small molecule is produced	1
	(ii)	M1 	ALLOW -OH	2
		M2 	ACCEPT in either order ALLOW -OH	
	(iii)	biodegradable	ACCEPT description	1
			Total marks for Question = 11	

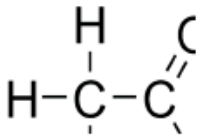
Q2.

Question number	Answer	Notes	Marks
(a) (i)	glucose → ethanol + carbon dioxide	ACCEPT fully correct chemical equation IGNORE yeast	1
(ii)	yeast	IGNORE zymase/enzymes	1
(iii)	**M1** 30 °C **M2** anaerobic conditions / absence of air/oxygen	ACCEPT any value between 20 and 40 inclusive IGNORE yeast IGNORE room temperature Answers can be in any order	2
(b) (i)	**B** $CH_3COOC_4H_9$ A is incorrect as this is propyl ethanoate C is incorrect as this is butyl propanoate D is incorrect as this is ethyl butanoate		1
(ii)	sweet/fruity/distinctive smell OWTTE		1
(iii)	perfumes/(food) flavourings/solvents	IGNORE (food) colourings ACCEPT any other appropriate use eg emulsifiers	1

(c)	(i)	(atom/group of atoms in a compound that) determines its chemical properties/reactions OWTTE	ALLOW (atom/group of atoms that) determines which homologous series a compound is in OWTTE	1
	(ii)	circle around		1
	(iii)	**M1** $\frac{60.00}{12}$ $\frac{4.44}{1}$ $\frac{35.56}{16}$ **M2** $\frac{5.(00)}{2.2225}$ $\frac{4.44}{2.2225}$ $\frac{2.2225}{2.2225}$ **OR** 2.25 2 1 **M3** 2.25 x 4 2 x 4 1 x 4 = 9:8:4	If upside down/use atomic numbers scores 0 ALLOW rounding of 2.2225 but should show at least 2 dp ALLOW other correct methods eg **M1** *Mr* (of aspirin) = 180 **M2** 9x12 or 108 8x1 or 8 4x16 or 64 ALL 3 needed for M2 **M3** $\frac{108}{180}$ x 100 = 60 (%) $\frac{8}{180}$ x 100 = 4.44 (%) $\frac{108}{180}$ x 100 = 35.56 (%) ALL 3 needed for M3	3 **Total 12**

Q3.

Question number	Answer	Notes	Marks
(a)			3

structural formula	CH_3COOH
name	ethanoic acid
empirical formula	CH_2O
displayed formula	

1 mark for each correct answer

ALLOW acetic acid

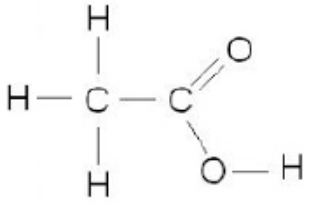
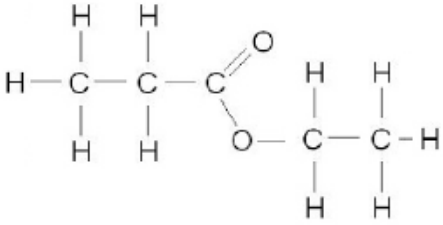
Must show O-H bond

(b)	(i)	**M1** potassium dichromate(VI)	VI not essential for the mark **ACCEPT** sodium dichromate(VI) **ALLOW** $K_2Cr_2O_7$	2
		M2 (dilute) sulfuric acid	**ALLOW** concentrated sulfuric acid **ALLOW** H_2SO_4 **ACCEPT** reagents in either order	
	(ii)	**B** orange to green A is incorrect as the colour does not change from green to orange C is incorrect as the colour does not change from red to yellow D is incorrect as the colour does not change from yellow to red		1

Question number	Answer	Notes	Marks
(c) (i)	alcohols are flammable/might catch fire/might ignite	**ACCEPT** esters/mixture are/is flammable/might catch fire/might ignite **ALLOW** alcohol/ester/ carboxylic acid might evaporate	1
(ii)	**C** methyl propanoate A ethyl methanoate is not the correct name of the compound B methyl ethanoate is not the correct name of the compound D propyl methanoate is not the correct name of the compound		1
			Total 8

Q4.

Question number	Answer	Notes	Marks
(a)	CH_3OH	IGNORE displayed formula	1 grad
(b) (i)	fermentation		1 cler
(ii)	Explanation including four from		4 exp
	M1 fermentation/reaction/respiration needs to be anaerobic	ALLOW M1 in air ethanol would react with oxygen / be oxidised	
	M2 because in air / aerobic conditions ethanol not produced	M2 in air ethanol would form ethanoic acid /carboxylic acid/vinegar	
	M3 because in air / aerobic conditions CO_2 and H_2O are produced		
	M4 (if temperature above 40 °C/too high) enzymes (in yeast) become denatured/lose their structure OWTTE		
	M5 causing fermentation/reaction to slow down /stop	ALLOW reference to optimum temperature (between 30 °C and 40 °C)	

Question number	Answer	Notes	Marks
(c) (i)	 M1 M2 $C_3H_6O_2$ M3 butanoic acid		3 grad
(ii)	carboxylic (acids)		1 grad
(d) (i)	(acid acts as) a catalyst/to speed up reaction	IGNORE references to activation energy	1 grad
(ii)	 M1 ester linkage M2 rest of molecule fully correct	 M2 DEP M1	2 exp
(iii)	M1 (Property:) distinctive/sweet/fruity smell M2 used in perfumes/flavourings	ALLOW volatile ALLOW any correct use eg in making soaps/ in solvents (for paints/varnishes)	2 exp
		Total for Q = 15	

Q5.

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>(a)</td><td><table><tr><th>Name</th><th>Structural formula</th><th>Relative formula mass</th></tr><tr><td>methanol</td><td>CH_3OH</td><td>32</td></tr><tr><td>ethanol</td><td>C_2H_5OH</td><td>46 (1)</td></tr><tr><td>butanol (1)</td><td>C_4H_9OH</td><td>74</td></tr></table></td><td>ALLOW correct names of isomers</td><td>2</td></tr>
<tr><td>(b) (i)</td><td>sulfuric acid</td><td>If oxidation number given must be correct
ALLOW H_2SO_4
IGNORE reference to concentration</td><td>1</td></tr>
<tr><td>(ii)</td><td>from orange to green</td><td></td><td>1</td></tr>
<tr><td>(c) (i)</td><td>ethyl ethanoate</td><td>ALLOW as one word</td><td>1</td></tr>
<tr><td>(ii)</td><td>$CH_3OH + CH_3COOH \rightarrow CH_3COOCH_3 + H_2O$
M1 CH_3COOH
M2 CH_3COOCH_3</td><td>ALLOW displayed formula</td><td>2</td></tr>
<tr><td colspan="3">(Total for Question = 7)</td></tr>
</table>

Q6.

Question number		Answer	Notes	Marks
(a)	(i)	**B** C_4H_{10} A is incorrect as C_2H_5 is not the molecular formula of an alkane C is incorrect as CH_2CH_2 is the structural formula of an alkene D is incorrect as $CH_3CH_2CH_3$ is the structural formula of an alkane		1
	(ii)	**C** C_3H_8 A is incorrect as CH_2 is not a molecular formula but is an empirical formula of an alkene B is incorrect as the empirical formula of C_2H_6 is CH_3 D is incorrect as the empirical formula of C_4H_{10} is C_2H_5		1
(b)	(i)	substitution		1
	(ii)	$CH_4 + Br_2 \rightarrow CH_3Br + HBr$	ALLOW multiples IGNORE state symbols even if incorrect	1
(c)	(i)	**M1** y (= 220 ÷ 44) = 5 **M2** **z** (= 108 ÷ 18) = 6		2
	(ii)	**M1** C_5H_{12} **M2** x = 8	ALLOW ECF in (ii) from incorrect values of y and z in (i) to score M1 the answer must be the formula of an alkane	2
(d)		An explanation including one of the following pairs **M1** carbon monoxide/CO is produced **M2** (carbon monoxide) is toxic/poisonous /reduces the capacity of the blood to carry oxygen OWTTE **OR** **M1** carbon/soot **M2** causes asthma/bronchitis/respiratory problems OWTTE	**M2** dep on **M1** ACCEPT prevents blood from carrying oxygen ALLOW correct explanation in terms of haemoglobin e.g. prevents haemoglobin from carrying oxygen	2 **Total 10**

Q7.

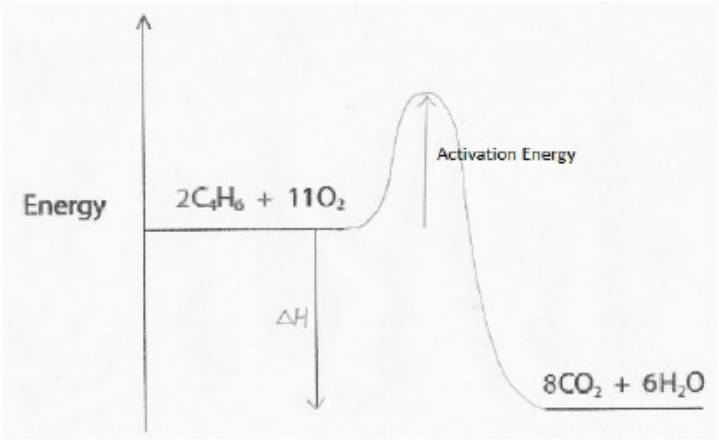
Question number	Answer	Notes	Marks
(a) (i)	M1 (X) measuring cylinder		2
	M2 (Y) pipette	**ALLOW** graduated pipette	
(ii)	(volume measurement with Y is) more precise ORA	**ALLOW** (volume measurement with Y is) more accurate ORA **ALLOW** (Y gives) a (more) exact volume /exactly 25 cm^3	1
(b) (i)	yellow		1
(ii)	there is no clear end point/ colour change is gradual (at the end point)/no sharp colour change OWTTE	**ALLOW** it has a range of colours	1
(c)	M1 moles of $HNO_3 = \frac{21.5 \times 0.6(00)}{1000}$ **OR** 0.0129 M2 moles of $Ba(OH)_2 = 0.0129 \div 2$ **OR** 0.00645 M3 conc. of $Ba(OH)_2 = \frac{0.00645 \times 1000}{25} = 0.258$ (mol/dm^3)	correct answer with or without working scores 3 **ALLOW** ecf on M2 **ACCEPT** alternative methods 0.516 scores 2 1.032 scores 2 **ALLOW** 2 sig figs correctly rounded throughout Penalise rounding to 1 sig fig once only	3
(d)	barium sulfate is insoluble /does not dissolve /forms a precipitate		1
			Total 9

Q8.

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	

Q9.

Question number	Answer	Notes	Marks
(a)	M1 heated	**ALLOW** boiled **IGNORE** vapourised/evaporated	3
	M2 fractionating	**ACCEPT** fractional distillation	
	M3 boiling point(s)	**ACCEPT** boiling temperature(s) **IGNORE** melting point(s)/low density	
(b)	road surfacing / roofing	**ALLOW** roads	1
(c) (i)	pentane		1
(ii)	(M_r = 5 x 12 + 12 x 1 =) 72		1

Question number	Answer	Notes	Marks
(d)	M1 alumina / silica	**ACCEPT** aluminium oxide / silicon dioxide / Al_2O_3 / SiO_2 / zeolite(s) / aluminosilicate(s)	2
	M2 any temperature in the range 600 - 700 °C inclusive		
(e)	($C_{10}H_{22} \rightarrow C_4H_{10}$) + C_2H_4 + C_4H_8	alkenes can be in either order	2
	M1 C_2H_4		
	M2 C_4H_8	**ALLOW** 1 mark for C_6H_{12} / $2C_3H_6$ / C_3H_6 + C_3H_6 **ALLOW** correct displayed formulae	
			Total 10

Q10.

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

Q11.

Question number	Answer	Mark
(a)(i)	• To provide an enzyme/zymase (1) • To increase the rate of the reaction (1)	**2**

Question number	Answer	Additional guidance	Mark
(a)(ii)	An explanation that links the following two points: • Oxygen (from the air) reacts with ethanol (1) • To form ethanoic acid (1)	accept the ethanol undergoes microbial oxidation to ethanoic acid for 2 marks	**2**

Question number	Answer	Additional guidance	Mark
(a)(iii)	An explanation that links the following two points: • Reaction is too slow at lower temperatures (1) • Zymase/the enzyme is denatured at higher temperatures (1)	accept the yeast is killed ignore yeast is denatured ignore zymase is killed	**2**

Question number	Answer	Mark
(b)(i)	$C_2H_4 + H_2O \rightarrow C_2H_5OH$	**1**

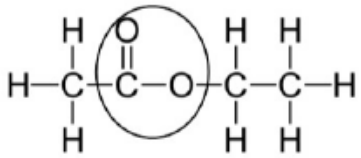
Question number	Answer	Additional guidance	Mark
(b)(ii)	Addition	accept hydration	**1**

Question number	Answer	Mark
(b)(iii)	Any two from the following: • phosphoric acid catalyst (1) • 300 °C (1) • 60–70 atm (1)	2

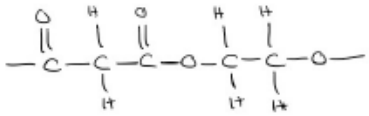
Question number	Answer	Additional guidance	Mark
(c)	(Carboxylic acid) propanoic acid (1) (Alcohol) butanol-1-ol/butanol (1)	accept propionic acid accept (*n*-)butyl alcohol	2

(Total for question = 12 marks)

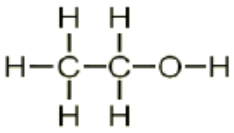
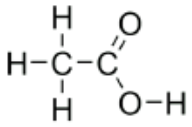
Q12.

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

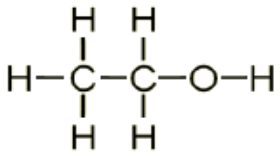
Question number	Answer	Notes	Marks
(d)	example calculation M1 moles barium hydroxide = (0.150 × 22.75)÷ 1000 **OR** 0.0034125 M2 moles ethanoic acid = 0.006825 M3 moles ethanoic acid to 3 significant figures = 0.00683	M1 needs to be given to at least 3 sig figs ALLOW M1 × 2 ALLOW answer to M2 to 3 significant 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

Q13.

Question number	Answer	Notes	Marks
(a)	Any two from: **M1** same general formula **M2** each member differs from the next by CH_2 **M3** same functional group **M4** similar chemical properties/reactions **M5** trend/steady increase in physical properties	**ALLOW** same chemical properties/reactions **ACCEPT** named physical properties e.g. trend in boiling points	2
(b) (i)	H_2SO_4	If name and formula given, name must be correct.	1
(ii)	**M1** from orange **M2** to green	colours must be in the correct order	2
(iii)	**M1**  **M2** 	Penalise no bond between O and H once only	2

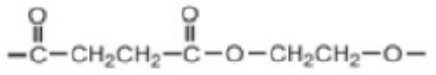
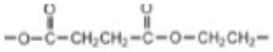
Question number	Answer	Notes	Marks
(c) (i)	A discussion which refers to any six of the following points: Advantages of fermentation/disadvantages of hydration **M1** sugar cane can be re-grown/is renewable **M2** crude oil is finite/cannot be replaced/is non-renewable **M3** fermentation uses lower temperatures so energy costs are lower/ hydration uses higher temperatures, so energy costs are higher **M4** fermentation uses lower pressure so energy costs are lower/ hydration uses higher pressure, so energy costs are higher **M5** yeast is a natural substance and not harmful/ phosphoric acid is corrosive Advantages of hydration/disadvantages of fermentation **M6** hydration is a faster process/ fermentation is a slower process **M7** hydration gives pure ethanol/ fermentation gives impure ethanol **M8** growing sugar cane takes up land which could be used for growing food/rearing livestock **M9** hydration is a continuous process/fermentation is a batch process		6
(ii)	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$	**ALLOW** $2C_2H_6O$ for ethanol **ALLOW** multiples and fractions	1
			Total 14

Q14.

Question number	Answer	Notes	Marks
(a) (i)	M1 300 (°C)	**ACCEPT** any temperature or range 250 to 350 inclusive. **ACCEPT** any correct alternative unit and quantity	2
	M2 60 to 70 (atm)	**ACCEPT** any pressure or range 60 to 70 inclusive **ACCEPT** any correct alternative unit and quantity	
(ii)		All bonds including bond between O and H must be shown.	1

(b) (i)	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$		2
	M1 all formulae correct	**ALLOW** C_2H_6O for ethanol	
	M2 balancing of correct formulae	**ACCEPT** multiples and fractions **IGNORE** state symbols even if incorrect M2 dep on M1	
(ii)	prevents blood from carrying oxygen/ reduces the capacity of blood to carry oxygen OWTTE	**ALLOW** references to combining with haemoglobin in red blood cells or forming carboxyhaemoglobin	1

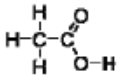
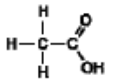
Question number	Answer	Notes	Marks
(c)	ethyl ethanoate	**ALLOW** ethyl acetate	1

(d)	(i)	condensation (polymerisation)		1
	(ii)	 + $2H_2O$ **M1** correct ester link **M2** rest of polymer structure correct with extension bonds **M3** $2H_2O$	**ACCEPT**  for **M1** and **M2** If brackets and n present equation must be fully balanced with n in front of each reactant and $2nH_2O$ for full marks, otherwise max 2 If dimer is drawn with OH at one end and COOH at the other a mark can be awarded for H_2O without the 2 as this equation is then balanced, so **M1** and **M3** can be awarded.	3 **Total 11**

Q15.

Question number	Answer	Additional guidance	Marks
(a) (i)	yeast	**IGNORE** zymase	1
(ii)	**C** (30 °C) is correct as it is the most suitable temperature for fermentation A is incorrect as at 0°C the enzymes would not be active so not the most suitable temperature for fermentation B is incorrect as at 10°C the enzymes would not be very active so not the most suitable temperature for fermentation D is incorrect as at 80°C the enzymes would be denatured so not the most suitable temperature for fermentation		1
(iii)	An explanation using either of the following linked pairs: **M1** oxygen in the air would react with ethanol **M2** to form ethanoic acid **OR** **M1** the fermentation/reaction/respiration needs to be anaerobic **M2** ethanol would not be formed /CO_2 and H_2O would form	**ACCEPT** ethanol would be oxidised **ALLOW** to form carboxylic acid **ALLOW** to form vinegar	2

(b) (i)	a substance that releases thermal energy/heat (energy) when burned/combusted	**IGNORE** energy on its own	1
(ii)	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ **M1** all formulae correct **M2** correctly balanced	**ACCEPT** multiples **M2** DEP **M1**	2

Question number	Answer	Additional guidance	Marks
(c)	**M1** (temperature) 300 °C	**ACCEPT** any value or range of values between 250 and 350 °C If no unit given assume it is Celsius **ACCEPT** equivalent temperatures in other units provided the unit is given	2
	M2 60 – 70 atm	**ACCEPT** any value or range of values between 60 and 70 atm If no unit given assume it is atm **ACCEPT** equivalent pressures in other units provided the unit is given	
(d) (i)	(from) orange (to) green		1
(ii)		**IGNORE** bond angles  scores 1 mark	2
(iii)	$CH_3COONa + \frac{1}{2} H_2$ **M1** for both products correct **M2** for correctly balanced	**ALLOW** $NaCH_3COO$ **ACCEPT** multiples **M2** DEP **M1**	2

Q16.

Question number	Answer	Notes	Marks
(a) (i)	fractionating column/ fractionating tower	**ALLOW** fraction(al) column /fraction(al) tower **IGNORE** fractional distillation	1
(ii)	fuel for ships/fuel for power stations		1
(iii)	**M1** fraction A refinery gases **M2** fraction F bitumen		2

(b)	(i)	C_nH_{2n+2}	**ALLOW** x or N in place of n	1
	(ii)	An explanation that links the following 3 points **M1** $C_{12}H_{26}$ has larger molecules/longer chain/ORA **M2** $C_{12}H_{26}$ has stronger intermolecular forces/ORA **M3** more energy is needed to separate the molecules/ overcome the forces in $C_{12}H_{26}$ /ORA	 **ACCEPT** forces between molecules for intermolecular forces **ALLOW** intermolecular bonds /bonds between molecules no **M2** or **M3** if implied that covalent bonds break	3
(c)	(i)	silica/alumina	**ACCEPT** silicon dioxide /aluminium oxide /SiO_2/Al_2O_3 /aluminosilicates /zeolite	1
	(ii)	$C_{12}H_{26} \rightarrow C_9H_{20} + C_3H_6$		1
				Total 10

Q17.

Question number	Answer	Notes	Marks
(a) (i)	**M1** (bitumen) (surfacing) roads/(surfacing) roofs	**ALLOW** other suitable uses	2 Exp
	M2 (gasoline) petrol / fuel for cars/vehicles	**ALLOW** other suitable uses e.g. fuel for cooking	
(ii)	An explanation that links the following two points		2 Exp
	M1 column is cooler near the top than at the bottom ORA	**ACCEPT** column cool near the top and hot at the bottom **ACCEPT** temperature decreases up the column ORA	
	M2 gasoline has a lower boiling point than bitumen (so is collected nearer the top) ORA	**ACCEPT** gasoline has a low boiling point (so is collected near the top) and bitumen has a high boiling point (so is collected near the bottom)	
(b) (i)	**M1** alumina/silica (catalyst)	**ACCEPT** Al_2O_3 / SiO_2 /aluminium oxide /silicon dioxide /aluminosilicate(s) /zeolite(s)	2 Exp
	M2 600 – 700 (°C)	**ACCEPT** range or any value within the range **ACCEPT** correct temperatures in other units	
(ii)	$C_{12}H_{26} \rightarrow C_7H_{16} + C_2H_4 + C_3H_6$ **M1** C_2H_4 **M2** C_3H_6	**ACCEPT** answers in either order	2 Exp
			Total 8

Q18.

Question number	Answer	Notes	Marks
(a) (i)	D nitrogen D is the only correct answer as nitrogen is the most abundant gas in unpolluted air. A is not correct as there are only trace amounts of hydrogen in unpolluted air. B is not correct as there are only trace amounts of methane in unpolluted air. C is not correct as there are only trace amounts of neon in unpolluted air.		1
(ii)	C 21% C is the only correct answer as the percentage of oxygen in the air is 21% A is not the correct answer as the percentage of oxygen in the air is not 0.04% B is not the correct answer as the percentage of oxygen in the air is not 0.9% D is not the correct answer as the percentage of oxygen in the air is not 35%		1
(b) (i)	cracking an alkane: ; complete combustion of an alkane: ✔ ; reaction between magnesium and hydrochloric acid: ; rusting of iron: ; thermal decomposition of copper(II) carbonate: ✔		2
(ii)	Any one from: M1 global warming M2 climate change	ALLOW greenhouse effect ALLOW an effect of global warming/climate change e.g. wildfires/ melting of polar ice caps/flooding	1
(iii)	argon		1

(c)	(i)	nitric acid	ALLOW HNO_3/ nitrous acid /HNO_2	1
	(ii)	sulfur dioxide	ALLOW SO_2 ALLOW other oxides of nitrogen	1
				Total for question = 8

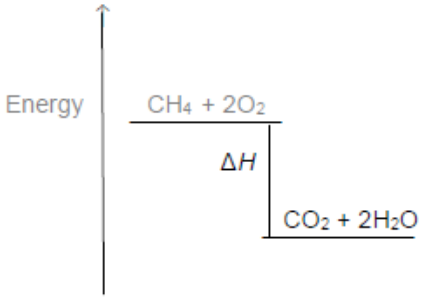
Q19.

Question number	Answer	Notes	Marks
(a) (i)	nitrogen	**ALLOW** N_2/N	1
(ii)	carbon dioxide	**ALLOW** CO_2	1
(iii)	argon	**ALLOW** Ar	1
(iv)	carbon dioxide	**ALLOW** CO_2	1
(b)	lighted splint (produces squeaky) pop		1
			5 marks

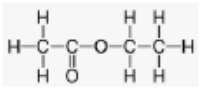
Q20.

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

Q21.

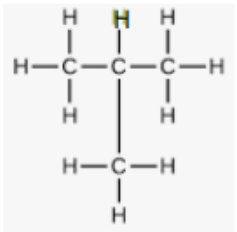
Question number	Answer	Notes	Marks
(a) (i)	Any **two** from: M1 volume of acid M2 temperature M3 mass / moles of magnesium M4 surface area / size of pieces of magnesium		2
(ii)	so as little gas as possible escapes	**ALLOW** so no gas escapes **IGNORE** references to accuracy **REJECT** references to 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

Q22.

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

Q23.

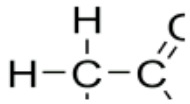
Question number	Answer	Notes	Marks
(a)	M1 use of amount in moles = $\frac{\text{volume of gas}}{\text{molar volume}}$ M2 correct evaluation Example calculation M1 amount in moles = $\frac{600}{24000}$ M2 = 0.025 (mol)	0.025 with no working scores 2 REJECT 0.03 for M2	2
(b)	M1 statement/use of amount in moles = $\frac{\text{mass}}{Mr}$ M2 substitution and correct evaluation: $Mr = \frac{1.45}{0.025} = 58$		2
(c)	molecular formula = C_4H_{10} = (4 x 12) + (10 x 1) = 58 OR alkane general formula = C_nH_{2n+2} so M1 (nx12) + (2n+2)x1 = 58 so 14n = 56 M2 n =4 so C_4H_{10}		1
(d)			1
		(Total for Question = 6)	

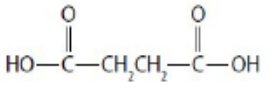
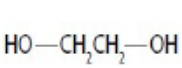
Q24.

Question number	Answer	Notes	Marks
(a)	M1 crude oil is heated / vapourised M2 vapours / gases / compounds / hydrocarbons rise up the column M3 the column is hotter at the bottom than the top M4 vapours / compounds / hydrocarbons condense at their boiling point	**ALLOW** boiled **ALLOW** temperature gradient of the column **ALLOW** vapours / compounds / hydrocarbons / condense at different heights **ALLOW** the vapours / compounds / hydrocarbons / fractions have different boiling points.	4
(b)	M1 temperature of 600°C - 700°C M2 catalyst of silica / alumina	**ALLOW** aluminosilicates / zeolites / silicon dioxide / aluminium oxide **IGNORE** references to pressure	2

Question number	Answer	Notes	Marks
(c) (i)	M1 nitrogen (from the air) reacts / combines with oxygen (from the air) M2 at high temperatures (in the car engine)	**REJECT** any implication that oxygen or nitrogen come from the fuel.	2
(ii)	Any one from: acid rain respiratory problems		1
(iii)	Example calculation M1 volume of carbon dioxide = 206 000 cm^3 / 2.06×10^5 cm^3 / 206 dm^3 M2 volume of carbon dioxide per km = 51 500 cm^3/ 5.15×10^4 cm^3 / 51.5 dm^3 M3 (51 500 ÷ 24 000) = 2.15 moles M4 M_r of carbon dioxide is 44 M5 mass of carbon dioxide per Km = 94.4 g	Division by 4 can happen in M1, M2, M3 or M5 **ALLOW** M1 ÷ 4 **ALLOW** M2 or M1 ÷ 24 000 **ALLOW** 94 – 95 g **ALLOW** ecf from incorrect M_r Correct answer of 94 – 95 g scores 5 marks.	5
			14 marks

Q25.

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

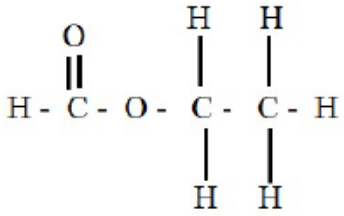
(c)	(i)	propyl methanoate	spelling must be correct **ALLOW** propyl formate	1
	(ii)	reversible reaction	**ALLOW** reaction which goes both ways **IGNORE** equilibrium	1
	(iii)	forward and backward reactions occur at the same rate OWTTE **OR** concentrations of reactants and products remain constant/stay 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

Q26.

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

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(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

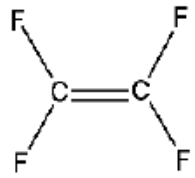
Question number	Answer	Notes	Marks
(c) (i)	ethyl methanoate	**ALLOW** ethyl formate **ALLOW** words written without gap	1 Grad
(ii)	**M1** ester linkage  **M2** rest of molecule correct  Structural formula of ethyl formate or ethyl methanoate	 **M2** dep on **M1**	2 Exp
(iii)	**M1** forward and reverse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

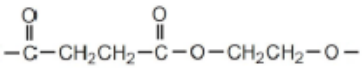
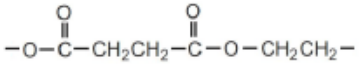
(d)	• calculate amount in moles of HCOOH • use equation to find amount in moles of CO_2 • multiply amount in moles of CO_2 by molar volume • evaluation of answer in cm^3 Example calculation **M1** n(HCOOH) = 2.3 ÷ 46 **or** 0.05(0) **M2** $n(CO_2)$ = 0.05(0) ÷ 2 **or** 0.025 **M3** (volume of CO_2) = 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**

Q27.

Question number	Answer	Additional guidance	Mark
(a)(i)	Chloroethene	accept vinyl chloride	1

Question number	Answer	Additional guidance	Mark
(a)(ii)	Poly(chloroethene)	accept polyvinyl chloride ignore PVC	1

Question number	Answer	Additional guidance	Mark
(b)		ignore bond angles	1

Question number	Answer	Additional guidance	Mark
(c)(i)	• Correct ester link (1) • Rest of unit correct (1) Example: 	accept: 	2

Question number	Answer	Additional guidance	Mark
(c)(ii)	Water/H_2O	if both name and formula given, both must be correct	1

(Total for question = 6 marks)

Q28.

Question number	Answer	Notes	Marks
(a)	fractional distillation	**ACCEPT** fractionation/fractionating **IGNORE** distillation alone	1 1
(b)	aircraft fuel/jet fuel/paraffin or fuel for lamps/ heaters	**ALLOW** heating oil **ALLOW** cooking fuel	
(c) (i)	butane	Spelling must be correct	1
(ii)	(M_r = 4 x 12 + 10 x 1 =) 58		1
(d) (i)	C_7H_{16}		1
(ii)	C_nH_{2n+2}	**ACCEPT** different letters to n / uppercase	1

Question number	Answer	Notes	Marks
(e) (i)	alumina / silica	**ACCEPT** aluminium oxide / silicon dioxide / Al_2O_3 / SiO_2 / zeolite(s) / aluminosilicate(s)	1
(ii)	An explanation that links the following two points **M1** greater demand for short chain alkanes (than long chain alkanes) **M2** more long-chain alkanes than are needed / too great a supply of /surplus of long-chain alkanes **OR** not enough short chain alkanes to meet demands	 **ALLOW** short chain alkanes are more useful (than long chain alkanes) **ALLOW** short chain alkanes needed for specific uses e.g. petrol	2
(f)	$(C_{11}H_{24} \rightarrow C_5H_{12}) + C_2H_4 + C_4H_8$ **M1** C_2H_4 **M2** C_4H_8	alkenes can be in either order **ALLOW** 1 mark for C_8H_{12} / $2C_3H_6$ / $C_3H_6 + C_3H_6$ **ALLOW** correct displayed formulae	2
			Total 11

Q29.

Question number	Answer	Notes	Marks
(a) (i)	M1 a compound/substance/molecule containing hydrogen/H and carbon/C (atoms) M2 only	no M1 if reference to element containing C and H OR C and H molecules M2 dep on M1 or near miss	2
(ii)	ethene has a double bond		1
(b)	A colourless A is the only correct answer because alkenes such as ethene react with bromine water forming a colourless solution B is not correct as bromine water is orange before it reacts with ethene C is not correct as the solution produced is not purple D is not correct as the solution produced is not red		1
(c) (i)	temperature = 300°C pressure = 60-70 atmospheres	ACCEPT any value or range of values between 250 and 350°C If no unit given assume it is Celsius ACCEPT equivalent temperatures in other units provided the unit is given ACCEPT any value or range of values between 60 and 70 atm If no unit given assume it is atm ACCEPT equivalent pressures in other units provided the unit is given	2
(ii)	C_2H_6O	IGNORE size of numbers REJECT C_2H_5OH	1
			Total for question = 7