PEARSON EDEXCEL IGCSE CHEMISTRY · 4CH1

CHEMISTRY



MARK SCHEME

SECTION 1: PRINCIPLES OF CHEMISTRY (PACK 1)

SCORE	PERCENTAGE
/279	%

STEMUP

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Mark Scheme

Q1.

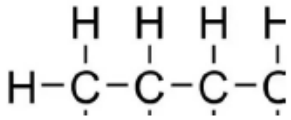
Question number	Answer	Notes	Marks
(a)	M1 dissolving M2 diffusion	Answers can be in either order IGNORE dilution	2
(b) (i)	A 3 B is incorrect as there are not 4 different types of atoms in $KMnO_4$ C is incorrect as there are not 6 different types of atoms in $KMnO_4$ D is incorrect as there are not 7 different types of atoms in $KMnO_4$		1
(ii)	(M_r = 39 + 55 + 16 x 4 =) 158		1
(c)	(something that) gives oxygen (to another substance)/takes/gains electrons (from another substance) OWTTE	ALLOW oxygen donor ALLOW electron acceptor ALLOW (something that) causes another substance to be oxidised/to lose electrons OWTTE ALLOW (something that) is reduced (in a reaction) ALLOW increases the oxidation number (of another species) OWTTE	1 **Total 5**

Q2.

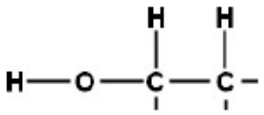
Question number	Answer	Notes	Marks
(a) (i)	glucose → ethanol + carbon dioxide	ACCEPT fully correct chemical equation IGNORE yeast	1
(ii)	yeast	IGNORE zymase/enzymes	1
(iii)	**M1** 30 °C **M2** anaerobic conditions / absence of air/oxygen	ACCEPT any value between 20 and 40 inclusive IGNORE yeast IGNORE 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 O II –C–O–H		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)	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 mol(KOH) = $\frac{45.00 \times 0.40}{1000}$ = 0.018		2
	M2 conc(CH_3COOH) = $\frac{0.018 \times 1000}{25}$ = 0.72 (mol/dm^3)	ALLOW ecf from M1 0.72 (mol/dm^3) without working scores 2	
(ii)	M1 mol(CO_2) = (0.0030÷2) = 0.0015		
	M2 vol(CO_2) = 0.0015 x 24000 = 36 (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	

Q4.

<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>

Q5.

Question number	Answer	Notes	Marks
(a)	Any two of the following observations. **M1** (sodium) floats/moves on surface (of water) **M2** (sodium) melts/forms a ball **M3** (sodium) gets smaller/disappears **M4** (sodium forms) white trail	 **ALLOW** dissolves **IGNORE** references to flame/heat released /temperature increases **IGNORE** fizzing /effervescence	2 Exp

(b)	(i)	$2Li + F_2 \rightarrow 2LiF$	**ALLOW** multiples or fractions **IGNORE** state symbols even if incorrect	1 Exp
	(ii)	**M1** flame test	**ALLOW** description of flame test	2 Exp
		M2 red (flame)	**ALLOW** crimson /scarlet **REJECT** orange-red/ brick red	
	(iii)	**M1** correct electron arrangement of lithium ion  lithium ion Li^+ $[2]^+$	**ACCEPT** any combination of dots and crosses **IGNORE** empty second shell	3 Exp
		M2 correct electron arrangement of fluoride ion  fluoride ion F^- [2,8]$^-$	Inner electron shell required to score M2	
		M3 correct charges on both ions (with or without brackets)	**M3** not dep on **M1** and **M2** correct	

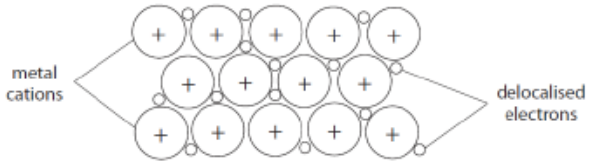
Question number	Answer	Notes	Marks
(c)	An explanation that links three of the following four points **M1** the outer electron is further from the nucleus in potassium / potassium has more shells/ potassium has larger atomic radius ORA **M2** there is more shielding (by the inner shells) in potassium ORA **M3** there is less attraction between the outer electron and the nucleus in potassium ORA **M4** (so outer) electron (in potassium) more easily lost ORA	 **ALLOW** potassium atom is bigger than a sodium atom outer electron needs to be mentioned at least once in the answer for full marks Max 2 if no mention of outer electron in the answer	3 Exp **Total 11**

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)	A labelled diagram showing **M1** at least three rows of at least three cations/atoms in a regular arrangement **M2** surrounded by (delocalised) electrons Example of diagram  	Max 1 if no labels Minimum requirement for 2 marks is + signs on atoms and electrons labelled or shown as e^-	2 Exp
(ii)	An explanation that links the following two points **M1** delocalised electrons **M2** flow/are mobile/move/are free to move	**IGNORE** free electrons/ sea of electrons **M2** dep on mention of electrons Any mention of ions/atoms moving scores 0	2 Exp

(b)	Any two of the following properties **M1** low density **M2** does not react with drink **M3** malleable	**ALLOW** lightweight **IGNORE** light **IGNORE** less dense **ALLOW** does not corrode/non-toxic **IGNORE** does not rust **ALLOW** easy to bend/ easy to shape **IGNORE** references to cost **IGNORE** can be recycled **IGNORE** any irrelevant properties e.g. high melting/boiling point/ good conductor/ductile	2 Exp

Question number	Answer	Notes	Marks
(c) (i)	aluminium/it is more reactive/higher in the reactivity series than carbon ORA	**ALLOW** aluminium is too reactive/too high in the reactivity series	1 Grad
(ii)	electrons are gained (by aluminium ion/Al^{3+})	**ACCEPT** oxidation state of aluminium/Al is decreased/ changes from +3 to 0 **REJECT** aluminium/Al gains electrons **IGNORE** references to loss of oxygen	1 Exp
(iii)	$2O^{2-} \rightarrow O_2 + 4e^{(-)}$ **M1** correct formulae of products **M2** balancing of correct formulae	**ACCEPT** multiples and fractions **M2** dep on **M1**	2 Exp **Total 10**

Q8.

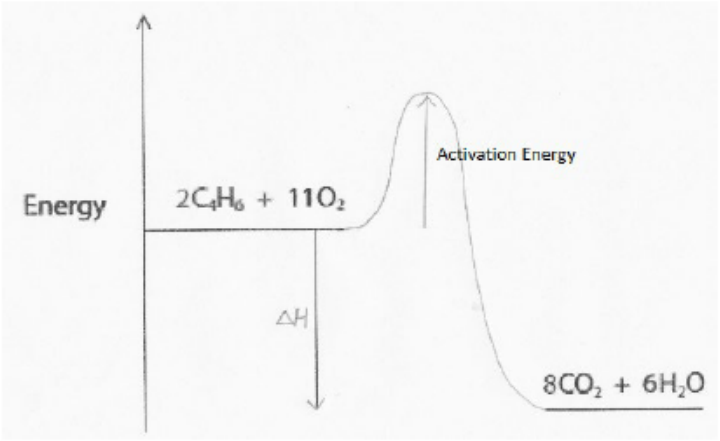
Question number	Answer	Notes	Marks
(a) (i)	**D** **D** is the correct answer because protons occur in the nucleus and have a positive charge. **A** is not the correct answer since electrons occur in the energy levels. **B** is not the answer since ions do not occur in the nucleus. **C** is not the correct answer since neutrons have no charge.		1
(ii)	7		1
(iii)	lithium	**ALLOW** Li	1
(b) (i)	M1 same number of protons M2 different number of neutrons	**ALLOW** same number of electrons **IGNORE** references to mass number and atomic number.	2
			5 marks

Q9.

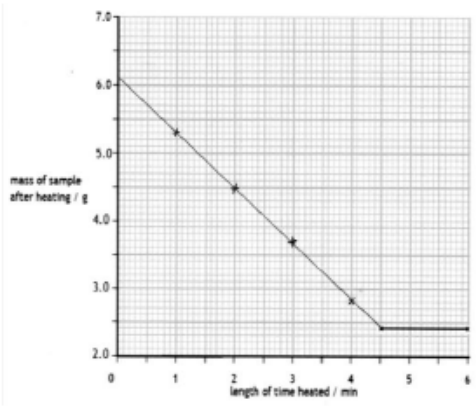
Question number	Answer	Notes	Marks
(a)	Explanation including following points M1 (unsaturated because) contains (carbon to carbon) double bond(s) M2 (hydrocarbon because) contains (the elements/atoms) carbon and hydrogen M3 only	 ALLOW contains C=C REJECT molecules M3 DEP on carbon and hydrogen	3 grad

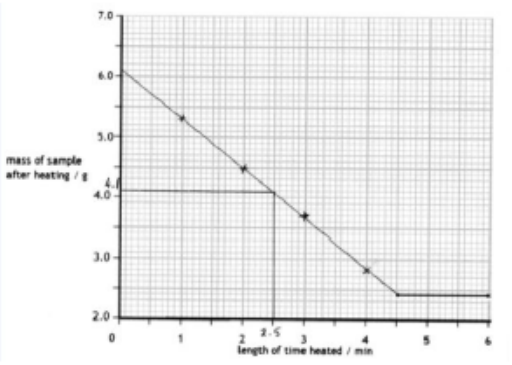
(b)	(i)	from orange to colourless	ALLOW yellow for orange or any combination of orange/yellow IGNORE clear	1 grad
	(ii)	calculation including following steps M1 calculation of energy involved in bond breaking in reactants M2 calculation of energy involved in bond making in products M3 evaluation of difference 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	

Q10.

Question number	Answer	Additional guidance	Mark
(a)	• All points plotted correctly (1) • Best fit line drawn (1) 	must be drawn with the aid of a ruler	2

Question number	Answer	Mark
(b)	• Answer read correctly from graph drawn/4.1 (g) (1) • Appropriate horizontal or vertical line drawn (1)  	2

Question number	Answer	Mark
(c)	All of the water has been removed/there is no more water left	1

Question number	Answer	Mark
(d)	• Calculate the amount of magnesium carbonate • Calculate the amount of water • Evaluation Example calculation: $n(MgCO_3) = (1.68 \div 84) = 0.02(0)(mol)$ (1) $n(H_2O) = (1.08 \div 18) = 0.06(0)(mol)$ (1) $x = 3$ (1)	3

Question number	Answer	Mark
(e)	• Calculate the amount of magnesium carbonate • Calculate the volume of carbon dioxide • Convert to cm^3 Example calculation: $n(MgCO_3) = (4.2 \div 84) = 0.05(0)(mol)$ (1) volume of $CO_2 = 0.05 \times 24 = 1.2\ (dm^3)$ (1) converting to $cm^3 = 1.2 \times 1000 = 1200\ (cm^3)$ (1)	3

(Total for question = 11 marks)

Q11.

Question number	Answer	Additional guidance	Marks
(a)	An explanation using either of the following linked pairs: **M1** use a fume cupboard **M2** because chlorine is toxic/poisonous OR **M1** wear goggles/safety glasses/gloves **M2** because acid/bleach (may be) irritant/corrosive	 **IGNORE** chlorine is dangerous/harmful/irritant **IGNORE** laboratory coats	 2
(b) (i)	**M1** 60 ÷ 24 000 **M2** 0.0025 (mol)	 0.0025 with no working scores 2 marks **REJECT** 0.003 for **M2**	2
(ii)	0.0025 **OR** answer to **M2** from (i)		1
(iii)	**M1** (0.0025 ÷ 4.00) × 1000 **M2** 0.625 (mol/dm^3)	Mark CSQ on (b)(ii) **ACCEPT** any number of sig fig except 1 (unless ECF answer is exactly 1 sig fig correct answer with no working throughout (b) scores 2 marks	2

Q12.

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>(a) (i)</td><td>(from) solid to liquid</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>iodine (s) → iodine (g)</td><td></td><td>1</td></tr>
<tr><td>(b)</td><td>(diagram showing) particles well spread out with none touching</td><td></td><td>1</td></tr>
<tr><td>(c)</td><td>
<table>
<tr><th>Statement</th><th>Tick</th></tr>
<tr><td>the particles only vibrate</td><td></td></tr>
<tr><td>the particles do not move</td><td></td></tr>
<tr><td>the particles have no gaps between them</td><td></td></tr>
<tr><td>the particles move randomly</td><td>✓</td></tr>
<tr><td>the particles have more energy than in ice</td><td>✓</td></tr>
<tr><td>the particles have a regular arrangement</td><td></td></tr>
</table>
tick in 4th box (1)
tick in 5th box (1)

if more than two ticks deduct 1 mark for each incorrect tick</td><td></td><td>2</td></tr>
<tr><td colspan="3">(Total for Question = 5)</td></tr>
</table>

Q13.

Question number	Answer	Additional guidance	Marks
(a)	<table><tr><th>Name of halogen</th><th>Physical state at room temperature</th><th>Colour</th></tr><tr><td>chlorine</td><td>gas</td><td>pale green</td></tr><tr><td>bromine</td><td>liquid</td><td>red-brown</td></tr><tr><td>iodine</td><td>solid</td><td>(dark) grey</td></tr></table>	**ALLOW** black **ALLOW** any combination of grey and black eg grey-black	2
(b)	**M1** (35 × 77.78) + (37 × 22.22) **OR** 3544.44 **M2** 3544.44 ÷ 100 **OR** 35.4444 OR **M1** ÷ 100 **M3** 35.4	(35 × 0.7778) + (37 × 0.2222) **OR** 35.4444/35.444/35.44 with no working scores 2 35.4 with no working scores 3 M3 can be ECF from an incorrect M2	3

(c)	An explanation that links together the following four points: **M1** add chlorine (solution) to potassium bromide (solution) **M2** (solution) turns orange **M3** bromine/Br_2 is displaced **M4** (therefore) chlorine is more reactive (than bromine)	 **ACCEPT** mix the two solutions **ALLOW** any combination of orange/yellow/brown **IGNORE** other observations eg bubbles **ALLOW** bromine/Br_2 is produced/formed **IGNORE** state of bromine **REJECT** bromide **IGNORE** a displacement reaction occurs **M3** can be scored by Br_2 as a product in an equation **ACCEPT** reverse argument "If a reaction occurs then chlorine is more reactive than bromine" scores **M4**	4

Q14.

Question number	Answer	Notes	Marks
(a)	**A** substance S is the correct answer because S only contains one dye as it produces only one spot **B** is not correct because T does not only contain one dye as it produces two spots **C** is not correct because U does not only contain one dye as it produces three spots **D** is not correct because V does not only contain one dye as it produces two spots		1 comp
(b)	explanation containing following points M1 (V contains) blue/B and red/R (dyes) M2 because V has spots at same height as those from blue/B and red/R OWTTE		2 grad
(c) (i)	M1 correct measurement of distance moved by spot Y M2 correct measurement of distance moved by solvent M3 use and evaluation of $R_f = \frac{\text{distance moved by spot Y}}{\text{distance moved by solvent}}$	ALLOW 5.7-6.1 ALLOW 8.7-9.1 ALLOW 1-4 sig fig ALLOW ECF from M1 M2 only if $R_f < 1$	3 exp
(ii)	spot from yellow food dye/Y does not move as far as spot from red food dye/R OWTTE	ORA	1 exp
		Total for Q	= 7

Q15.

Question number	Answer	Notes	Marks
(a)	**M1** (from) yellow **M2** (to) orange	 **ACCEPT** red **ALLOW** pink 1 mark for two correct colours in the wrong order	2
(b)	A description that makes reference to any **four** of the following points **M1** he should not rinse flask with sodium hydroxide solution **or** he should rinse flask with water **M2** he should use a pipette to measure out the sodium hydroxide solution **M3** he should not rinse the burette with water **or** he should rinse the burette with sulfuric acid **M4** he should record the initial burette reading **M5** he should place a white tile under the flask **M6** he should swirl the flask whilst adding the acid **M7** he should add the acid dropwise near the end-point **M8** repeat the titration (to obtain an average/ concordant results)	 **ACCEPT** he should use a pipette instead of a measuring cylinder **ALLOW** white paper **IGNORE** stir	4

Question number	Answer	Notes	Marks
(c)	• calculate the amount, in moles, of sodium hydroxide • calculate the amount, in moles, of sulfuric acid • calculate the concentration of sulfuric acid Example calculation **M1** $n(NaOH) = 0.0250 \times 0.200$ **or** 0.005 (mol) **M2** $n(H_2SO_4) = 0.005 \div 2$ **or** 0.0025 (mol) **M3** conc^n = (0.0025 ÷ 0.0167) = 0.150 (mol/dm^3)	 answer to **M1** ÷ 2 answer to **M2**÷0.0167 **ALLOW** 0.1497 or any number of sig fig except one Correct answer without working scores 3 **ACCEPT** alternative methods	3 **Total 9**

Q16.

Question number	Answer	Notes	Marks
(a)	Explanation including the following points: (metals) M1 contain delocalised electrons M2 (which) move/flow/are mobile/are free to move (through the metal structure) and two from (covalent compounds) M3 contain neutral molecules / molecules with no overall charge M4 electrons held (tightly) in covalent bonds (so) M5 no electrons free to move (so do not conduct)	IGNORE free electrons/sea of electrons M2 dependent on mention of electrons If any mention of ions/atoms moving cannot score M1 M2 ALLOW do not contain ions ALLOW there are no delocalised electrons If state ions present cannot score M3 M4 M5	4
(b)	ion(s)	ALLOW hydrogen ion/H^+ ALLOW chloride ion/Cl^-	1

(c)	(i)	all points plotted correctly (within half a small square)		1
	(ii)	point at (0.4, 25) circled		1
	(iii)	straight line of best fit through origin drawn with ruler		1
	(iv)	explanation linking M1 the volume/reading is less than expected M2 because the current was less than 0.4A / some gas escaped/ there was a leak	ALLOW reading taken before 5 minutes	2
	(v)	the greater the current the greater the volume (of gas)	ACCEPT directly proportional ACCEPT positive correlation	1

Question number	Answer	Notes	Marks
(d) (i)	(transfer of two/same number of electrons produces) one mole of chlorine/Cl_2 and one mole of hydrogen/H_2	ALLOW same number of moles of chlorine/Cl_2 and hydrogen/H_2 ALLOW molecules for moles	1
(ii)	chlorine dissolves/soluble in acid/solution	ALLOW dissolves/soluble in water	1
		(Total for Question = 13)	

Q17.

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 M2 any temperature in the range 600 - 700 °C inclusive	**ACCEPT** aluminium oxide / silicon dioxide / Al_2O_3 / SiO_2 / zeolite(s) / aluminosilicate(s)	2
(e)	($C_{10}H_{22} \rightarrow C_4H_{10}$) + 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_6H_{12} / $2C_3H_6$ / $C_3H_6 + C_3H_6$ **ALLOW** correct displayed formulae	2
			Total 10

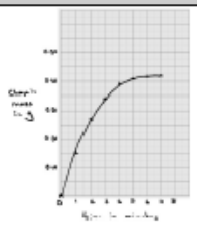
Q18.

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

Q19.

Question number	Answer	Notes	Marks
(a) (i)	all points plotted ± half a square		1
(ii)	curved line of best fit		1
(iii)	An explanation that links the following two points M1 curve shows increasing mass (of negative electrode) because (more) copper deposits/forms M2 line becomes horizontal because there are no more copper(II) ions left in the solution/ all the copper has been deposited/formed OWTTE	 ALLOW line becomes horizontal as there is no copper sulfate solution left	2
(b) (i)	A description that refers to two of the following points M1 fill a test tube/measuring cylinder with copper sulfate solution M2 place the tube over the positive electrode M3 collect gas/oxygen by displacement of solution/water	 ALLOW fill a test tube/ measuring cylinder with water	2
(ii)	$2H_2O \rightarrow O_2 + 4H^+ + 4e^{(-)}$ M1 all formulae correct M2 correct balancing of correct formulae **OR** $4OH^- \rightarrow O_2 + 2H_2O + 4e^{(-)}$ M1 all formulae correct M2 correct balancing of correct formulae	 M2 dep on M1 M2 dep on M1	2

(c)	(i)	M1 layers (of atoms or ions) M2 can slide over one another	ALLOW sheets/rows M2 dep on M1 ALLOW atoms/ions slide over each other for M2	2
	(ii)	M1 delocalised electrons M2 are free to move (throughout the structure)	IGNORE sea of electrons /free electrons M2 dep on mention of electrons in M1 0 marks if reference to ions moving	2
				Total for question = 12

Q20.

Question number	Answer	Notes	Marks
(a)	An explanation that links the following two points **M1** electrons are delocalised **M2** (electrons) can move/can flow/are mobile	 **IGNORE** sea of electrons /free electrons **REJECT** cations/atoms move for both marks **M2** dep on M1 or mention of electrons i.e. 'electrons move' scores 1 mark	2
(b) (i)	**M1** brown/pink/pink-brown solid formed **M2** bubbles/fizzing/effervescence	**ACCEPT** brown/pink coating/deposit on the electrode **ALLOW** red-brown **REJECT** orange **REJECT** precipitate **ALLOW** 1 mark if both observations correct but at incorrect electrodes **IGNORE** gas produced /evolved/released **IGNORE** name of gas	2
(ii)	copper **ion(s)**/Cu^{2+} gains electrons	**ACCEPT** oxidation state of copper goes down / goes from +2 to 0 **IGNORE** references to loss of oxygen **ALLOW** electrons are gained **REJECT** copper/Cu gains electrons	1

(iii)	An explanation that links the following two points **M1** the (blue) colour is caused by copper **ions**/Cu^{2+} **M2** copper ions/Cu^{2+} are being discharged/ removed from the solution	 **ACCEPT** concentration of copper ions/Cu^{2+} decreases **ALLOW** copper ions/Cu^{2+} form copper	2

Question number	Answer	Notes	Marks
(c)	• calculate the mass of water removed • calculate the amount, in moles, of $CuSO_4$ • calculate the amount, in moles, of water • divide amount of H_2O by amount of $CuSO_4$ Example calculation **M1** (12.5 – 8.0) = 4.5 (g) **M2** $n(CuSO_4)$ = 8.0 ÷ 159.5 = 0.05(0) (mol) **M3** $n(H_2O)$ = 4.5 ÷ 18 = 0.25 (mol) **M4** 0.25 ÷ 0.05(0) (= 5)	**ACCEPT** alternative methods which show that the answer is 5	4 **Total 11**

Q21.

Question number	Answer	Notes	Marks
(a)	potassium	ALLOW K	1
(b)	(paper) chromatography		1
			1
(c) (i)	sodium chloride	ALLOW NaCl	1
(ii)	air		1
(iii)	sulfur	ALLOW S	**Total 5**

Q22.

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

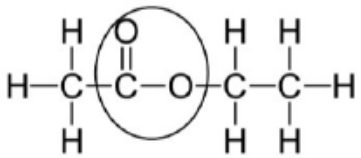
Question number	Answer	Additional guidance	Mark
(b)(ii)	Addition	accept hydration	1

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

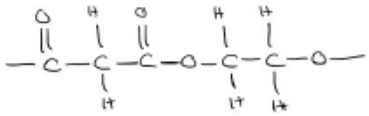
Question number	Answer	Additional guidance	Mark
(c)	(Carboxylic acid) propanoic acid (1) (Alcohol) butanol-1-ol/butanol (1)	accept propionic acid accept (*n*-)butyl alcohol	2

(Total for question = 12 marks)

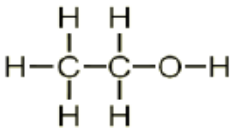
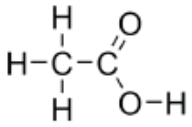
Q23.

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

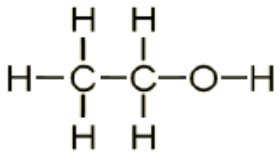
Question number	Answer	Notes	Marks
(d)	example calculation M1 moles barium hydroxide = (0.150 × 22.75)÷ 1000 **OR** 0.0034125 M2 moles ethanoic acid = 0.006825 M3 moles ethanoic acid to 3 significant figures = 0.00683	M1 needs to be given to at least 3 sig figs ALLOW M1 × 2 ALLOW answer to M2 to 3 significant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

Q24.

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

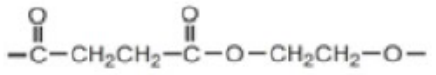
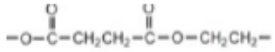
Question number	Answer	Notes	Marks
(c) (i)	A discussion which refers to any six of the following points: Advantages of fermentation/disadvantages of hydration **M1** sugar cane can be re-grown/is renewable **M2** crude oil is finite/cannot be replaced/is non-renewable **M3** fermentation uses lower temperatures 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

Q25.

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**

Q26.

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

Q27.

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)	$C_{12}H_{26}$ --> 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

Q28.

Question number	Answer	Notes	Marks
(a) (i)	argon	**ALLOW** Ar	1
(ii)	nitrogen	**ALLOW** N_2/N	1
(iii)	hydrogen	**ALLOW** H_2/H	1
(b)	climate change/global warming /oceans becoming more acidic	**ALLOW** greenhouse effect **ALLOW** effects of global warming e.g. melting of polar ice caps/flooding/wild fires **IGNORE** acid rain **REJECT** references to ozone layer	1
(c)	M1 bubble/pass/add the gas/carbon dioxide into limewater M2 (limewater) turns cloudy/milky	 **ALLOW** white precipitate M2 dep on mention of limewater **REJECT** addition of extra reagents for both marks	2
			Total 6

Q29.

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

Q30.

Question number	Answer	Notes	Marks
(a) (i)	calcium + water → calcium hydroxide + hydrogen	**ACCEPT** fully correct balanced chemical equation. $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ **IGNORE** state symbols even if incorrect	1
(ii)	Any two from **M1** effervescence/fizzing/bubbles **M2** calcium/metal/solid disappears/becomes smaller OWTTE **M3** test tube/beaker feels warm/hot	 **IGNORE** gas given off **ALLOW** calcium/metal /solid dissolves **ALLOW** heat produced /temperature increases	2

(b) (i)	A description that makes reference to the following five points **M1** dissolve each of the solids in water/make a solution of each of the solids **M2** mix/add (the two solutions together) **M3** filter (the mixture) **M4** wash the precipitate/solid/barium sulfate /salt/residue (with water) **M5** suitable method of drying the solid	 **ALLOW M1** and **M2** if just one of the solids is dissolved in water and then the other solid is added to it. **M2** dep on **M1** or on reference to the **solutions** being mixed If implication is that filtering is to obtain crystals from the solution no **M3** e.g. dry in a (warm) oven/dry between filter papers **ALLOW** leave to dry **REJECT** hot oven or direct heating (with Bunsen burner) If evaporation of solution to form crystals do not award **M4** but allow **M5** for suitable drying method	5

(ii)	$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ **M1** all formulae correct **M2** state symbols correct	If formulae incorrect or full equation given (even if incorrect) **M2** can still be awarded for correct state symbols. If NaCl in equation must be (aq).	2

Question number	Answer	Notes	Marks
(c) (i)	**C** decomposition A is incorrect as it is not an addition reaction B is incorrect as oxygen is not a reactant D is incorrect as nothing is neutralised here		1
(ii)	• calculate the amount, in moles, of magnesium nitrate • use the equation to find the total amount, in moles, of gas produced • multiply this amount by 24 • answer given to two significant figures Example calculation **M1** *n*(magnesium nitrate) = 7.7 ÷ 148 **or** 0.052 (mol) **M2** *n*(gas) = 5 x 0.052 ÷ 2 **or** 0.13 (mol) **M3** Total volume of gas = 0.13 x 24 **or** 3.12 **M4** 3.1(dm^3)	5 x answer to **M1** ÷2 answer to **M2** x 24 answer to **M3** to 2 sig fig Allow any number of sig fig for **M1**, **M2** and **M3** 3.1 without working scores 4 3.12 without working scores 3	4
			Total 15