PEARSON EDEXCEL IGCSE CHEMISTRY · 4CH1

# CHEMISTRY



## MARK SCHEME

### SECTION 4: ORGANIC CHEMISTRY (PACK 2)

| SCORE | PERCENTAGE |
| --- | --- |
| /244 | % |

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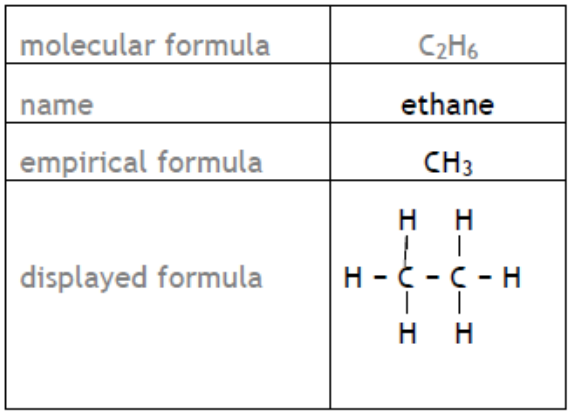
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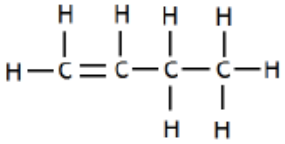
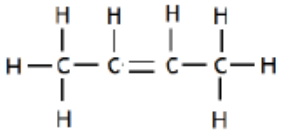
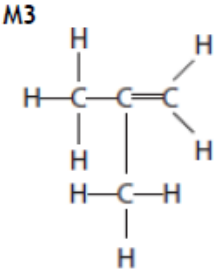
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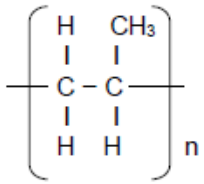
## Mark Scheme

Q1.

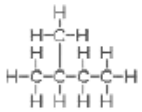
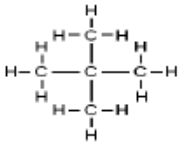
| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) |  | Penalise incorrect use of case, superscripts | 3 |
| (ii) | **2**$C_2H_6$ + **7**$O_2$ → **4**$CO_2$ + **6**$H_2O$ | **ACCEPT** multiples and fractions | 1 |
| (iii) | Any two from<br>**M1** carbon monoxide/CO<br>**M2** carbon/C<br>**M3** water (vapour)/steam/$H_2O$ | <br><br>**ALLOW** soot<br>**IGNORE** carbon dioxide | 2 |

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| | | | | |
|---|---|---|---|---|
| (b) | (i) | A addition<br><br>B is incorrect as it is not a decomposition reaction<br>C is incorrect as no solid precipitate is produced<br>D is incorrect as it is not a substitution reaction | | 1 |
| | (ii) | Any two from<br><br>M1<br><br><br>M2<br><br><br>M3<br> | Do not accept displayed formulae of cyclic alkanes<br><br>**ALLOW** cis-trans (E/Z) isomers of but-2-ene for both marks | 2 |
| | (iii) | isomers | **ALLOW** isomerism | 1 |

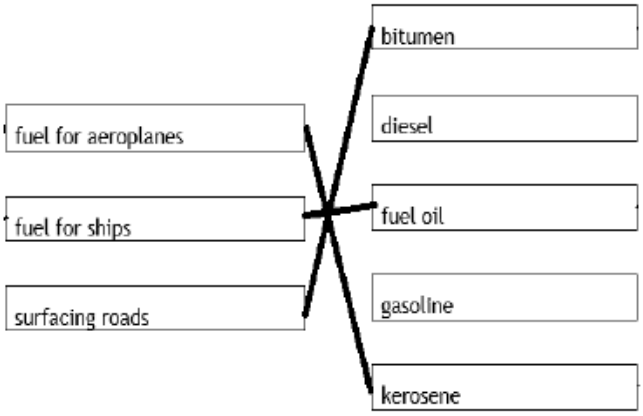
| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (c) (i) | <br>**M1** correct repeat unit<br>**M2** extension bonds, brackets and n after brackets | If double bond between carbon atoms scores 0 | 2 |
| (ii) | A discussion which refers to the following points<br>**M1** polymers/poly(propene) will remain in landfill indefinitely OWTTE<br>**M2** (as they) are inert /unreactive/do not biodegrade<br>**M3** burning produces toxic gases | **ALLOW** burning produces greenhouse gases | 3 |
| | | | **Total 15** |

Q2.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) | **M1** (compounds with) same molecular formula | **ALLOW** same number of carbons and hydrogens / atoms of each element | 2 |
| | **M2** different structural / displayed formulae | **ALLOW** different structures / arrangement of atoms | 1 |
| (ii) | (5 x 12 + 12 x1 =) 72 | | 1 |
| (iii) | pentane | spelling must be correct | 1 |
| (iv) | **M1**  | either order | 2 |
| | **M2**  | | |

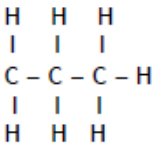
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|---|---|---|---|
| (b) | A description that refers to any five of the following points: | **IGNORE** any colour changes given | 5 |
| | **M1** ethane needs UV (radiation) to react | **IGNORE** UV for ethene | |
| | **M2** ethane produces bromoethane | **IGNORE** any references to temperature and pressure | |
| | **M3** ethane produces hydrogen bromide / HBr | **ALLOW** formulae | |
| | **M4** reaction with ethane involves breaking C-H bond / reaction with ethene involves breaking C=C bond | | |
| | **M5** ethane reaction is substitution | | |
| | **M6** ethene produces dibromoethane | | |
| | **M7** ethene reaction is addition | | |
| | | **ALLOW** formula | |
| | | **M1, M2, M3** and **M6** can be scored from word or chemical equations | |
| | | | **Total 11** |

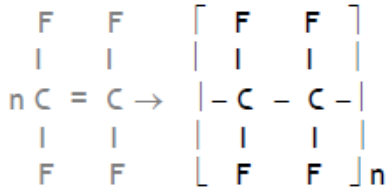
Q3.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) | alkanes | | 1 |
| (b) (i) | **A** boiling point is the correct answer because fractional distillation depends on differences in boiling point<br>**B** is not correct because fractional distillation does not depend on differences in density<br>**C** is not correct because fractional distillation does not depend on differences in melting point<br>**D** is not correct because fractional distillation does not depend on differences in solubility | | 1 |
| (b) (ii) | <br>1 mark for each correct line from boxes on left | If more than one line from a box on left do not award mark for that box | 3 |
| (c) | explanation including the following points:<br><br>M1 (common impurity in fuels is) sulfur<br><br>M2 sulfur burns/combusts/reacts (in air/oxygen) to form sulfur dioxide/$SO_2$<br><br>M3 sulfur dioxide/$SO_2$ dissolves in/reacts with rain/water to form acid rain | If M2 M3 not scored ALLOW 1 mark for reference to sulphur dioxide/$SO_2$ and acid rain | 3 |

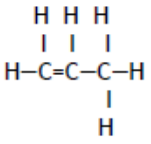
| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (d) (i) | cracking | | 1 |
| (ii) | M1 (catalyst) silica/alumina | ALLOW silicon dioxide/aluminium oxide<br>ALLOW formulae | 2 |
| | M2 (temperature) 600-700 (°C) | ALLOW zeolite | |
| (iii) | $C_{13}H_{28} \rightarrow C_8H_{18}$ + | | |
| | M1 $C_3H_6$ + | in either order<br>ALLOW structural formulae | 2 |
| | M2 $C_2H_4$ | | |
| | | ALLOW 1 mark for single product $C_5H_{10}$ | |
| | | **(Total for Question = 13)** | |

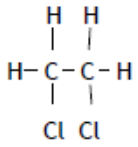
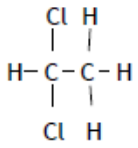
Q4.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) | propane | spelling must be correct | 1 |
| (ii) |  | | 1 |
| (iii) | $C_nH_{2n+2}$ | **ALLOW** upper case N or different letter e.g. x | 1 |
| (b) (i) | shared pair of electrons (between two atoms) | **REJECT** if between molecules | 1 |
| (ii) | An explanation that links the following three points | | 3 |
| | M1 $C_4H_{10}$ has larger molecules/longer chain ORA | **ALLOW** $C_4H_{10}$ has more carbon (and hydrogen) atoms | |
| | M2 $C_4H_{10}$ has stronger intermolecular forces ORA | **ACCEPT** forces between molecules<br>**ALLOW** intermolecular bonds | |
| | M3 more energy needed to separate the molecules /overcome the forces in $C_4H_{10}$ ORA | No **M2** or **M3** if implied that covalent bonds break | |

| | | | |
|---|---|---|---|
| (c) (i) | <br>M1 correct repeat unit<br>M2 extension bonds brackets and n | **REJECT** double bond between carbons for both marks<br>n must be on RHS of bracket and extension bonds do not have to go through brackets | 2 |
| (ii) | Any one from<br>M1 food will not bind to/ bond with the coating<br>M2 hard/tough /long lasting coating<br>M3 resistant to heat/ will not melt<br>M4 inert/ unreactive | **ALLOW** coating will not react with the food/ non-toxic/ not poisonous<br>**ALLOW** high melting point | 1 |
| | | | Total 10 |

Q5.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) | molecular formula: $C_3H_6$<br>name of this alkene: propene<br>empirical formula: $CH_2$<br>general formula: $C_nH_{2n}$<br>displayed formula: <br>1 mark for each correct answer | **ACCEPT** propylene<br>**ACCEPT** N or other letters e.g. x | 4 |
| b) i) | (contains a carbon carbon) double bond | **ACCEPT multiple bond** | 1 |
| ii) | M1 add bromine water<br>M2 decolourises/changes to colourless | **REJECT bromine**<br>**REJECT bromide**<br>**ALLOW** turns colourless<br>**IGNORE** clear<br>M2 dep M1 or near miss | 2 |

| | | | | |
|---|---|---|---|---|
| (c) | (i) | $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ | **ACCEPT** multiples | 1 |
| | (ii) | **D** Substitution<br><br>A is incorrect as it is not an addition reaction<br>B is incorrect as it is not a decomposition reaction<br>C is incorrect as it is not a neutralisation reaction | | 1 |
| | (iii) | Ultraviolet radiation/light | **ACCEPT** UV/ultraviolet rays | 1 |
| (d) | (i) | **M1** (isomers have) the same molecular formula<br><br>**M2** (but) different structural/displayed formulae | <br><br>**ALLOW** different structures<br>**ALLOW** different arrangement of atoms | 2 |
| | (ii) | **M1** <br><br>**M2**  | | 2 |
| | | | | **Total 14** |

Q6.

| Question number | Answer | Mark |
|---|---|---|
| **(a)** | An explanation that makes reference to the following points:<br><br>• (all) contain carbon and hydrogen (1)<br>• only/but no other elements (1) | **2** |

| Question number | Answer | Mark |
|---|---|---|
| **(b)** | (The only one that shows) all atoms and all bonds | **1** |

| Question number | Answer | Mark |
|---|---|---|
| (c) | A, C, D and F | 1 |

| Question number | Answer | Mark |
|---|---|---|
| (d)(i) | ($C_3H_8$ + $5O_2$ →) $3CO_2$ + $4H_2O$<br>• 1 mark for both product formulae correct (1)<br>• 1 mark for balancing (1) | 2 |

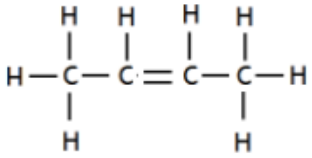
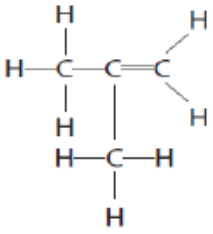
| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| (d)(ii) | An explanation that makes reference to the following points:<br>• sulfur dioxide reacts with water (1)<br>• to form an acid (1) | accept sulfuric or sulfurous | 2 |

Q7.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) | curve of best fit | **REJECT** dot to dot line | 1 |
| (ii) | M1 lines shown on graph | **ALLOW** extra point on curve at 7 carbon atoms | 2 |
| | M2 value correctly read from graph (expected value between 97 and 103°C) | **ACCEPT** value to ± 1°C | |
| (iii) | An explanation that links the following three points | | 3 |
| | M1 the boiling point increases as the number of carbons / the chain length increases | **ALLOW** boiling point increases as the $M_r$ increases | |
| | M2 because the intermolecular forces (of attraction) get stronger | **REJECT** directly proportional | |
| | M3 and therefore take more energy to overcome / break | M3 dep on M2<br><br>Any mention of breaking covalent bonds does not score M2 or M3 | |
| (b) | M1 same **molecular** formula | | 2 |
| | M2 different **displayed** / **structural** formulae | **ALLOW** different structures/ different arrangement of atoms | |
| (c) (i) | M1 82.8 ÷ 12 **or** 6.9<br>17.2 ÷ 1 **or** 17.2 | 0 marks if upside down calculation or use of atomic numbers | 2 |
| | M2 (divide by smallest to give) 1:2.5 which is 2:5 | **ACCEPT** alternative methods | |
| (ii) | $C_4H_{10}$ | | 1 |
| (d) | M1 moles of $CO_2$ = 7 **or** X = 7 | | 3 |
| | M2 moles of $H_2O$ = 8 **or** Y = 8 | | |
| | M3 balancing number = 11 **or** Z = 11 | **ALLOW** ecf from incorrect values of X and Y | |
| | | | 14 marks |

Q8.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) | S | | 1 |
| (ii) | T and U | | 1 |
| (iii) | U | | 1 |
| (b) | A description that makes reference to the following three points<br><br>**M1** (add) bromine water<br><br>**M2** no change / stays orange<br><br>**M3** (bromine water) decolourised / changes (from orange) to colourless | <br><br>**ACCEPT** $Br_2$ (aq)<br><br>**ALLOW** no reaction<br><br>If initial colour of bromine water is given in M2 or M3 it must be correct -ALLOW any combination of orange/yellow/brown - but penalise once only<br><br>If bromine given for M1 then in M2 and M3 allow any combination of red/orange/brown/yellow<br><br>**M2** and **M3** dep on bromine water/bromine in **M1**<br><br>If no reagent and correct M2 and M3 - score 1<br><br>if incorrect reagent and correct M2 and M3 score 0<br><br>**IGNORE** clear<br><br>**REJECT** discoloured<br><br>**ALLOW M1** acidified potassium manganate(VII)<br>**M2** no change/stays purple<br>**M3** decolourised / goes colourless | 3 |

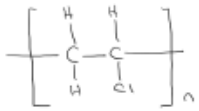
| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (c) | Any **two** of the following points<br><br>**M1** (can be represented by a) general formula<br><br>**M2** each member differs from the next by a $CH_2$ group OWTTE<br><br>**M3** (each member has) same functional group<br><br>**M4** (each member has) similar/same chemical properties / similar/same (chemical) reactions<br><br>**M5** trend in physical properties (between successive members) | **ACCEPT** react in similar/same way<br><br>**ACCEPT** named physical property, e.g. boiling point<br><br>**REJECT** similar/same physical properties | 2 |
| (d) (i) | but-1-ene | **ALLOW** 1-butene | 1 |
| (ii) | **Either**<br><br>**Or**<br> | **ACCEPT** cis or trans isomer<br><br>**REJECT** displayed formulae of cyclic alkanes | 1 |

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (e) (i) | • Divide percentages by relative atomic masses<br>• Divide results by smallest value to obtain ratio<br><br>Example calculation<br><br>**M1** C: $\frac{36.36}{12}$ H: $\frac{6.06}{1}$ F: $\frac{57.58}{19}$<br><br>**M2** $\frac{3.03}{3.03}$ $\frac{6.06}{3.03}$ $\frac{3.03}{3.03}$<br><br>**OR** 1 2 1 | 0 marks if division by atomic numbers or upside down calculation | 2 |
| (ii) | • divide relative molecular mass by empirical formula mass<br>• correct molecular formula<br><br>Example calculation<br><br>**M1** $\frac{66}{12 + 2 + 19}$ **OR** $\frac{66}{33}$ OR 2<br><br>**M2** $C_2H_4F_2$ | **ACCEPT** symbols in any order<br><br>correct answer without working scores 2 marks.<br><br>$2CH_2F$ scores 1 | 2 |
| | | | **Total 14** |

Q9.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) | Any five from<br><br>M1 fractional distillation<br><br>M2 crude oil heated/vapourised<br><br>M3 reference to (fractionating) column/tower<br><br>M4 which is hotter at the bottom than at the top<br><br>M5 shorter hydrocarbons/chains/molecules have lower boiling point (and rise higher/towards the top)<br><br>M6 fractions/hydrocarbons/gases/vapours/kerosene condense(s) at (levels depending on) their boiling points OWTTE | <br><br><br>**ALLOW** boiled<br><br><br>**ALLOW** reference to temperature gradient<br>**ALLOW** the hydrocarbons/gases/vapours cool as they rise up the column<br><br>**ACCEPT** reverse argument<br><br>**ALLOW** correct reference to position of kerosene fraction below refinery gases and gasoline fractions or above diesel and fuel oil fractions | 5 |

| | | | | |
|---|---|---|---|---|
| (b) | (i) | $C_8H_{18}$ | | 1 |
| | (ii) | Any four from | | 4 |
| | | M1 fractional distillation/crude oil produces more long-chain hydrocarbons than can be used (directly) | **ALLOW** short(er) chain hydrocarbons are in higher demand/more useful than long(er) chain hydrocarbons ORA | |
| | | M2 cracking produces short chain alkanes | **ALLOW** cracking changes long(er) chain hydrocarbons into short(er) chain hydrocarbons | |
| | | M3 short chain alkanes/hydrocarbons are more flammable/can be used as fuels | | |
| | | M4 cracking produces alkene(s) | **IGNORE** named alkene | |
| | | M5 alkenes can be used to make polymers | **ALLOW** named alkene forming (named) polymer e.g. ethene can be used to make poly(ethene)/polymer | |

| | | | |
|---|---|---|---|
| (c) | A Addition<br>The only correct answer is A because the reaction between an alkene and a halogen forming a halogenoalkane is addition.<br>B is not the correct answer since this reaction is not combustion.<br>C is not the correct answer since this reaction is not decomposition.<br>D is not the correct answer since this reaction is not substitution. | | 1 |
| (d) (i) | <br>M1 single bond between the two carbons **and** single bonds to three hydrogens and one chlorine<br><br>M2 two extension bonds and n | n can be anywhere after brackets<br>extension bonds do not have to go through brackets<br>M2 dep on M1 | 2 |
| (ii) | M1 they are inert/unreactive<br><br>M2 (so) they are non-biodegradable/ do not (naturally) break down/decompose (in landfill sites)<br><br>OR<br><br>M1 when burned<br><br>M2 they produce toxic fumes | **ALLOW** take long time to break down (so landfill sites may fill up) | 2 |
| | | Total for question = 15 marks | |

Q10.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| a | **2** $C_2H_4$ + **4** HCl + **(1)** $O_2$ → **2** $C_2H_4Cl_2$ + **2** $H_2O$ | **ACCEPT** multiples and fractions | **1** |
| b | breaking down by heating OWTTE | | **1** |
| c i | (it) contains a (carbon to carbon) double bond | | **1** |
| ii | **M1** add bromine water/solution<br><br>**M2** (bromine water/solution) is decolourised/ turns (from orange to) colourless | **ACCEPT** $Br_2$(aq) as long as the state symbol is present<br><br>**IGNORE** clear<br><br>**REJECT** discoloured<br><br>If initial colour of bromine water given it must be correct- **ALLOW** any combination of orange/yellow/brown<br><br>**M2** dep on **M1** or near miss<br><br>**ALLOW**<br>**M1** add acidified potassium manganate(VII)<br><br>**M2** potassium manganate(VII) is decolourised/turns (from purple) to colourless<br><br>**REJECT** any other initial colour | **2** |
| d | poly(chloroethene) /polychloroethene | **ACCEPT** polyvinyl chloride<br><br>**ALLOW** PVC | **1** |

Q11.

| Question number | | Answer | Notes | Marks |
|---|---|---|---|---|
| (a) | (i) | (crude oil/it is) heated / vapourised | **ALLOW** evaporated / boiled<br>**REJECT** melted | 1 |
| | (ii) | gasoline | **ALLOW** petrol | 1 |
| | (iii) | road (surfacing) / roofs / tarmac | | 1 |
| (b) | (i) | M1 silica / alumina (catalyst)<br><br>M2 600 to 700 °C | **ACCEPT** $SiO_2$/$Al_2O_3$ / silicon dioxide / aluminium oxide /aluminosilicates / zeolites | 2 |
| | (ii) | Any two from: | | 2 |
| | | M1 shorter-chain <u>alkanes</u> are in high(er) demand / more useful / used for petrol / more flammable | **ALLOW** <u>$C_8H_{18}$</u> is in high(er) demand (than $C_{13}H_{28}$) / more useful / used for petrol / more flammable<br><br>**IGNORE** shorter-chain alkanes are used as fuels | |
| | | M2 <u>alkenes</u> are needed / used to make polymers | **ALLOW** <u>$C_2H_4$</u> / <u>$C_3H_6$</u> are needed / used to make polymers / plastics<br><br>shorter chain hydrocarbons / the products are in high(er) demand / more useful / more flammable scores 1 **if no other mark awarded**<br><br>to create shorter alkanes and alkenes scores 1 **if no other mark awarded** | |

| | | | |
|---|---|---|---|
| (c) | An explanation that links the following three points:<br><br>M1 sulfur dioxide produced when fuel is burned<br><br>M2 (sulfur dioxide) dissolves in / reacts with rain / water<br><br>M3 (causing) acid rain | <br><br>**ALLOW** sulfur / fuel reacts with oxygen / oxidises forming sulfur dioxide<br>**IGNORE** sulfur trioxide and sulfur oxide<br><br>**ACCEPT** (sulfur oxide / sulfur trioxide) dissolves in / reacts with rain / water<br>**IGNORE** mixes | 3 |
| | | | **Total 10** |

Q12.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) | M1 X is darker in colour than kerosene ORA<br><br>M2 X has higher boiling point than kerosene ORA<br><br>M3 X is more viscous than kerosene ORA | | 3 |
| (b) (i) | M1 3 $CO_2$ + 9 $H_2O$<br><br>M2 10 $O_2$ | <br><br>M2 dep on M1 | 2 |
| (ii) | carbon monoxide reduces the capacity of the blood to transport oxygen OWTTE | **ACCEPT** correct references to haemoglobin / carboxyhaemoglobin | 1 |
| (iii) | An explanation including any three of the following:<br><br>M1 (common impurity in fuels is) sulfur<br><br>M2 (sulfur) burns/combusts/reacts (in air/ oxygen) to form sulfur dioxide/$SO_2$<br><br>M3 sulfur dioxide/$SO_2$ dissolves in/reacts with rain/water (to form)<br><br>M4 acid rain | | 3 |
| (c) (i) | M1 single bond between the carbons and each carbon single bonded to two hydrogens<br><br>M2 two extension bonds and n after the bracket | <br><br>M2 dep on M1 | 2 |
| (ii) | M1 poly(ethene) is unreactive/does not react/inert<br><br>M2 (so) non-biodegradable/does not decompose/does not break down (in landfill sites) | <br><br>**ALLOW** takes many years or a long time to decompose/break down OWTTE<br>**ALLOW** reference to space is limited in landfill sites OWTTE | 2 |
| | | | |
| | | Total for question | = 13 |

Q13.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) | $C_7H_{16}$ | Penalise incorrect use of case and subscripts | 1 |
| (ii) | (surfacing) roads/roofs | **ALLOW** other correct uses | 1 |
| (iii) | A description that makes reference to the following three points | | 3 |
| | **M1** gasoline has a **lighter** colour /ORA | **ACCEPT** reference to specific colours e.g. gasoline is colourless/ bitumen is black | |
| | **M2** gasoline has a **lower** boiling point /ORA | statements must be comparisons | |
| | **M3** gasoline has a **lower** viscosity /ORA | | |
| (b) (i) | An explanation that links the following four points | | 4 |
| | **M1** water vapour/steam condenses | **ALLOW** turns to liquid | |
| | **M2** (because) the ice (and water) is below 100°C/ the boiling point of water | **ALLOW** (because) the ice (and water) are cold /at a low temperature/ at 0 °C | |
| | **M3** carbon dioxide is still a gas/ does not condense (in the U-tube) | | |
| | **M4** (because) the ice (and water) is above - 78 °C/ the sublimation point of carbon dioxide | | |
| (ii) | A description including the following two points | | 2 |
| | **M1** anhydrous copper(II) sulfate is white | | |
| | **M2** (when water is present) it turns blue | | |
| | | | Total 11 |

Q14.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) | argon / helium | **ACCEPT** Ar / He | 1 |
| (ii) | nitrogen | **ACCEPT** $N_2$ | 1 |
| (iii) | carbon dioxide | **ACCEPT** $CO_2$ | 1 |
| (iv) | carbon dioxide | **ACCEPT** $CO_2$ | 1 |
| (b) (i) | $S + O_2 \rightarrow SO_2$ | | 1 |
| (ii) | acid rain | **ACCEPT** an adverse effect of acid rain e.g. kills fish, damages plants, corrodes limestone/marble buildings/statues etc.<br><br>**IGNORE** toxic/pollutant | 1<br><br>**Total 6** |

Q15.

| Question number | Answer | Mark |
|---|---|---|
| (a)(i) | B and E | 1 |

| Question number | Answer | Mark |
|---|---|---|
| (a)(ii) | (the only one that shows) All atoms and all bonds | 1 |

| Question number | Answer | Mark |
|---|---|---|
| (a)(iii) | • D and F (1)<br>• they have the same molecular formula/the same number of each type of atom (1)<br>• but different structures/atoms joined together in different ways/different structural formulae (1) | 3 |

| Question number | Answer | Mark |
|---|---|---|
| (a)(iv) | 4 | 1 |

| Question number | Answer | Mark |
|---|---|---|
| (b)(i) | An explanation that makes reference to the following points:<br><br>• incomplete combustion/lack of oxygen (1)<br>• leads to the formation of carbon monoxide (1) | 2 |

| Question number | Answer | Mark |
|---|---|---|
| (b)(ii) | It reduces the capacity of blood to transport oxygen | 1 |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| (c) | An explanation that makes reference to the following points:<br><br>• nitrogen in the air and oxygen react (1)<br>• at high temperatures (1)<br>• which causes the formation of nitrogen oxide(s) (1)<br>• oxides then react with water (vapour) in the atmosphere to form nitric acid (1) | accept equation and formulae such as $NO/NO_2/NO_x$<br>accept nitrous acid and formulae | 4 |

**(Total for question = 13 marks)**

Q16.

| Question number | Answer | Mark |
|---|---|---|
| (a) | A description that makes reference to five of the following points:<br><br>• crude oil is heated/vaporised (1)<br>• the vapour enters the lower part of the column (1)<br>• there is a temperature gradient up the column (1)<br>• the vapour in the diesel fraction rises up the column until it condenses (1)<br>• at a height where its boiling point is lower than the temperature in the column (1)<br>• so the diesel fraction is removed (1) | 5 |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| (b) | An explanation that makes reference to the following three points:<br><br>• dodecane contains hydrogen and carbon (1)<br>• only/and no other elements (1)<br>• and contains only single bonds (1) | accept does not contain double bonds/multiple bonds | 3 |

| Question number | Answer | Mark |
|---|---|---|
| (c) | C | 1 |

| Question number | Answer | Mark |
|---|---|---|
| (d) | $C_8H_{18}$ | 1 |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| (e)(i) | Ultraviolet radiation | accept ultraviolet light | 1 |

| Question number | Answer | Mark |
|---|---|---|
| (e)(ii) | HCl | 1 |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| (e)(iii) | • All 6 atoms with a dot and cross representing each bonding pair of electrons (1)<br>• 3 lone pairs of electrons on Cl and none on any of the H atoms (1) | accept 2 dots or 2 crosses for each bond<br><br>accept any combination of dots and crosses | 2 |

| Question number | Answer | Mark |
|---|---|---|
| (e)(iv) | Substitution | 1 |

| Question number | Answer | Mark |
|---|---|---|
| (f)(i) | D | 1 |

| Question number | Answer | Mark |
|---|---|---|
| (f)(ii) | • Dividing percentages by atomic masses (1)<br>• Dividing results by smallest value<br>OR<br>obtaining ratio (1)<br>• Writing empirical formula (1)<br><br>Example calculation:<br><br>C: 25.9 / 12 = 2.16 / 3<br>H: 5.0 / 1 = 5.0 / 7<br>Br: 57.6 / 80 = 0.72 / 1<br>O: 11.5 / 16 = 0.72 / 1<br><br>$C_3H_7BrO$<br><br>accept symbols in any order | 3 |

**(Total for question = 19 marks)**

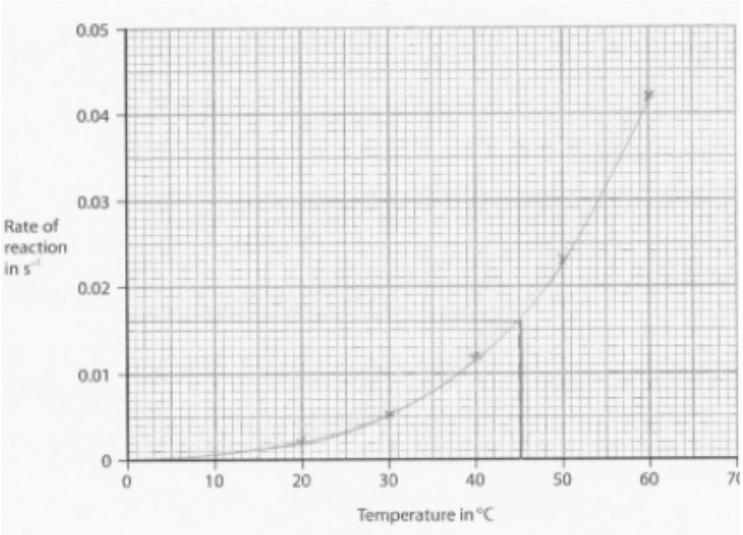
Q17.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) | 6/six | | 1 |
| (ii) | One of the following two points<br><br>methanol/it) does not contain only carbon and hydrogen<br>OR<br>(methanol/it) contains (an atom of) oxygen | | 1 |
| (b) (i) | M1 two/ pair of electrons<br><br>M2 shared between two atoms | <br><br>**ACCEPT (electrons)** attracted to the nuclei (of the two atoms in the bond)<br><br>**ACCEPT**<br>M1 (electrostatic) attraction between two nuclei<br>M2 (and the) shared pair(s) of electrons (between them) | 2 |
| (ii) | M1 4 pairs of electrons around central carbon atom, with one pair to O and 3 pairs to H<br><br>M2 rest of molecule fully correct | **ALLOW** any combination of dots and crosses<br><br>M2 DEP on M1 | 2 |

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (c) (i) | • Divide percentages by relative atomic masses<br>• Divide results by smallest value to obtain ratio<br>• Write empirical formula<br><br>Example calculation<br><br>M1 C: $\frac{38.7}{12}$ H: $\frac{9.7}{1}$ O: $\frac{51.6}{16}$<br><br>M2 $\frac{3.225}{(3.225)}$ $\frac{9.7}{(3.225)}$ $\frac{3.225}{(3.225)}$<br><br>OR 1 3 1<br><br>M3 $CH_3O$ | 0 marks if division by atomic numbers or upside-down calculation<br><br>M2 subsumes M1<br><br>**ACCEPT** symbols in any order | 3 |
| (ii) | • Divide relative molecular mass by empirical formula mass<br>• Write molecular formula<br><br>Example calculation<br><br>M1 $\frac{62}{12 + 3 + 16}$ **OR** $\frac{62}{31}$ (= 2)<br><br>M2 $C_2H_6O_2$ | **ACCEPT** symbols in any order<br><br>Correct answer without working scores 2 marks | 2 |
| | | | **Total 11** |

Q18.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) | Sulfur | ALLOW sulphur | 1 cler |
| (b) | any two from<br><br>M1 concentration of hydrochloric acid<br><br>M2 concentration of sodium thiosulfate<br><br>M3 height of eye above flask OWTTE<br><br>M4 same size of flask | ALLOW same colour/darkness /size of cross /use same cross | 2 exp |

| | | | |
|---|---|---|---|
| (c) | any one from<br><br>M1 the thiosulfate/solution would cool down/not remain at required temperature<br><br>M2 larger (percentage) errors in values of times (as they become smaller) | IGNORE references to some of solution might evaporate<br><br>ALLOW too short a time leads to less accurate readings OWTTE | 1 exp |
| (d) | M1 all points plotted correctly (to the nearest grid line)<br><br>M2 curve of best fit drawn<br><br><br> | IGNORE curve below 20 and above 60 | 2 exp |

| | | | | |
|---|---|---|---|---|
| (e) | (i) | M1 line on graph from 45 °C to curve<br><br>M2 candidate value of rate from graph at 45 °C (expected value approx. 0.016/7) | ALLOW mark on curve at 45 °C<br><br>ACCEPT value to +/– 0.0005 | 2 exp |
| | (ii) | M1 substitute answer from (i) into (time = 1 ÷ rate)<br><br>M2 correct value | <br><br>ACCEPT answers to 2 or more sig figs<br><br>rate = 0.016 time = 62.5<br>rate = 0.0165 time = 60.6<br>rate = 0.017 time = 58.8 | 2 exp |
| | (iii) | as temperature increases rate of reaction increases | ORA<br>ALLOW positive correlation<br><br>REJECT linear/directly proportional | 1 grad |
| (f) | | explanation including following points<br><br>(when temperature increases)<br><br>M1 (mean) kinetic energy of particles increases<br><br>M2 (so) more successful collisions per second/unit time / more frequent successful collisions<br><br>M3 rate (of reaction) increases | <br><br><br>ALLOW particles move faster<br><br>IGNORE vibrate more/faster<br><br>ALLOW reference to more frequent collisions between particles having energy ≥ activation energy<br><br>ALLOW reaction is faster /speeds up | 3 exp |
| | | | Total Q =14 | |

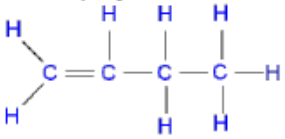
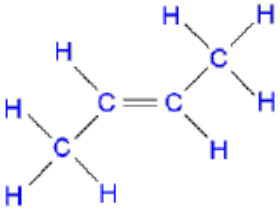
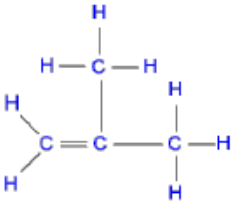
Q19.

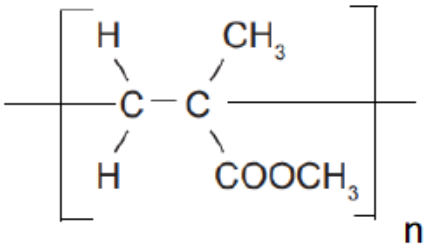
| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) | **B** decomposition<br><br>**A** is not correct because when sodium hydrogencarbonate is heated combustion does not take place<br><br>C is not correct because when sodium hydrogencarbonate is heated oxidation does not take place<br><br>D is not correct because when sodium hydrogencarbonate is heated reduction does not take place | | 1 comp |
| (ii) | (because) carbon dioxide/gas is produced/given off | | 1 grad |
| (b) (i) | to obtain a constant mass OWTTE /<br>to show the reaction is complete OWTTE | ACCEPT to ensure only $Na_2CO_3$ is left (in crucible)<br><br>ACCEPT to ensure all the $NaHCO_3$ has reacted /decomposed | 1 exp |
| (ii) | M1 advantage: to stop any solid/$Na_2CO_3$/$NaHCO_3$ spitting out/being lost<br><br>M2 disadvantage: the gas(es)/$CO_2$/$H_2O$/steam could not easily escape OWTTE | REJECT references to stopping gases escaping | 2 exp |

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (c) (i) | 3.25 (g) | | 1 exp |
| (ii) | • calculate moles of $NaHCO_3$<br>• use equation to determine moles of $Na_2CO_3$<br>• multiply by $M_r$ to find mass of $Na_2CO_3$<br><br>Example calculation:<br><br>M1 3.25 ÷ 84 **OR** 0.0387 (mol)<br><br>M2 0.0387 ÷ 2 **OR** 0.01935 (mol)<br><br>M3 0.01935 x 106 = 2.05 (g)<br><br>**OR**<br>• use of equation to relate mass of $NaHCO_3$ to mass of $Na_2CO_3$<br>• shows how to find mass of $Na_2CO_3$ using 3.25g $NaHCO_3$<br>• correct evaluation of answer<br><br>Example calculation:<br><br>M1 (2x84)/168 (g) $NaHCO_3$ → 106 (g) $Na_2CO_3$<br><br>M2 3.25 (g $NaHCO_3$)→ (106÷168) x 3.25 (g $Na_2CO_3$)<br>M3 2.05 (g $Na_2CO_3$) | mark CQ on (i)<br><br>ALLOW any number of sig figs except 1<br><br>2.05 (g) without working scores 3 marks<br><br>4.1 (g) without working scores 2 marks<br><br>mark CQ on (i) | 3 exp |

| | | | | |
|---|---|---|---|---|
| (d) | (i) | M1 percentage yield = 4.2÷4.8 **OR** 0.875<br><br>M2 = (0.875 x 100) = 87.5 (%) | ACCEPT 88 (%)<br>Correct answer without working scores 2 | 2 grad |
| | (ii) | any one from<br><br>M1 sodium hydrogencarbonate was impure<br><br>M2 not all sodium hydrogencarbonate reacted/decomposed | | 1 grad |
| | | | Total Q = 12 marks | |

Q20.

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (a) (i) | explanation linking<br><br>M1 (molecules/compounds) having same molecular formulae<br><br>M2 but different structural/displayed formulae | <br><br><br><br>ALLOW different structures<br>ALLOW different arrangement of atoms | 2 |
| (ii) | M1 displayed formula of but-1-ene<br><br><br>M2 displayed formula of but-2-ene<br> | IGNORE bond angles<br><br><br><br>ALLOW displayed formula of methylpropene<br> | 2 |

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (b) (i) | explanation linking<br><br>M1 molecule is unsaturated as contains (carbon to carbon) double bond<br><br>M2 molecule not a hydrocarbon as contains oxygen | <br><br><br><br>ACCEPT does not contain hydrogen and carbon only | <br><br>2 |
| (ii) | addition | | 1 |
| (iii) | <br>M1 correct repeat unit structure<br><br>M2 extension bonds, brackets and n | <br><br>n can be anywhere after bracket<br>extension bonds do not have to go through brackets<br>M2 DEP M1 or near miss | 2 |

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| (c) (i) | M1 calculation of mass of octane<br><br>M2 calculation of Mr of $C_8H_{18}$ and $CO_2$<br><br>M3 link between mass/mol $C_8H_{18}$ and mass/mol $CO_2$<br><br>M4 calculation of mass $CO_2$ in g<br><br>M5 calculation of mass $CO_2$ in kg<br><br>Example calculation:<br><br>M1 50 x 700 = 35000 (g)<br><br>M2 $M_r$ of $C_8H_{18}$ = 114 and $M_r$ $CO_2$ = 44<br><br>M3 114g $C_8H_{18}$ produces (8 x 44 =) 352 (g) $CO_2$ | | 5 |

| | | | |
|---|---|---|---|
| | M4 35000 g $C_8H_{18}$ produces $\frac{35000 \times 352}{114}$<br>= 108070.2 (g) $CO_2$<br><br>M5 = 108 (kg)<br><br>Alternative method using mol:<br><br>M1 50 x 700 = 35000 (g)<br><br>M2 $M_r$ of $C_8H_{18}$ = 114 and Mr $CO_2$ = 44<br><br>M3 n ($C_8H_{18}$) = $\frac{35000}{114}$ = 307.0175 mol<br>so n ($CO_2$) = 8 x 307.0175 = 2456.14 mol<br><br>M4 mass $CO_2$ = 2456.14 x 44 = 108070.2 (g)<br><br>M5 = 108 (kg) | ALLOW 2 sig fig or more in M4 and M5<br><br>ALLOW 2 sig fig or more in M3 M4 and M5<br><br>MARK CSQ in both methods<br><br>correct answer without working scores 5 | |
| (ii) | global warming/climate change | IGNORE greenhouse effect | 1 |
| | | | **(Total for Question = 15)** |