(a) (i) fizz / effervescence / bubbles
   *allow calcium carbonate decreases in size or dissolves*
   1
   because carbon dioxide produced / released
   *allow because gas produced / released*
   1
   limewater turns cloudy / milky / white
   1
   because (a precipitate of or solid) calcium carbonate forms
   *allow because of carbon dioxide if not already credited*
   1

(ii) \[
    \begin{align*}
    &H \\
    &\quad| \\
    &H \quad C \quad C \equiv O \\
    &\quad| \\
    &H \quad O \quad \equiv H
    \end{align*}
\]
   *allow -OH*
   *do not allow lower case ‘h’*
   1

(iii) acid
   *must be in this order*
   *ignore any name of an acid*
   1
   ester(s)
   1

(b) white (precipitate) no change
   no change no change
   *all four correct 2 marks*
   *any two correct 1 mark*
   2

(c) (i) lilac
   *allow purple*
   1
   red
   *must be in this order*
   1

(ii) colours are masked / changed by each flame colour
   1
(a) \[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \]
allow multiples

(b) 3444 J

if answer incorrect:

one mark for temperature increase = 16.4 °C
one mark for mass of water = 50 g
ecf for one incorrect value gains two marks for correct calculation
no ecf for two incorrect values

(c) (i) 1276 (kJ per mole)
ignore + or -
if answer incorrect:

\[ [(5 \times 413) + 347 + 358 + 467] + [(3 \times 495)] = 4722 \text{ (1 mark)} \]
\[ [(4 \times 799) + (6 \times 467)] = 5998 \text{ (1 mark)} \]
correct subtraction of calculated energy values (1 mark)

(ii) because energy released when bonds form is greater than energy used when bonds broken
allow converse
if no mark awarded allow one mark for energy is used to break bonds
or
one mark for energy is released when bonds form

(iii) products line lower than reactants

activation energy labelled

overall energy change labelled

3

3

(a) any one from:

• disposal or does not decompose (in landfill sites) or collection or sorting for recycling
  ignore non-biodegradable alone
• lack of space or more landfill sites
• other specified problems with waste (eg. litter or eyesore or harm to animals or destroys habitats)
  ignore pollution unqualified.
if 2 marks not awarded, award 1 mark for one of the following:

- a double bond between the two carbons and no additional trailing bonds
- two C atoms bonded together with three single bonds to hydrogen atoms and one single bond to a chlorine atom. no additional Cl or H.

(c) intermolecular forces or forces between the chains

allow intermolecular bonds

(intermolecular forces are) weak

ignore references to no cross links between chains.

allow 1 mark for weak forces between layers.

which are easily overcome (by heat) or need little energy to overcome or chains / molecules can slide over one another (when heated)

if weak bonds or breaking covalent bonds mentioned only the third marking point is available.

(d) Monomer A – carboxylic acid

do not allow carbolic

Polymer C - ester (linkage)
(a) (i) the products are at a lower energy level than the reactants

accept products have less energy / less energy at the end than the beginning

(ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route

accept adsorption or 'increases concentration at the surface'

ignore absorption

(that has) lower activation energy

allow weakens bonds

allow idea of increased successful collisions.

DO NOT ALLOW answers stating catalysts provide energy for M1 and M2

(b) one pair of electrons in each overlap (8 pairs in total)

allow any combination of dots, crosses or other symbols

the rest of the diagram correct with four non-bonding electrons on the oxygen giving a total of eight electrons in oxygen outer energy level.

 landlords 2 marks
(c) (i) ±3024 (J)
   correct answer with or without working gains 3 marks
   if the answer is incorrect, award up to 2 marks for the following steps:
   • $\Delta T = 14.4(°C)$
   • $50 \times 4.2 \times 14.4$
   allow ecf for incorrect $\Delta T$

(ii) 0.015(2173913)
   correct answer with or without working gains 3 marks
   if answer is incorrect, allow 1 mark each for any of the following steps up to a max of 2.
   • 0.70g
   • $M_r$ of ethanol = 46
   • $0.70 / 46$
   allow ecf in final answer for arithmetical errors

(iii) ±198 720(J / mole)
   c(i) ÷ c(ii)
   allow ecf from (c)(i) and (c)(ii)
   0.015 gives 201600
   0.0152 gives 198947
   0.01522 gives 198686

(d) (as the molecules get bigger or the number of carbon atoms increases) the intermolecular forces
   allow intermolecular bonds

   (intermolecular forces) increase
   allow more / stronger (intermolecular forces)

   and therefore require more (heat) energy to overcome
   breaking covalent bonds or unspecified bonds max 1 mark (M3)

(a) (i) (conical) flask
   1

(ii) measuring cylinder / pipette / burette
   1
(b) (i) any two from:
• so anomalous results could be identified / ignored
• so a mean / average could be taken
• (to improve) accuracy

(ii) 19

(iii) increases / gets longer / gets bigger

(iv) anomalous / does not agree with other times for C\textsubscript{10}H\textsubscript{22}

(v) any one from:
• shorter hydrocarbon used
• volume of hydrocarbon too small
• started timing late
• stopped timing too early / when liquid left in funnel
must suggest why the result is lower than the others.
allow the temperature was higher or the students used a wider funnel.

(c) (i) flammable

(ii) suitable safety precaution

reason that links the safety precaution to the hazard symbols

\textit{eg:}
• wear gloves
• (because) it is hazardous to health / harmful / toxic / irritant
\textit{or}
• do not pour down sink or dispose of properly
• (because) it is harmful to the environment / kills fish
\textit{or}
• wear a mask or do it in the fume cupboard or a well-ventilated area
• respiratory irritant
(d) (i) points plotted correctly (within half small square)

   all six points correct scores 2
   3, 4 or 5 points correct scores 1

   smooth curve of best fit

(ii) point at 46 °C circled

   allow point furthest from the line as drawn

(iii) working shown on graph

   value read from graph line drawn (within half small square)

(iv) the higher the temperature the lower the viscosity

   allow the higher the temperature the lower / shorter the time taken for 1 mark

   non-linear or change gets smaller as temperature gets higher

   answer relating temperature to time taken can score a maximum of 2 marks.

(v) identifying source of the error

   method of avoiding the error

   eg:
   • the temperature will drop
   • insulate the funnel
   or
   • runs out before all added
   • put a tap on the funnel

(a) (i) 25 °C

   (ii) (fractional) distillation
(b) (i) (fertile) land is used to grow fuel crops or crops are grown for fuel or farmers get a better price for crops for fuel or crops for biofuels take up space

ignore biofuels are made from food or plants

less food grown or food prices rise or less (fertile) land to grow food

(ii) (crops / plants) take in carbon dioxide (while growing / during photosynthesis)

so the CO₂ given out was previously taken in

do not accept burning biofuels does not release CO₂ or releases less CO₂ unqualified

if no other mark awarded, a statement of “carbon neutral” scores 1 mark
(c) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a ‘best-fit’ approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
At least one statement about the effect of a condition on either rate or yield.

Level 2 (3–4 marks)
Correct statements about the effect of at least one condition on rate and yield.

Level 3 (5–6 marks)
Correct statements about the effect of at least one condition on rate and yield and at least one correct statement about compromise conditions.

Examples of the points made in the response

Temperature
• a higher temperature gives a lower yield
• a higher temperature gives a faster rate

Pressure
• a higher pressure gives a higher yield
• increase in yield gets less as pressure increases
• a higher pressure gives a faster rate
• increase in rate increases as pressure increases

Catalyst
• using a catalyst speeds up reaction
• catalysts allow a lower temperature to be used and so save energy / reduce energy costs

Compromise
• a higher pressure gives a greater yield but increases costs / (safety) risks
• a high pressure gives a faster rate but increases costs / risks
• a high temperature makes reaction faster but reduces yield
• a catalyst makes reaction faster so a lower temperature can be used which will increase the yield

(a) circle round any one (or more) of the covalent bonds
any correct indication of the bond – the line between letters

(b) Methane contains atoms of two elements, combined chemically
(c) (i) activation energy labelled from level of reagents to highest point of curve

*ignore arrowheads*

enthalpy change labelled from reagents to products

![Diagram of activation energy and enthalpy change](image)

*arrowhead must go from reagents to products only*

(ii) \[2 \text{ O}_2\]

\[2 \text{ H}_2\text{O}\]

*if not fully correct, award 1 mark for all formulae correct. Ignore state symbols*

(iii) carbon monoxide is made

this combines with the blood / haemoglobin or prevents oxygen being carried in the blood / round body or kills you or is toxic or poisonous

*dependent on first marking point*

(iv) energy is taken in / required to break bonds

*accept bond breaking is endothermic*

energy is given out when bonds are made

*accept bond making is exothermic*

the energy given out is greater than the energy taken in

*this mark only awarded if both of previous marks awarded*
(d) (i) energy to break bonds = 1895

\[ \text{calculation with no explanation max = 2} \]

energy from making bonds = 1998

\[ 1895 - 1998 = -103 \]

\[ \text{or} \]

energy to break bonds = 656
energy from making bonds = 759

\[ 656 - 759 = -103 \]

allow:

\[ \text{bonds broken} - \text{bonds made} = 413 + 243 - 327 - 432 = -103 \text{ for 3 marks.} \]

(ii) The C — Br bond is weaker than the C — Cl bond.

[15]

(a) (i) mixture (of different substances)

(ii) boiling (points)

(iii) distillation
(b) (i) combustion

(ii) (reactant)

oxygen

allow correct formulae

(products)

products in any order

carbon dioxide

allow carbon or carbon monoxide

and

water

allow water vapour or steam or hydrogen oxide

(iii) (burning sulfur) produces sulfur dioxide / $S_2O_2$

allow it / sulfur reacts with oxygen ignore sulfur oxide

causes acid rain

(c) (i) propane is a fuel

(ii) double bond drawn between carbon atoms

do not allow any other bonds or symbols

(iii) orange to colourless

(iv) poly(pentene)

allow polymer(s)
(a) any four from:
- (crude oil is) heated
- to evaporate / vaporise / boil (the substances / hydrocarbons)
- the column is hotter at the bottom or is cooler at the top
- (vapours / fractions) condense
- at their boiling points or at different levels.

marks can be taken from a diagram
max 3 marks for reference to cracking
allow fractional distillation allow vapours (enter the column)
allow temperature gradient or (vapours) cool as they rise
allow description e.g. vapour turns to liquid
allow they have different boiling points

(b) acid rain is caused by

allow consequences of acid rain

sulfur dioxide or oxides of nitrogen
second marking point is dependent on first marking point

they react with / are neutralised by calcium carbonate or limestone

OR
global warming is caused by carbon dioxide

carbon dioxide will react or dissolve in suspension of limestone
allow greenhouse effect is caused by or allow consequences of global warming

(c) (i) $C_2H_4$

must be formula
ignore any name

(ii) a single bond between carbon atoms

would score 3 marks

other four bonds linking hydrogen atoms and $C_3H_7$ group plus two trailing / connecting bonds

n at the bottom right hand corner of the bracket
(iii) has a shape memory
or
(a smart polymer) can return to original shape (when conditions change)

(a) oxygen

allow correct answer shown in box if answer line blank

(b) vinegar

allow correct answer shown in box if answer line blank

(c) C

(d) Ester

(e) pleasant smell

volatile

allow low boiling point / evaporates