Mark schemes

(a) condenses  
(b) the fractions have different boiling points  
(c) propane  
\( \text{do not accept propene} \)  
(d) \( C_nH_{2n+2} \)  
(e) \( CH_4 + 2 O_2 \rightarrow CO_2 + 2 H_2O \)  
\( \text{allow multiples} \)  
(f) bromine water  
(g) to assess the environmental impact (of the stages in the life of a product)  
\( \text{allow to see the effect / harm / damage on the Earth / environment / planet} \)  
\( \text{ignore references to energy, pollution, carbon footprint, carbon dioxide, sustainability} \)  
(h) Level 2: Scientifically relevant features are identified; the ways in which they are similar / different is made clear and the magnitude of the similarity / difference noted.  
\( \text{Level 1: Relevant features are identified and differences noted.} \)  
\( \text{No relevant content} \)  
\( \text{Indicative content} \)

- burning 10 000 bags produces 10 kg more of carbon dioxide than landfill  
- putting 10 000 bags in landfill produces 0.02 kg more of solid residue than burning  
- putting 10 000 bags in landfill produces 50% more sulfur dioxide than burning  
- burning 10 000 bags produces 25 kg of carbon dioxide, but landfill only produces 15 kg  
- putting 10 000 bags in landfill produces 0.07 kg of solid residue but burning only produces 0.05 kg  
- landfill produces less carbon dioxide than burning  
- landfill produces more solid residue than burning  
- burning produces less sulfur dioxide than landfill
(a) hydrogen

ignore H

carbon

ignore C

in either order

(b) plankton

(c) fractional distillation

d) to vaporise the hydrocarbons / (crude) oil

allow to evaporate the hydrocarbons / (crude) oil

ignore to boil the hydrocarbons / (crude) oil

(e) fuel oil

(f) lowest boiling point bar correctly plotted (260 °C)

highest boiling point bar correctly plotted (340 °C)

correct label added to axis: diesel (oil)

allow ± ½ a square

3

(a) A

(b) tension (in the kite string)

weight

allow gravity

(c) as object only remains stationary when resultant force is zero

or

if there was a non-zero resultant force, it would accelerate

allow relevant references to Newton’s First or Second Law as appropriate
(d) kite will begin to move / accelerate

because there is now a resultant force

\textbf{or}

forces are no longer balanced

(e) vertical force (1.8 N) drawn to a suitable scale

force 5.9 N drawn at 135° to vertical force with same scale

parallelogram completed with resultant drawn

magnitude of resultant in range 4.64–4.88 (N)

(a) Flask

(b) Fractional distillation

(c) A – boiling

\textit{in this order}

B – condensing

(d) Octane

(e) Formulation

(f) the fuel is a pure compound

and crude oil is a mixture

\textbf{or}

the fuel is made up of four hydrocarbons

\textit{allow crude oil contains a large number of compounds and the fuel contains four}

and crude oil could have many more

(g) \((35 + 37 + 37 / 3) = 36.33\)
allow $(35 + 48 + 37 + 37 / 4 =) 39(.25)$ for 1 mark

(a) decane

(b) icosane

(c) ethene
<table>
<thead>
<tr>
<th>Level 3:</th>
<th>Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.</th>
<th>5-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2:</td>
<td>Relevant points (reasons/causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.</td>
<td>3-4</td>
</tr>
<tr>
<td>Level 1:</td>
<td>Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.</td>
<td>1-2</td>
</tr>
<tr>
<td>No relevant content</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Indicative content**

- crude oil is heated
- hydrocarbons/compounds vaporise
- vapours enter the fractionating column near the bottom
- there is a temperature gradient in the column or the column is hotter at the bottom and cooler at the top
- vapours / hydrocarbons / fractions condense
- to become liquid
- at their boiling points
- different substances have different boiling points
- so the different fractions collect at different levels
- hydrocarbons / fractions with smallest molecules have lowest boiling points
- collect as gases at top of the column where temperature is lower
- hydrocarbons / fractions with larger molecules have higher boiling points
- so collect nearer the bottom
- where temperature is higher

(a) \[ CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \]
(b) toxic

accept causes death

acid rain

or

respiratory problems

accept respiratory problems / asthma

global dimming

(c)

| Level 3: A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given. | 5-6 |
| Level 2: Some logically linked reasons are given. There may also be a simple judgement. | 3-4 |
| Level 1: Relevant points are made. They are not logically linked. | 1-2 |
| No relevant content | 0 |

**Indicative content**

- methane is the best fuel because it gives more energy per gram than coal, and gives less carbon dioxide per kJ of energy produced
- petrol is best because it being a liquid is easier to handle than gas or coal - although the energy content is lower than the others, it gives out less carbon dioxide than coal
- methane has more energy per gram than coal
- coal produces most carbon dioxide
- coal can produce sulfur dioxide

(a) break large molecules into small molecules

to satisfy demand

example
(b) 50.4 kg = 50 400 g

\[ \frac{50 400}{28} \]

\[ 1.8 \times 10^3 \]

(c) \[ \frac{1.8}{3} = 0.6 \]

\[ 0.6 \times 296 \]

\[ = 177.6 \text{ kg} \]

(a) \( C_{16}H_{34} \)

(b) heat to vaporise the hydrocarbons / (crude) oil

- allow heat to evaporate the hydrocarbons / (crude) oil
- allow alkanes for hydrocarbons
- ignore boil

- temperature (of column) decreases from bottom to top
- as gases / vapours rise up the column, they condense
- at different points according to their boiling point

(c) (energy required to break bonds = (2 \times 347) + (8 \times 413) + (5 \times 495) =)

\[ 6473 \text{ (kJ/mol)} \]

(energy released when bonds formed = (6 \times 799) + (8 \times 467) =)

\[ 8530 \text{ (kJ/mol)} \]

(overall energy change = 6473 - 8530 =)

\[ -2057 \text{ (kJ/mol)} \]

- allow calculation of difference between their values from step 1 and step 2
- ignore order / sign

- an answer of 2057 (kJ/mol) or \(-2057 \text{ (kJ/mol)}\) scores 3 marks
(d) **Level 2:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

**Level 1:** Some logically linked reasons are given. There may also be a simple judgement.

No relevant content

**Indicative content**

- carbon dioxide is released by both (during combustion)
- carbon dioxide emissions contribute to global warming
- fuels from plants are carbon-neutral when taking into account the CO₂ taken in by the plants as they grow
- combustion of crude oil-derived fuels causes sulfur dioxide emissions
- sulfur dioxide emissions cause acid rain
- transport of crude oil can lead to oil spills
- transport of both releases carbon dioxide
- fuel from plants require a large area of land to grow plants
- fuel from plants may displace food crops
- clearing land to grow plants for fuel may contribute to deforestation
- growing plants for fuel can destroy habitats or reduce biodiversity
- fuel from plants can be produced from recycled cooking oil so reduces waste

(e) \[
\text{(moles of } C_4 H_ {10} = \frac{14.5}{58} = 0.25)
\]

\[
\text{(moles of } O_2 = \frac{72}{32} = 2.25)
\]

0.25 moles butane requires

\[
0.25 \times \frac{13}{2} = 1.625
\]

moles of oxygen

1.625 is less than 2.25 moles (so oxygen is in excess) therefore butane is limiting

or

2.25 moles oxygen requires

\[
0.25 \times \frac{13}{2} = 0.346 \text{ moles of butane (1)}
\]

0.346 is greater than 0.25 moles therefore butane is limiting (1)
or

(0.25 : 2.25 =)
1 : 9
or 2 : 18 (1)

9 is greater than 6.5
or 18 is greater than 13

(therefore oxygen is in excess) so butane is limiting (1)

alternative approach:

116 (g butane reacts with) 416 (g oxygen) (1)
(14.5 g butane requires)

\[
\frac{416}{116} \times 14.5 (1)
\]

= 52 g oxygen (1)

52 is less than 72 so (oxygen is in excess) therefore butane is limiting (1)

or

116 (g butane reacts with) 416 (g oxygen) (1)
(72 g oxygen requires)

\[
\frac{116}{416} \times 72 (1)
\]

= 20.1 g butane (1)

20.1 is greater than 14.5 so butane is limiting (1)

an incorrect answer for one step does not prevent allocation of marks for subsequent steps

[16]