GCSE Chemistry

Fractional Distillation

Mark Scheme

Time available: 75 minutes
Marks available: 71 marks

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1. (a) **C**

B

A

must be in this order

1

(b) higher

1

lower

1

must be in this order

(c) scale labelled at 20, 30, 40, (50) % at 2 cm intervals

1

(**K**) bar drawn to 44%

allow a tolerance of ± ½ a small square

1

(d) contains more kerosene

*allow **K** contains less kerosene*

1

(e) a catalyst

1

steam

1

(f) $C_{11}H_{24}$

1

(g) a single bond between two carbon atoms

1

(h) carbon dioxide

1

water

1

[12]

2. (a) crude oil is heated to vaporise (the hydrocarbons)

1

there is a temperature gradient in the (fractionating) column

allow a (fractionating) column is cooler going up

1

(so) the gases condense at different levels
or
(so) lubricating oil condenses below naphtha (and petroleum gases do not condense)

1

(because of their) different boiling points

1

(b) detergents

1

solvents

1

(c) $C_9H_{20} + 14\ O_2 \rightarrow 9\ CO_2 + 10\ H_2O$

allow multiples

*allow **1** mark for*

$C_9H_{20} + O_2 \rightarrow CO_2 + H_2O$ with incorrect / no multipliers

2

(d) (when burned sulfur impurities) produce sulfur dioxide

1

(which) causes acid rain
or
(which) causes respiratory problems

allow specified effects of acid rain

allow specified respiratory problems

1

(e) as molecular size increases viscosity increases

1

(and) heavy fuel oil has larger molecules (than kerosene)

1

allow converse statements

(f) (name of process) cracking

1

(conditions) high temperature

allow a stated temperature in the range 300 to 900 °C

1

steam / catalyst

1

(g) C_7H_{14} and C_8H_{16}

1

[16]

3. (a) a temperature between 400 (°C) and 500 (°C) inclusive

allow a temperature range entirely within 400 (°C) and 500 (°C) inclusive

1

(b)

ignore quoted values for boiling points
ignore references to melting points
ignore references to intermolecular forces or chain length
allow temperature of vaporisation / condensation for boiling points throughout

(diesel oil has a) lower boiling point / range than heavy fuel oil

1

(but diesel oil has a) higher boiling point / range than kerosene

*allow the boiling range (of diesel oil) is between those of heavy fuel oil and kerosene for **2** marks.*

1

(c)

ignore references to cost

any **two** from:

- (too) viscous

  allow references to difficulty of flow

- not (very) flammable

  allow references to difficulty of ignition / burning

  *do **not** accept bitumen takes more energy to burn*

- boiling point (too) high

  allow not (very) volatile

2

(d) C_6H_{14}

1

(e)

ignore references to pressure

high temperature

allow a quoted temperature above 320 °C

ignore hot / heat

1

any **one** from:

- steam
- catalyst

ignore name of catalyst
allow alumina
allow aluminium oxide
allow porous pot
allow zeolite

1

(f)

allow converse argument for larger molecules

greater demand (for smaller molecules)

1

any **one** from:
(because smaller molecules are)

- more useful
- better fuels
- used to make alkenes
- used to make polymers

allow a named polymer
ignore plastics

1

(g) C_3H_6

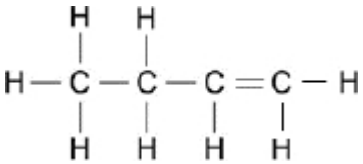
1

[11]

4. (a) C_5H_{10}

1

(b)



1

(c) bar labelled petrol to 28.6 (%)

allow a tolerance of $\pm \frac{1}{2}$ *a square*

1

(d) 100 tonnes

1

(e) 7.1 + 11.1 + 17.2 = 35.4

1

$\frac{2000 \times 35.4}{100}$

allow ecf from step 1

1

= 708 (kg)

*an answer of 1276 (kg) gains **2** marks*

1

(f) higher percentage (by mass) of heavier fractions
or
higher percentage of larger molecules

1

(g) **Level 3 (5-6 marks):**
Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.

Level 2 (3-4 marks):
Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

Level 1 (1-2 marks):
Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

Level 0
No relevant content.

Indicative content

fractional distillation
- oil heated / boiled / vaporised
- fractionating column used
- fractions have different boiling ranges / temperatures
- column hotter at bottom

or

column cooler at top
- fractions condense at different levels
- heavy fractions collect at bottom

or

light fractions collect at top

cracking
- high temperature
- catalyst or steam
- large molecules split into small molecules
- mixture of alkanes and alkenes produced

6

[14]

5. (a) (i) hydrogen / H and carbon / C

answers can be in either order

if letters given, must be capital H

1

(ii) C_nH_{2n+2}

1

(b) (most) crude oil <u>vaporises / evaporates</u> **or** crude oil enters as a <u>vapour</u>

1

(vapour) cools as it rises up the tower / column **or** tower / column cooler at the top **or** negative temperature gradient

1

the fractions have different boiling / condensation points / ranges

accept the larger the molecules, the higher the boiling point / condensation point

1

so they will condense at different levels in the tower

allow will collect at different levels if condensation mentioned

allow will condense to give different fractions

*if no other mark is gained allow **1** mark for mention of heating*

1

(c) (i) C_8H_{18}

if one answer is given C_8H_{18} is the only acceptable answer

credit any correct combination of alkanes and alkenes, eg C_5H_{12} and C_3H_6

1

(ii) hot / high temperature

accept any temperature in the range 300 − 900 °C

'heat' is insufficient

1

catalyst

*accept a named catalyst − alumina **or** zeolites **or** aluminosilicates **or** broken pot*

ignore other named catalysts

allow (mixing with) steam as an alternative to second marking point

ignore pressure

1

[9]

6. (a) (i) exothermic

accept combustion

*allow burning **or** oxidation **or***

redox

1

(ii) carbon monoxide / *CO* (is produced)

allow monoxide (is produced) ignore carbon oxide

1

because there is incomplete / partial combustion (of the fuel)

accept because there is insufficient oxygen / air (to burn the fuel)

1

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance.

0 marks
No relevant content.

Level 1 (1-2 marks)
There is a statement that crude oil is heated **or** that substances are cooled. However there is little detail and any description may be confused or inaccurate.

Level 2 (3-4 marks)
There is some description of heating / evaporating crude oil **and either** fractions have different boiling points **or** there is an indication of a temperature difference in the column.

Level 3 (5-6 marks)
There is a reasonable explanation of how petrol is or fractions are separated from crude oil using evaporating **and** condensing.

If cracking is given as a preliminary or subsequent process to fractional distillation then ignore.

However, if cracking / catalyst is given as part of the process, maximum is **level 2**.

Examples of chemistry points made in the response could include:

- Some / most of the hydrocarbons (or petrol) evaporate / form vapours or gases
- When some of / a fraction of the hydrocarbons (or petrol) cool to their boiling point they condense
- Hydrocarbons (or petrol) that have (relatively) low boiling points and are collected near the top of the fractionating column or hydrocarbons with (relatively) high boiling points are collected near the bottom of the fractionating column
- The process is fractional distillation
- Heat the crude oil / mixture of hydrocarbons or crude oil / mixture is heated to about 350°C
- Some of the hydrocarbons remain as liquids
- Liquids flow to the bottom of the fractionating column
- Vapours / gases rise up the fractionating column
- Vapours / gases cool as they rise up the fractionating column
- The condensed fraction (or petrol) separates from the vapours / gases and flows out through a pipe
- Some of the hydrocarbons remain as vapours / gases
- Some vapours / gases rise out of the top of the fractionating column
- There is a temperature gradient in the fractionating column or the fractionating column is cool at the top and hot at the bottom

6

[9]