

1. Fractional distillation ✓

DO NOT ALLOW just 'distillation'

Because fractions have different boiling points ✓

For fractions, **ALLOW** components **OR** hydrocarbons **OR** compounds

ALLOW condense at different temperatures

ALLOW because van der Waals' forces differ between molecules

IGNORE reference to melting points

IGNORE 'crude oil' **OR** 'mixture' has different boiling points'

..... **but ALLOW** 'separates crude oil by boiling points

[2]

2. (i) Decane ✓

DO NOT ALLOW deceane

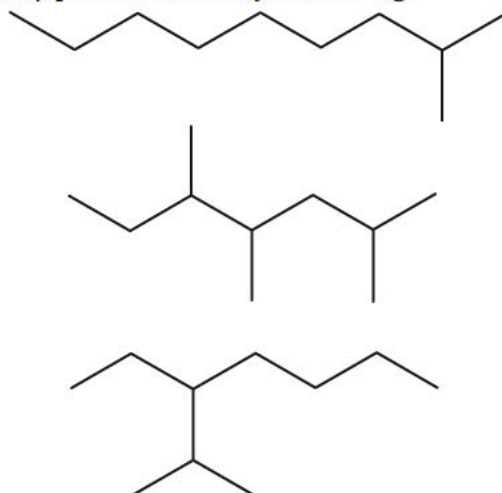
1

(ii) Skeletal formula of branched $C_{10}H_{22}$ ✓

Formula **must** be skeletal

AND must not include any symbol, e.g. CH_3

Any possible skeletal formulae e.g.



1

- (iii) Decane has more surface contact
OR branched chains have less surface contact ✓

Both answers need to be comparisons

Assume 'it' refers to decane

IGNORE surface area

ALLOW straight chains can get closer together

OR branched chains cannot get as close to one another

IGNORE branched chains are more compact

Decane has more van der Waals' forces

OR branched chains have fewer van der Waals' forces ✓

ALLOW Decane has stronger van der Waals' forces

OR branched chains have weaker van der Waals' forces

More intermolecular forces is **not** sufficient

2

- (iv) Branched chains have more efficient combustion

OR decane has less efficient combustion ✓

ALLOW branched chains are easier to burn

OR easier to combust

OR burn better

OR more efficient fuel

OR less likely to produce pre-ignition or knocking

OR increases octane rating

ALLOW ORA for decane

Better fuel is **NOT** sufficient

Burns more cleanly is **NOT** sufficient

1

[5]

3. (i) $\text{C}_{10}\text{H}_{22} + 15\frac{1}{2}\text{O}_2 \rightarrow 10\text{CO}_2 + 11\text{H}_2\text{O}$

ALLOW any correct multiple

IGNORE state symbols

All **four** species correct ✓

balancing of four correct species ✓

2

- (ii) $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$ ✓

ALLOW any correct multiple including fractions

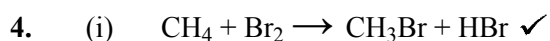
IGNORE state symbols

The mark is for the equation

IGNORE writing

1

[3]



*ALLOW any correct multiple
IGNORE state symbols*

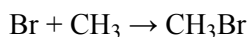
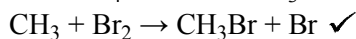
1

- (ii) Dibromomethane
OR tribromomethane
OR tetrabromomethane ✓

*ALLOW 1,1-dibromomethane
OR 1,1,1-tribromomethane etc
ALLOW 1-dibromomethane
DO NOT ALLOW 2,2-dibromomethane etc
ALLOW correct formulae e.g. CH_2Br_2*

1

- (iii) $\text{Br}_2 \rightarrow 2\text{Br}$
OR homolytic fission of bromine ✓



Ethane made when two methyl radicals react



*All equations can be described in words
Radicals do NOT need a single dot
IGNORE any state symbols
ALLOW any other suitable termination*

Quality of Written Communication – Consists of
initiation step linked to correct equation
propagation step linked to one equation in which there is a radical on
the left and a radical on the right
termination step linked to correct equation:

2 names of steps linked to correct equations ✓

BUT

3 names of steps linked to correct equations ✓✓

*If no equations are given to link the names of the step then
award one mark for mention of all three steps*

7

[9]

5. Cracking ✓

ALLOW catalytic or thermal cracking ✓

[1]

6. (i) $C_8H_{18} + 8\frac{1}{2}O_2 \rightarrow 8CO + 9H_2O$ ✓

ALLOW any correct multiples

IGNORE state symbols

1

(ii) limited supply of air **OR** not enough O_2 ✓

ALLOW use of air or oxygen

IGNORE it is not completely oxidised

1

[2]

7. skeletal formula of a branched isomer of C_8H_{18} ✓

skeletal formula of a cyclic hydrocarbon **OR** skeletal formula of substituted arene of C_8H_{10} ✓

ALLOW any ring between C_3 and C_8 with 8 carbon atoms per molecule

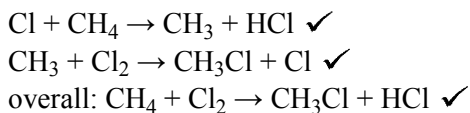
IGNORE wrong names

If two correct structural or displayed formulae drawn award one mark

[2]

8. (i) $\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2$ ✓
 $\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2$ ✓
 overall: $\text{O}_3 + \text{O} \rightarrow 2\text{O}_2$ ✓

OR



Marks must come from one or other of the radical process and not from both of them.

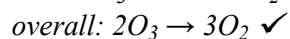
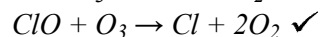
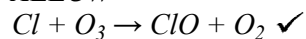
If two processes are described then an incorrect step in one process will contradict a correct step in the other process.

ALLOW overall equation mark even if the steps are wrong

*the radicals do **NOT** need a single dot*

IGNORE any state symbols

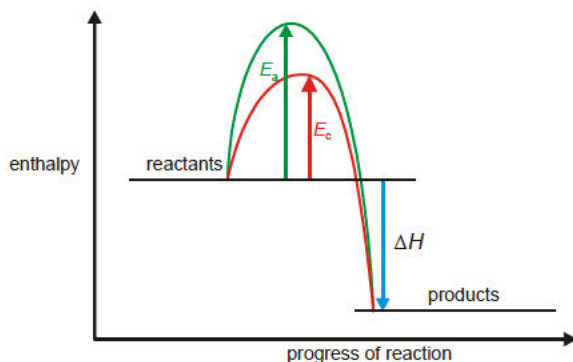
ALLOW



ALLOW any saturated hydrocarbon including cyclic

ALLOW ecf for second step and overall reaction if wrong hydrocarbon used e.g. C_2H_4 is used in first step

- (ii) ΔH shown **and** products below reactants ✓
 E_a shown ✓
 E_c shown $< E_a$ ✓



NOT double headed arrows but apply *ecf* for more than one double headed arrow

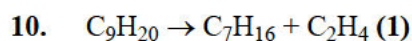
ALLOW one mark if two correctly labelled curves are drawn but the arrows are not shown or are incorrectly drawn
 The arrows must be positioned as closely as possible to the maximum height of the curves but allow some degree of *bod*

3

[6]

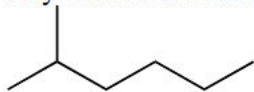
9. (i) 120–130 (1) 1
 (ii) boiling point increases with increase in *Mr*/molecular formula/number of carbon atoms/chain length (1)
 more intermolecular forces/electrons/surface area/
 surface interactions/van der Waal forces (1) □ 2

[3]



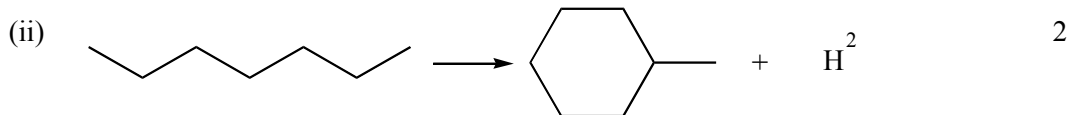
[1]

11. (i) Any branched isomer of heptane with correct name, e.g.



2-methylhexane (1)

2



[4]

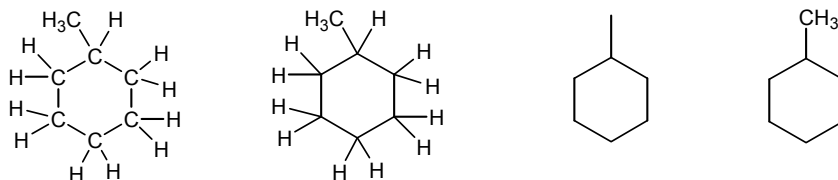
12. (i) species with an unpaired electron (1) 1
 (ii) uv (light)/high temperature/min of 400° C/sunlight (1) 1
 (iii) homolytic (fission) (1) 1
 (iv) $C_4H_{10} + Cl\cdot$ (1) $\rightarrow C_4H_9\cdot + HCl$ (1)
 $C_4H_9\cdot + Cl_2$ (1) $\rightarrow C_4H_9Cl + Cl\cdot$ (1) 2

[5]

13. separation by (differences in) boiling point 1



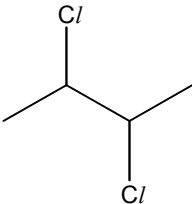
- (i) Any of 1



- (ii) $C_7H_{16} \rightarrow C_7H_{14} + H_2$ (or by structural formula) 1

- (i) 2,2-dimethylpentane 1
 (ii) 3-methylhexane, 3,3 dimethylpentane or (3)-ethylpentane in any unambiguous form. 2
 (iii) 2,2,3-trimethylbutane 1
 (iv) if branched, difficult to pack/less surface interaction/less points of contact 1
 less van der Waals' forces/ less intermolecular bonds/less energy needed to boil 1

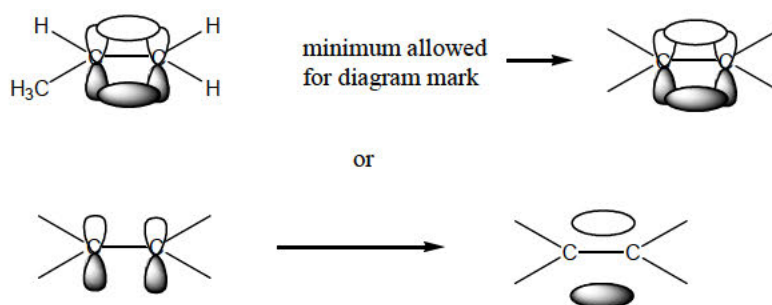
[10]

14. (a) (i) uv/sunlight/high temperature (range 400 – 700 °C) 1
- (ii) $Cl_2 \rightarrow 2Cl\bullet$ 1
- $C_4H_{10} + Cl\bullet \rightarrow HCl + \bullet C_4H_9/C_4H_9\bullet$ 1
- $\bullet C_4H_9/C_4H_9\bullet + Cl_2 \rightarrow C_4H_9Cl + Cl\bullet$ 1
- (iii) any two free radicals from (a) (ii) 1
- (iv) homolytic (fission) 1
- (b) (i) 2, 3-dichlorobutane 1
- (ii) 1
- 
- (iii) any dichlorobutane **except** 2,3-dichlorobutane. 1

[9]

15. **Bonding:** π -bond formed by overlap of (adjacent) p-orbitals/ π -bond labelled on diagram 1

diagram to show formation of the π -bond 1



Shape/bond angles:

tetrahedral around the CH_3 1

bond angle = $109^\circ 28'$ / (109 - 110°) 1

trigonal planar around each C in the $\text{C}=\text{C}$ 1

bond angle = 120° (118 - 122°) 1

Cis-trans

cis & *trans* correctly labelled eg but-2-ene 1

require a double bond because it restricts rotation 1

each C in the $\text{C}=\text{C}$ double bond must be bonded to two different atoms or groups 1

QWC

Allow mark for well constructed answer and use of **three** terms like: orbital, tetrahedral, trigonal, planar, rotation, spatial, stereoisomers, geometric 1

[10]

16. (i) (free radical) substitution 1

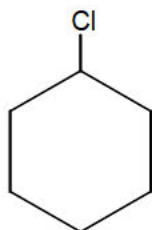
(ii) 1-bromohexane, 2-bromohexane and 3-bromohexane 3

[4]

17.	Recognises that either a catalyst or high temperature (heat is not sufficient) is required	1
	cracking suitable balanced equation	1
	reforming equation or statement indicating formation of a ring/cyclic compound	1
	suitable balanced equation with H ₂	1
	(balanced equation showing formation of a ring scores both marks)	1
	isomerisation suitable balanced equation	1
	The processed products are:	1
	• used in fuels/used in petrol • better /more efficient fuels/increase octane number/rating • alkenes (from cracking) produce polymers/alcohols • H₂ used for Haber process/fuels/hydrogenation of oils	3
	QWC SPAG – look for two complete sentence that present a coherent argument	1

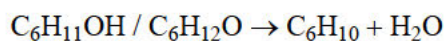
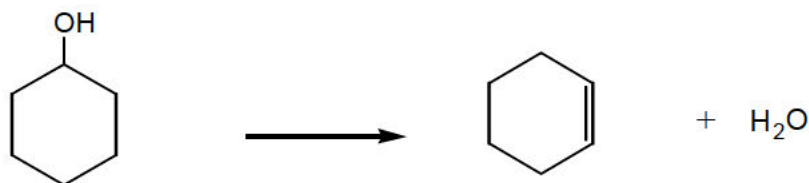
[9]

18.	(a) (i)	1
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(ii)	H ₂ SO ₄ /Al ₂ O ₃ /(hot) pumice/H ₃ PO ₄ (H ₂ SO ₄ (aq) or dil H ₂ SO ₄ loses the mark)	1
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(iii)		1
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(b) (i) 1



diol

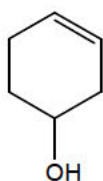
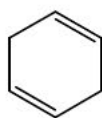
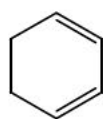
also allow



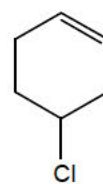
Cl-alcohol

(ii) 2

from the diol allow



from the Cl-alcohol allow



[6]

19. (a) (i) compound/molecule containing hydrogen and carbon **only** 1

(ii) $C_{10}H_{22}$ 1

(iii) C_5H_{11} {ecf from (ii)} 1

(b) (i) (a particle that) contains/has a single/unpaired electron 1

(ii) UV (light) /sunlight/high temp 1

(iii) homolytic (fission)/ homolysis 1

(iv) $C_{12}H_{26} + Cl\bullet \rightarrow \bullet C_{12}H_{25} + HCl$ 1

(the dot for the free radical does not have to be on the C)

$\bullet C_{12}H_{25} + Cl_2 \rightarrow C_{12}H_{25}Cl + Cl\bullet$ 1

(v) six 1

(c) (i) $C_{12}H_{26} \rightarrow 2C_2H_4 + 1C_8H_{18}$ 2

(1 mark for correct formula of octane or ethene)

(ii) octane/ ecf from (c) (i) 1

(d) (i)



1 mark for correct reagent and 1 mark for correct product.

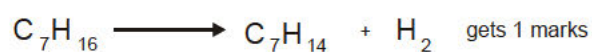
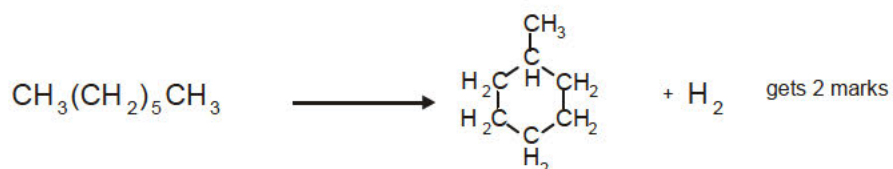
2

(ii) 1 mark for any unambiguous formula of cyclohexane

1

1 mark for 1H_2 but check that formula of heptane is correct/equation balanced.

1



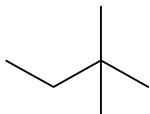
[16]

20. (a) octane,
hexadecane. 545 +/- 5
if °C penalise once.

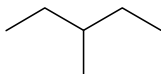
400 +/- 5 1
1

(b) fractional distillation

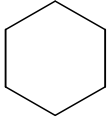
1

- (c) (i)
- 

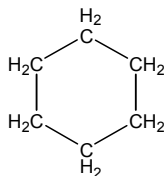
✓



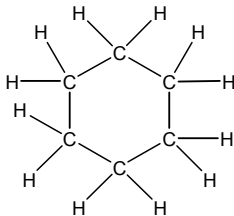
✓
- 2
- (ii) 2-methylpentane 1
- (iii) **C, B and A** 1
- (iv) the more branching/the shorter the chain... the lower the boiling point/
less energy needed to separate the molecules 1
- long chain have greater surface area/surface interactions/more VdW forces
or converse argument about short/branched chains. 1
- (d) (i)
- not just C_6H_{12}



or



or


- 1
- (ii) $C_6H_{14} \rightarrow C=H_{12} + H_2$ 1
- (iii) better fuels/more volatile/lower boiling point/reduces knocking/
increases octane rating/used as (petrol) additives 1
- (e) (i) M_r of $(CH_3)_3COH = 74$ 1
- $\% \text{ oxygen} = (16/74) \times 100 = 21.6 \%$ 1
- (ii) $(CH_3)_3COH + 6O_2 \rightarrow 4CO_2 + 5H_2O$ 2
- 1 mark for CO_2 and H_2O only

[16]

21. (i) $Cl_2 \rightarrow 2Cl\bullet$ 1
- (ii) uv (light)/high temperature/min of 400 °C/sunlight 1
- (iii) $Cl\bullet + C_6H_{12} \rightarrow C_6H_{11}\bullet + HCl$
 $C_6H_{11}\bullet + Cl_2 \rightarrow C_6H_{11}Cl + Cl\bullet$ 1
- (iv) react with each other/suitable equation
 solvent W = water/aqueous/aqueous ethanol 1
 solvent X = ethanol/alcohol 1

[5]

22. identifies the three process as cracking, reforming, isomerisation 1
- recognises the need for high temperature or a catalyst 1
- equation for cracking 1
- equation for isomerisation 1
- state that reforming converts chains into rings/cyclic compounds 1
- equation for reforming (balanced with H_2 could score two marks) 1
- oil is finite/non-renewable 1
- ethanol is renewable/sustainable 1
- from plants/crops/sugar cane/sugar beet/glucose/sugar/ fermentation 1
- $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ 1
- QWC
- organise relevant information clearly and coherently, using specialist vocabulary when appropriate (minimum of 4 from cracking/ isomerisation/ reforming/ renewable/ feedstock/ finite/fermentation/non-renewable/sustainable/zeolite/bimetallic catalyst/ etc)
 - reasonable spelling, punctuation and grammar throughout 1

[11]

- W = water/aqueous/aqueous ethanol 1
- solvent X = ethanol/alcohol 1

[5]

23. (a) C_6H_{14} 1

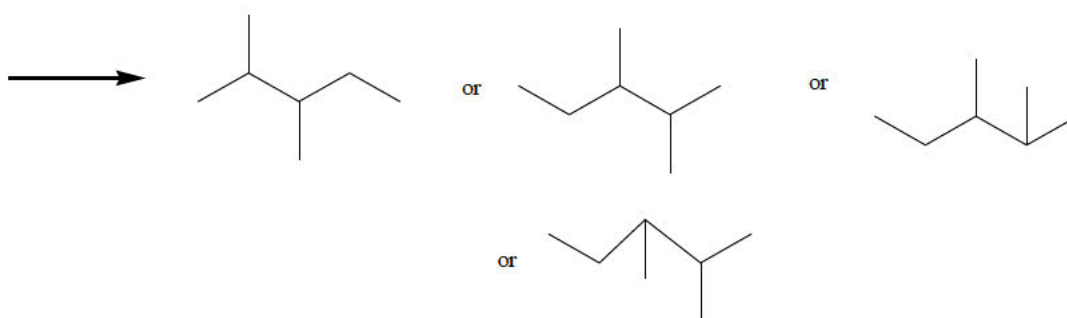
- (b) (i) boiling point increases with increase in M_R /molecular formula/ N° of carbon atoms/chain length 1
- (ii) more intermolecular forces/electrons/surface area/
surface interactions/van der Waal forces 1
- (iii) 120 – 130 °C 1

[4]

24. (i) $C_9H_{20} \longrightarrow C_7H_{16} + C_2H_4$ 1
- (ii) $C_2H_4 + H_2O \longrightarrow C_2H_5OH$ 1
- temperature > 100 °C/ steam 1
- phosphoric acid (catalyst) 1

[4]

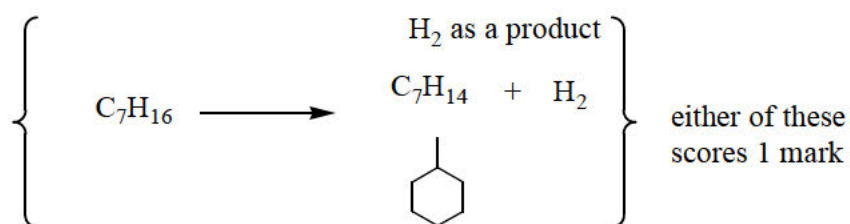
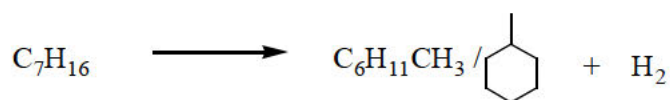
25. (a) (i) 1



- (ii) 85 – 98 °C 1

2

(b)



- (c) more efficient fuel/better fuel/ higher octane number/reduces

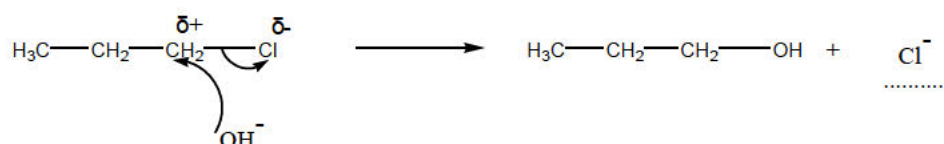
knocking/more volatile/lower boiling points/burn better/burn more easily/quicker ✓

1

[5]

26. (a) (i) reaction 1 1
 (ii) reaction 4 1
 (iii) reaction 3 1

- (b) (i) lone pair/electron pair donor 1



Correct dipole 1

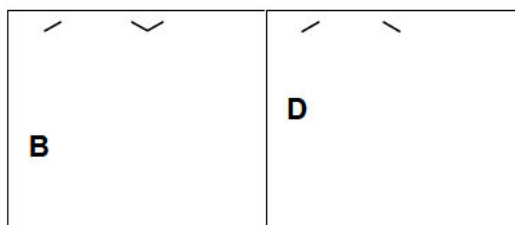
Curly arrow from the O in the OH⁻ to C in the CH₂ 1

Curly arrow to show movement of bonded pair in the C-Cl bond 1

Cl⁻ as a product 1

- (c) (i) same molecular formula, different structure/arrangement of atoms. (same formula, different structure.) 2

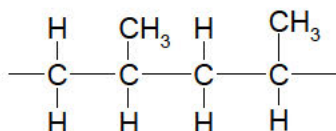
- (ii) 2



- (d) (i) addition, (not additional) 1

- (ii) poly(propene)/ polypropene/ polypro-1-ene, polypropylene 1

- (iii) 1



[15]

27. (i) homolytic ✓ 1
- (ii) $\text{Cl}_2 \rightarrow 2\text{Cl}\bullet$ (need $\bullet$ on the Cl... penalise only once in the 3 equations) ✓ 1
- (iii) I $(\text{C}_5\text{H}_{10}) + \underline{\text{Cl}\bullet} \rightarrow (\bullet\text{C}_5\text{H}_9) + \underline{\text{HCl}}$ ✓ 1
- II $(\bullet\text{C}_5\text{H}_9) + \underline{\text{Cl}_2} \rightarrow \underline{\text{C}_5\text{H}_9\text{Cl}} + \underline{\text{Cl}\bullet}$ ✓ 1

[4]

28. Variation in boiling points. (max = 4 marks)

As chain length increases, boiling point increases ✓ 1

due to increased number of electrons/ surface area/ more van der Waals forces /
intermolecular forces/ more surface interactions ✓ 1

As branching increases, boiling point decreases ✓ 1

straight chains can pack closer together/ straight chains have greater surface area/ ✓ 1

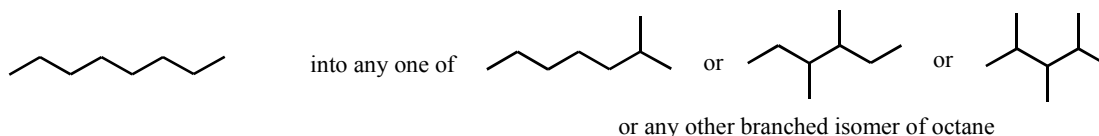
more van der Waals forces /more intermolecular forces/ more surface interactions

Isomerisation

(max = 4 marks)

(produces) branched chain alkanes ✓ 1

equation to illustrate any isomerisation (of octane) ✓ 1



Branched chains are better/more efficient fuels/used as additives ✓ 1

because they are more volatile/easier to ignite/burn more easily/higher octane
number(rating)/lower boiling points/reduces knocking (pinking) ✓ 1

QWC mark

- use of suitable chemical terms such as van der Waals, intermolecular forces/
intermolecular bonds/volatile/ knocking/ pinking/pre-ignition
- reasonable spelling, punctuation and grammar throughout ✓ 1

[9]