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 ✓

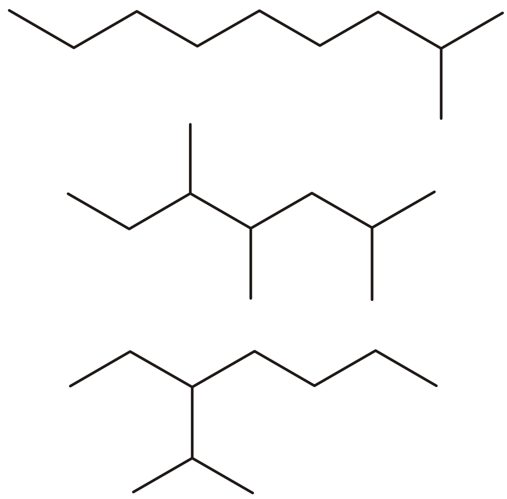
DO NOT ALLOW deceane

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 chain 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) $C_{10}H_{22} + 15½O_2 \longrightarrow 10CO_2 + 11H_2O$

***ALLOW** any correct multiple*
***IGNORE** state symbols*

All **four** species correct ✓

balancing of four correct species ✓

2

(ii) $N_2 + O_2 \longrightarrow 2NO$ ✓

***ALLOW** any correct multiple including fractions*
***IGNORE** state symbols*

The mark is for the equation
***IGNORE** writing*

1

[3]

4. (i) $CH_4 + Br_2 \longrightarrow CH_3Br + HBr$ ✓

__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) $Br_2 \rightarrow 2Br$
OR homolytic fission of bromine ✓

$Br + CH_4 \rightarrow HBr + CH_3$ ✓
$CH_3 + Br_2 \rightarrow CH_3Br + Br$ ✓

$Br + CH_3 \rightarrow CH_3Br$
OR $Br + Br \rightarrow Br_2$ ✓

Ethane made when two methyl radicals react
OR $CH_3 + CH_3 \rightarrow C_2H_6$ ✓

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) $Cl + O_3 \rightarrow ClO + O_2$ ✓
$ClO + O \rightarrow Cl + O_2$ ✓
overall: $O_3 + O \rightarrow 2O_2$ ✓

OR

$Cl + CH_4 \rightarrow CH_3 + HCl$ ✓
$CH_3 + Cl_2 \rightarrow CH_3Cl + Cl$ ✓
overall: $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ ✓

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
$Cl + O_3 \rightarrow ClO + O_2$ ✓
$ClO + O_3 \rightarrow Cl + 2O_2$ ✓
overall: $2O_3 \rightarrow 3O_2$ ✓

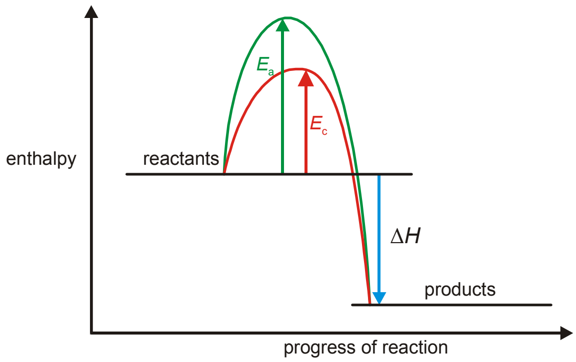
ALLOW *any saturated hydrocarbon including cyclic*
ALLOW *ecf for second step and overall reaction if wrong hydrocarbon used e.g.* C_2H_4 *is used in first step*

3

(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

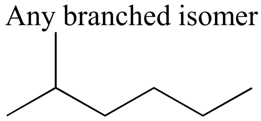
(ii) boiling point increases with increase in *M*r/molecular formula/number of carbon atoms/chain length **(1)**
more intermolecular forces/electrons/surface area/
surface interactions/van der Waal forces **(1)**□ 2

[3]

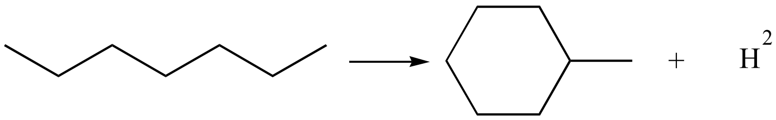
10. $C_9H_{20} \rightarrow C_7H_{16} + C_2H_4$ **(1)**

[1]

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



2-methylhexane **(1)** 2

(ii)  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) $C_4H_{10} + Cl\bullet$ **(1)** $\rightarrow C_4H_9\bullet + HCl$ **(1)**

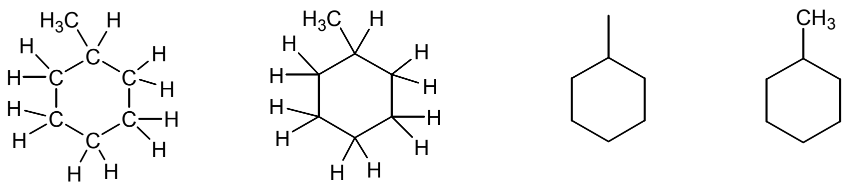
$C_4H_9\bullet + Cl_2$ **(1)** $\rightarrow C_4H_9Cl + Cl\bullet$ **(1)** 2

[5]

13. separation by (differences in) boiling point 1

$C_7H_{16} \rightarrow C_4H_{10} + C_3H_6$ 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

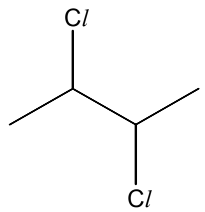
$\bullet C_4H_9/C_4H_9\bullet + Cl_2 \rightarrow C_4H_9Cl + Cl\bullet$ 1

(iii) any two free radicals from (a) (ii) 1

(iv) homolytic (fission) 1

(b) (i) 2, 3-dichlorobutane 1

(ii) 1

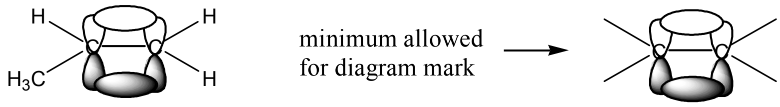


(iii) any dichlorobutane **except** 2,3-dichlorobutane. 1

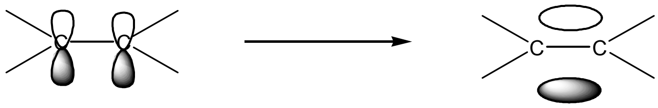
[9]

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



or



Shape/bond angles:

tetrahedral around the CH_3 1

bond angle = 109°28/ (109-110°) 1

trigonal planar around each C in the C=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 C=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

suitable balanced equation with H_2 1

(balanced equation showing formation of a ring scores both marks) 1

isomerisation suitable balanced equation

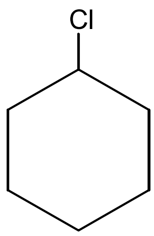
The **processed products** are: 1

- used in fuels/used in petrol
- better /more efficient fuels/increase octane number/rating
- alkenes (from cracking) produce polymers/alcohols
- H_2 used for Haber process/fuels/hydrogenation of oils 3

QWC SPAG – look for two complete sentence that present a coherent argument 1

[9]

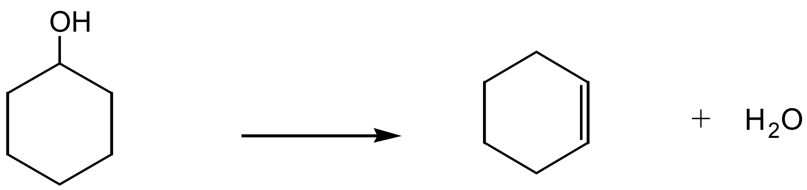
18. (a) (i) 1



(ii) H_2SO_4/Al_2O_3/(hot) pumice/H_3PO_4 1

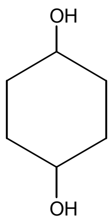
(H_2SO_4(aq) or dil H_2SO_4 loses the mark)

(iii) 1



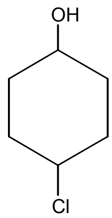
$C_6H_{11}OH$ / $C_6H_{12}O \rightarrow C_6H_{10} + H_2O$

(b) (i) 1



diol

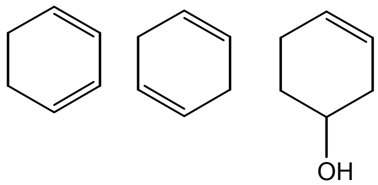
also allow



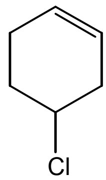
Cl-alcohol

(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)

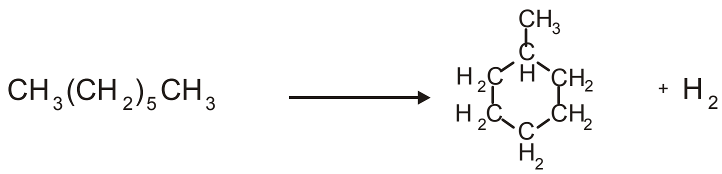
1 mark for correct reagent and 1 mark for correct product. 2

(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

gets 2 marks

gets 2 marks



gets 2 marks

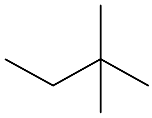
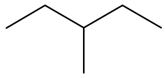
$C_7H_{16} \longrightarrow C_7H_{14} + H_2$ gets 1 marks

[16]

20. (a) octane, 400 +/- 5 1
hexadecane. 545 +/- 5 1
if °C penalise once.

(b) fractional distillation 1

(c) (i)

 ✓  ✓

2

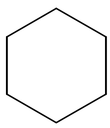
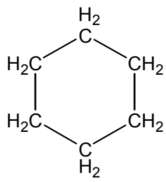
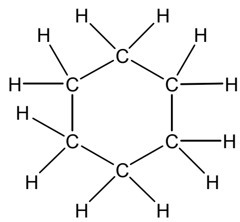
(ii) 2-methylpentane 1

(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) <u>better</u> fuels/<u>more</u> volatile/<u>lower</u> boiling point/reduces knocking/ increases octane rating/used as (petrol) additives 1

(e) (i) M_r of $(CH_3)_3COH = 74$ 1

% oxygen = (16/74) × 100 = 21.6 % 1

(ii) $(CH_3)_3COH + 6O_2 \rightarrow 4CO_2 + 5H_2O$

1 mark for CO_2 and H_2O only 2

[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 catayst/ 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

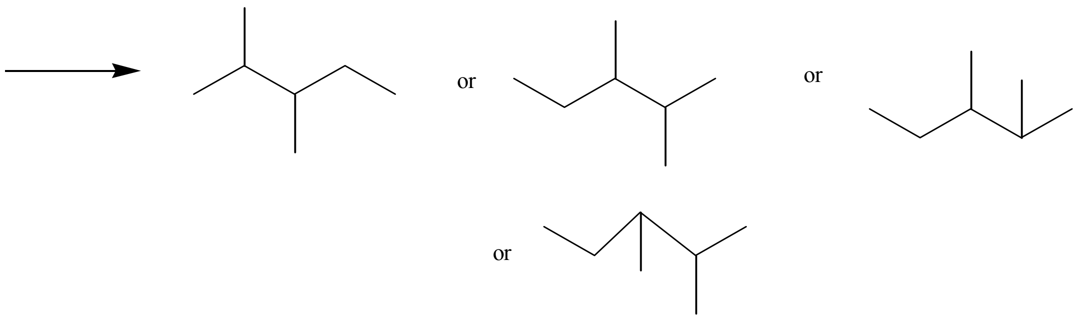
(ii) $C_2H_4 + H_2O \longrightarrow C_2H_5OH$ 1

temperature > 100 °C/ steam 1

phosphoric acid (catalyst) 1

[4]

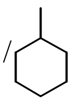
25. (a) (i) 1



(ii) 85 –98 °C 1

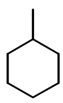
2

(b)

$C_7H_{16} \longrightarrow C_6H_{11}CH_3$ /  + H_2

H_2 as a product

$C_7H_{16} \longrightarrow C_7H_{14} + H_2$



either of these scores 1 mark

(c) more efficient fuel/better fuel/ higher octane number/reduces knocking/more volatile/lower boiling points/burn better/burn more easily/quicker ✓ 1

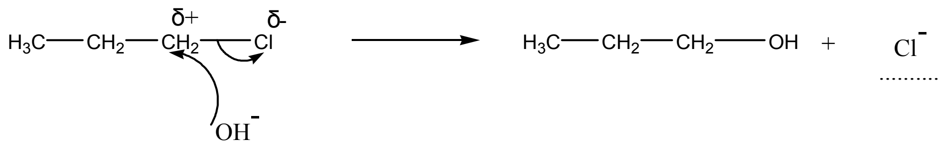
[5]

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

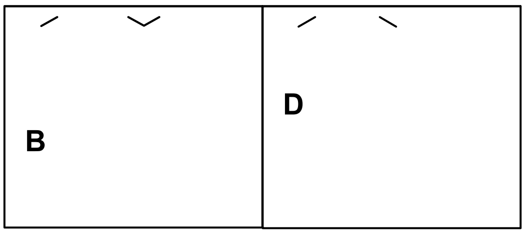
Curly arrow from the O in the OH^- to C in the CH_2 1

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

C*l*$^-$ as a product 1

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

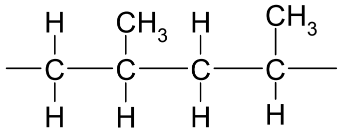
(ii) 2



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

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

(iii) 1



[15]

27. (i) homolytic ✓ 1

(ii) $Cl_2 \rightarrow 2Cl\bullet$ *(need • on the Cl… penalise only once in the 3 equations)* ✓ 1

(iii) I $(C_5H_{10}) + \underline{Cl\bullet} \rightarrow (\bullet C_5H_9) + \underline{HCl}$ ✓ 1

II $(\bullet C_5H_9) + \underline{Cl_2} \rightarrow \underline{C_5H_9Cl} + \underline{Cl\bullet}$ ✓ 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

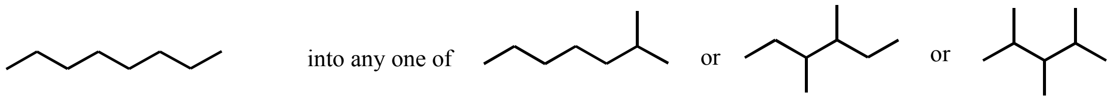
straight chains can pack closer together/ straight chains have greater surface area/ ✓ 1

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



or any other branched isomer of octane

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]