1. (a) (i) fractional distillation or fractionation 1

(ii) C_9H_{20} only 1

(iii) $C_{11}H_{24} + 17O_2 \rightarrow 11CO_2 + 12H_2O$ 1

(iv) $C_{11}H_{24} + 6O_2 \rightarrow 11C + 12H_2O$ 1

(b) (1) $C_{10}H_{22} \rightarrow C_3H_6 + C_7H_{16}$ 1

(ii) correctly drawn structure of methylpropene 1
(insist on clearly drawn C-C and C=C bonds)

(c) Any two from 2
- o chemically similar or chemically the same or react in the same way
- o same functional group
- o same general formula
- o differ by CH_2

(penalise same molecular formula or same empirical formula)

[8]

2. (a) (i) any two from:
show a gradation/trend/gradual change in physical properties/
a specified property
differ by CH_2
chemically similar or react in the same way
have the same functional group 2
(penalise 'same molecular formula')
(penalise 'same empirical formula')

(ii) fractional distillation or fractionation 1

(iii) contains only single bonds or has no double bonds

(credit 'every carbon is bonded to four other atoms' provided
it does not contradict by suggesting that this will always be H) 1

(b) (i) the molecular formula gives the actual number of atoms of each
element/type in a molecule/hydrocarbon/compound/formula 1
(penalise 'amount of atoms')
(penalise 'ratio of atoms')

(ii) $C_{14}H_{30}$ only 1
(penalise as a contradiction if correct answer is accompanied by other structural formulae)

(iii) $C_{10}H_{22} + 5½O_2 \rightarrow 10C + 11H_2O$ 1
(or double this equation)

(c) (i) $\frac{1}{2}N_2 + \frac{1}{2}O_2 \rightarrow NO$ 1
(or double this equation)

(ii) Platinum or palladium or rhodium 1

(iii) $2CO + 2NO \rightarrow 2CO_2 + N_2$ or

$2NO \rightarrow N_2 + O_2$ or
(ignore extra O_2 molecules provided the equation balances)

$C + 2NO \rightarrow CO_2 + N_2$
(or half of each of these equations)

$C_8H_{18} + 25NO \rightarrow 8CO_2 + 12\frac{1}{2}N_2 + 9H_2O$ 1
(or double this equation)

[10]

3. (a) C 22.24/12 = 1.85 H 3.71/1 = 3.71 Br 74.05/79.9 = 0.927 **(1)**
ratio C:H:Br = 2:4:1 $\therefore C_2H_4Br$ **(1)**
empirical mass = 107.9 $\therefore$ mol formula = 215.8/107.9 × $C_2H_4Br = C_4H_8Br_2$ **(1)**

must use % to justify answer

or
C (22.24/100) × 215.8 = 47.99 i.e. 48/12 = 4 carbon atoms **(1)**
H (3.71/100) × 215.8 = 8.01 i.e. 8/1 = 8 hydrogen atoms **(1)**
Br (74.05/100) × 215.8 = 159.8 i.e. 159.8/79.9 = 2 bromine atoms **(1)**

or
C (48/215.8) × 100 = 22.24% **(1)**
H (8/215.8) × 100 = 3.71 % **(1)**
Br (159.8/215.8) × 100 = 74.05% **(1)** 3

(b) **any two pairs of marks**

1,1-dibromo-(2-)methylpropane **(1)**
graphical formula to suit $(CH_3)_2CHCHBr_2$ **(1)**
1,2-dibromo-(2-)methylpropane **(1)**
graphical formula to suit $(CH_3)_2C(Br)CH_2Br$ **(1)**
1,3-dibromo-(2)-methylpropane **(1)**
graphical formula to suit $BrCH_2CH(CH_3)CH_2Br$ **(1)**
allow unambiguous names

mark name and structure independently
accept order of bromo / methyl reversed
penalise once for each of
numbering from wrong end and di in dibromo omitted max 4

[7]

4. (a) 2-bromo-3-methylbutane

correct spelling each of bromo, methyl and butane **(1)**
for numbers – 2 & 3 either order **(1)** 2

(b) compounds with the same molecular formula / compounds or molecules with the same number and type of atoms
not atoms or elements instead of compounds **(1)**

different structural formulae / different arrangement of atoms / different structures / different graphical (displayed) formulae / functional groups in different places **(1)** 2

[4]

5. 1(-)bromobutane 1

correct structure for 1-bromo-2-methylpropane 1
(C–C bonds must be clear where drawn)

[2]

6. (a) (i) compounds/mixtures/alkanes/hydrocarbons/molecules with a boiling point range/similar boiling point/similar number of carbon atoms/similar chain length; 1
(insist on "similar" rather than "same")
(ignore references to size or M_r)
(penalise references to bond breaking/cracking as contradictions)

(ii) molecules have different boiling points/intermolecular forces/sizes/chain lengths/M_r; 1
(ignore references to melting points)
(credit the idea that molecules condense at different temperatures)

(iii) the column has a higher temperature at the base *(Q of L mark)*

OR

the column has a lower temperature at the top; 1
(the statement needs to be expressed in good English and show a clear understanding of the correct temperature difference)
(penalise "negative OR positive temperature gradient" without qualification to what the candidate means, otherwise ignore)
(ignore references to the boiling points of the molecules) (credit correct statements which use specific temperatures with a maximum temperature of 500 °C at the base)

(b) (i) $C_8H_{18} + 8\frac{1}{2} O_2 \rightarrow 8CO + 9H_2O$; 1

(or double this equation)

(ii) correctly drawn structure of 2,2,3-trimethylpentane 1

(penalise the use of 'sticks' once on the paper, including the structures in the 2(a)(ii) and 2(c)(iii)mechanisms) (credit correctly condensed structures)

(c) cracking produces/makes ethene/propene/alkenes/motor fuels/petrol

OR

cracking makes more useful products/high(er) value products

OR

cracking satisfies the high demand for small(er) products; 1

(ignore the idea that cracking makes or leads to plastics or polyethene) (high demand needs to be qualified)

(d) zeolite

OR

aluminosilicate OR $A1_2O_31$; 1

(e) alkene(s); 1

(credit "small or short chain alkenes")
(penalise "cycloalkenes")
(penalise additional types of compounds (e.g. branched alkanes) as a contradiction)
(do not credit examples or formulae, but ignore if these are correct and in addition to the word "alkene")

[8]

7. (a) $C_{15}H_{32} + 23\ O_2 \rightarrow 15\ CO_2 + 16\ H_2O$

Products (1)
Balance (1)
If wrong reactant C.E

(b) Identity of product: CO or carbon monoxide **(1)**

Equation: $CH_4 + \frac{3}{4} O_2 \rightarrow CO + 2\ H_2O$ **(1)**

Any balanced equation using CH_4, producing CO
Not could also make C + CO_2

[4]

8. (a) Crude oil is heated to vaporise it / **oil vaporised (1)**
(Vapour passed into fractionating) tower / column **(1)**
Top of tower cooler than bottom
or **negative temperature gradient (1)**
fractions separated by b.p
OR condensed at different temperatures OR levels
OR low boiling fractions at the top
OR at the top small molecules or light components (1) max 3

(b) (i) Identify shortfall in supply - e.g. petrol / small molecules **(1)**
Higher value products **OR more useful products (1)**
OR cracking produces more of material (problem solving)

(ii) Motor fuels
Aromatic hydrocarbons
Branched alkanes / hydrocarbons
Cycloalkanes
Any two (2)
Ignore specific fractions, alkanes, shorter alkanes, penalise alkenes, and hydrogen

4

(c) *Catalyst*: Zeolite / aluminosilicate **(1)**
Conditions: High temp OR around 450 °C [300 – 600] °C **NOT heat / warm (1)**
Slight pressure [> 1 atm ≤ 10 atm **OR 1 megaPa, 1000 kPa] (1)**
NOT high pressure

3

[10]

9. (a) (i) Kerosine or parafin **(1)**

(ii) Boiling point **(1)** 2

(b) (i) $C_{19}H_{40}$ **(1)**

(ii) $C_{16}H_{34} \rightarrow 2C_2H_4 + C_3H_6 + C_9H_{20}$
or $C_{16}H_{34} \rightarrow 4C_2H_4 + 2C_3H_6 + C_2H_6$ **(2)** 4

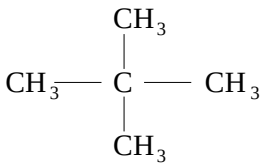
[5]

10. but-1-ene **(1)**

[1]

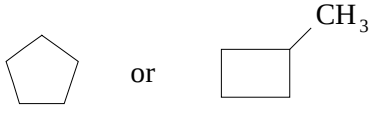
11. (a) petrochemicals **(1)**
Kerosine or paraffin **(1)**
Power stations or ships **(1)** 3

(b) (i)



(1)

(ii) 2



(1)

(c) (i) C_8H_{18} **(1)**

(ii) $C_{12}H_{26}$ **(1)** 2

[7]

12. (a) (i) Gas oil or diesel **(1)**

(ii) $C_{16}H_{34}$ **(1)** $\rightarrow C_8H_{18} + 2C_3H_6 + C_2H_4$ eq^n **(1)**

(iii) To produce polymers **(1)** 4

(b) (i) large surface area **(1)**
faster reaction **(1)**

(ii) $C_8H_{18} + 25NO \rightarrow 8CO_2 + 9H_2O + 12½N_2$ **(2)** 4

[8]

13. (a) Missing fraction = naphtha *(allow naphtha from list if not quoted separately*) **(1)** Order = mineral oil (lubricating oil), gas oil (diesel),

kerosene (paraffin),
naphtha, petrol (gasoline) **(1)**
Mark order consequential on M1 (if no missing fraction given, M2 = 0) Accept correct reversed order

Negative temperature gradient on the column
or temperature of column decreases upwards **(1)**

Larger molecules **or** heavier fractions condense at higher temperatures **or** lower down the column **or** reference to different boiling points (*ignore mp*) **(1)** 4

(b) Type of mechanism = (free) radical / homolytic fission **- used in complete sentence phrase (1)**

$C_{21}H_{44} \rightarrow 3\ C_2H_4 + 2\ C_3H_6 + C_9H_{20}$ **correct alkenes (1)**
Accept CH_2CH_2 & CH_2CHCH_3 **all correct (1)** 3

(c) (i) Sulphur (containing impurities) burn to form **or** forms SO_2 **or** correct oxides of sulphur *(if oxide identified, must be correct)* **(1)**
OR equation: e.g. $S + O_2 \rightarrow SO_2$ **or** $H_2S + 1½O_2 \rightarrow SO_2 + H_2O$

Leading to acid rain (*must have specified oxides of S **or burning***)
or toxic product **or** respiratory problems **(1)**

(ii) NO formed by reaction between N_2 and O_2 from the air **(1)**
OR $N_2 + O_2 \rightarrow 2NO$
High combustion temperature **or** spark in engine **(1)**
provides E_A **or** sufficient heat / energy to break N≡N **(1)**

(iii) Need to remove NO as forms acid rain **or** toxic product **or** causes respiratory problems **(1)**
$2NO + O_2 \rightarrow 2NO_2$ **(1)**
$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ **(1)**

Need to remove CO as it is poisonous **(1)**

Catalytic converter **(1)**
uses Pt / Rh / Pd / Ir (*wrong answer cancels a correct one*) **(1)**
Provides active sites / reduces E_A **(1)**
Forms $N_2 + CO_2$ **(1)**
$2NO + 2CO \rightarrow N_2 + 2CO_2$ (*correct equation worth last 2 marks*) **(1)** Max 10

[17]

14. (a) pollutants: CO **(1)**
NO or NO_2 **(1)**
unburned hydrocarbons **(1)**

CO from incomplete combustion **(1)**
eg $C_8H_{18} + 8\frac{1}{2} O_2 \rightarrow 8CO + 9H_2O$ (eq^n 1)
NO from $N_2 + O_2 \rightarrow 2NO$ **(1)**
spark **(1)** max 7

removal: reaction between NO_x and CO or C_xH_y
to form harmless products **(1)**

eq^n : $2NO + 2CO \rightarrow N_2 + 2CO_2$ **(2)**
$C_8H_{18} + 25NO \rightarrow 8CO_2 + 9H_2O + 12\frac{1}{2}N_2$ **(2)**

one of Pt/Rh/Pd catalyst **(1)** max 4

(b) Demand for heavy fraction: low or for petrol: high **(1)**
Supply of heavy fraction: high or of petrol: low **(1)**
larger Mr are less volatile/have higher bp **(1)**
due to stronger intermolecular forces **(1)** 4

[15]

15. Cracking **(1)**

radical mechanism **(1)**

Any two equations e.g $C_{10}H_{22} \rightarrow C_2H_4 + C_8H_{18}$

$C_{10}H_{22} \rightarrow 2C_2H_4 + C_6H_{14}$ **(2)**

$C_{10}H_{22}$ or larger alkanes: low demand/high abundance/less useful **(1)**

C_2H_4 or smaller alkanes: high demand/low abundance/more useful **(1)**

Uses: ethene to make polymers/plastics/ethanol **(1)**

octane or smaller alkanes - for petrol or fuels **(1)** 8

[8]

16. (a) heated / vaporised / boiled

passed into column / tower

condense at different heights / liquefy at different heights

similar molecules (size, bp, mass) condense together / **(1)**
small molecules at the top and big molecules at the bottom 4

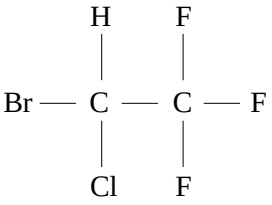
(b) larger **(1)**

reduces decomposition **(1)** 2

(c) (i) hexane or valid isomers **(1)**
propene **(1)** 2

(ii) C_3H_6 **(1)** 1

(d) $CHCl_3$ **(1)**
$C_2HBrClF_3$ or correct structural formula **(1)**



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[11]