M1. (a) Single bonds only /no double or multiple bonds;

1

Contains carbon and hydrogen only;

C and H only
not C and H molecules

1

Alkanes;

1

(b) (1) Fractions or hydrocarbons or compounds have different boiling points/ separation depends on bp;

Ignore mp and vdw

1

(2) bp depends on size/ M_r/ chain length;

If refer to bond breaking/cracking/ blast furnace/oxygen/air 2 max

1

(3) Temp gradient in tower or column / cooler at top of column or vice versa;

QWC

1

(4) Higher bp / larger or heavier molecules at bottom (of column) or vice versa;

Not increasing size of fraction
Not gases at top

1

(c) Large molecules or compounds or long chain hydrocarbons (broken) into smaller molecules or compounds or smaller chain hydrocarbons;

QWC

1

Zeolite or aluminosilicate (catalyst);

1

$C_{14}H_{30} \rightarrow C_8H_{18} + C_6H_{12}$;

Only

1

Smaller chain molecules are in more demand or have higher value or vice versa;

Insufficient to say more useful/have more uses

1

(d) $C_8H_{18} + 8½\ O_2 \rightarrow 8CO + 9H_2O$;

Allow multiples

1

Rh/ Pd/Pt/Ir or in words;

Penalise contradiction of name and symbol

1

$2CO + 2NO \rightarrow 2CO_2 + N_2$ / $2CO + O_2 \rightarrow 2CO_2$;

Allow multiples

1

Greenhouse gas/ absorbs infrared radiation;

1

(e) car less powerful/ car stops/ reduced performance/ won't run smoothly/ can't accelerate;

Not incomplete combustion or bad effect on engine

Not doesn't go as far.

1

Test it (before sale) /Quality control etc;

1

(f) (compounds with) same molecular formula / same no and type of atoms;

Not atoms/elements with same molecular formula.
If same <u>*chemical*</u> *formula, can allow M2*

1

And different structure/ structural formula;

M2 consequential on M1
Allow displayed formula for M2

1

2,2,4-trimethylpentane;

Only (but allow numbers in any order)

1

[20]

M2. (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)**
Type of mechanism: Carbocation / heterolytic fission **(1)**
Conditions: High temp OR around 450 °C [300 – 600] °C **NOT heat / warm (1)**
Slight pressure [> 1 atm $\leq$ 10 atm **OR 1 megaPa, 1000 kPa] (1)**

NOT high pressure

4

[11]

M3. (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** 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 $N\equiv N$ **(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]

M4. (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

(penalise 'same molecular formula')

(penalise 'same empirical formula')

2

(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

(penalise 'amount of atoms')

(penalise 'ratio of atoms')

1

(ii) $C_{14}H_{30}$ only

(penalise as a contradiction if correct answer is accompanied by other structural formulae)

1

(iii) $C_{10}H_{22} + 5\frac{1}{2}O_2 \rightarrow 10C + 11H_2O$

(or double this equation)

1

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

(or double this equation)

1

(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)

$C_8H_{18} + 25NO \rightarrow 8CO_2 + 12\frac{1}{2}N_2 + 9H_2O$

(or double this equation)

1

[10]