M1. (a) (i) $C_8H_{18} + 8½O_2 \rightarrow 8CO + 9H_2O$ **(1)**

OR double this equation

(ii) *Condition*: Spark OR <u>high</u> T OR T = 2500 – 4000 °C **(1)**

Equation: $N_2 + O_2 \rightarrow 2NO$ **(1)**

OR half this equation

3

(b) (i) platinum OR rhodium OR palladium **(1)**

(ii) $2CO + 2NO \rightarrow N_2 + 2CO_2$ **(1)**

OR half this equation

2

(c) *Reason for SO_2 in exhaust gases*: fraction / petrol / fuels <u>contain sulphur</u> or <u>sulphur-containing</u> impurities (which burn to give SO_2) **(1)**

Environmental effect SO_2: acid rain OR a specific effect **(1)**

NOT greenhouse effect
NOT damages ozone layer

2

[7]

M2. (a) (i) A molecule/compound/it consists/it is composed/it is made up of hydrogen/H and carbon/C <u>only</u> **(1)**

QoL

(ii) release (heat) <u>energy</u> (when burned) **(1)**
OR provides a (useable form of) <u>energy</u>
OR is a source of <u>energy</u>

Accept heat ≡ energy
<u>NOT</u> is energy / is heat
NOT burns exothermically

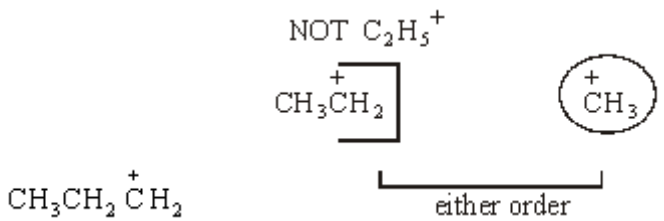
(iii) $C_4H_{10} + 6½O_2 \rightarrow 4CO_2 + 5H_2O$ **(1)**
OR $2C_4H_{10} + 13\ O_2 \rightarrow 8CO_2 + 10H_2O$
ignore state symbols

(iv) $C_4H_{10} + 4½O_2 \rightarrow 4CO + 5H_2O$ **(1)**
OR $2C_4H_{10} + 9O_2 \rightarrow 8CO + 10H_2O$
ignore state symbols
(iii) and (iv) if not C_4H_{10} = CE

(v) Limited or reduced supply of air / oxygen **(1)**
OR low temperature OR poor mixing
OR insufficient oxygen / air OR shortage of O_2
NOT no oxygen / lack of oxygen / not in excess

5

(b) *Structure 1* *Structure 2* *Structure 3*



allow credit for positive charge around C atom
no alternative carbocations allowed

2

(c) (i) C_2H_6 / $CH_3CH_3 \rightarrow CH_2{=}CH_2$ / $H_2C{=}CH_2$ / $C_2H_4 + H_2$ / CH_2CH_2
NOT $CH_2.CH_2$

(ii) Al_2O_3 OR Zeoli(y)te OR aluminosilicate **(1)**
NOT bauxite
ignore SiO_2
NOT Aluminium Silicate
NOT porous pot
NOT SiO_2 alone

(iii) More useful / needed fuels / products OR implied

OR more valuable products

OR <u>qualified</u> demand exeeds supply

OR to produce motor fuels OR petrol OR cycloalkanes OR aromatic hydrocarbons OR balanced alkanes OR smaller molecules OR alkenes

3

[10]

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 <u>column</u>
or temperature of <u>column</u> 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) <u>burn</u> to form **or** <u>forms</u> 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 <u>break</u> 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]