

- M1.**
- (a) (i) Prevents release of toxic CO
More energy efficient (releases more energy on combustion) 1
- (ii) $C_6H_{14} + 6.5O_2 \rightarrow 6CO + 7H_2O$ 1
- Suitable product eg CO or C 1
- Balanced equation 1
- (iii) Detect CO gas or C (soot or particles) in exhaust gases 1
- (b) $CH_3CH_2CH_2CH(CH_3)_2$ 1
- 2-methylpentane 1
- $CH_3CH_2CH(CH_3)CH_2CH_3$ etc 1
- (c) (i) $CH_3CH_2CH_2CH=CH_2$ 1
- (ii) Alumino silicate etc 1
- (iii) Can be made into polymers (or alcohols etc) 1
- (d) (i) % atom economy = mass CH_2Cl_2 /total mass
reactants = $85 \times 100/158$ 1

= 53.8%

1

- (ii) Because expensive chlorine is not incorporated into desired product Raise money by selling HCl

1

[14]

- M2.** (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

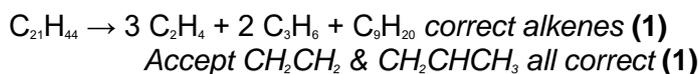
Negative temperature gradient on the column
or temperature of column decreases upwards (1)

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)



3

- (c) (i) Sulphur (containing impurities) burn to form or forms SO₂ or oxides of sulphur (*if oxide identified, must be correct*) (1)
OR equation: e.g. S + O₂ → SO₂ or H₂S + 1½O₂ → SO₂ + H₂O

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]

- M3.** (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 [$> 1 \text{ atm} \leq 10 \text{ atm}$ OR **1 megaPa, 1000 kPa**] (1)
NOT high pressure

4

[11]

- M4.** (a) (i) A molecule/compound/it consists/it is composed/it is made up of
hydrogen/H and carbon/C only (1)
QoL

- (ii) release (heat) energy (when burned) (1)
OR provides a (useable form of) energy
OR is a source of energy
Accept heat \equiv energy
NOT is energy / is heat
NOT burns exothermically

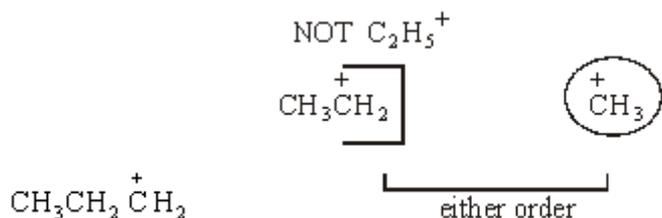
- (iii) $\text{C}_4\text{H}_{10} + 6\frac{1}{2}\text{O}_2 \rightarrow 4\text{CO}_2 + 5\text{H}_2\text{O}$ (1)
OR $2\text{C}_4\text{H}_{10} + 13 \text{O}_2 \rightarrow 8\text{CO}_2 + 10\text{H}_2\text{O}$
ignore state symbols

- (iv) $\text{C}_4\text{H}_{10} + 4\frac{1}{2}\text{O}_2 \rightarrow 4\text{CO} + 5\text{H}_2\text{O}$ (1)
OR $2\text{C}_4\text{H}_{10} + 9\text{O}_2 \rightarrow 8\text{CO} + 10\text{H}_2\text{O}$
ignore state symbols
(iii) and (iv) if not $\text{C}_4\text{H}_{10} = \text{CE}$

- (v) Limited or reduced supply of air / oxygen **(1)**
 OR low temperature OR poor mixing
 OR insufficient oxygen / air OR shortage of O₂
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) C₂H₆ / CH₃CH₃ → CH₂=CH₂ / H₂C=CH₂ / C₂H₄ + H₂ / CH₂CH₂

NOT CH₂.CH₂

- (ii) Al₂O₃ OR Zeoli(y)te OR aluminosilicate **(1)**

NOT bauxite

ignore SiO₂

NOT Aluminium Silicate

NOT porous pot

NOT SiO₂ alone

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

OR more valuable products

OR qualified demand exceeds supply

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

3

[10]

