M1. (a) $C_{16}H_{34} + 24.5O_2 \rightarrow 16CO_2 + 17H_2O$

Allow multiples

Ignore state symbols in equation

1

(b) Solidifies/freezes/goes viscous/waxing occurs

Allow does not vapourise/less volatile

Lack of Oxygen = 0

Apply list principle

1

(c) (i) $N_2 + O_2 \rightarrow 2NO$

Allow multiples/Ignore state symbols in equation

1

Spark/(very) high temp/2500 °C – 4000 °C

Ignore pressure/catalyst/low % of oxygen

Not just heat/hot

Apply list principle eg if high temp 150 °C = 0

1

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

Allow multiples/Ignore state symbols in equation

OR

$C_8H_{18} + 25NO \rightarrow 8CO_2 + 12.5\ N_2 + 9H_2O$

Allow other alkane reacting with NO in correctly balanced equation

OR

$C + 2NO \rightarrow CO_2 + N_2$

OR

$2NO \rightarrow N_2 + O_2$

1

Pt/Pd/Rh/Ir

Penalise contradiction of name and symbol

1

(iii) $4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$

Allow multiples/Ignore state symbols in equation

1

(d) (i) High temp/

anywhere in range 400 °C – 900 °C/

anywhere in range 670-1200K/high pressure/anywhere in range 5000 kPa up to 8000 kPa/

Not catalyst/heat

1

(ii) $C_{16}H_{34} \rightarrow C_6H_{14} + 2C_4H_8 + C_2H_4$

Or $C_{16}H_{34} \rightarrow C_6H_{14} + C_4H_8 + 3C_2H_4$

Do not allow multiples

Ignore state symbols in equation

1

(iii) Polymers/plastics/named polymer

Allow polyesters or polyamides

Ignore object made from polymer

1

[10]

M2. (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) $C_{10}H_{22} + 5½O_2 \rightarrow 10C + 11H_2O$

(or double this equation)

1

(c) (i) $½N_2 + ½O_2 \rightarrow NO$

(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)

$C_8H_{18} + 25NO \rightarrow 8CO_2 + 12½N_2 + 9H_2O$

(or double this equation)

1

[10]

M3. (a) (i) Covalent;

If not covalent CE = 0.
If blank, mark on.

1

Shared <u>pair of electrons</u> (one from each atom);

Not shared electrons.

1

(ii) Hydrogen bonds / H bonds;

Not just hydrogen.

1

Van der Waals/London/dispersion forces/temporary induced dipole;

1

(b) Showing all the lone pairs on both molecules;

Allow showing both lone pairs on the O involved in the H-bond.

1

Showing the partial charges on O and H on both molecules;

Allow showing both partial charges on the O and H of the other molecule involved in the H bond.

1

Showing the Hydrogen bond from the lone pair on O of one molecule to the delta + on the H of the other molecule;

1

(c) (i) $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$;

Accept multiples.
Allow C_2H_6O.

1

(ii) CO is (produced which is) toxic/ poisonous/C (may be produced) which is toxic/ C is a respiratory irritant/ C (particles) exacerbate asthma/C causes global dimming/ smog;

Must relate to C or CO.
Any mention of SO_2 NO_2 or other pollutants CE = 0.

1

(iii) More fuel needed (which costs more)/Wastes fuel/ less fuel burnt (so need more to buy more)/engine gets sooty so need to pay for engine to be cleaned/Have to fit catalytic converter;

Not just costs more.
Not engine gets sooty unless qualified.

1

(d) (i) (React) with CaO/ calcium oxide/quicklime/lime;

Accept $CaCO_3$/ calcium carbonate/limestone.
Not chalk.

1

All the sulfur dioxide may not react with the CaO or $CaCO_3$ / may not have time to react/ incomplete reaction;

Accept incomplete reaction.

1

(ii) Occupies a (much) smaller volume;

Not easier to store or transport.

1

[13]

M4. (a) (i) single (C-C) bonds only/no double (C=C) bonds

1

Allow all carbon atoms bonded to four other atoms
Single C-H bonds only = 0
C=H CE

C and H (atoms) only/purely/solely/entirely

Not consists or comprises
Not completely filled with hydrogen
CH molecules = CE
Element containing C and H = CE

1

(ii) C_nH_{2n+2}

Formula only
C_xH_{2x+2}

1

(b) (i) $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$

Accept multiples
Ignore state symbols

1

(ii) gases produced are greenhouse gases/contribute to Global warming/effect of global warming/climate change

Allow CO_2 or water is greenhouse gas/causes global warming
Acid rain/ozone CE = 0

1

(c) carbon

Allow C
Allow soot

1

(d) (i) $C_9H_{20} \rightarrow C_5H_{12} + C_4H_8$

OR

$C_9H_{20} \rightarrow C_5H_{12} + 2C_2H_4$

Accept multiples

1

(ii) Plastics, polymers

Accept any polyalkene/haloalkanes/alcohols

1

(iii) so the bonds break ***OR*** because the bonds are strong

IMF mentioned = 0

1

(e) (i) 1,4-dibromo-1-chloropentane/1-chloro-1,4-dibromopentane

Ignore punctuation

1

(ii) Chain/position/positional

Not structural or branched alone

1

[11]

M5. (a) O = 74.1%

1

$\frac{25.9}{14}$ $\frac{74.1}{16}$

If atomic numbers or molecular masses are used lose M2

1

1.85 4.63
1 2.5
N_2O_5

1

This ratio alone will not score the final mark. (It would get 2)
Allow 3 marks for N_2O_5

(b) Toxic/poisonous/<u>forms</u> an acidic gas/forms NO_2 which is acidic/ respiratory irritant/forms HNO_3 when NO reacts with <u>water and oxygen</u>/ triggers asthma attacks/greenhouse gas/photochemical smog/ contributes to global warming/formation of acid rain

ignore NO is an acidic gas or NO is acidic in water
Not references to ozone layer

1

(c) $2NO + O_2 \rightarrow 2NO_2$

Accept multiples or fractions of equation
Ignore wrong state symbols

1

(d) Nitrogen/N_2 and oxygen/O_2 combine/react

QWC (not N and O combine)
Not nitrogen in fuel

Allow $N_2 + O_2 \rightarrow 2NO$ for M1 only

1

spark/high temperature/2500-4000 °C

1

(e) $2NO + 2CO \rightarrow N_2 + 2CO_2$

OR

$2NO \rightarrow N_2 + O_2$

Accept multiples or fractions of equation
Ignore wrong state symbols
Allow $C_8H_{18} + 25NO \rightarrow 8CO_2 + 12.5N_2 + 9H_2O$

1

[8]

M6. (a) (i) $C_4H_{10} + 6\frac{1}{2}O_2 \rightarrow 4CO_2 + 5H_2O$

Allow multiples

1

(ii) insufficient oxygen/low temperature/poor mixing of butane and air

Allow insufficient air
Allow lack or oxygen/air
Do not allow no oxygen
Not incomplete combustion

1

(b) (i) Sulfur dioxide/SO_2

Allow sulfur trioxide/SO_3
(allow spelling of sulphur to be sulphur)

1

(ii) It is basic/the gas (SO_2) is acidic

Idea of neutralisation
It = calcium oxide

1

(iii) bigger surface area to react

Do not allow cheaper

1

[5]