M1. (a) (i) C_nH_{2n} / C_xH_{2x}

1

(ii) <u>Fractional distillation</u> / GLC / gas liquid chromatography / fractionation
*Do **not** allow cracking / distillation*

1

(b) (i) But-1-ene / but1ene
Ignore hyphens and commas
*Do **not** allow butene-1 / but-2-ene / butane / butane /alkene / C_4H_8 / propene / straight-chain alkene*

1

(ii) A structure of cyclobutane or
methyl-cyclopropane
Allow skeletal formula.

1

(c) (i) $C_{15}H_{32} \rightarrow 2C_4H_8 + C_7H_{16}$
Do not accept multiples.

1

(ii) Thermal cracking
Not catalytic cracking or cracking.

1

To produce products that are in greater demand / more valuable / more expensive / more profitable
The (unsaturated) alkene or the (unsaturated) molecule or X produced can be polymerised or can be made into plastics.
Ignore more useful products.

1

(iii) Break (C–C or C–H) bonds

Allow to overcome the activation energy.
Allow to break the carbon chain.
Penalise breaking wrong bonds.

1

(d) (i)   <u>H</u>$_2$

Only.

1

(ii)   Fuel / LPG
Allow camping gas, lighter fuel, propellant, refrigerant, cordless appliances.
Do not allow petrol or motor fuel.
Ignore natural gas.

1

(iii) $C_4H_{10} + 2.5O_2 \rightarrow 4C + 5H_2O$
Accept multiples.

1

(iv) SO_2 / sulfur dioxide
If other sulfur oxides, mark on.

1

Calcium oxide / CaO / lime / quicklime
Allow CaCO$_3$ / allow Ca(OH)$_2$ or names.
Allow any solid base.
M2 dependent on M1.
Do not allow limewater.

1

(v)   Neutralisation
Allow acid-base reaction.
Allow flue gas desulfurisation / FGD

1

(e)   (Molecules) are similar sizes / have similar M_r / have similar number of electrons

Chemical error CE = 0/2 if breaking bonds.

Allow similar number of carbon and hydrogen atoms / similar surface area / similar chain length.

Can accept same number of carbon atoms.

Do not accept same number of H atoms / same number of bonds.

Ignore similar amount of bonds.

1

Similar van der Waals forces <u>between molecules</u> / similar <u>intermolecular</u> forces (IMF)

Not similar incorrect IMF eg dipole-dipole

1

[16]

M2. (a) (i) **M1** **(could be scored by a correct mathematical expression which** <u>**must**</u> **have**
<u>**all**</u> ΔH**symbols and the $\sum$ or SUM)**

M1 $\underline{\Delta H_r} = \Sigma\Delta H_f$ **(products)** - $\Sigma\Delta H_f$ **(reactants)**

OR a <u>correct cycle of balanced equations with 1C, 3H$_2$ and 1O$_2$</u>

M2 $\underline{\Delta H_r} = - 201 + (- 242) - (- 394)$
$\underline{\Delta H_r} = - 201 - 242 + 394$
$\underline{\Delta H_r} = - 443 + 394$
(This also scores M1)

M3 $= - 49$ (kJ mol^{-1})
(Award 1 mark ONLY for + 49)

Correct answer gains full marks

Credit 1 mark ONLY for + 49 (kJ mol^{-1})

For other incorrect or incomplete answers, proceed as follows

• *check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (**M1** and **M2**)*

• *If no AE, check for a correct method; this requires either*
correct cycle of balanced equations with 1C, 3H$_2$ and 1O$_2$

*OR a clear statement of **M1** which could be in words and*
*scores only **M1***

3

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(ii)   It is an element / elemental

    Ignore reference to "standard state"

    OR

    By definition

    1

(b)   **M1** (The yield) increases / goes up / gets more

    *If M1 is given as "decreases" / "no effect" / "no change" then CE= 0 for clip, but mark on only **M2** and **M3** from a blank M1*

    M2   There are <u>more moles / molecules</u> (of gas) on the <u>left</u> / of reactants
    OR   <u>fewer moles / molecules</u> (of gas) on the <u>right</u>
    / products
    OR   there are <u>4 moles /molecules</u> (of gas) on the <u>left</u> and <u>2 moles / molecules</u> on the right.
    OR   (equilibrium) shifts / moves <u>to the side with less moles / molecules</u>

    *Ignore "volumes", "particles" "atoms" and "species" for **M2***

    M3: Can only score M3 if <u>M2 is correct</u>

    The (position of) <u>equilibrium shifts / moves</u> (from left to right) to <u>oppose the increase in pressure</u>

    *For **M3**, <u>not</u> simply "to oppose the change"*

    *For **M3** credit the <u>equilibrium shifts / moves</u> (to right) to <u>lower / decrease the pressure</u>*

    (There must be a <u>specific</u> reference to the change that is opposed)

    3

(c)   **M1**   Yield increases goes up

    M2   The (forward) reaction / to the right is <u>endothermic</u> OR <u>takes in/ absorbs heat</u>

        OR

    The reverse reaction / to the left is <u>exothermic</u> OR <u>gives out / releases heat</u>

    *If M1 is given as "decrease" / "no effect" / "no change" then CE= 0 for clip, but mark on only **M2** and **M3** from a blank **M1***

    Can only score M3 <u>if M2 is correct</u>

    M3 The (position of) <u>equilibrium shifts / moves</u> (from left to right) <u>to oppose the increase</u>
    <u>in temperature</u> **(QoL)**

Page 5

*For **M3**, not simply "to oppose the change"*
*For **M3**, credit the (position of) equilibrium shifts / moves*
(QoL)
*to absorb the heat **OR***
*to cool the reaction **OR***
to lower the temperature
(There must be a specific reference to the change that is opposed)

3

(d)   (i)   An activity which has no net / overall (annual) carbon emissions to the atmosphere
OR
An activity which has no net / overall (annual) greenhouse gas emissions to the atmosphere.
OR
There is no change in the total amount / level of carbon dioxide /CO_2 carbon /greenhouse gas present in the atmosphere.

The idea that the carbon /CO_2 given out equals the carbon /CO_2 that was taken in from the atmosphere

1
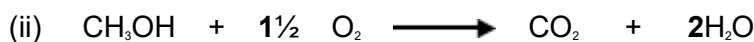
(ii) CH_3OH +   **1½** O_2 ⟶ CO_2 +   **2**H_2O
Ignore state symbols
Accept multiples

1

(iii)   **3**H_2 +   **1½** O_2 ⟶   **3**H_2O
Ignore state symbols

OR

Accept multiples
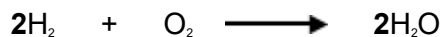
2H_2 + O_2 ⟶   **2**H_2O
Extra species must be crossed through

1

(e)   **M1** $q = m c \Delta T$
Award full marks for correct answer
Ignore the case for each letter

OR $q = 140 × 4.18 × 7.5$

M2 $= 4389$ (J) OR 4.389 (kJ) OR 4.39 (kJ) OR 4.4 (kJ)(also scores M1)

M3   Using 0.0110 mol
therefore ΔH = **– 399** (kJmol⁻¹)
OR **– 400**

> *Penalise **M3** ONLY if correct numerical answer but sign is incorrect; +399 **gains 2 marks***
>
> *Penalise **M2** for arithmetic error and mark on*
>
> *In **M1**, do not penalise incorrect cases in the formula*
>
> *If ΔT = 280.5; score q = m c ΔT only*
>
> *If c = 4.81 (leads to 5050.5) penalise **M2** ONLY and mark on for **M3** = – 459*

+399 or +400 gains 2 marks

> *Ignore incorrect units*

3

[16]

M3.   (a) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

> *Accept multiples*
>
> *Ignore state symbols even if incorrect*

1

Not enough oxygen / air

1

CMM / methane is a greenhouse gas / contributes
to global warming

> *Do not allow formation of CO_2 / CO_2 is a greenhouse gas*
>
> *Apply list principle, eg*
>
> *CH_4 is a greenhouse gas and toxic = 0*
>
> *CH_4 is a greenhouse gas and damages ozone = 0*
>
> *Allow CH_4 and CO_2 are greenhouses gases*
>
> *Allow collect to use as a fuel so fossil fuels do not run out (as quickly)*

1

(b) $CH_3SH + 3O_2 \rightarrow CO_2 + 2H_2O + SO_2$

> *Accept multiples*
>
> *Ignore state symbols even if incorrect*

1

Calcium oxide is basic (and SO_2 is acidic) /

CaO neutralises SO_2 /

CaO reacts with SO_2 to form gypsum / salt / solid /
$CaSO_4$ / $CaSO_3$

Allow CaO + $SO_2 \rightarrow CaSO_3$

M2 and M3 can only be scored if SO_2 seen somewhere in the answer

1

Acid rain

*Allow consequence of acid rain eg increased rusting of iron /
fish in lakes die / problems for asthmatics*

Apply list principle
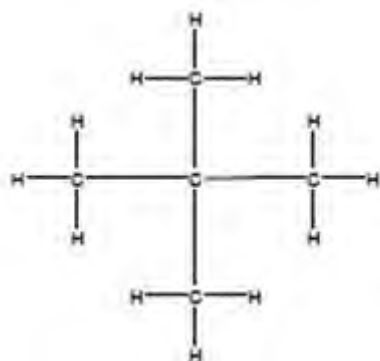
Ignore air pollution

1

[6]

M4. (a) $C_n H_{2n+2}$

Allow x in place of n

1

(b)

<u>Chain</u>

Must show every bond

Allow branched chain

2

(c) C_9H_{20}

Only

1

To break the (C-C and/or C-H) bonds

> *M2=0 if break C=C*

1

To make products which are in greater demand / higher value / make alkenes

> *Not more useful products*
> *Allow specific answers relating to question*

1

(d) $C_5H_{12} + 3O_2 \rightarrow 5C + 6H_2O$

> *Allow other balanced equations which give C and CO/CO$_2$*

1

Causes global dimming / exacerbates asthma / causes breathing problems / makes visibility poor / smog

> *Apply list principle*
> *Ignore causes cancer / toxic*

1

(e) $\dfrac{106.5}{143}$ (x 100)

1

74.48%

> *Allow 74.5%*

1

3

> *Only*

1

(f)   2,3-dichloro-3-methylpentane

> *Ignore punctuation*

1

C_3H_6Cl

> *Only*

1

[13]

M5.(a)   (i) $C_8H_{18} + 8\frac{1}{2} O_2 \rightarrow 8CO + 9H_2O$

Accept multiples

1

(ii)   Not enough oxygen or air (available for complete combustion) /lack of oxygen or air / too much octane

Ignore poor ventilation, low temp, poor mixing, incomplete combustion

1

(b)   (i) $2CO + 2NO \rightarrow 2CO_2 + N_2$

Allow multiples

1

(ii)   Pt / Pd / Rh / Ir or names

Apply list principle

1

Big(ger) surface area / increased reaction rate / removes more of the gases /ensures complete reaction

Allow (ceramic) withstands high temperatures

1

(c)   (i)   Acid rain

Allow consequence of acid rain

Ignore greenhouse gas / global warming / ozone

1

(ii)   CaO/ lime / $CaCO_3$ /limestone

Allow chemical names

1

Neutralises the gas or words to that effect/it is basic/ SO_2 is acidic

Allow 'reacts with it' or 'it is alkaline'

Ignore 'absorb'

1

[8]