

- M1. (a) (i) C_nH_{2n} / C_xH_{2x} 1
- (ii) Fractional distillation / 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) $\underline{\text{H}_2}$

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) $\text{C}_4\text{H}_{10} + 2.5\text{O}_2 \rightarrow 4\text{C} + 5\text{H}_2\text{O}$

Accept multiples.

1

(iv) SO_2 / sulfur dioxide

If other sulfur oxides, mark on.

1

Calcium oxide / CaO / lime / quicklime

Allow CaCO_3 / allow $\text{Ca}(\text{OH})_2$ 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 between molecules / similar intermolecular forces (IMF)

Not similar incorrect IMF eg dipole-dipole

1

[16]

M2. (a) (i) **M1 (could be scored by a correct mathematical expression which must have**

all ΔH symbols and the Σ or SUM)

M1 $\Delta H_r = \Sigma \Delta H_f$ (products) - $\Sigma \Delta H_f$ (reactants)

OR a correct cycle of balanced equations with 1C, 3H₂ and 1O₂

M2 $\Delta H_r = -201 + (-242) - (-394)$

$\Delta H_r = -201 - 242 + 394$

$\Delta H_r = -443 + 394$

(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, 3H₂ and 1O₂

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

scores only M1

3

- (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 more moles / molecules (of gas) on the left / of reactants
OR fewer moles / molecules (of gas) on the right
/ products

OR there are 4 moles /molecules (of gas) on the left and 2 moles / molecules on the right.

OR (equilibrium) shifts / moves to the side with less moles / molecules
*Ignore "volumes", "particles" "atoms" and "species" for **M2***

M3: Can only score M3 if M2 is correct

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

*For **M3**, not simply "to oppose the change"*

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

(There must be a specific reference to the change that is opposed)

3

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

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

OR

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

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 if M2 is correct

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

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

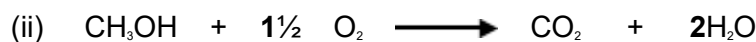
An activity which has no net / overall (annual) greenhouse gas emissions to the atmosphere.

OR

There is no change in the total amount / level of carbon dioxide /CO₂ carbon /greenhouse gas present in the atmosphere.

The idea that the carbon /CO₂ given out equals the carbon /CO₂ that was taken in from the atmosphere

1



Ignore state symbols

Accept multiples

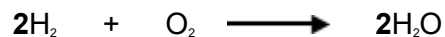
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Ignore state symbols

OR

Accept multiples



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 $q = 140 \times 4.18 \times 7.5$

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

M3 Using 0.0110 mol
therefore $\Delta H = -399$ (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 $\Delta T = 280.5$; score $q = m c \Delta T$ 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) $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$

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) $\text{CH}_3\text{SH} + 3\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + \text{SO}_2$

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 SO₂ to form gypsum / salt / solid /
CaSO₄ / CaSO₃

Allow CaO + SO₂ → CaSO₃

M2 and M3 can only be scored if SO₂ 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

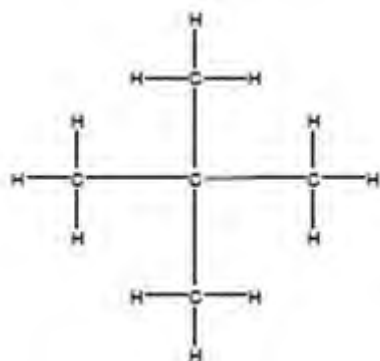
[6]

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

Allow x in place of n

1

(b)



Chain

Must show every bond

Allow branched chain

2

(c) C₉H₂₀

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



Allow other balanced equations which give C and CO/CO₂

1

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

Apply list principle

Ignore causes cancer / toxic

1

(e) $\frac{106.5}{143} \times 100$

1

74.48%

Allow 74.5%

1

3

Only

1

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

Ignore punctuation

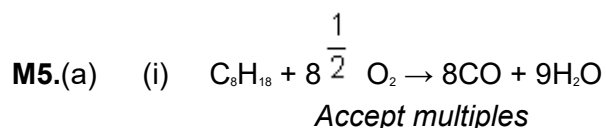
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C₅H₆Cl₂

Only

1

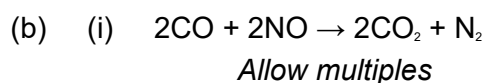
[13]



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



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 / CaCO₃ /limestone
Allow chemical names

1

Neutralises the gas or words to that effect/it is basic/ SO₂ is acidic
Allow 'reacts with it' or 'it is alkaline'

Ignore 'absorb'

1

[8]