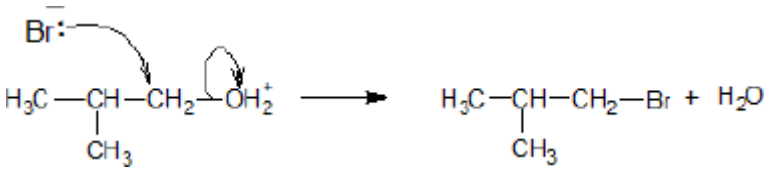
M1.(a) (i) **M1** double-headed curly arrow from the lone pair of the bromide ion to the C atom of the CH_2

Penalise additional arrows.

M2 double-headed arrow from the bond to the O atom

As follows



2

(ii) **M1** nucleophilic substitution

***M1** both words needed (allow phonetic spelling).*

M2 1-bromo(-2-)methylpropane

***M2** Require correct spelling in the name but ignore any hyphens or commas.*

2

(b) **M1** hydrolysis

*For **M1** give credit for 'hydration' on this occasion only.*

M2 C≡N with absorption range 2220–2260 (cm^{-1})

*Credit 1 mark from **M2** and **M3** for identifying C≡N **and** either O–H(acids) **or** C=O **or** C–O without reference to wavenumbers or with incorrect wavenumbers.*

M3 O–H(acids) with absorption range 2500–3000 (cm^{-1})

OR

C=O with absorption range 1680–1750 (cm^{-1})

OR

C–O with absorption range 1000–1300 (cm^{-1})

*Apply the list principle to **M3***

3

(c) (i) **M1** Yield / product **OR** ester increases / goes up / gets more

***M2** (By Le Chateliers principle) the position of equilibrium is driven / shifts / moves to the right / L to R / in the forward direction / to the*

product(s)

M3 – requires a correct statement in M2

(The position of equilibrium moves)

to oppose the increased concentration of ethanol

to oppose the increased moles of ethanol

to lower the concentration of ethanol

to oppose the change and decrease the ethanol

*If no reference to **M1**, marks **M2** and **M3** can still score BUT if **M1** is incorrect CE=0*

*If there is reference to 'pressure' award **M1** ONLY.*

3

(ii) ***M1***

Catalysts provide an alternative route / pathway / mechanism

OR

surface adsorption / surface reaction occurs

*For **M1**, not simply 'provides a surface' as the only statement.*

***M1** may be scored by reference to a specific example.*

M2

that has a lower / reduced activation energy

OR

lowers / reduces the activation energy

*Penalise **M2** for reference to an increase in the energy of the molecules.*

*For **M2**, the student may use a definition of activation energy without referring to the term.*

*Reference to an increase in successful collisions in unit time alone is not sufficient for **M2** since it does not explain why this has occurred.*

2

[12]

M2.*(a)* *(i)* *(Compounds with the) same molecular formula*

Allow same number and type of atom for M1

Ignore same general formula.

1

But different structural formula / different displayed formula / different structures / different skeletal formula

M2 dependent on M1

Not different positions of atoms / bonds in space.

1

(ii) *But-2-ene*

Allow but-2-ene.

Allow but 2 ene.

Ignore punctuation.

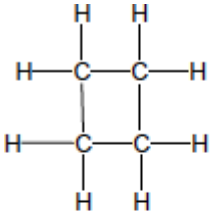
1

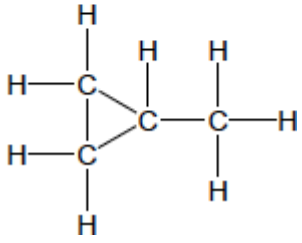
(iii) *(2)-methylprop-(1)-ene*

Do not allow 2-methyleprop-1-ene.

1

(iv)





Do not allow skeletal formulae.

Penalise missing H and missing C

1

(b) *(i)* $C_4H_8 + 2O_2 \rightarrow 4C + 4H_2O$

Accept multiples.

1

(ii) *Exacerbates asthma / breathing problems / damages lungs / smog / smoke / global dimming*

Ignore toxic / pollutant / soot / carcinogen.

Do not allow greenhouse effect / global warming / acid rain / ozone.

1

(c) (i) $C_{16}H_{34}$

Allow $H_{34}C_{16}$

C and H must be upper case.

1

(ii) *Jet fuel / diesel / (motor) fuel / lubricant / petrochemicals / kerosene / paraffin / central heating fuel / fuel oil*

Ignore oil alone.

Not petrol / bitumen / wax / LPG / camping fuel.

1

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

Accept multiples.

1

(ii) *Ir / iridium*

OR

Pt / platinum

OR

Pd / palladium

OR

Rh / rhodium

1

[11]

M3.(a) *2-bromo-2,3-dimethylbutane*

Ignore punctuation.

1

$C_nH_{2n+1}Br$ or $C_nH_{2n+1}X$ or $C_xH_{2x+1}Br$

Any order.

1

Stronger / more <u>vdw</u> (forces) <u>between molecules</u> (of 1-bromohexane)

QoL

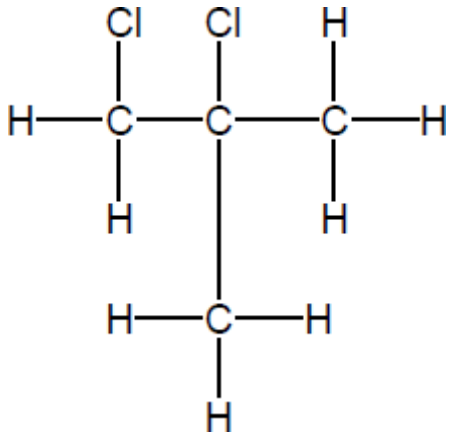
Allow converse arguments for Z

Not just more IMF.

Ignore size of molecule.

1

(b)



1

C_2H_4Cl

Any order

1

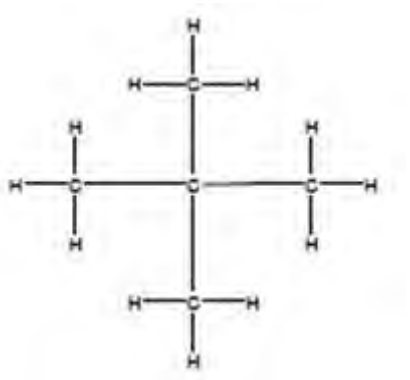
[5]

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) 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) $\frac{106.5}{143}$ *(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_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) $\underline{H_2}$

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) $C_4H_{10} + 2.5O_2 \rightarrow 4C + 5H_2O$

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]