

## Mark schemes

1

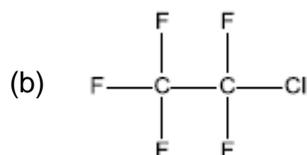
- (a) 2,2,4-trimethylpentane  
*This answer only but ignore punctuation* 1
- (b) M1 (fractional or simple) distillation  
*Incorrect process in M1 CE=0*  
*If M1 blank, mark on for M2 and M3 (ignore boiling, condensing)* 1
- M2 idea that isooctane / the one with the lower boiling point boils (first)  
(or reaches top of column first)  
*Ignore reference to octane boiling and being collected at higher temperature*  
*If temperature referred to, should be between 99 and 124°C*  
*“it” refers to isooctane*  
*M2 – allow vaporises/evaporates first* 1
- M3 idea that isooctane condenses / liquefies and collected  
*Penalise M2 and M3 if octane boils first*  
*In M2 and M3 – if no specific reference to individual alkanes, could score one mark for M2 + M3 combined if M2 and M3 both otherwise correct*  
*M2 and M3 must refer to a laboratory apparatus (not to an industrial process)* 1
- (c)  $C_8H_{18} + 12\frac{1}{2}O_2 \rightarrow 8CO_2 + 9H_2O$   
*Accept multiples; ignore state symbols*  
*Accept any correct structural representation of isooctane* 1
- (d) M1 Alternative route/mechanism/pathway 1
- M2 With lower activation energy  
*Accept  $E_a$  for activation energy* 1
- (e)  $2CO + 2NO \rightarrow 2CO_2 + N_2$   
*Accept multiples; ignore state symbols* 1

- (f) M1 to reduce amount of metals needed / small amount of metal needed  
*Relates to low amount of metal* 1
- M2 Increase / maximise / produce large surface area or to give catalyst a larger surface area: volume ratio or so that high(er) proportion of atoms/metal is on surface  
*Is related to large surface area* 1
- (g) M1 bromine (water or in organic solvent or CCl<sub>4</sub>) / Br<sub>2</sub> (aq) / Br<sub>2</sub>  
*No reagent or an incorrect reagent (e.g. bromide), CE=0;  
Penalise Br (or incorrect formula of other correct reagent) but mark on for M2  
It must be a whole reagent and/or correct formula  
If oxidation state given in name, it must be correct  
If 'manganate' or 'manganate(IV)' or incorrect formula, penalise M1 but mark on  
Ignore 'acidified'* 1
- M2 (orange/yellow to) colourless / decolourised / loses its colour  
*Ignore goes clear  
Ignore brown/red, but penalise other incorrect colours* 1
- Alternatives:  
M1 = potassium manganate(VII), M2 = colourless  
M1 = conc sulfuric acid, M2 = brown  
M1 = iodine, M2 = colourless*

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2

- (a) M1  $\bullet\text{Cl} + \text{O}_3 \rightarrow \bullet\text{ClO} + \text{O}_2$  1
- M2  $\bullet\text{ClO} + \text{O}_3 \rightarrow \bullet\text{Cl} + 2\text{O}_2$  1
- M1 and M2 could be in either order  
Credit the dot anywhere on the radical  
Penalise absence of dot once only  
Individual multiples acceptable but both need to be doubled if two marks are to be awarded  
Ignore state symbols*



*Must be displayed formula*

1

(c) Does not contain Cl or does not release Cl (atoms/radicals)  
or no C-Cl bonds  
or C-F bond(s) strong / does not break / no F (atom/radicals) released

1

(d) M1  $\text{CHF}_2\text{CH}_3 + \bullet\text{F} \rightarrow \bullet\text{CF}_2\text{CH}_3 + \text{HF}$

1

M2  $\bullet\text{CF}_2\text{CH}_3 + \text{F}_2 \rightarrow \text{CF}_3\text{CH}_3 + \bullet\text{F}$

1

*M1 and M2 could be in either order*

*Credit the dot anywhere on the radical*

*Penalise absence of dot once only*

(e) M1 moles  $\text{CF}_3\text{CH}_3 = 1410/84(.0) (=16.8, 16.79 \text{ mol})$

1

M2 molecules =  $M1 \times 6.022 \times 10^{23} = 1.01 \times 10^{25}$  (3sf only)

1

*Correct answer scores both marks*

*Allow M2 for M1  $\times$  Avogadro with answer to 3 sf (but must have attempted to calculate moles for M1)*

*Ignore incorrect units*

(f) (bonds) vibrate/stretch/bend OR (as bonds) are polar  
*NOT polar molecules; 'they' = bonds*

1

[9]

3 A

[1]

4 A

[1]

5 (a) (i) Alkane(s)  
*Ignore  $C_nH_{2n+2}$*

1

(ii)  $C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$   
*Allow multiples*

1

(iii) 2, 2, 4-trimethylpentane

1

(b) (i) But-1-ene  
*Ignore (E or Z)* 1

(ii)  $C_{14}H_{30}$  1

(iii) Thermal  
*If catalytic CE = 0* 1

High pressure / 7000kPa / 70 atms

and

High temperature/temperature in range 400-1000°C (673–1273K)

*(Allow  $\geq 1000$  kPa or  $\geq 10$  atms – no upper value)*

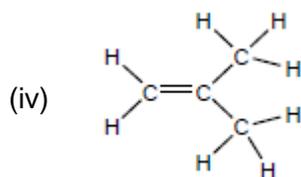
*Allow high temperature and pressure or high pressure and temperature*

*If no units for temperature allow 673-1000*

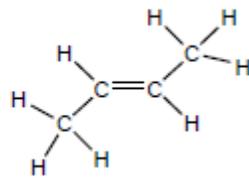
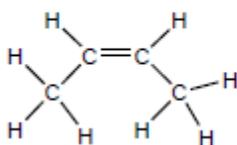
*Must show unambiguous structure*

*Penalise lack of displayed formula once only*

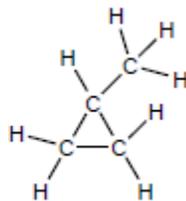
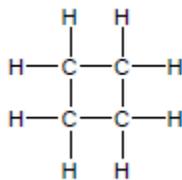
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1



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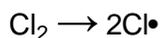
[10]

**6****IGNORE** state symbols**ALLOW** multiples

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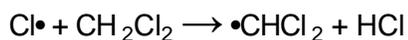
*This answer only*

1

*Penalise absence of dot once only*

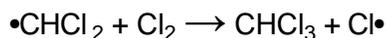
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1st Propagation step

*Penalise + and/or – charges every time*

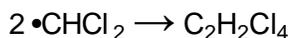
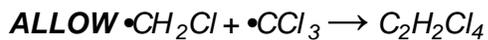
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2nd Propagation step

**ALLOW**  $\cdot$  anywhere on  $\cdot\text{CHCl}_2$  but, if drawn out as a structure, then $\cdot$  must be on C

1

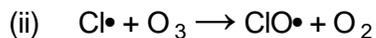
Termination

*Mark independently***IGNORE** state symbols throughout

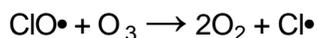
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**ALLOW**  $\cdot$  anywhere on  $\cdot\text{CF}_3$  unless displayed

1

*Equations can be in either order**Penalise absence of  $\cdot$  once only*

1

**ALLOW**  $\cdot$  anywhere on  $\cdot\text{ClO}$ **NOT**  $\cdot\text{O}_3$ 

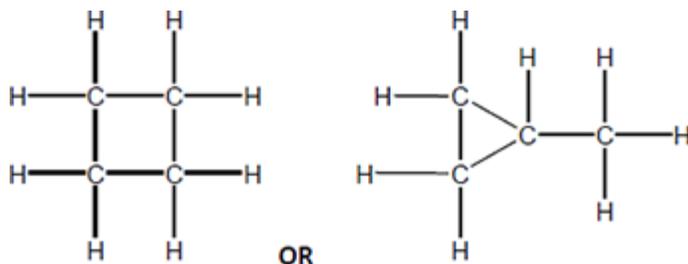
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[9]

**7**

(a) Alkenes

1



Correctly drawn molecule of cyclobutane or methyl cyclopropane,  
need not be displayed formula

1

- (b)  $C_6H_{14}$  (or correct alkane structure with 6 carbons)

Allow hexane or any other correctly named alkane with 6 carbons

1

- (c) Poly(but-2-ene)

1

- (d) High pressure

Allow pressure  $\geq$  MPa

Mention of catalyst loses the mark

1

- (e) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

### Level 3

All stages are covered and the explanation of each stage is generally correct and virtually complete.

Answer communicates the whole process coherently and shows a logical progression from stage 1 and stage 2 (in either order) to stage 3.

5–6 marks

### Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows progression. Some steps in each stage may be out of order and incomplete.

3–4 marks

### Level 1

Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.

1–2 marks

## Level 0

Insufficient correct chemistry to gain a mark.

0 marks

### **Indicative chemistry content**

**Stage 1:** consider effect of higher temperature on yield

(Or vice versa for lower temperature)

- Le Chatelier's principle predicts that equilibrium shifts to oppose any increase in temperature
- Exothermic reaction, so equilibrium shifts in endothermic direction / to the left
- So a Higher T will reduce yield

**Stage 2:** consider effect of higher temperature on rate

(Or vice versa for lower temperature)

- At higher temperature, more high energy molecules
- more collisions have  $E > E_a$
- So rate of reaction increases / time to reach equilibrium decreases

**Stage 3:** conclusion

Industrial conditions chosen to achieve (cost-effective) balance of suitable yield at reasonable rate

[11]

8

D

[1]

9

(a) 2,2,4-trimethylpentane

1

(b) 5

1

(c)  $C_{20}H_{42} \longrightarrow C_8H_{18} + 2C_3H_6 + 3C_2H_4$

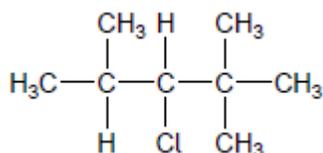
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(d) Mainly alkenes formed

1

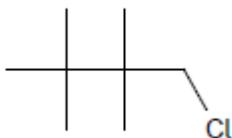
(e) 4 (monochloro isomers)

1



1

(f)



1

- (g)  $C_8H_{17}^{35}Cl = 96.0 + 17.0 + 35.0 = 148.0$   
and  $C_8H_{17}^{37}Cl = 96.0 + 17.0 + 37.0 = 150.0$

*Both required*

1

$$M_r \text{ of this } C_8H_{17}Cl = \frac{(1.5 \times 148.0)}{2.5} + \frac{(1.0 \times 150.0)}{2.5} = 148.8$$

1

- (h)  $\frac{24.6}{12} \quad \frac{2.56}{1} \quad \frac{72.8}{35.5} = 2.05 : 2.56 : 2.05$

$$\text{Simplest ratio} = \frac{2.05}{2.05} : \frac{2.56}{2.05} : \frac{2.05}{2.05}$$

$$= 1 : 1.25 : 1$$

1

$$\text{Whole number ratio } (\times 4) = 4 : 5 : 4$$

1

$$MF = C_8H_{10}Cl_8$$

1

[12]

10

C

[1]