**M1.**(a) Saturated − single bonds only / no double bonds

1

Hydrocarbon − contains carbon and hydrogen (atoms) <u>only</u>

1

(b) $C_{16}H_{34} + 16.5O_2 \longrightarrow 16CO + 17H_2O$

*Allow multiples*

1

(c) (On combustion) $SO_2$ produced

*Allow equation to produce $SO_2$. Ignore sulfur oxides.*

1

Which causes acid rain

*If formula shown it must be correct*

*M2 is dependent on M1. But if M1 is sulfur oxides, allow M2.*

*For M2 allow consequence of acid rain or $SO_2$.*

*Ignore greenhouse effect and toxic*

1

(d) (i) $C_{16}H_{34} \longrightarrow C_8H_{18} + C_2H_4 + 2C_3H_6$

*Allow multiples*

1

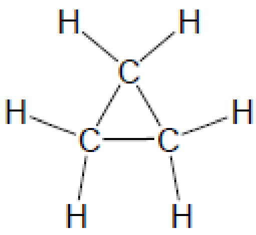
(ii) polypropene / propan(-1 or 2-)ol / propane(-1,2-)diol / isopropanol / propanone / propanal

*Accept alternative names*

*Ignore plastic and polymer*

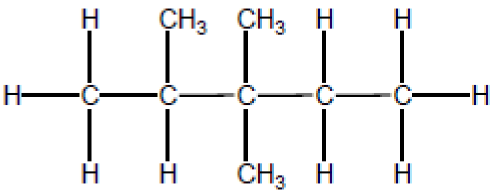
1

(iii)



1

(e)



*Allow any unambiguous representation*

1

(f) 2,4-dichloro-2,4-dimethylhexane

*Only but ignore punctuation*

1

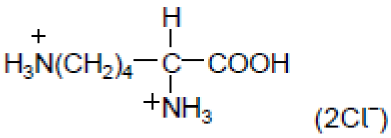
**[10]**

**M2.**(a) <u>2,6-diaminohexanoic acid</u>

*Ignore additional , or – or spaces.*

1

(b) (i)



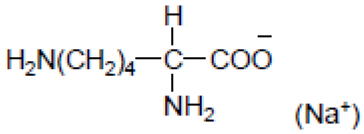
*NB both N must be protonated.*

*Allow* $-NH_3^+$ *allow* $CO_2H$ *Allow* $-^+H_3N$.

*Penalise* $-C_4H_8-$ *here.*

1

(ii)



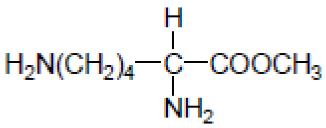
*Allow $CO_2^-$.*

*Allow $-H_2N$.*

*Allow –COONa but penalise O–Na bond shown.*

**1**

(iii)

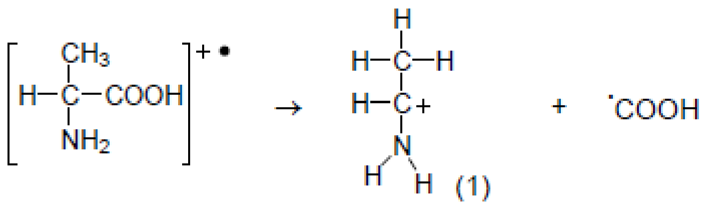


*Allow $CO_2CH_3$.*

*Allow $-NH_3^+$ or $-H_2N$.*

**1**

(c)



*1 for <u>displayed formula</u> of fragment ion.*

*1 for molecular ion of alanine AND radical.*

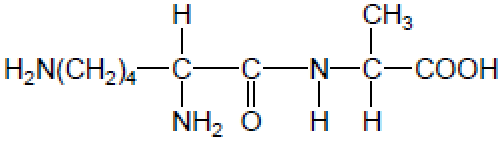
*Allow molecular ion without brackets and fragment ion in brackets with outside +.*

*Allow dot anywhere on radical.*

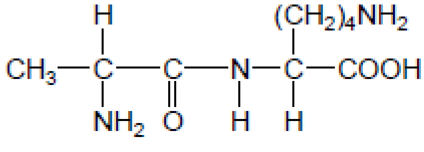
*Allow $[C_3H_7NO_2]^{+\bullet}$ for molecular ion.*

**2**

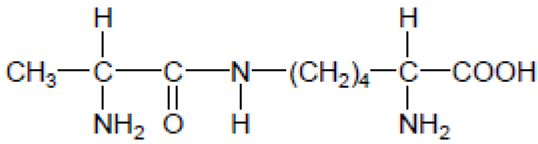
(d)



**OR**



**OR**



*Dipeptide, not repeating unit /.*

*Allow $CO_2H$ Allow $–H_2N$.*

*Allow –CONH–.*

**1**

(e) M1 In acid lysine has double positive or more positive charge

**1**

M2 (Lysine ion) has greater affinity / greater attraction / adheres better / sticks better to polar / stationary phase

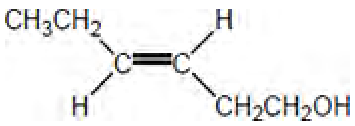
*M2 only scores after a correct M1.*

*Ignore greater retention time.*

**1**

**[9]**

**M3.**(a)



**1**

(b)

**1**

(c) **Stage 1**: consider the groups joined to right hand carbon of the C=C bond

*Extended response*

*Maximum of 5 marks for answers which do not show a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.*

Consider the atomic number of the atoms attached

*M1 can be scored in stage 1 or stage 2*

**1**

C has a higher atomic number than H, so $CH_2OH$ takes priority

1

**Stage 2**: consider the groups joined to LH carbon of the C=C bond

Both groups contain C atoms, so consider atoms one bond further away

1

C, (H and H) from ethyl group has higher atomic number than H, (H and H) from methyl group, so ethyl takes priority

1

**Stage 3**: conclusion

The highest priority groups, ethyl and $CH_2OH$ are on same side of the C=C bond so the isomer is Z

*Allow M5 for correct ECF conclusion using either or both wrong priorities deduced in stages 1 and 2*

1

The rest of the IUPAC name is 3-methylpent-2-en-1-ol

1

(d) Moles of maleic acid = 10.0 / 116.0 = $8.62 \times 10^{-2}$

AND mass of organic product expected = $(8.62 \times 10^{-2}) \times 98.0$ = 8.45 g

Or moles of organic product formed = 6.53 / 98.0 = $6.66 \times 10^{-2}$

1

% yield = 100 × 6.53 / 8.45

OR = $100 \times (6.66 \times 10^{-2}) / (8.62 \times 10^{-2})$

= 77.294 = 77.3%

**AND** statement that the student was NOT correct

1

**[10]**

**M4.**(a) Crude oil **OR** petroleum

*Not petrol.*

1

Fractional distillation / fractionation

*Not distillation alone.*

1

(b) $C_{12}H_{26} + 12.5O_2 \longrightarrow 12CO + 13H_2O$

*Allow balanced equations that produce $CO_2$ in addition to CO.*

*Accept multiples.*

1

(c) (i) M1 Nitrogen and oxygen (from air) react / combine / allow a correct equation

*If nitrogen from petrol / paraffin / impurities CE = 0 / 2.*

1

M2 at high temperatures

*Allow temperatures above 1000 °C or spark.*

*Not just heat or hot.*

*M2 dependent on M1.*

*But allow 1 mark for nitrogen and oxygen together at high temperatures.*

1

(ii) $2NO + O_2 \longrightarrow 2NO_2$

*Allow multiples.*

1

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

*Allow multiples.*

1

(d) (i) $C_nH_{2n+2}$

*Allow $C_xH_{2x+2}$*

CnH2n+2

*Allow CxH2x+2*

**1**

(ii) $C_{12}H_{26} \longrightarrow C_6H_{14} + C_6H_{12}$

*Only.*

**1**

$C_3H_7$

*Only.*

**1**

Zeolite / aluminosilicate(s)

*Ignore aluminium oxide.*

**1**

(iii) Larger molecule / longer carbon chain / more electrons / larger surface area

**1**

More / stronger <u>van der Waals' forces between molecules</u>

*Allow dispersion forces / London forces / temporary induced dipole-dipole forces <u>between molecules.</u>*

*If breaking bonds, CE = 0 / 2.*

**1**

(e) 2,2,3,3,4,4-hexamethylhexane

*Only.*

*Ignore punctuation.*

**1**

Chain

*Ignore branch(ed).*

**1**

(f) $Cl_2$

*Only.*

Cl–Cl

*Not $CL_2$ or Cl2 or CL2 or $Cl^2$ or $CL^2$.*
*Ignore Chlorine.*

**1**

**[16]**

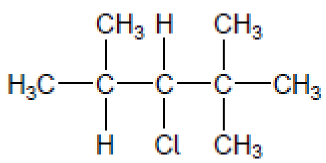
**M5.**(a) 2,2,4-trimethylpentane **1**

(b) 5 **1**

(c) $C_{20}H_{42} \longrightarrow C_8H_{18} + 2C_3H_6 + 3C_2H_4$ **1**

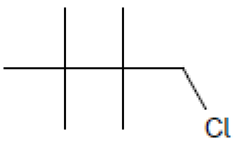
(d) Mainly alkenes formed **1**

(e) 4 (monochloro isomers) **1**



**1**

(f)



**1**

(g) $C_8H_{17}{}^{35}Cl$ = 96.0 + 17.0 + 35.0 = 148.0
<u>and</u> $C_8H_{17}{}^{37}Cl$ = 96.0 + 17.0 + 37.0 = 150.0
*Both required*

1

$M_r$ 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) $\frac{24.6}{12}$ $\frac{2.56}{1}$ $\frac{72.8}{35.5}$ = 2.05 : 2.56 : 2.05

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

= 1 : 1.25 : 1

1

Whole number ratio (× 4) = 4 : 5 : 4

1

MF = $C_8H_{10}Cl_8$

1

[12]