

27 What is the major product when 2-methylpent-2-ene reacts with hydrogen bromide?

- A 1-bromo-2-methylpentane
- B 2-bromo-2-methylpentane
- C 3-bromo-2-methylpentane
- D 4-bromo-2-methylpentane

27 Which intermediate ion forms in the greatest amount during the addition of HBr to propene?

- A $\text{CH}_3\text{CH}^+\text{CH}_3$
- B $\text{CH}_3\text{CH}_2\text{CH}_2^+$
- C $\text{CH}_3\text{CH}^-\text{CH}_2\text{Br}$
- D $\text{CH}_3\text{CHBrCH}_2^-$

28 Two hydrocarbons, $\text{R}-\text{CH}_3$ and $\text{R}'-\text{CH}_3$, react separately with bromine in the presence of ultraviolet light. One of these hydrocarbons is unsaturated.

In each case, free radical substitution reactions occur.

R is $\text{CH}_3\text{CHC}(\text{CH}_3)$.

R' is $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2$.

Which row is correct?

	a propagation stage for the saturated hydrocarbon	a termination stage for the unsaturated hydrocarbon
A	$\text{R}-\text{CH}_2\cdot + \text{Br}\cdot \rightarrow \text{R}-\text{CH}_2\text{Br}$	$\text{R}'-\text{CH}_2\cdot + \text{Br}\cdot \rightarrow \text{R}'-\text{CH}_2\text{Br}$
B	$\text{R}-\text{CH}_2\cdot + \text{Br}_2 \rightarrow \text{R}-\text{CH}_2\text{Br} + \text{Br}\cdot$	$\text{R}'-\text{CH}_2\cdot + \text{Br}_2 \rightarrow \text{R}'-\text{CH}_2\text{Br} + \text{Br}\cdot$
C	$\text{R}'-\text{CH}_3 + \text{Br}\cdot \rightarrow \text{R}'-\text{CH}_2\cdot + \text{HBr}$	$2\text{R}-\text{CH}_2\cdot \rightarrow \text{R}-\text{CH}_2\text{CH}_2-\text{R}$
D	$2\text{R}'-\text{CH}_2\cdot \rightarrow \text{R}'-\text{CH}_2\text{CH}_2-\text{R}'$	$\text{R}-\text{CH}_3 + \text{Br}\cdot \rightarrow \text{R}-\text{CH}_2\cdot + \text{HBr}$

29 The fumes from the exhausts of petrol-burning cars contain the following pollutants.

- 1 unburnt hydrocarbons
- 2 nitrogen dioxide
- 3 carbon monoxide

Which pollutants are removed by oxidation in a catalytic converter?

- A 1, 2 and 3
- B 1 and 2 only
- C 1 and 3 only
- D 2 and 3 only

- 25** Two hydrocarbons, $\text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_3$ and $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$, react separately with chlorine in the presence of ultraviolet light.

In each reaction, free-radical substitution occurs.

Which row is correct?

	identity of the hydrocarbon that can also undergo electrophilic addition	a termination stage of the free-radical substitution of the saturated hydrocarbon
A	$\text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_3$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\cdot + \text{Cl}\cdot \rightarrow \text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{Cl}$
B	$\text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_3$	$\text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_2\cdot + \text{Cl}\cdot \rightarrow \text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_2\text{Cl}$
C	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\cdot + \text{Cl}\cdot \rightarrow \text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{Cl}$
D	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$	$\text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_2\cdot + \text{Cl}\cdot \rightarrow \text{CH}_2\text{CHC}(\text{CH}_3)\text{CH}_2\text{Cl}$

- 3 Cycloalkanes show similar chemical properties to alkanes but have the same empirical formula as alkenes.

(a) Define empirical formula.

.....
 [1]

(b) Cyclopentane, C_5H_{10} , has four cyclic structural isomers. One of these isomers is **C**, shown in Fig. 3.1.

Complete Fig. 3.1 to show two other cyclic structural isomers of C_5H_{10} .

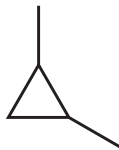
cyclopentane 			C 
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Fig. 3.1

[2]

(c) Cyclopentane reacts with Cl_2 in the presence of ultraviolet light to form C_5H_9Cl .

(i) The reaction is initiated by the bond fission of Cl_2 .

State the type of bond fission shown in the initiation step.

..... [1]

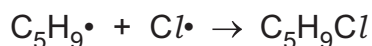
(ii) Complete the equations to show the two propagation steps that follow the initiation step.

propagation 1 $C_5H_{10} + \dots \rightarrow C_5H_9\cdot + \dots$

propagation 2 $C_5H_9\cdot + \dots \rightarrow \dots$

[2]

(iii) The final step is shown.



Give the name for this step in the reaction.

..... [1]

(d) Fig. 3.2 shows a reaction cycle involving cyclopentane, cyclopentene and $\text{C}_5\text{H}_9\text{Cl}$.

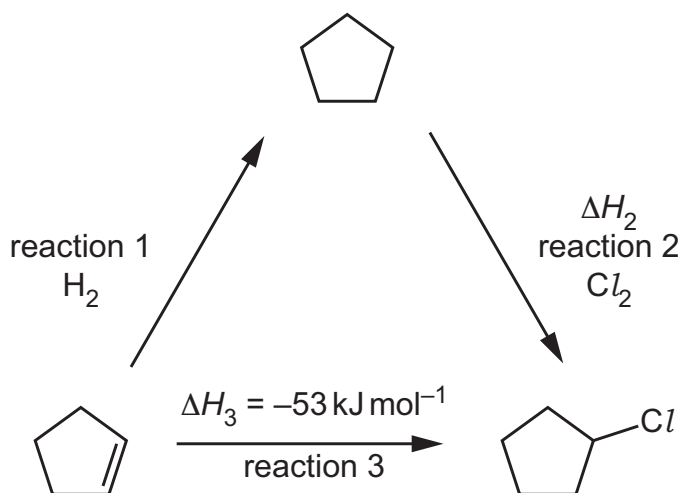


Fig. 3.2

(i) Identify a suitable reagent for reaction 3.

..... [1]

(ii) Use the data in Fig. 3.2 and in Table 3.1 to calculate the enthalpy change of reaction 2, ΔH_2 .

Table 3.1

compound	enthalpy change of combustion, $\Delta H_c / \text{kJ mol}^{-1}$
	-3292
	-3115
H_2	-286

(e) Cyclopentene, C_5H_8 , reacts with hot concentrated acidified $KMnO_4$ to form compound **W**, $C_5H_8O_4$.

(i) Draw the structure of **W**.

[1]

(ii) The infrared spectrum of **W** is shown in Fig. 3.3.

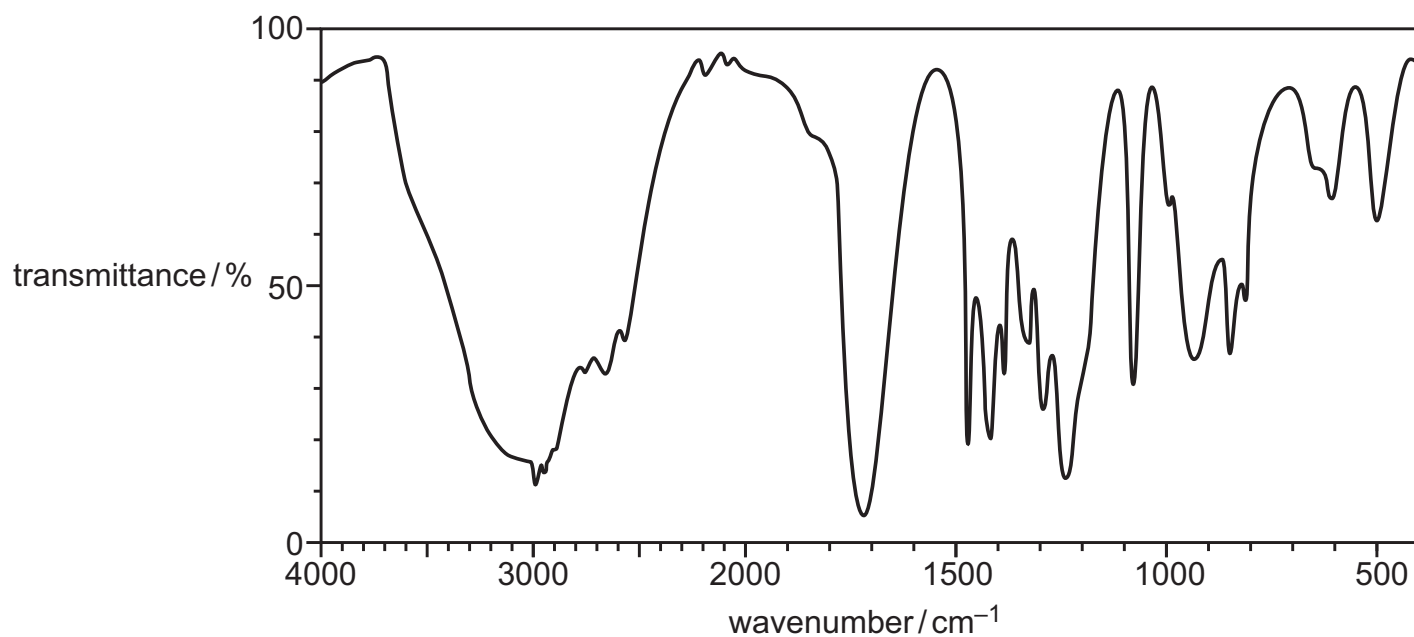


Fig. 3.3

Identify **two** absorptions in the infrared spectrum of **W** that would **not** be present in the infrared spectrum of cyclopentene.

- Write **1** or **2** on Fig. 3.3 against each of these two absorptions.
- Complete Table 3.2 to show which bond is responsible for each absorption that you have identified in Fig. 3.3.

Table 3.2

absorption	1	2
bond responsible		

[2]

Table 3.3

bond	functional groups containing the bond	characteristic infrared absorption range (in wavenumbers)/cm ⁻¹
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C–H	alkane	2850–2950
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

[Total: 13]

- 3 The alkanes are a homologous series of organic molecules. Alkanes are generally unreactive and are commonly used as fuels.

(a) Define homologous series.

.....
..... [2]

(b) Give two reasons to explain the general unreactivity of alkanes.

1
2 [2]

(c) Alkanes with low relative molecular mass, M_r , are more useful than those found in heavier crude oil fractions.

Name the process that is used to obtain alkanes with low M_r from heavier crude oil fractions.

..... [1]

(d) Hexane, C_6H_{14} , has four structural isomers.

Fig. 3.1 shows hexane and two of its structural isomers.

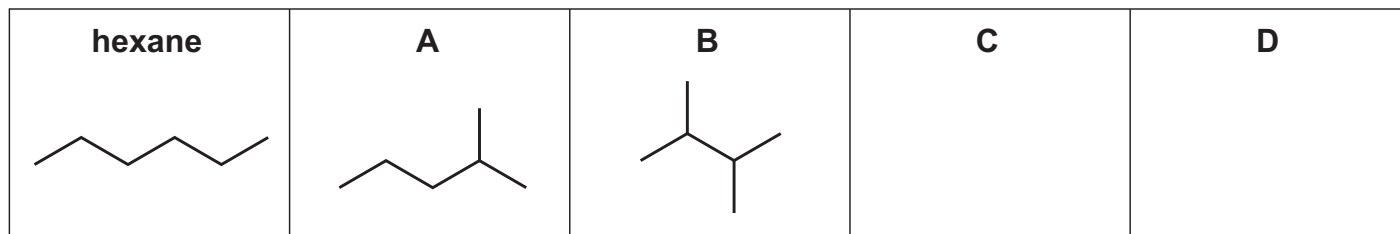


Fig. 3.1

(i) Complete Fig. 3.1 by drawing structures for **C** and **D**, the other two structural isomers of hexane. [2]

(ii) **A**, **B** and hexane have different boiling points.

Arrange **A**, **B** and hexane in order of increasing boiling point.

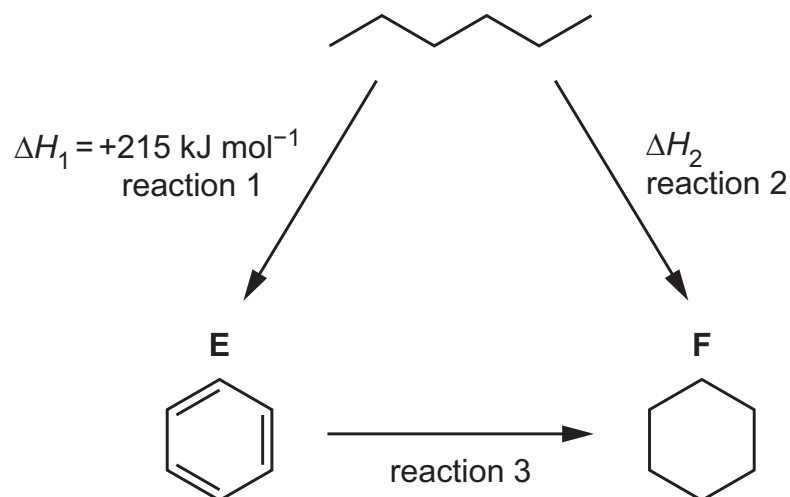
Explain your answer.

lowest < < highest

.....
.....
.....

[3]

- (e) Hexane can be converted into compounds **E** and **F** at high temperature and pressure. Fig. 3.2 shows the reaction scheme involving hexane, **E** and **F**.

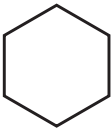
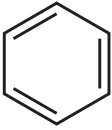


- (i) Identify a suitable reagent for reaction 3.

..... [1]

- (ii) Use the data in Fig. 3.2 and in Table 3.1 to calculate the enthalpy change of reaction 2, ΔH_2 .

Table 3.1

compound	enthalpy change of formation, $\Delta H_f^\circ / \text{kJ mol}^{-1}$
	-156
	+48

$\Delta H_2 = \dots\dots\dots \text{kJ mol}^{-1}$ [2]

- (iii) Write an equation for the complete combustion of hexane.

..... [1]

9 (a) Explain why amides are much weaker bases than amines.

.....

.....

.....

..... [2]

(b) Fig. 9.1 shows the preparation of 2-phenylethylamine, $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{NH}_2$, by three different routes.

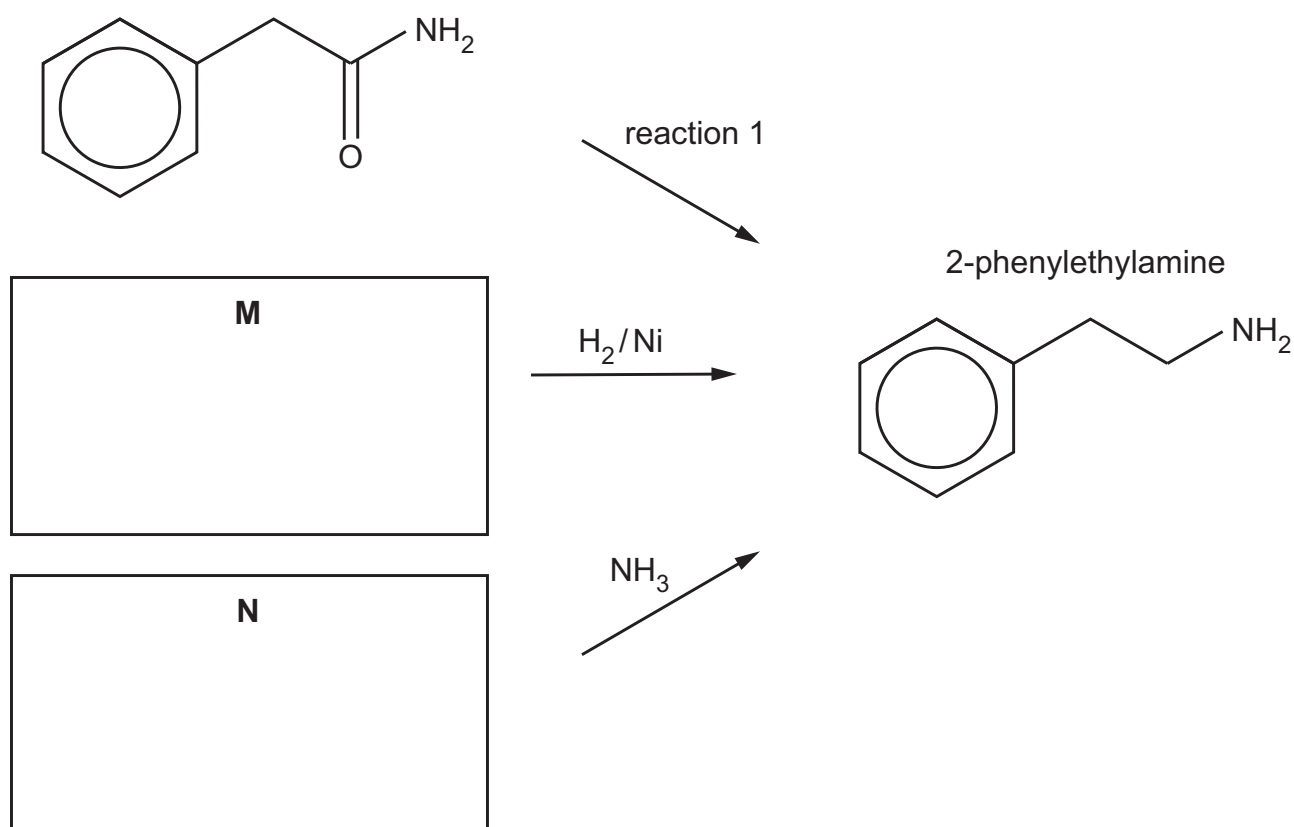


Fig. 9.1

(i) Suggest structures for compounds **M** and **N** and draw them in the boxes in Fig. 9.1. [2]

(ii) Give the reagents and conditions for reaction 1.

..... [1]

(c) Fig. 9.2 shows compound **H** which is a useful starting material in organic synthesis.

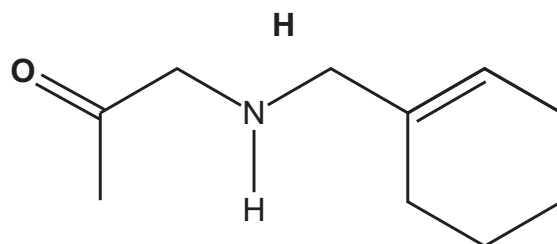


Fig. 9.2

H contains an alkene and an amine functional group.

Name the **other** functional group and give the classification of the amine group in **H**.

other functional group in **H**

classification of amine

[1]

(d) Ozonolysis involves the oxidative cleavage of a C=C bond in alkenes using ozone, O₃, as shown in Fig. 9.3.

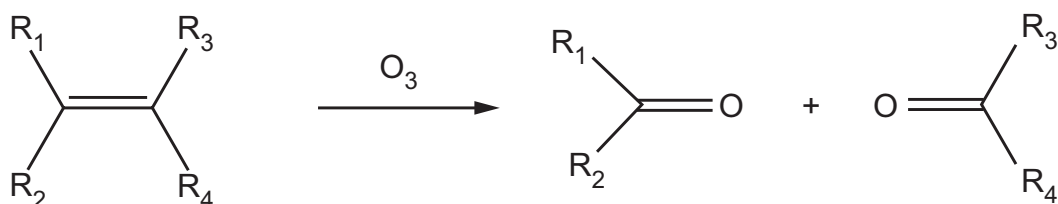


Fig. 9.3

Fig. 9.4 shows the first step in this reaction which involves the formation of an ozonide intermediate.

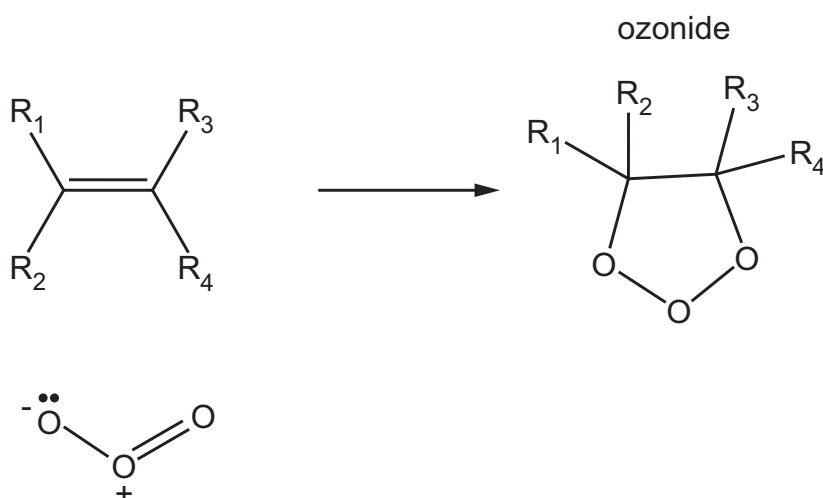
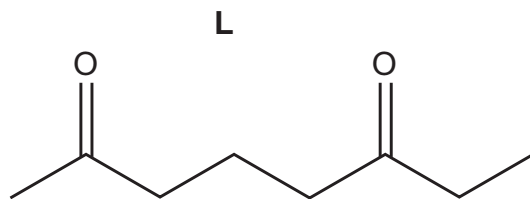


Fig. 9.4

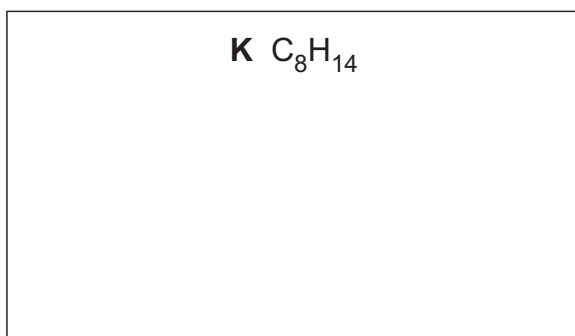
(i) On Fig. 9.4, draw **three** curly arrows to complete the mechanism of this step.

[2]

- (ii) **L** is formed from alkene **K**, C_8H_{14} , by a similar reaction to that shown in Fig. 9.3.



Suggest the structure of **K**.



[1]

[Total: 9]

Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ (4.18 $\text{J g}^{-1} \text{ K}^{-1}$)

