

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	$\text{R}-\text{CH}_2^\bullet + \text{Br}^\bullet \rightarrow \text{R}-\text{CH}_2\text{Br}$	$\text{R}'-\text{CH}_2^\bullet + \text{Br}^\bullet \rightarrow \text{R}'-\text{CH}_2\text{Br}$
B	$\text{R}-\text{CH}_2^\bullet + \text{Br}_2 \rightarrow \text{R}-\text{CH}_2\text{Br} + \text{Br}^\bullet$	$\text{R}'-\text{CH}_2^\bullet + \text{Br}_2 \rightarrow \text{R}'-\text{CH}_2\text{Br} + \text{Br}^\bullet$
C	$\text{R}'-\text{CH}_3 + \text{Br}^\bullet \rightarrow \text{R}'-\text{CH}_2^\bullet + \text{HBr}$	$2\text{R}-\text{CH}_2^\bullet \rightarrow \text{R}-\text{CH}_2\text{CH}_2-\text{R}$
D	$2\text{R}'-\text{CH}_2^\bullet \rightarrow \text{R}'-\text{CH}_2\text{CH}_2-\text{R}'$	$\text{R}-\text{CH}_3 + \text{Br}^\bullet \rightarrow \text{R}-\text{CH}_2^\bullet + \text{HBr}$

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	$\text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_3$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2^\bullet + \text{Cl}^\bullet \rightarrow \text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{Cl}$
B	$\text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_3$	$\text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_2^\bullet + \text{Cl}^\bullet \rightarrow \text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_2\text{Cl}$
C	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2^\bullet + \text{Cl}^\bullet \rightarrow \text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{Cl}$
D	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$	$\text{CH}_3\text{CHC}(\text{CH}_3)\text{CH}_2^\bullet + \text{Cl}^\bullet \rightarrow \text{CH}_2\text{CHC}(\text{CH}_3)\text{CH}_2\text{Cl}$

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
			

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]

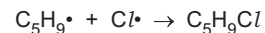
(ii) Complete the equations to show the two propagation steps that follow the initiation step.

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 C_5H_9Cl .

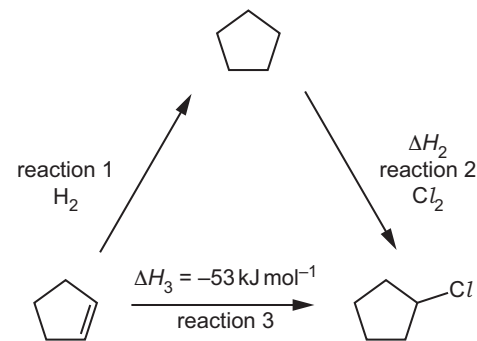


Fig. 3.2

(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

④ $\Delta H_2 = \dots \text{ kJ mol}^{-1}$ [2]

(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.

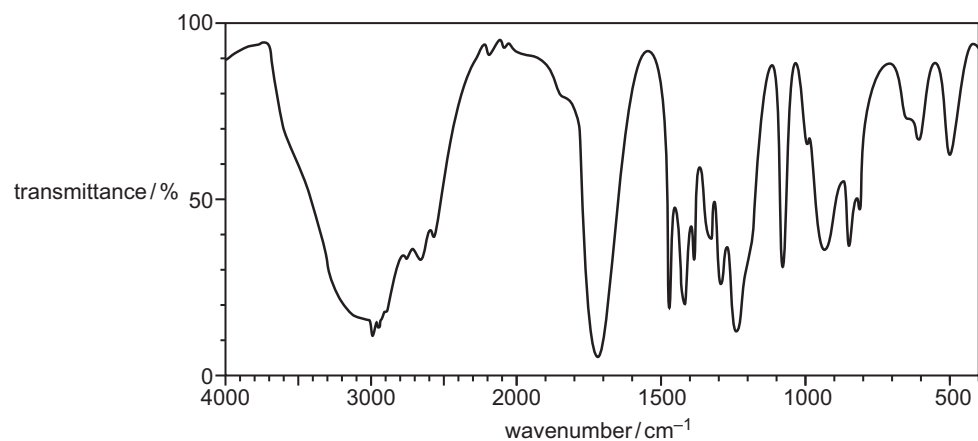


Fig. 3.3

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.

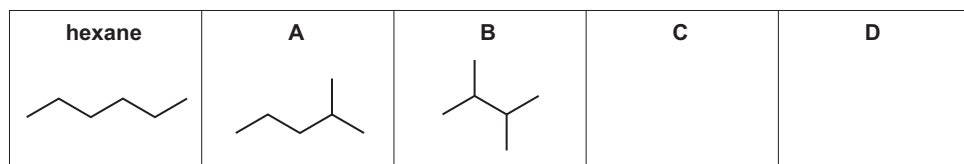


Fig. 3.1

(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**.

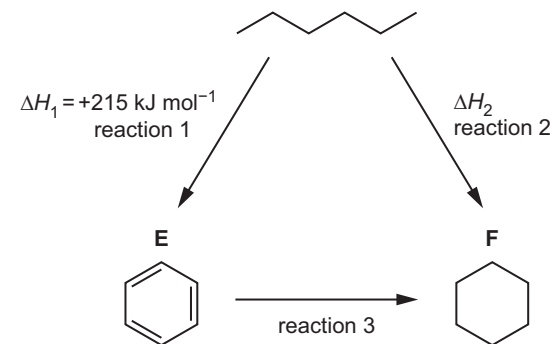


Fig. 3.2

(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 formation, $\Delta H_f / \text{kJ mol}^{-1}$
	-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, $C_6H_5CH_2CH_2NH_2$, by three different routes.

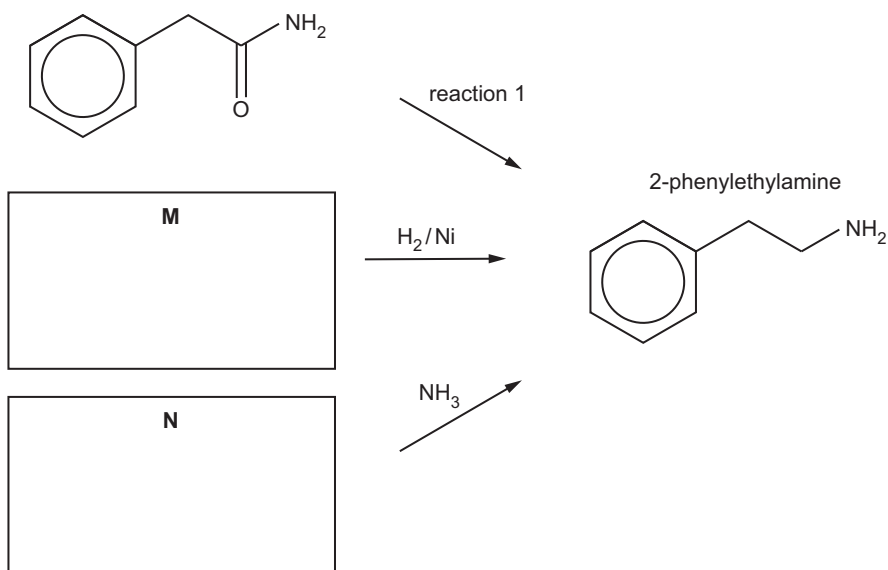


Fig. 9.1

(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.

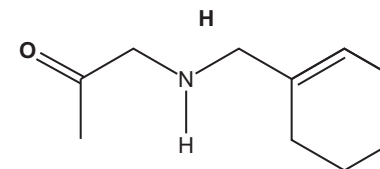


Fig. 9.2

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, O_3 , as shown in Fig. 9.3.

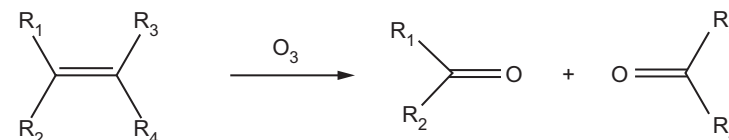


Fig. 9.3

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

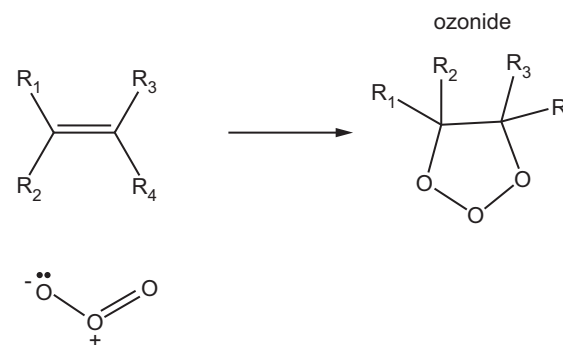
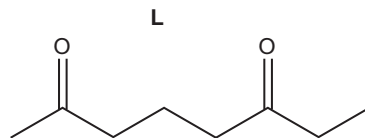


Fig. 9.4

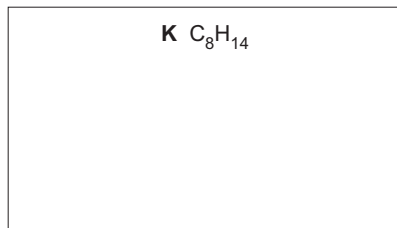
(i) On Fig. 9.4, draw **three** curly arrows to complete the mechanism of this step.

[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	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ ($4.18 \text{ J g}^{-1} \text{ K}^{-1}$)

The Periodic Table of Elements

Group																		
1	2	Key										1	13	14	15	16	17	18
3	4	atomic number atomic symbol name relative atomic mass										1	5	6	7	8	9	2
Li lithium 6.9	Be beryllium 9.0										H hydrogen 1.0	B boron 10.8	C carbon 12.0	N nitrogen 14.0	O oxygen 16.0	F fluorine 19.0	He helium 4.0	
11	12											Al aluminum 27.0	Si silicon 28.1	P phosphorus 31.0	S sulfur 32.1	Cl chlorine 35.5	Ne neon 20.2	
Na sodium 23.0	Mg magnesium 24.3																	
19	20																	
K potassium 39.1	Ca calcium 40.1																	
37	38																	
Rb rubidium 85.5	Sr strontium 87.6																	
55	56																	
Cs caesium 132.9	Ba barium 137.3																	
87	88																	
Fr francium 223	Ra radium 226																	

lanthanoids

57	La	lanthanum	138.9	58	Ce	cerium	140.1	59	Pr	praseodymium	140.9	60	Nd	neodymium	144.2	61	Pm	—	62	Sm	samarium	150.4	63	Eu	eucium	152.0	64	Gd	gadolinium	157.3	65	Tb	terbium	158.9	66	Dy	dysprosium	162.5	67	Ho	holmium	164.9	68	Er	erbium	167.3	69	Tm	thulium	168.9	70	Yb	yterbium	173.1	71	Lu	lutetium	175.0									
72	Hf	hafnium	178.5	73	Ta	tantalum	180.9	74	W	tungsten	183.8	75	Re	rhenium	186.2	76	Os	osmium	190.2	77	Ir	iridium	192.2	78	Pt	platinum	195.1	79	Au	gold	197.0	80	Hg	mercury	200.6	81	Tl	thallium	204.4	82	Pb	lead	207.2	83	Bi	bismuth	209.0	84	Po	polonium	209	85	At	astatine	210	86	Rn	radon	222								
87	Fr	francium	223	88	Ra	radium	226	89	Ac	actinium	227	90	Th	thorium	232	91	Pa	protactinium	231	92	U	uranium	238	93	Np	neptunium	237	94	Pu	plutonium	244	95	Am	americium	243	96	Cm	curium	247	97	Bk	berkelium	247	98	Cf	californium	251	99	Es	einsteinium	252	100	Fm	fermium	257	101	Md	mendelevium	258	102	No	nobelium	259	103	Lr	lawrencium	262

actinoids