Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS

B410U20-1

S23-B410U20-1

TUESDAY, 23 MAY 2023 – MORNING

CHEMISTRY – AS component 2

Energy, Rate and Chemistry of Carbon Compounds

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 6.**	**10**	
Section B	**7.**	**19**	
	8.	**12**	
	9.	**9**	
	10.	**16**	
	11.	**14**	
	Total	**80**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions.
Section B Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q.9**(a).

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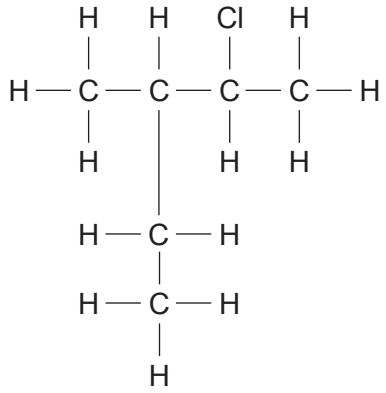
SECTION A

Answer **all** questions.

1. Name the compound whose formula is shown below. [1]



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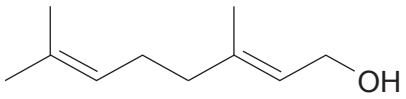
2. Geraniol is an alcohol which occurs in the essential oils of many aromatic plants. Its skeletal formula is shown below.



Give the **molecular** formula of geraniol. [1]

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3. State the meaning of the term homolytic bond fission. [1]

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4. Hydrofluorocarbons, HFCs, are synthetic compounds which have replaced chlorofluorocarbons, CFCs, as refrigerants in cooling systems because they do not deplete the ozone layer.

Explain why HFCs do not deplete the ozone layer. [2]

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5. Draw the structure of (*E*)-2-iodobut-2-ene. [2]

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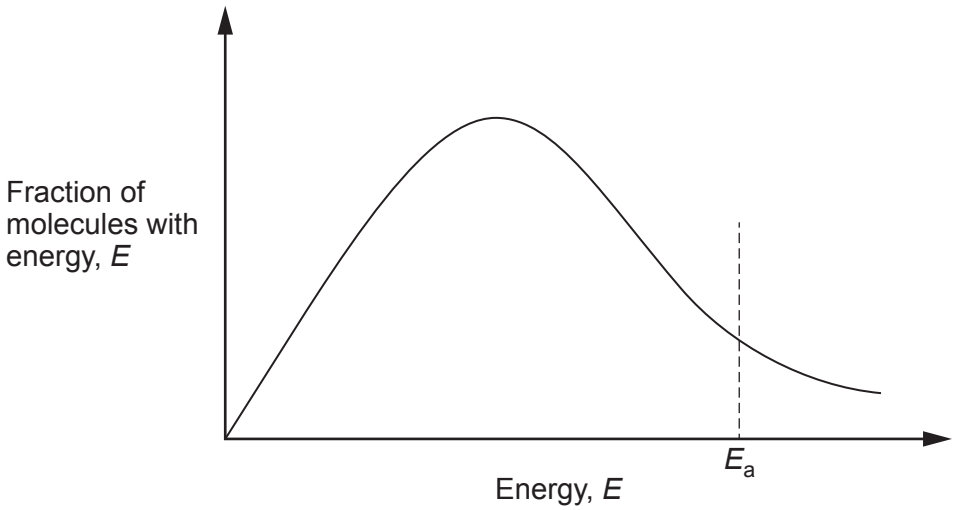
6. The diagram below shows the distribution of energies of gas molecules in a reaction at 20 °C.



(a) On the same axes, draw a curve to show the distribution of energies of the same gas molecules with the reaction at 10 °C. [1]

(b) Use the diagram to explain the difference in reaction rate between the two reactions. [2]

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SECTION B

Answer **all** questions.

7. (a) Propan-2-ol is the simplest example of a secondary alcohol. It is a common ingredient in many antiseptics.

A student carried out an experiment to determine the enthalpy change of combustion of propan-2-ol.

A spirit burner containing propan-2-ol was placed under a beaker containing 100 cm^3 of water. The burner was ignited and the alcohol allowed to burn until the temperature of the water rose by 25.4 °C. After the burner had cooled it was found that 0.362 g of propan-2-ol had been burned.

(i) State what is meant by a secondary alcohol. [1]

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(ii) Write an equation for the complete combustion of propan-2-ol. [1]

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(iii) Calculate a value for the enthalpy change of combustion of propan-2-ol in $kJ\,mol^{-1}$. [4]

$\Delta_c H$ = ... $kJ\,mol^{-1}$

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(iv) The teacher said that the actual value for the enthalpy change of combustion of propan-2-ol is $-2006\,kJ\,mol^{-1}$.

Calculate the percentage error in the student's experimental value. [1]

Percentage error = ... %

(v) Suggest **one** reason, other than heat loss, why the value obtained for the enthalpy change of combustion is smaller than the theoretical value. [1]

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(b) The equation for the combustion of propene is as shown.

$$C_3H_6(g) + 4\tfrac{1}{2}O_2(g) \longrightarrow 3CO_2(g) + 3H_2O(g) \qquad \Delta_c H^\theta = -2058 \text{ kJ mol}^{-1}$$

(i) Use this and the average bond enthalpy values given in the table to calculate the average bond enthalpy for the O═O bond. [4]

Bond	Average bond enthalpy / kJ mol^{-1}
C═C	612
C—C	348
C—H	412
C═O	805
O—H	463

Average bond enthalpy = ... kJ mol^{-1}

(ii) Suggest why the student could not use the method in (a) to determine the enthalpy change of combustion of propene. [1]

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(c) Propan-2-ol can react with ethanoic acid in the presence of concentrated sulfuric acid to form an ester and water. This reaction is reversible so an equilibrium mixture is produced and the ester is removed by distillation.

(i) Write the equation for the reaction between propan-2-ol and ethanoic acid.

Clearly show the structure of the ester formed. [2]

(ii) Explain fully why the ester can be separated from the equilibrium mixture by distillation. [2]

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(iii) I. Explain why the yield of ester in the equilibrium mixture is increased by removing the ester. [1]

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II. Concentrated sulfuric acid is a dehydrating agent.

Suggest why the yield of ester in the equilibrium mixture is increased by adding concentrated sulfuric acid. [1]

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8. (a) Alkanes and alkenes are hydrocarbons. Alkanes can be obtained from fossil fuels such as petroleum.

Alkenes can be obtained by cracking long-chain hydrocarbons. They are more reactive than alkanes.

(i) The use of fossil fuels to meet our energy needs has many disadvantages, but there are some benefits.

Give one advantage of the use of fossil fuels. [1]

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(ii) Name a **solid** pollutant that may form if a fossil fuel is burned incompletely in air. [1]

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(iii) Explain why alkenes are more reactive than alkanes. [2]

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(iv) One molecule of decane, $C_{10}H_{22}$, can be cracked to give one molecule of pentane and two other products.

Write an equation for this reaction. [1]

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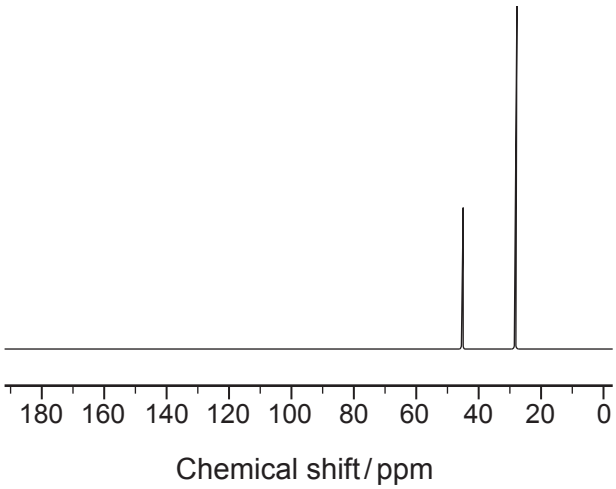
Examiner only

(b) The information given below relates to liquid **X**.

Quantitative analysis shows that it contains 29.2% carbon and 5.8% hydrogen by mass. The remainder is bromine.

The mass spectrum shows two molecular ion signals at m/z 122 and m/z 124 in the ratio of 1:1.

Its ^{13}C NMR spectrum is shown below.



(i) Use **all** the information to identify liquid **X**. [5]

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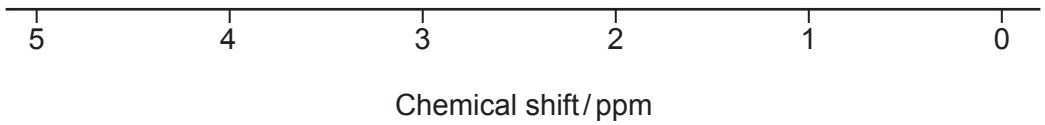
(ii) Sketch the low resolution ^{1}H NMR spectrum of liquid **X**.

Identify which protons are responsible for each peak giving the approximate chemical shift (ppm) and the relative area of each peak. [2]



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9. (a) A student is provided with unlabelled samples of the three liquids listed below.

1-chloropropane hex-1-ene propanoic acid

Describe chemical tests, apart from the use of an indicator, that the student should carry out to positively identify each of the three liquids.

You should include balanced equations for any reactions that occur. [6 QER]

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(b) 1-Chloropropane, C_3H_7Cl, can be converted into propylamine, $C_3H_7NH_2$.

If the percentage yield of the reaction is 34.5%, calculate the mass of propylamine made from 8.93 g of 1-chloropropane.

Give your answer to an **appropriate** number of significant figures. [3]

$M_r(C_3H_7Cl) = 78.6$ $M_r(C_3H_7NH_2) = 59.1$

Mass of propylamine = ... g

9

Examiner only

10. A student carried out an experiment to study the rate of the reaction between barium carbonate and hydrochloric acid.

$$BaCO_3 + 2HCl \longrightarrow BaCl_2 + H_2O + CO_2$$

M_r 197

He started with 1.50 g of barium carbonate and 30.0 cm^3 of 0.400 mol dm^{-3} hydrochloric acid. The experiment was carried out at 25 °C and 1 atm.

He determined the rate by following the loss in mass over 5 minutes.

(a) State which reactant is in excess. Use the data given to justify your answer. [2]

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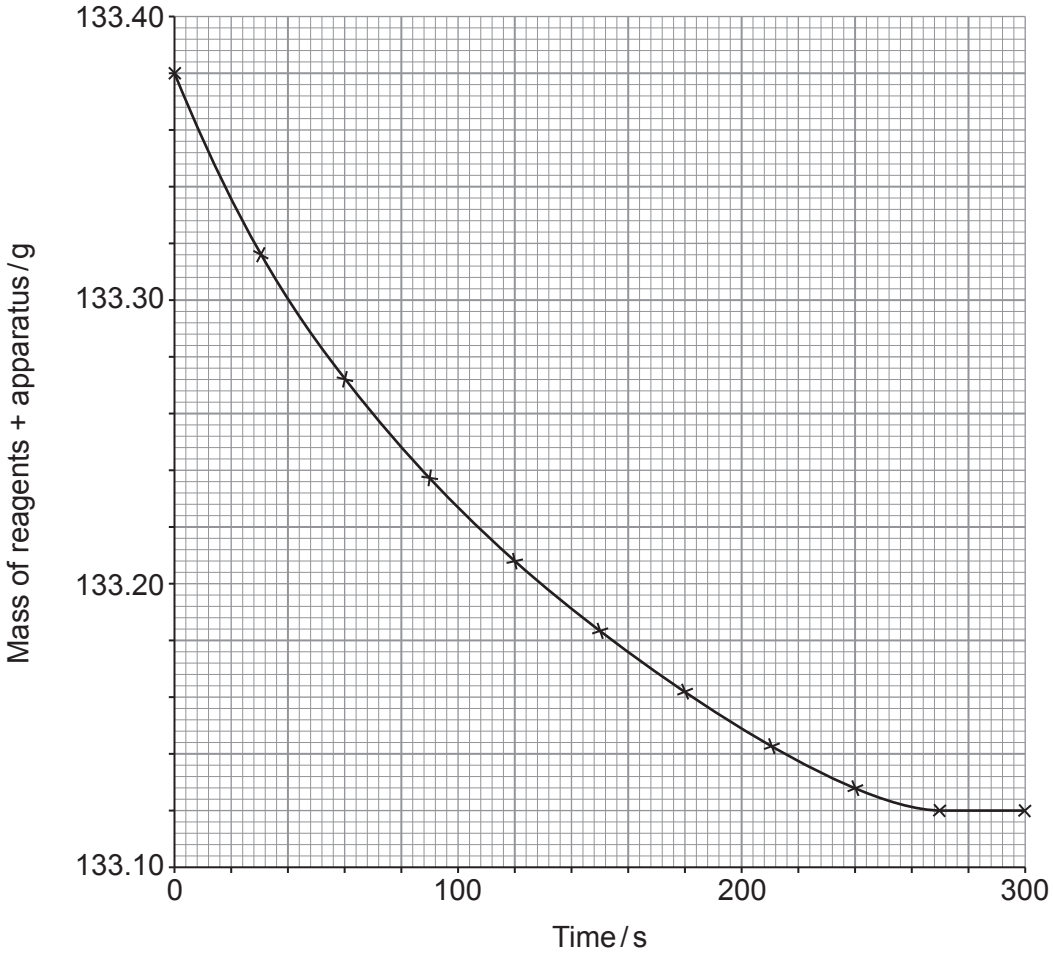
Examiner only

The student plotted his results as follows.



(b) (i) Use the graph to calculate the **mean** rate of the reaction, in $g\,s^{-1}$. [1]

Mean rate = ... $g\,s^{-1}$

(ii) Use the graph to calculate the **initial** rate of the reaction, in $g\,s^{-1}$. [2]

Initial rate = ... $g\,s^{-1}$

Examiner only

(c) (i) Use the graph to describe how the rate of the reaction changes over the 5 minutes. [1]

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(ii) Use collision theory to explain why the rate of this reaction changes as the reaction proceeds. [2]

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(d) Outline the method the student used to carry out this experiment.

A diagram may be used in support of your answer. [3]

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(e) Another method to follow this reaction is by measuring the volume of carbon dioxide produced over time.

Name the apparatus you would use to collect the carbon dioxide. [1]

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(f) Use the graph to calculate the volume (in cm^3) of carbon dioxide formed during this reaction at 25 °C.

You **must** show your working. [2]

Volume = ... cm^3

(g) Another student said that if you used the same mass of calcium carbonate instead of barium carbonate, the volume of carbon dioxide formed would be less because the relative formula mass of calcium carbonate is less.

Is she correct? Justify your answer. [2]

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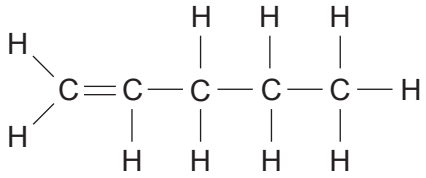
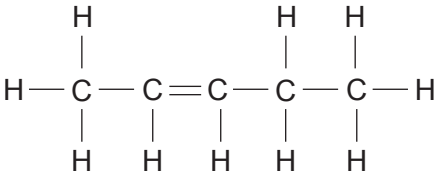
11. Five non-cyclic structural isomers have the molecular formula C_5H_{10}.

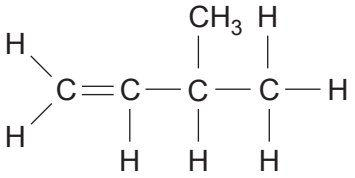
Three of these are shown below.



pent-1-ene



pent-2-ene



3-methylbut-1-ene

(a) Draw the structures of the other **two** isomers.

Do **not** include both the *E* and the *Z* isomer of the same structure. [2]

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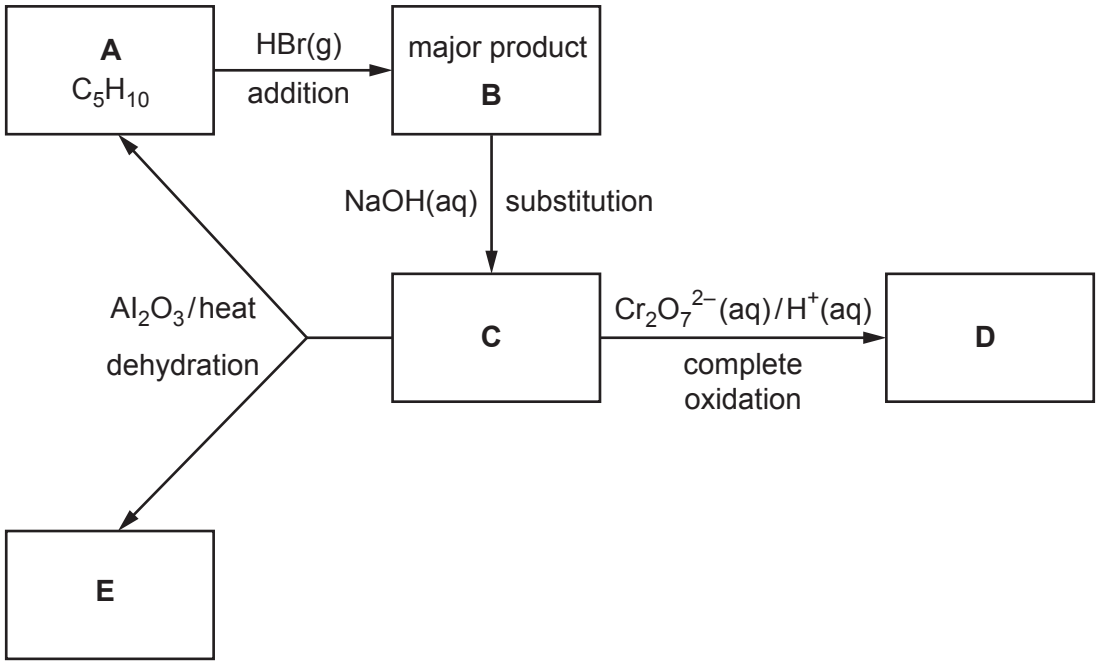
(b) Compound **A** is one of the five isomers on the previous page.

Study the reaction scheme and the information below.



Compound **D** does **not** react with aqueous sodium carbonate.

Compound **E** does **not** show *E-Z* isomerism.

(i) Use the information to name the homologous series to which compounds **B**–**E** belong. Give your reasoning. [6]

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(ii) State what you would observe when compound **C** is oxidised to compound **D**. [1]

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(iii) Compound **B** can also undergo an elimination reaction.

State the reagent(s) and conditions needed for this reaction. [1]

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(iv) Compound **A** can **only** be 3-methylbut-1-ene.

It cannot be pent-2-ene because its reaction with HBr would give two products in significant quantities.

I. Explain why compound **A** cannot be pent-1-ene. [2]

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II. Explain why compound **A** cannot be either of the two isomers drawn in part (a). [2]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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TUESDAY, 23 MAY 2023 – MORNING

CHEMISTRY – AS component 2
Data Booklet

Avogadro constant	N_A	$= 6.02 \times 10^{23}\ \text{mol}^{-1}$
molar gas constant	R	$= 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
molar gas volume at 273 K and 1 atm	V_m	$= 22.4\ \text{dm}^3\ \text{mol}^{-1}$
molar gas volume at 298 K and 1 atm	V_m	$= 24.5\ \text{dm}^3\ \text{mol}^{-1}$
Planck constant	h	$= 6.63 \times 10^{-34}\ \text{J s}$
speed of light	c	$= 3.00 \times 10^{8}\ \text{m s}^{-1}$
density of water	d	$= 1.00\ \text{g cm}^{-3}$
specific heat capacity of water	c	$= 4.18\ \text{J g}^{-1}\ \text{K}^{-1}$
ionic product of water at 298 K	K_w	$= 1.00 \times 10^{-14}\ \text{mol}^2\ \text{dm}^{-6}$
fundamental electronic charge	e	$= 1.60 \times 10^{-19}\ \text{C}$

temperature (K) = temperature (°C) + 273

$1\ \text{dm}^3 = 1000\ \text{cm}^3$
$1\ \text{m}^3 = 1000\ \text{dm}^3$
1 tonne = 1000 kg
1 atm = 1.01×10^5 Pa

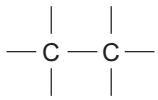
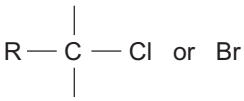
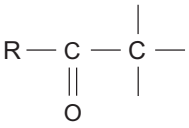
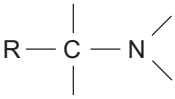
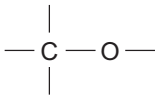
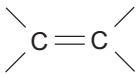
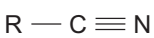
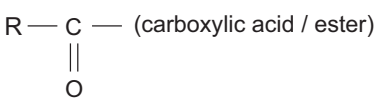
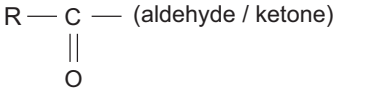
Multiple	Prefix	Symbol
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

Multiple	Prefix	Symbol
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G

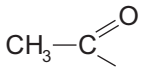
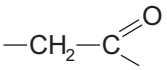
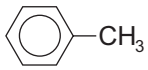
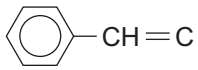
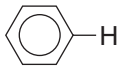
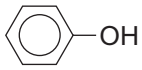
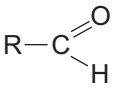
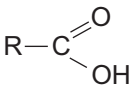
Infrared absorption values

Bond	Wavenumber / cm^{-1}
C — Br	500 to 600
C — Cl	650 to 800
C — O	1000 to 1300
C = C	1620 to 1670
C = O	1650 to 1750
C ≡ N	2100 to 2250
C — H	2800 to 3100
O — H (carboxylic acid)	2500 to 3200 (very broad)
O — H (alcohol / phenol)	3200 to 3550 (broad)
N — H	3300 to 3500

^{13}C NMR chemical shifts relative to TMS = 0

Type of carbon	Chemical shift, δ (ppm)
	5 to 40
	10 to 70
	20 to 50
	25 to 60
	50 to 90
	90 to 150
	110 to 125
	110 to 160
	160 to 185
	190 to 220

^{1}H NMR chemical shifts relative to TMS = 0

Type of proton	Chemical shift, δ (ppm)
$-CH_3$	0.1 to 2.0
$R-CH_3$	0.9
$R-CH_2-R$	1.3
$CH_3-C\equiv N$	2.0
	2.0 to 2.5
	2.0 to 3.0
	2.2 to 2.3
HC—Cl or HC—Br	3.1 to 4.3
HC—O	3.3 to 4.3
R—OH	4.5 *
—C═CH	4.5 to 6.3
—C═CH—CO	5.8 to 6.5
	6.5 to 7.5
	6.5 to 8.0
	7.0 *
	9.8 *
	11.0 *

*variable figure dependent on concentration and solvent

THE PERIODIC TABLE