Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/01**

Paper 1 Multiple Choice **For examination from 2022**

SPECIMEN PAPER **1 hour 15 minutes**

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

0123456789

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **16** pages. Blank pages are indicated.

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1 Which molecule contains eight bonding electrons?

A CO_2 **B** C_2H_4 **C** C_3H_6 **D** NH_3

2 Beams of charged particles are deflected by an electric field. In identical conditions the angle of deflection of a particle is proportional to its charge / mass ratio.

In an experiment, protons are deflected by an angle of +15°. In another experiment under identical conditions, particle Y is deflected by an angle of –5°.

What could be the composition of particle Y?

	protons	neutrons	electrons
A	1	2	1
B	3	3	5
C	4	5	1
D	4	5	3

3 The mass spectrum of a sample of lithium shows that it contains two isotopes, ^{6}Li and ^{7}Li.

The isotopic abundances are shown in the table.

isotope	isotopic abundance
^{6}Li	7.42%
^{7}Li	92.58%

What is the relative atomic mass of this sample of lithium, given to three significant figures?

A 6.07 **B** 6.50 **C** 6.90 **D** 6.93

4 Diamond, graphite and buckminsterfullerene are different forms of the element carbon.

Which statement is correct for all three substances?

A Bond angles of 120° are present.

B Delocalised electrons are present.

C Giant molecular crystalline lattice structures are present.

D σ bonds are present.

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5 A medal has a total surface area of 150 cm^2. It is evenly coated with silver by electrolysis. Its mass increases by 0.216 g.

How many atoms of silver are deposited per cm^2 on the surface of the medal?

A 8.0×10^{18} **B** 1.8×10^{19} **C** 8.7×10^{20} **D** 1.2×10^{21}

6 Nitrogen has a higher first ionisation energy than oxygen.

Which statement explains this observation?

A The radius of an oxygen atom is smaller.

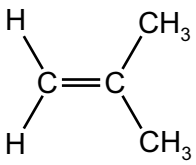
B An oxygen atom has more electron shells occupied.

C Oxygen has paired electrons in the 2p sub-shell.

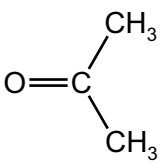
D An oxygen atom has more protons in the nucleus.

7 Which molecule has the largest overall dipole moment?

A



B



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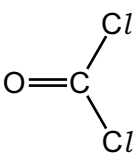

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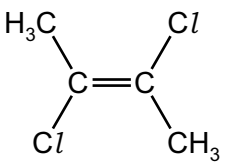

8 The complete combustion of 2 moles of an alkane produces 665 dm^3 of carbon dioxide measured at 400 K and 1×10^5 Pa. Carbon dioxide can be assumed to behave as an ideal gas under these conditions.

What is the formula of the alkane?

A C_5H_{12} **B** C_8H_{18} **C** $C_{10}H_{22}$ **D** $C_{20}H_{42}$

9 Which expression gives the standard enthalpy change of combustion of methane?

A $\Delta H_f^\ominus(CH_4) + \Delta H_f^\ominus(CO_2) - 2\Delta H_f^\ominus(H_2O)$

B $\Delta H_f^\ominus(CO_2) + 2\Delta H_f^\ominus(H_2O) + \Delta H_f^\ominus(CH_4)$

C $\Delta H_f^\ominus(CH_4) + 2\Delta H_f^\ominus(H_2O) - \Delta H_f^\ominus(CO_2)$

D $\Delta H_f^\ominus(CO_2) + 2\Delta H_f^\ominus(H_2O) - \Delta H_f^\ominus(CH_4)$

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10 Solutions containing chlorate(I) ions are used as household bleaches and disinfectants. These solutions decompose on heating as shown.

$$3ClO^- \rightarrow ClO_3^- + 2Cl^-$$

Which oxidation states are shown by chlorine in these three ions?

	ClO^-	ClO_3^-	Cl^-
A	+1	+3	–1
B	–1	+3	+1
C	+1	+5	–1
D	–1	+5	+1

11 When K_2MnO_4 is dissolved in water, the following reaction occurs.

$$aMnO_4^{2-}(aq) + bH_2O(l) \rightarrow cMnO_4^-(aq) + dMnO_2(s) + eOH^-(aq)$$

What could be the values of *a* and *c* in the balanced chemical equation?

	a	*c*
A	2	1
B	3	1
C	3	2
D	4	3

12 Methanol can be produced from hydrogen and carbon monoxide.

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$$

What is the expression for K_p for this reaction?

A $K_p = \dfrac{2p_{H_2}^2 \times p_{CO}}{p_{CH_3OH}}$

B $K_p = \dfrac{p_{H_2}^2 \times p_{CO}}{p_{CH_3OH}}$

C $K_p = \dfrac{p_{CH_3OH}}{p_{H_2}^2 \times p_{CO}}$

D $K_p = \dfrac{p_{CH_3OH}}{2p_{H_2}^2 \times p_{CO}}$

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13 4.0 g of powdered calcium carbonate, M_r = 100, are added to 100 cm^3 of 0.10 mol dm^{-3} hydrochloric acid. The volume of carbon dioxide produced is recorded every 30 seconds.

time / s	30	60	90	120	150	180	210	240
total volume of carbon dioxide given off / cm^3	40	70	88	101	110	116	120	120

Which row of the table is correct?

	why the rate of the reaction changes with time	why the reaction stops
A	fewer collisions between reacting molecules occur	the calcium carbonate is used up
B	fewer collisions between reacting molecules occur	the hydrochloric acid is used up
C	more collisions between reacting molecules occur	the calcium carbonate is used up
D	more collisions between reacting molecules occur	the hydrochloric acid is used up

14 Which statement about ideal gases is correct?

A Ideal gases have finite particle volume and no intermolecular forces of attraction.

B Ideal gases have finite particle volume and weak intermolecular forces of attraction.

C Ideal gases have zero particle volume and no intermolecular forces of attraction.

D Ideal gases have zero particle volume and weak intermolecular forces of attraction.

15 A mixture of gases consists of 12.0 g of hydrogen, 42.0 g of nitrogen and 4.0 g of helium. What is the mole fraction of hydrogen in the mixture?

A 0.21

B 0.60

C 0.71

D 0.75

16 What is the definition of the bond energy of the Br–Br covalent bond?

A The energy required to produce one mole of bromine atoms in the gaseous state.

B The energy required to produce one mole of bromine atoms in the liquid state.

C The energy required to break one mole of Br–Br bonds in the gaseous state.

D The energy required to break one mole of Br–Br bonds in the liquid state.

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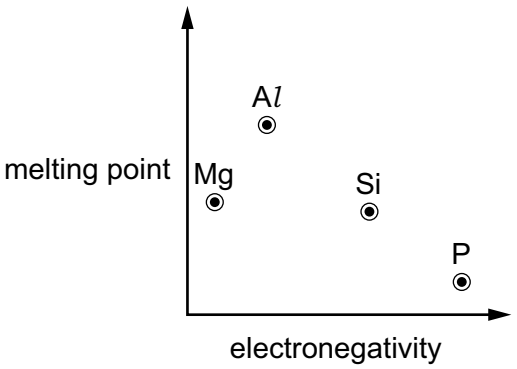
17 Which graph correctly shows the relative melting points of the elements Mg, A*l*, Si and P plotted against their relative electronegativities?

A



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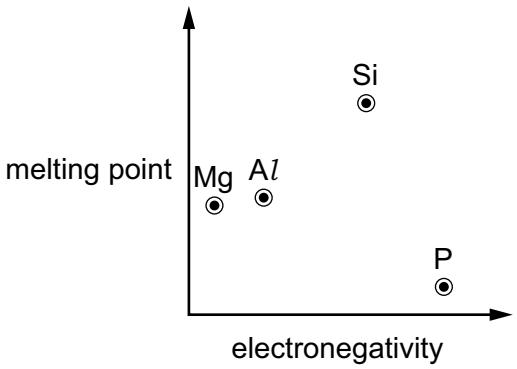

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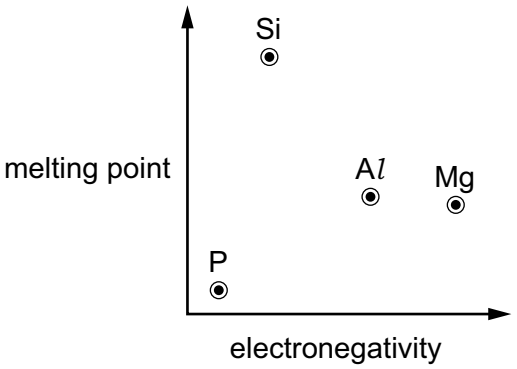

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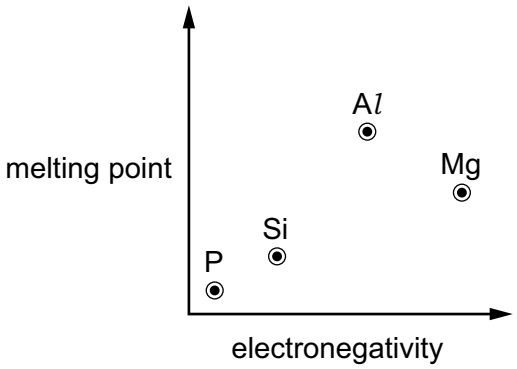

18 An excess of MgO is shaken with water. The resulting mixture is filtered, this is filtrate W. Two drops of dilute sulfuric acid are added and any observation is noted.

An excess of BaO is shaken with water. The resulting mixture is filtered, this is filtrate X. Two drops of dilute sulfuric acid are added and any observation is noted.

Which row is correct?

	filtrate of **higher** pH	observation on addition of sulfuric acid to the filtrate of **higher** pH
A	W	no change
B	W	white precipitate
C	X	no change
D	X	white precipitate

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19 Samples of magnesium carbonate, $MgCO_3$, are placed in crucibles R and S. The sample in crucible R is heated until there is no further loss in mass, and then allowed to cool. The sample in crucible S is left unheated.

Dilute hydrochloric acid is then added to both crucibles.

On adding the dilute hydrochloric acid, which observations are correct?

	R	S
A	gas produced	gas produced
B	gas produced	no gas produced
C	no gas produced	gas produced
D	no gas produced	no gas produced

20 When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.

Which statement is correct?

A Hydrogen sulfide is the product of a reduction reaction.

B Iodide ions are stronger oxidising agents than sulfate ions.

C Sulfur atoms from the sulfuric acid are both oxidised and reduced.

D Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

21 A solution of sodium hydroxide reacts with 3 mol of chlorine under certain conditions. The reaction produces 5 mol of sodium chloride and 1 mol of X, the only other chlorine-containing product.

What is the formula of compound X?

A $NaClO$ **B** $NaClO_2$ **C** $NaClO_3$ **D** $NaClO_4$

22 Redox reactions are common in the chemistry of Group 17 elements.

Which statement is correct?

A Br^- ions will reduce Cl_2 but **not** I_2.

B Cl_2 will oxidise Br^- ions but **not** I^- ions.

C F_2 is the weakest oxidising agent out of F_2, Cl_2, Br_2 and I_2.

D I^- ions are the weakest reducing agent out of F^-, Cl^-, Br^- and I^-.

23 Which statements describe a trend in Period 3 between **every pair** of adjacent elements from sodium to chlorine?

A The atomic radius decreases.

B The first ionisation energy decreases.

C The melting point decreases.

D The electrical conductivity increases.

24 Nitrogen forms pollutant oxide Y in a car engine.

Further oxidation of Y to Z occurs in the atmosphere. In this further oxidation, 1 mol of Y reacts with 0.5 mol of gaseous oxygen molecules.

Which statement is correct?

A Compound Z does **not** react further in the atmosphere.

B A molecule of Y has 15 electrons.

C The oxidation number of nitrogen increases by one from Y to Z.

D Y is a non-polar molecule.

25 Structural isomerism and stereoisomerism should be considered when answering this question.

Each of the following carbonyl compounds is reacted with $NaBH_4$. The product of each reaction is heated with Al_2O_3 at 600 °C, giving either only one isomer or a mixture of isomers.

Which carbonyl compound will produce the most isomers?

A butanal

B butanone

C pentan-3-one

D propanone

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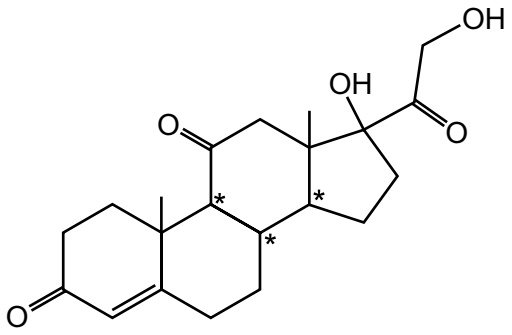
26 The drug cortisone has the formula shown.



In addition to those chiral centres marked by an asterisk (*), how many **other** chiral centres are present in the cortisone molecule?

A 0 **B** 1 **C** 2 **D** 3

27 An alkene is reacted with acidified manganate(VII) ions, MnO_4^-. The organic product has a relative molecular mass greater than that of the alkene by 34.

What conditions should be used?

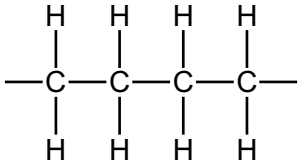
A cold, concentrated MnO_4^-

B cold, dilute MnO_4^-

C hot, concentrated MnO_4^-

D hot, dilute MnO_4^-

28 The diagram shows a short length of an addition polymer chain.

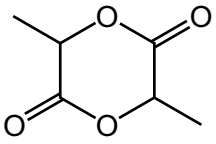


The polymer has a relative molecular mass of approximately 10 000.

Approximately how many monomer units are joined together in each polymer molecule?

A 180 **B** 360 **C** 625 **D** 710

29 Lactide is an intermediate in the manufacture of a synthetic fibre.



lactide

Which compound, on heating with an acid catalyst, can produce lactide?

A hydroxyethanoic acid

B 2-hydroxybutanoic acid

C 2-hydroxypropanoic acid

D 3-hydroxypropanoic acid

30 Diols in which both hydroxy groups are bonded to the same carbon atom spontaneously eliminate a molecule of water to produce a carbonyl compound.

Which compound is hydrolysed to form a product that gives a positive reaction with 2,4-dinitrophenylhydrazine but **not** with Fehling's reagent?

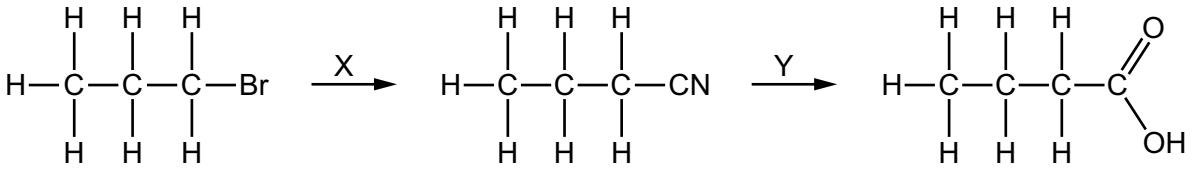
A 1,1-dibromopropane

B 1,2-dibromopropane

C 1,3-dibromopropane

D 2,2-dibromopropane

31 X and Y are the reagents required to convert 1-bromopropane into butanoic acid in the following reaction.



What are the correct identities of X and Y?

	X	Y
A	HCN	HC*l*(aq)
B	KCN in C_2H_5OH	NaOH(aq)
C	KCN in C_2H_5OH	HC*l*(aq)
D	HCN	NaOH(aq)

32 Q is a compound with the molecular formula $C_4H_{10}O$. Q can be oxidised with acidified potassium dichromate(VI). Q **cannot** be made by reducing a carboxylic acid with $LiAlH_4$.

What is the structure of Q?

A $CH_3CH(OH)CH_2CH_3$

B $CH_3CH_2CH_2CH_2OH$

C $(CH_3)_3COH$

D $(CH_3)_2CHCH_2OH$

33 A sample of 2.30 g of ethanol is mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture is then boiled under reflux for one hour. The required organic product is then collected by distillation. The yield of product is 60.0%.

Which mass of product is collected?

A 1.32 g **B** 1.38 g **C** 1.80 g **D** 3.00 g

34 Compound R gives a positive test with alkaline aqueous iodine. Compound R does **not** display stereoisomerism.

What could be compound R?

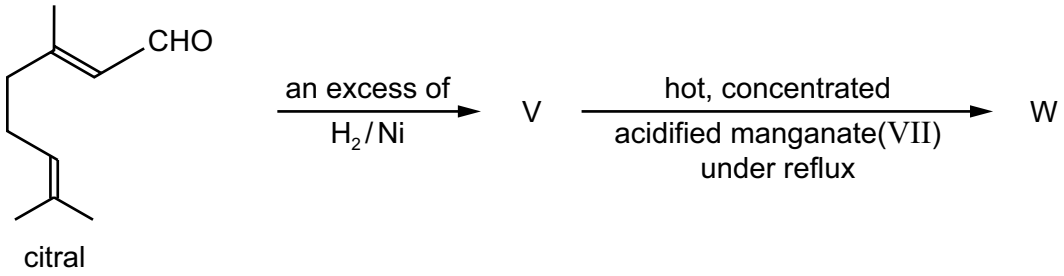
A $CH_3COCH_2CH_2OH$

B $CH_3CH_2CH(OH)CHO$

C $CH_3COCH(OH)CH_3$

D $(CH_3)_2C(OH)CHO$

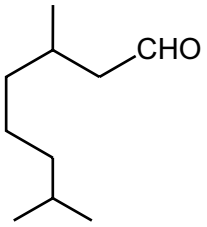
35 Citral is found in lemongrass oil. It can react to give compound W.



citral

What could compound W be?

A



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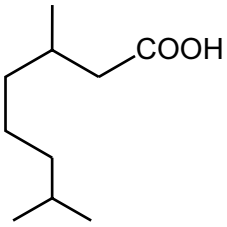

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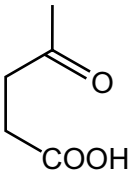

D



36 P and Q are alkenes. They are geometric isomers of each other.

Which statement is correct?

A P and Q give different products with hot, concentrated, acidified potassium manganate(VII).

B P and Q have different empirical formulae.

C P and Q have different functional groups.

D P and Q have different skeletal formulae.

37 The following statements are about the reaction of NaOH(aq) with the three chloroalkanes shown.

$CH_3CH_2CHClCH_3$ $(CH_3)_2CHCH_2Cl$ $(CH_3)_3CCl$

Which statement is correct?

A $(CH_3)_2CHCH_2Cl$ reacts with NaOH(aq) by an S_N2 mechanism.

B The tertiary chloroalkane reacts more quickly than the others because the carbon atom bonded to the C*l* atom is more positive in this molecule.

C The C*l* atoms in the three chloroalkanes are attacked by OH^-.

D The molecular formula of the major product is C_4H_8 for each reaction.

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38 For which mixture is the observation described correctly?

	reagents	observation
A	pentanal + Fehling's reagent	blue solution changes to orange / red precipitate
B	pentanal + hot, acidified potassium dichromate(VI)	green solution changes to orange solution
C	pentan-2-one + warm Tollens' reagent	colourless solution changes to silver mirror
D	C_6H_{14} + acidified potassium manganate(VII)	purple solution changes to colourless solution

39 Which statement is correct?

A C_3H_7COOH can be used to form propyl propanoate in a single reaction.

B The empirical formula of C_3H_7COOH is the same as its molecular formula.

C Each of C_3H_7OH and C_3H_7COOH reacts separately with $NaBH_4$.

D Each of C_3H_7OH and C_3H_7COOH reacts separately with sodium metal.

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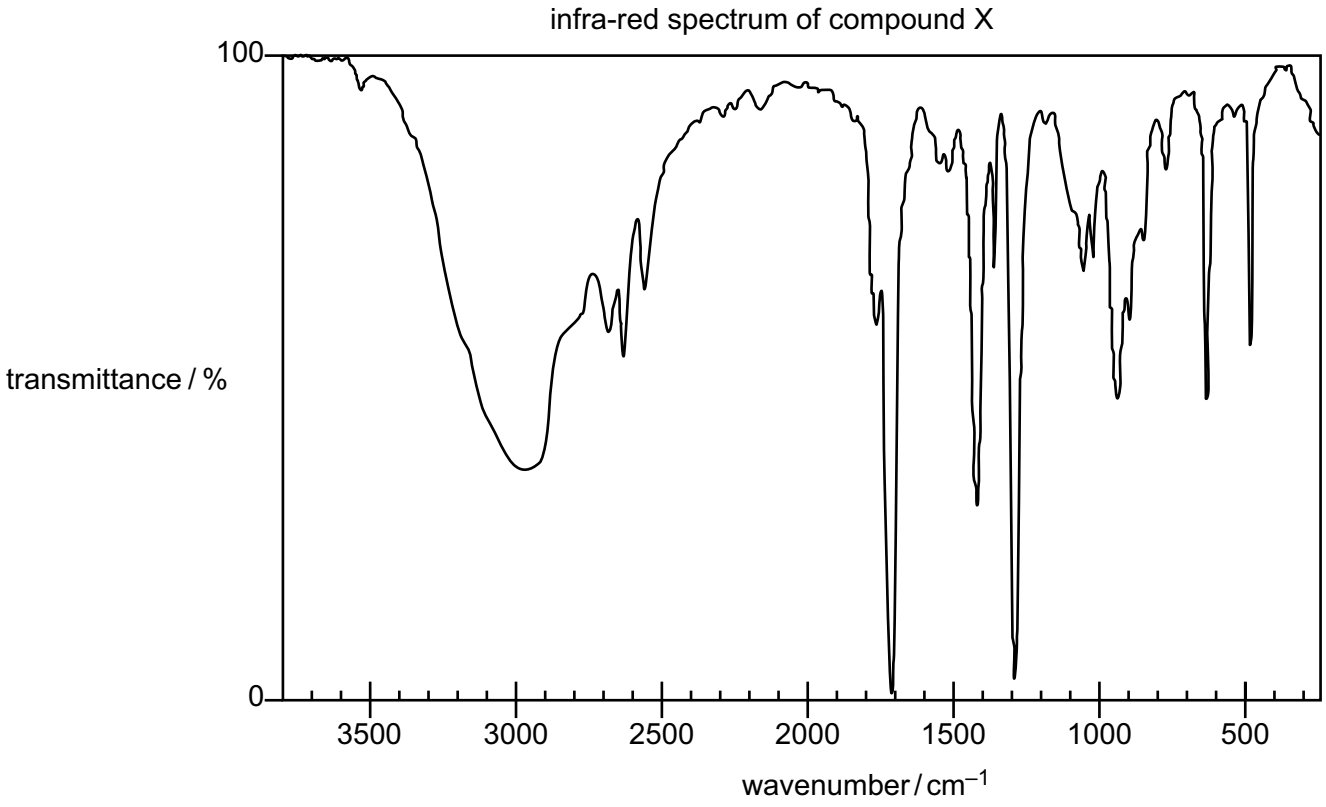
40 Compound X consists of carbon, hydrogen and oxygen only. It has only one functional group.



bond	functional group containing the bond	characteristic infra-red 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	2850–3100
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

What can be deduced about X?

A X is an aldehyde or ketone.

B X is an alcohol.

C X is a carboxylic acid.

D X is an alkene.

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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	$L = 6.022 \times 10^{23}\,\text{mol}^{-1}$
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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

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The Periodic Table of Elements

Group																		
1	2											13	14	15	16	17	18
								1 H hydrogen 1.0									2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3											13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	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 –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 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 ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

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