Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **February/March 2024**

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)

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.

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1 Which species contains the same number of neutrons as $^{14}_{6}C$ and the same number of electrons as $^{23}_{11}Na^{+}$?

A $^{17}_{9}F$ **B** $^{16}_{7}N^{3-}$ **C** $^{20}_{10}Ne$ **D** $^{16}_{8}O^{2-}$

2 Which process has the largest enthalpy change per mole?

A $Al^{3+}(g) \rightarrow Al^{4+}(g) + e^{-}$

B $P^{5+}(g) \rightarrow P^{6+}(g) + e^{-}$

C $S^{6+}(g) \rightarrow S^{7+}(g) + e^{-}$

D $Si^{4+}(g) \rightarrow Si^{5+}(g) + e^{-}$

3 Which sodium compound contains 74.2% by mass of sodium?

A sodium carbonate

B sodium chloride

C sodium hydroxide

D sodium oxide

4 What is the maximum volume of sulfur dioxide gas measured at room conditions produced from burning 100 dm^3 of diesel fuel containing 0.8346 g of sulfur?

A 291 cm^3 **B** 312 cm^3 **C** 582 cm^3 **D** 624 cm^3

5 Which row shows the correct number of covalent bonds in a molecule of methylpropene?

	total number of sigma (σ) bonds in the molecule	total number of pi (π) bonds in the molecule
A	10	1
B	10	2
C	11	1
D	11	2

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6 Aluminium chloride exists as Al_2Cl_6 molecules at room temperature. When heated to a high temperature, $AlCl_3$ molecules are formed.

What are the arrangements of the bonding pairs of electrons around the aluminium atom in the two forms of aluminium chloride?

	$AlCl_3$	Al_2Cl_6
A	planar	planar
B	planar	tetrahedral
C	tetrahedral	tetrahedral
D	tetrahedral	octahedral

7 The table shows the physical properties of four substances.

Which substance has a giant covalent structure?

	melting point / °C	boiling point / °C	electrical conductivity of solid	electrical conductivity of liquid	electrical conductivity of aqueous solution
A	–119	39	poor	poor	insoluble
B	–115	–85	poor	poor	good
C	993	1695	poor	good	good
D	1160	2230	poor	poor	insoluble

8 At room temperature and pressure, H_2O is a liquid and H_2S is a gas.

What is the reason for this difference of state?

A O has higher first and second ionisation energies than S.

B The covalent bond between O and H is stronger than the covalent bond between S and H.

C There is significant hydrogen bonding between H_2O molecules but **not** between H_2S molecules.

D The instantaneous dipole-induced dipole forces between H_2O molecules are stronger than the instantaneous dipole-induced dipole forces between H_2S molecules.

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9 The enthalpy change for a reaction can be calculated from values of:

- enthalpies of formation, $\Delta H_f^{\ominus}$
- enthalpies of combustion, $\Delta H_c^{\ominus}$
- bond energies, E.

The enthalpy change of the reaction given = $\Delta H_r^{\ominus}$.

$$2C_2H_6(g) + 3O_2(g) \rightarrow 2CH_4(g) + 2CO_2(g) + 2H_2O(l)$$

Which expression could be used to calculate $\Delta H_r^{\ominus}$?

A $\Delta H_c^{\ominus}(C_2H_6(g))$

B $2\Delta H_c^{\ominus}(C_2H_6(g)) - 2\Delta H_c^{\ominus}(CH_4(g))$

C $E(C–C) + 2E(C–H) - 4E(C=O) - 4E(H–O)$

D $\Delta H_f^{\ominus}(CH_4(g)) + \Delta H_f^{\ominus}(CO_2(g)) + \Delta H_f^{\ominus}(H_2O(l)) - \Delta H_f^{\ominus}(C_2H_6(g))$

10 Which reaction has an enthalpy change equal to the standard enthalpy change of formation of propane?

A $3C(g) + 4H_2(g) \rightarrow C_3H_8(g)$

B $3C(g) + 8H(g) \rightarrow C_3H_8(g)$

C $3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$

D $3C(s) + 4H_2(g) \rightarrow C_3H_8(l)$

11 One of the reactions in the rechargeable lead / acid battery is shown.

$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

Which statement about this reaction is correct?

A Lead is both oxidised and reduced.

B Lead is neither oxidised nor reduced.

C Lead is oxidised only.

D Lead is reduced only.

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12 $KMnO_4$ is an oxidising agent. Its reaction with Fe^{2+} is shown in the following ionic equation.

$$...X...MnO_4^- + ...Fe^{2+} + ...H^+ \rightarrow .....Mn^{2+} + ...Y...Fe^{3+} + ...H_2O$$

What are X and Y when the equation is balanced?

	X	Y
A	1	1
B	1	3
C	1	5
D	5	1

13 Nitrogen and hydrogen are mixed in a reaction vessel. The reaction reaches equilibrium giving a mixture of nitrogen, hydrogen and ammonia gases.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The mixture of gases present at equilibrium at a total pressure of 300 atm is shown.

gas	number of mol in mixture
nitrogen	180
hydrogen	590
ammonia	160

What is the equilibrium constant, K_p, for the forward reaction?

A $6.65 \times 10^{-6}\,atm^{-2}$

B $7.13 \times 10^{-5}\,atm^{-2}$

C $0.599\,atm^{-2}$

D $1.50 \times 10^{5}\,atm^{2}$

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14 A mixture of hydrogen gas and iodine gas is placed in a reaction vessel of volume *V* at temperature *T*.

The reaction $H_2 + I_2 \rightleftharpoons 2HI$ is allowed to come to equilibrium.

All substances remain in the gaseous state.

Argon gas is then pumped into the reaction vessel. The temperature in the vessel is maintained at *T*.

How are the rate of the forward reaction and the partial pressure of HI at equilibrium affected?

	rate of forward reaction	partial pressure of HI at equilibrium
A	increased	increased
B	increased	unaffected
C	unaffected	increased
D	unaffected	unaffected

15 Two experiments are carried out to study the reaction between zinc and sulfuric acid.

experiment 1 Small lumps of zinc are added to excess dilute sulfuric acid.

experiment 2 The reaction is carried out at a lower temperature and with one other change.

Both experiments produce the same total volume of gas and are completed in the same time.

What is the second change made in experiment 2?

A A catalyst is added.

B A greater mass of zinc is added.

C A greater volume of sulfuric acid is added.

D Larger lumps of zinc are used.

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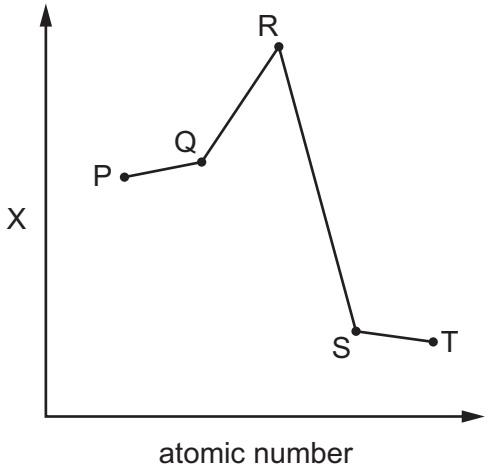
16 The relative magnitude of the property X of five elements is shown. P, Q, R, S and T are all in Period 3 and have consecutive atomic numbers.

The letters are **not** the actual chemical symbols of the elements.



Which row is correct for property X and element R?

	property X	element R
A	electrical conductivity	Al
B	electronegativity	Si
C	melting point	Al
D	second ionisation energy	Si

17 Element X is in Period 3. Element X reacts with oxygen to produce a solid, Y.

When solid Y is added to water, a solution with a pH of less than 7 is produced.

What is the identity of element X?

A sodium

B silicon

C phosphorus

D sulfur

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18 This question refers to isolated gaseous species.

The species F^-, Ne and Na^+ are isoelectronic. This means they have the same number of electrons.

In which order do their radii increase?

	smallest →		largest
A	Na^+	F^-	Ne
B	F^-	Ne	Na^+
C	Na^+	Ne	F^-
D	Ne	F^-	Na^+

19 Separate samples of magnesium and calcium are added to an excess of dilute sulfuric acid. The observations are summarised in the table.

metal	observations
magnesium	vigorous reaction, bubbles of gas produced, magnesium completely dissolves
calcium	vigorous reaction initially, bubbles of gas produced, reaction soon stops and leaves most of the calcium unreacted

Which statement explains the difference in these observations?

A Calcium is a better oxidising agent than magnesium.

B Calcium is a better reducing agent than magnesium.

C Magnesium is a more reactive metal with all dilute acids than calcium.

D Magnesium sulfate is more soluble than calcium sulfate.

20 Dolomite is a double carbonate, $CaMg(CO_3)_2$, and can be used instead of calcium carbonate for treating acidic soils.

The three statements all refer to the agricultural use of these carbonates.

1 Dolomite and calcium carbonate are both less soluble than $Ca(OH)_2$.

2 One mole of dolomite has the same neutralising effect as one mole of calcium carbonate.

3 Dolomite and calcium carbonate both increase the pH of acidic soils.

Which statements are correct?

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

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21 This question is about two salts, NaI and NaC*l*.

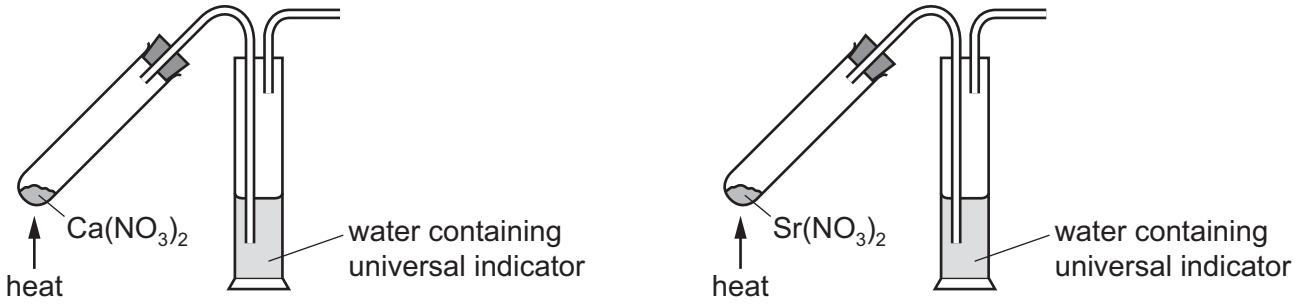
The two solid salts are separately added to warm concentrated H_2SO_4 and the results noted.

Aqueous solutions of the two salts are separately added to $AgNO_3(aq)$ and then concentrated $NH_3(aq)$ is added and the results noted.

Which row is correct?

	salt	identity of one product formed with concentrated H_2SO_4	observation after $AgNO_3(aq)$ and $NH_3(aq)$ are added
A	NaC*l*	Cl_2	colourless solution
B	NaC*l*	H_2S	white precipitate
C	NaI	H_2S	yellow precipitate
D	NaI	I_2	colourless solution

22 The diagram shows the process of adding calcium nitrate and strontium nitrate to separate boiling tubes and heating them. Identical conditions are used.



As the reactions proceed, the water containing universal indicator changes colour.

Which row describes the colour change and identifies the nitrate that causes the quickest colour change?

	colour change of universal indicator	nitrate that causes the quickest colour change
A	green to blue	$Ca(NO_3)_2$
B	green to blue	$Sr(NO_3)_2$
C	green to red	$Ca(NO_3)_2$
D	green to red	$Sr(NO_3)_2$

23 The equations for three reactions involving chlorine or its compounds are listed.

1 $2KClO_3 \rightarrow 2KCl + 3O_2$

2 $4KClO_3 \rightarrow 3KClO_4 + KCl$

3 $6KOH + 3Cl_2 \rightarrow 3H_2O + 5KCl + KClO_3$

Which statement about these equations is correct?

A Equation 1 describes the formation of a compound used to kill bacteria in drinking water.

B Equation 1 does **not** represent a redox reaction.

C Equation 2 describes the formation of potassium chlorate(IV).

D Equations 2 and 3 both represent disproportionation reactions.

24 Nitrogen monoxide, NO, is a primary pollutant produced by petrol engines and is found in their exhaust gases.

Which reaction occurs in a catalytic converter and decreases the emission of nitrogen monoxide?

A $NO(g) + CO(g) \rightarrow NO_2(g) + C(s)$

B $NO(g) + CO_2(g) \rightarrow NO_2(g) + CO(g)$

C $2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$

D $2NO(g) + CO_2(g) \rightarrow 2NO_2(g) + C(s)$

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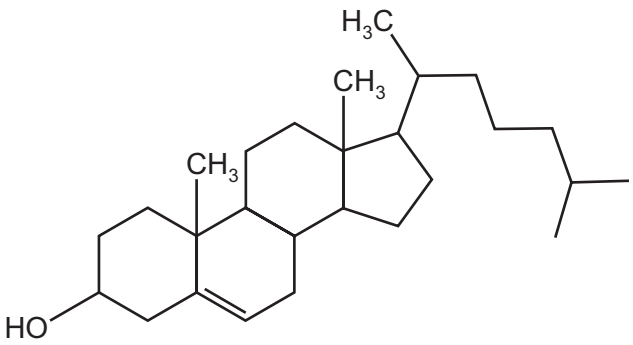
25 The diagram shows the structure of the naturally occurring molecule cholesterol.

cholesterol



Student X stated that the 17 carbon atoms in the 4 rings all lie in the same plane.

Student Y stated that this molecule displays cis/trans isomerism at the C=C double bond.

Which students are correct?

A both student X and student Y

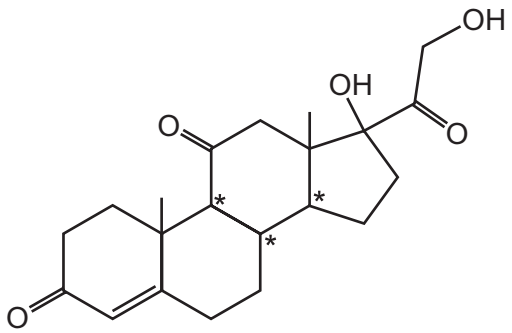
B neither student X nor student Y

C student X only

D student Y only

26 The drug cortisone has the formula shown.

cortisone



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 But-2-ene reacts with cold dilute acidified $KMnO_4$ to give product X.

But-2-ene reacts with hot concentrated acidified $KMnO_4$ to give product Y.

Which statement about product X and product Y is correct?

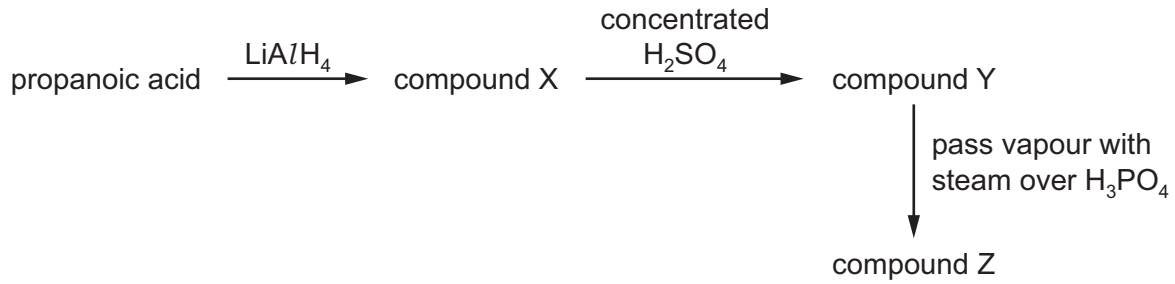
A Both product X and product Y will react with 2,4-dinitrophenylhydrazine.

B Neither product X nor product Y will react with 2,4-dinitrophenylhydrazine.

C Product X will react with 2,4-dinitrophenylhydrazine, product Y will not.

D Product Y will react with 2,4-dinitrophenylhydrazine, product X will not.

28 A sequence of reactions takes place. The major product is compound Z.



What is compound Z?

A propanone

B propene

C propan-1-ol

D propan-2-ol

29 Which statement is correct?

A Bromoethane reacts with NaOH(aq) to form ethene as a major product.

B 1-chlorobutane reacts more rapidly than 1-bromobutane with NaOH(aq) at the same temperature.

C Hydrolysis of $(C_2H_5)_3CBr$ occurs mostly by the S_N2 mechanism.

D The $CH_3CH_2CH_2CH_2^+$ ion is less stable than the $(CH_3)_3C^+$ ion.

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30 In the hydrolysis of bromoethane by aqueous NaOH, what is the nature of the attacking group and of the leaving group?

	attacking group	leaving group
A	electrophile	electrophile
B	electrophile	nucleophile
C	nucleophile	electrophile
D	nucleophile	nucleophile

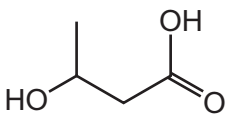
31 X is an organic compound containing the elements carbon, hydrogen and oxygen only.

The table shows the observations made from three chemical tests carried out on X.

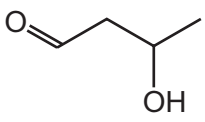
reagent added	observation
Na(s)	effervescence
$Na_2CO_3(s)$	effervescence
hot $H^+ / Cr_2O_7^{2-}(aq)$	remains orange

What is a possible structure of X?

A



B



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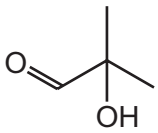

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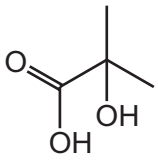

32 How many moles of oxygen gas are needed for the complete combustion of 1 mol of $(CH_3)_3COH$?

A 6 **B** 6.5 **C** 12 **D** 13

33 In which pair will each compound give a different visible result with alkaline $I_2(aq)$?

A CH_3CH_2OH and CH_3CHO

B CH_3CHO and CH_3COCH_3

C CH_3COOH and $C_2H_5COC_2H_5$

D CH_3CH_2OH and C_2H_5CHO

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34 Which reagent gives a positive result with propanone?

A alkaline I_2(aq)

B aqueous bromine

C Fehling's reagent

D Tollens' reagent

35 Esters can be hydrolysed with an aqueous alkali or an aqueous acid to form two products.

The table compares the two methods.

Which row is correct?

	aqueous alkali	aqueous acid
A	complete conversion to a salt and an organic acid	forms an equilibrium mixture with an organic acid and an alcohol
B	forms an equilibrium mixture with a salt and an organic acid	complete conversion to a salt and an alcohol
C	complete conversion to a salt and an alcohol	forms an equilibrium mixture with an organic acid and an alcohol
D	complete conversion to a salt and an alcohol	complete conversion to an organic acid and an alcohol

36 Structural isomerism only should be considered when answering this question.

How many compounds with molecular formula $C_5H_{11}Br$ are **primary** halogenoalkanes?

A 4 **B** 5 **C** 7 **D** 8

37 Compound Z is formed by the reaction scheme shown.

$$CH_3CH_2Br \xrightarrow[\text{KCN in ethanol}]{\text{warm with}} \text{compound X} \xrightarrow[\text{dilute HC}l]{\text{reflux with}} \text{compound Z}$$

What is the formula of compound Z?

A CH_3CH_2Cl

B CH_3CH_2CN

C CH_3COOH

D CH_3CH_2COOH

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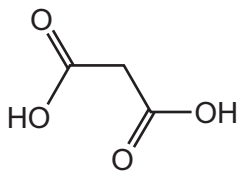
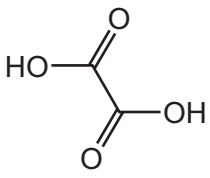
38 Hydroxyethanal, $HOCH_2CHO$, is heated under reflux with an excess of acidified $K_2Cr_2O_7$ until no further oxidation takes place.

What is the skeletal formula of the organic product?

A



B



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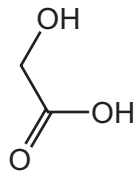

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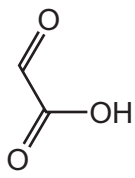


39 The formula shows the repeat unit of an addition polymer.

$$–CH(CH_3)CH(CH_2CH_3)–$$

What is the correct name of the monomer from which this polymer is made?

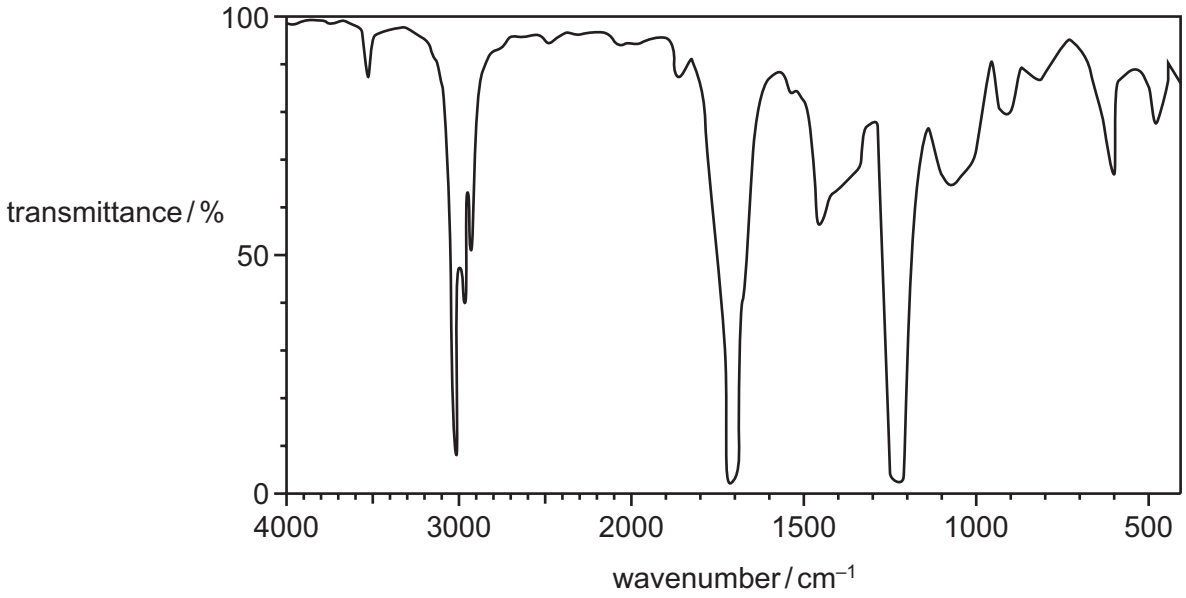
A 1-methyl-2-ethylethene

B 1-ethylprop-1-ene

C pent-2-ene

D pent-1-ene

40 The infrared spectrum of a compound is shown.



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 3200–3600

Which functional group could the compound contain?

A alcohol

B carboxylic acid

C ester

D nitrile

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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	3	4	5	6	7	8	9	10	11	12	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 –