



# 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)



## 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. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

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

1 Which molecule contains eight bonding electrons?

- A**  $\text{CO}_2$             **B**  $\text{C}_2\text{H}_4$             **C**  $\text{C}_3\text{H}_6$             **D**  $\text{NH}_3$

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  $+15^\circ$ . In another experiment under identical conditions, particle Y is deflected by an angle of  $-5^\circ$ .

What could be the composition of particle Y?

	protons	neutrons	electrons
<b>A</b>	1	2	1
<b>B</b>	3	3	5
<b>C</b>	4	5	1
<b>D</b>	4	5	3

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

The isotopic abundances are shown in the table.

isotope	isotopic abundance
${}^6\text{Li}$	7.42%
${}^7\text{Li}$	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  $120^\circ$  are present.  
**B** Delocalised electrons are present.  
**C** Giant molecular crystalline lattice structures are present.  
**D**  $\sigma$  bonds are present.

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

How many atoms of silver are deposited per  $\text{cm}^2$  on the surface of the medal?

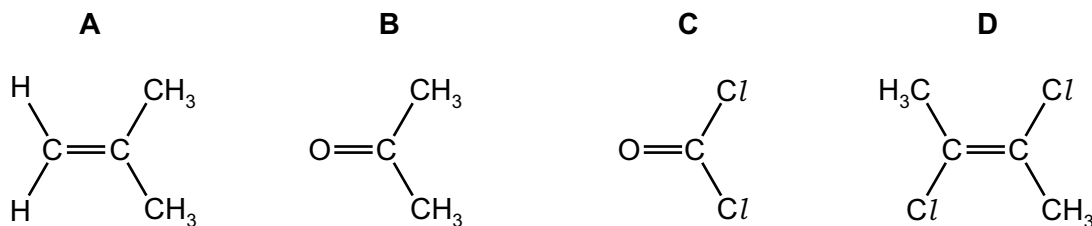
- A  $8.0 \times 10^{18}$     B  $1.8 \times 10^{19}$     C  $8.7 \times 10^{20}$     D  $1.2 \times 10^{21}$

- 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?



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

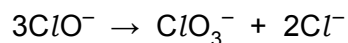
What is the formula of the alkane?

- A  $\text{C}_5\text{H}_{12}$     B  $\text{C}_8\text{H}_{18}$     C  $\text{C}_{10}\text{H}_{22}$     D  $\text{C}_{20}\text{H}_{42}$

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

- A  $\Delta H_f^\ominus(\text{CH}_4) + \Delta H_f^\ominus(\text{CO}_2) - 2\Delta H_f^\ominus(\text{H}_2\text{O})$   
 B  $\Delta H_f^\ominus(\text{CO}_2) + 2\Delta H_f^\ominus(\text{H}_2\text{O}) + \Delta H_f^\ominus(\text{CH}_4)$   
 C  $\Delta H_f^\ominus(\text{CH}_4) + 2\Delta H_f^\ominus(\text{H}_2\text{O}) - \Delta H_f^\ominus(\text{CO}_2)$   
 D  $\Delta H_f^\ominus(\text{CO}_2) + 2\Delta H_f^\ominus(\text{H}_2\text{O}) - \Delta H_f^\ominus(\text{CH}_4)$

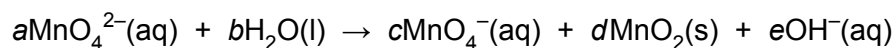
- 10 Solutions containing chlorate(I) ions are used as household bleaches and disinfectants. These solutions decompose on heating as shown.



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

	$\text{ClO}^-$	$\text{ClO}_3^-$	$\text{Cl}^-$
<b>A</b>	+1	+3	-1
<b>B</b>	-1	+3	+1
<b>C</b>	+1	+5	-1
<b>D</b>	-1	+5	+1

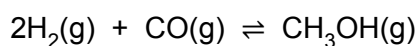
- 11 When  $\text{K}_2\text{MnO}_4$  is dissolved in water, the following reaction occurs.



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

	$a$	$c$
<b>A</b>	2	1
<b>B</b>	3	1
<b>C</b>	3	2
<b>D</b>	4	3

- 12 Methanol can be produced from hydrogen and carbon monoxide.



What is the expression for  $K_p$  for this reaction?

**A**  $K_p = \frac{2p_{\text{H}_2}^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

**B**  $K_p = \frac{p_{\text{H}_2}^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

**C**  $K_p = \frac{p_{\text{CH}_3\text{OH}}}{p_{\text{H}_2}^2 \times p_{\text{CO}}}$

**D**  $K_p = \frac{p_{\text{CH}_3\text{OH}}}{2p_{\text{H}_2}^2 \times p_{\text{CO}}}$

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

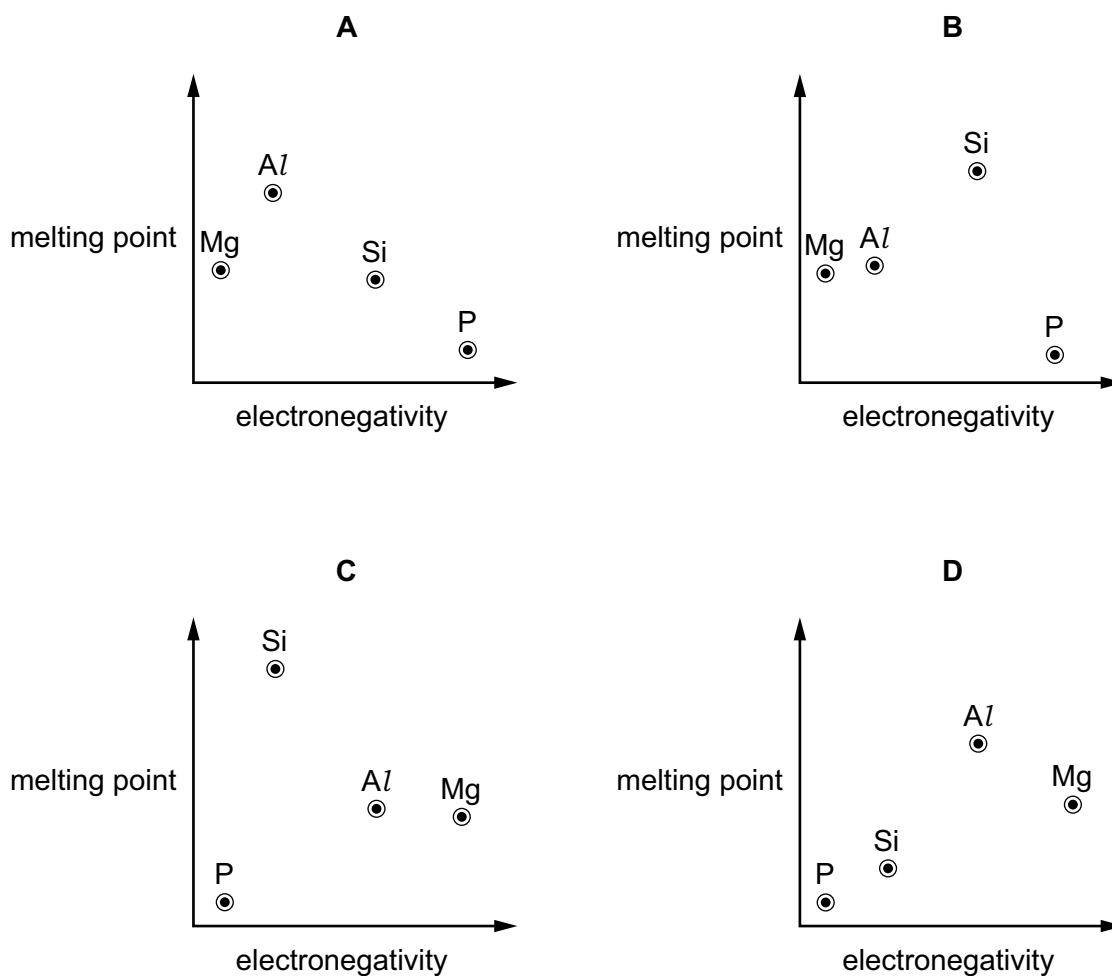
time/s	30	60	90	120	150	180	210	240
total volume of carbon dioxide given off/ $\text{cm}^3$	40	70	88	101	110	116	120	120

Which row of the table is correct?

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

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



- 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 <b>higher</b> pH	observation on addition of sulfuric acid to the filtrate of <b>higher</b> pH
<b>A</b>	W	no change
<b>B</b>	W	white precipitate
<b>C</b>	X	no change
<b>D</b>	X	white precipitate

- 19 Samples of magnesium carbonate,  $\text{MgCO}_3$ , 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
<b>A</b>	gas produced	gas produced
<b>B</b>	gas produced	no gas produced
<b>C</b>	no gas produced	gas produced
<b>D</b>	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**  $\text{NaClO}$       **B**  $\text{NaClO}_2$       **C**  $\text{NaClO}_3$       **D**  $\text{NaClO}_4$
- 22 Redox reactions are common in the chemistry of Group 17 elements.

Which statement is correct?

- A**  $\text{Br}^-$  ions will reduce  $\text{Cl}_2$  but **not**  $\text{I}_2$ .  
**B**  $\text{Cl}_2$  will oxidise  $\text{Br}^-$  ions but **not**  $\text{I}^-$  ions.  
**C**  $\text{F}_2$  is the weakest oxidising agent out of  $\text{F}_2$ ,  $\text{Cl}_2$ ,  $\text{Br}_2$  and  $\text{I}_2$ .  
**D**  $\text{I}^-$  ions are the weakest reducing agent out of  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$  and  $\text{I}^-$ .

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.

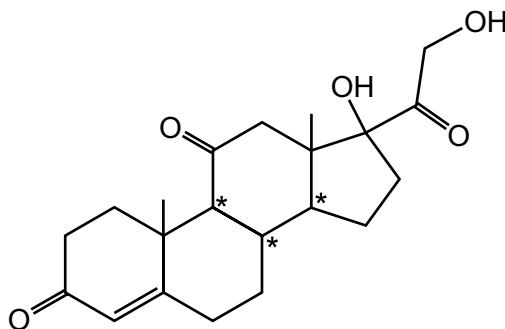
Each of the following carbonyl compounds is reacted with  $\text{NaBH}_4$ . The product of each reaction is heated with  $\text{Al}_2\text{O}_3$  at  $600^\circ\text{C}$ , giving either only one isomer or a mixture of isomers.

Which carbonyl compound will produce the most isomers?

- A butanal
- B butanone
- C pentan-3-one
- D propanone



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?

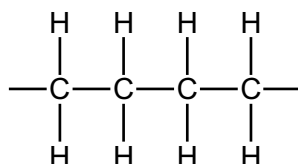
- A 0                      B 1                      C 2                      D 3

27 An alkene is reacted with acidified manganate(VII) ions,  $\text{MnO}_4^-$ . The organic product has a relative molecular mass greater than that of the alkene by 34.

What conditions should be used?

- A cold, concentrated  $\text{MnO}_4^-$   
 B cold, dilute  $\text{MnO}_4^-$   
 C hot, concentrated  $\text{MnO}_4^-$   
 D hot, dilute  $\text{MnO}_4^-$

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

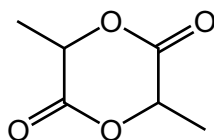


The polymer has a relative molecular mass of approximately 10 000.

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.



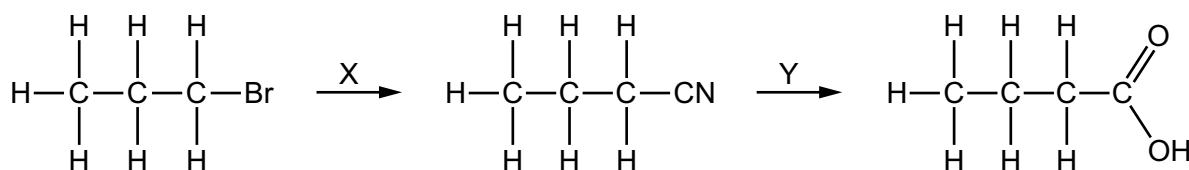
lactide

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
<b>A</b>	HCN	HCl(aq)
<b>B</b>	KCN in C <sub>2</sub> H <sub>5</sub> OH	NaOH(aq)
<b>C</b>	KCN in C <sub>2</sub> H <sub>5</sub> OH	HCl(aq)
<b>D</b>	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 2.30g 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%.

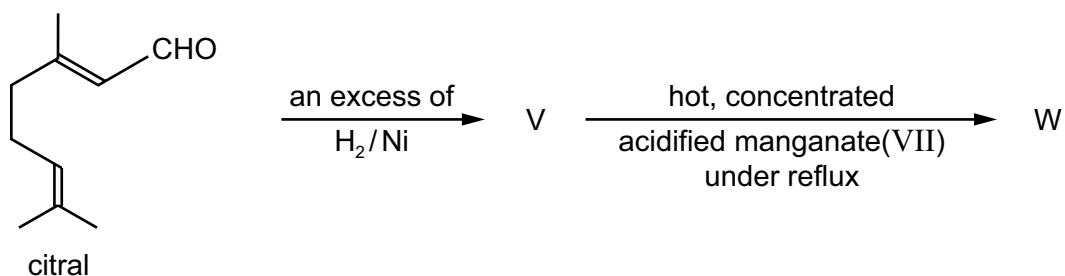
Which mass of product is collected?

- A 1.32g      B 1.38g      C 1.80g      D 3.00g
- 34 Compound R gives a positive test with alkaline aqueous iodine. Compound R does **not** display stereoisomerism.

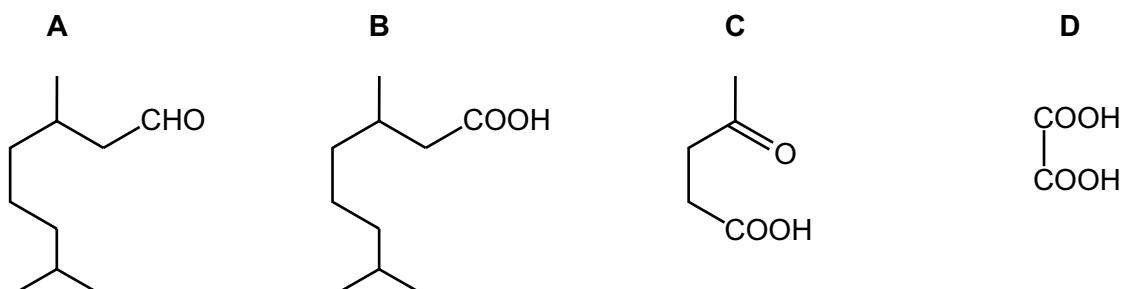
What could be compound R?

- 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.



What could compound W be?

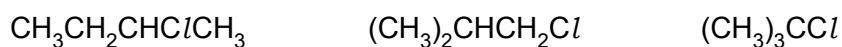


36 P and Q are alkenes. They are geometric isomers of each other.

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.



Which statement is correct?

- A  $(\text{CH}_3)_2\text{CHCH}_2\text{Cl}$  reacts with NaOH(aq) by an  $\text{S}_{\text{N}}2$  mechanism.
- B The tertiary chloroalkane reacts more quickly than the others because the carbon atom bonded to the Cl atom is more positive in this molecule.
- C The Cl atoms in the three chloroalkanes are attacked by  $\text{OH}^-$ .
- D The molecular formula of the major product is  $\text{C}_4\text{H}_8$  for each reaction.

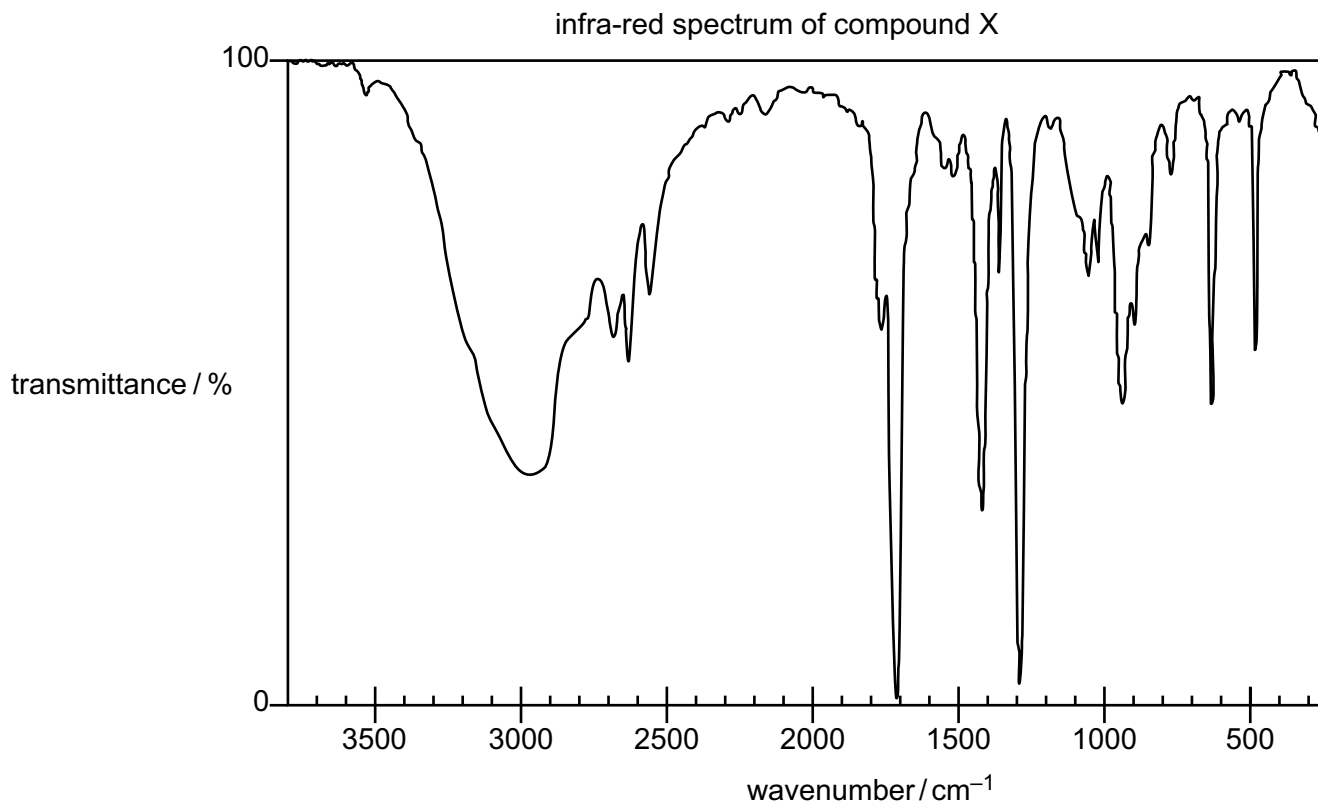
38 For which mixture is the observation described correctly?

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

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) / $\text{cm}^{-1}$
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.

**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 $\text{J g}^{-1} \text{ K}^{-1}$ )

The Periodic Table of Elements

		Group															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;"> <b>Key</b>                      atomic number                      atomic symbol                      name                      relative atomic mass                 </div> <div style="border: 1px solid black; padding: 5px;">                     1                      H                      hydrogen                      1.0                 </div> </div>															
3	4																
Li lithium 6.9	Be beryllium 9.0																
11	12																
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 —	Ra radium —																
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71			
La lanthanum 138.9	Ce cerium 140.1	Pr praseodymium 140.9	Nd neodymium 144.4	Pm promethium —	Sm samarium 150.4	Eu europium 152.0	Gd gadolinium 157.3	Tb terbium 158.9	Dy dysprosium 162.5	Ho holmium 164.9	Er erbium 167.3	Tm thulium 168.9	Yb ytterbium 173.1	Lu lutetium 175.0			
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103			
Ac actinium —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —			

lanthanoids

actinoids

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