



Cambridge Pre-U

CHEMISTRY

9791/01

Paper 1 Multiple Choice

October/November 2020

1 hour

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet Data booklet
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

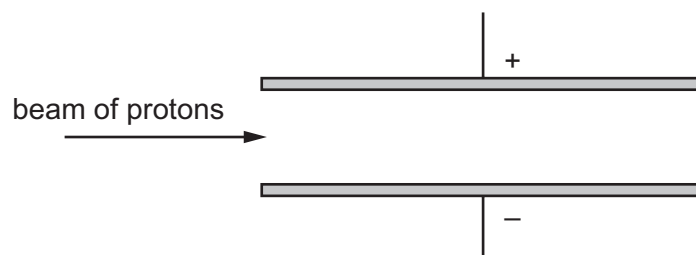
- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

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



- 1 A beam of protons was passed through an electrostatic field between two charged plates. The electrostatic field deflected the beam of protons.



The experiment was repeated using a beam of electrons in place of the beam of protons. The velocity of the electrons was the same as the velocity of the protons.

How does the amount and direction of deflection of the beam of electrons compare to the amount and direction of deflection of the beam of protons?

	amount of deflection of beam of electrons	direction of deflection of beam of electrons
A	deflected less than beam of protons	opposite direction to beam of protons
B	deflected less than beam of protons	same direction as beam of protons
C	deflected more than beam of protons	opposite direction to beam of protons
D	deflected more than beam of protons	same direction as beam of protons

- 2 The compound $\text{Mn}_3(\text{PO}_4)_2$ contains the phosphate ion in which phosphorus has an oxidation state of +5.

What is the electronic configuration of the manganese ion in $\text{Mn}_3(\text{PO}_4)_2$?

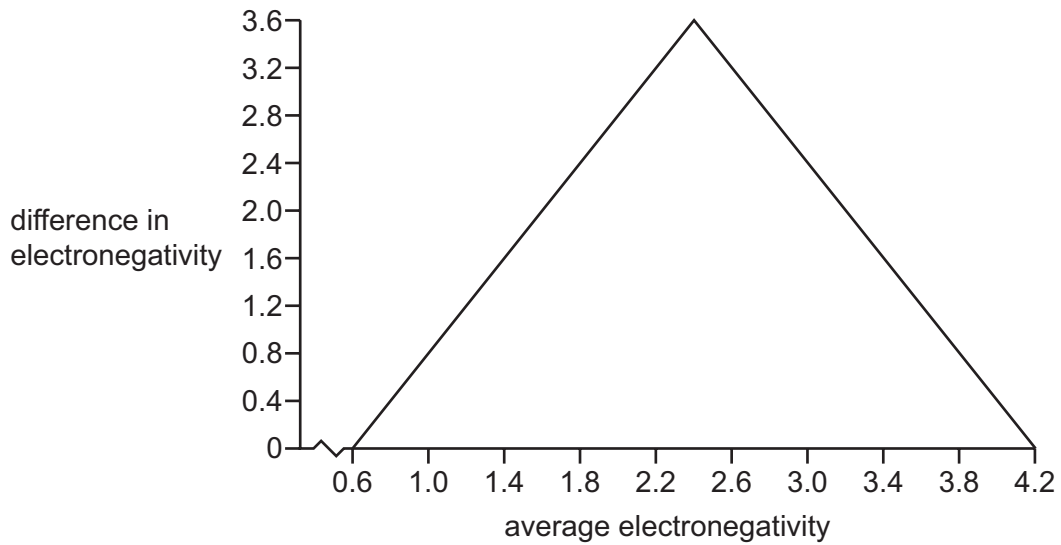
- A** $[\text{Ar}] 3d^4$ **B** $[\text{Ar}] 3d^5$ **C** $[\text{Ar}] 3d^3 4s^2$ **D** $[\text{Ar}] 3d^5 4s^2$

- 3 Acids are used in many chemical reactions.

For which reaction mixture is the role of acid described correctly?

	reaction mixture	role of acid
A	ethanoic acid, ethanol and concentrated sulfuric acid	oxidising agent
B	ethanol, potassium dichromate(VI) and dilute sulfuric acid	catalyst
C	ethene, steam and phosphoric acid	dehydrating agent
D	sodium bromide and concentrated sulfuric acid	oxidising agent

- 4 A van Arkel diagram can be used to predict the bonding in Group 14 oxides.

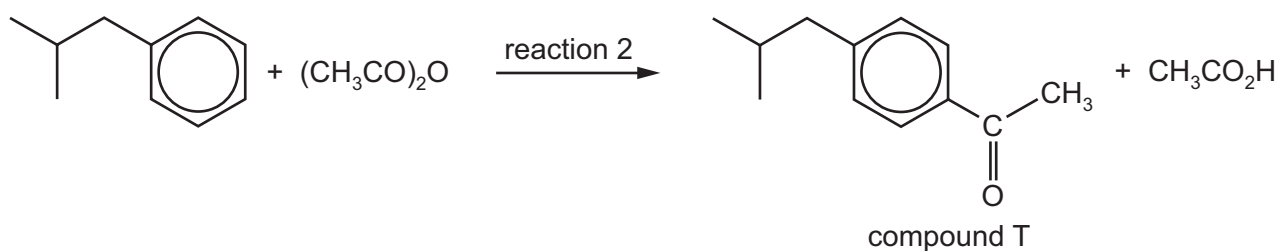
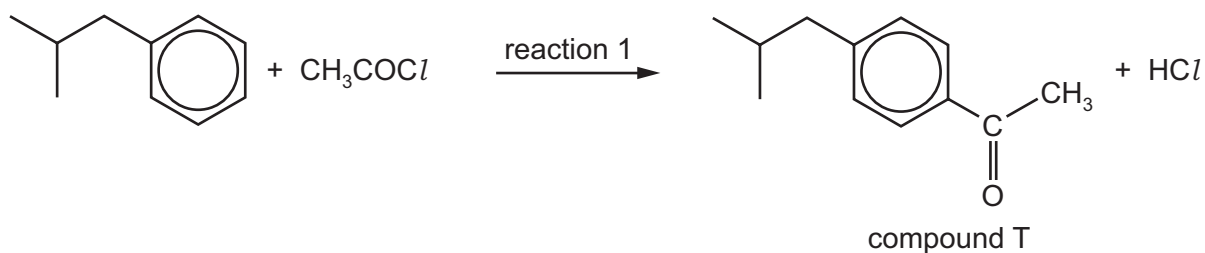


What is the bonding in the Group 14 oxide XO which has an average electronegativity of 3.0 and a difference in electronegativity of 0.9?

- A** covalent
B intermediate between ionic and covalent
C ionic
D metallic
- 5 How many neutrons are present in 0.13 g of ^{13}C ?
 [L = the Avogadro constant]
- A** $0.06L$ **B** $0.07L$ **C** $0.13L$ **D** $0.91L$

- 6 Ibuprofen is an over-the-counter pain killer. There are a number of ways to synthesise this drug.

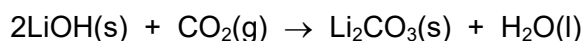
The first step in the synthesis of ibuprofen involves the production of compound T by either reaction 1 or reaction 2.



Assuming compound T is the only utilised product, which statement is correct?

- A** Adding a catalyst to either reaction will increase its atom economy.
- B** Reaction 1 has a higher atom economy than reaction 2.
- C** Reaction 2 has a higher atom economy than reaction 1.
- D** Since both reactions use the same starting material, and the utilised product is the same in both reactions, the reactions have the same atom economy.
- 7 Lithium hydroxide has been used to remove carbon dioxide from the air inside spacecraft.

The overall equation for the reaction is shown.



What is the maximum mass of carbon dioxide that can be removed from the air inside spacecraft by 100 g of lithium hydroxide?

- A** 50.0 g **B** 92.1 g **C** 184 g **D** 368 g
- 8 The thermal decomposition of ammonium nitrate gives only two products: steam and an oxide of nitrogen, X.

What is the oxidation number of nitrogen in X?

- A** +1 **B** +2 **C** +3 **D** +4

9 Alcohols can undergo an elimination reaction to produce alkenes.

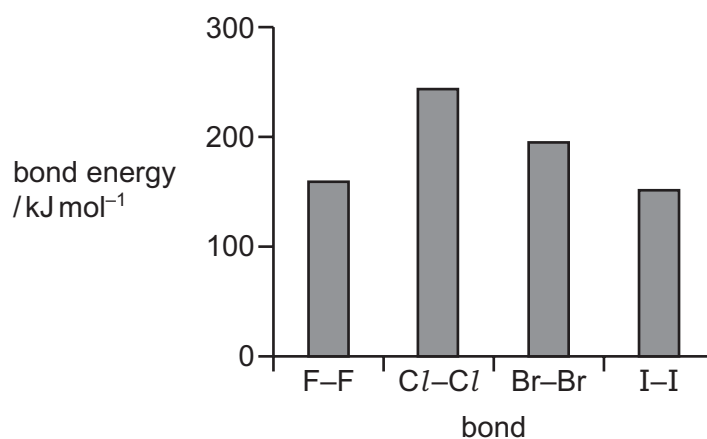
How many isomeric alkenes can be produced by the elimination of water from butan-2-ol?

- A 2 B 3 C 4 D 5

10 Which description involves the largest number of moles of the substance given?

- A 480 cm³ of HCl(g) at room temperature and pressure
 B 1.92 g of ozone
 C H⁺(aq) in 0.100 dm³ of 0.500 mol dm⁻³ CH₃CO₂H(aq)
 D OH⁻(aq) in 0.500 dm³ of 0.100 mol dm⁻³ NaOH(aq)

11 The graph shows the trend in bond energies for the halogens.



Which statements explain the shape of the graph in terms of pairs of electrons?

- As the atoms get smaller the lone pairs on the two atoms get close enough to repel.
- As the bonding pair gets further from the nuclei the bond strength decreases.
- The bonding pair experiences different amounts of net attraction from each nucleus.

- A 1 and 2 B 1 only C 2 only D 2 and 3

12 Scandium, Sc, is a d-block element but it is not considered a transition element.

Which statement explains why?

- A Sc has a high melting point.
 B Sc has 9 electrons fewer than Zn.
 C The electronic configuration of Sc is [Ar]3d¹4s².
 D The only stable Sc ion, Sc³⁺, has no d electrons.

13 Four compounds of Period 3 elements are listed.



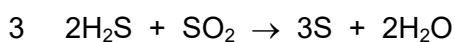
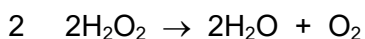
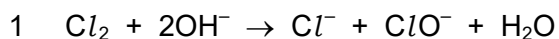
Water is added to separate samples of each of the four compounds.

Pairs of the resulting solutions are mixed together.

From which pair is it possible to get a solution with a pH of 7?

- A NaCl and Na₂O
- B NaCl and SO₂
- C Na₂O and SiCl₄
- D SiCl₄ and SO₂

14 Which reactions involve both a positive **and** a negative change in the oxidation number of a single element?



- A 1 and 2 only
- B 1, 3 and 4 only
- C 2, 3 and 4 only
- D 1, 2, 3 and 4

15 In which pair of molecules or ions do **both** species contain a bond angle of 107°?

- A CH₃⁺ and NH₃
- B H₂O and NH₂⁻
- C NH₃ and NH₂⁻
- D NH₃ and H₃O⁺

16 The information relates to element E.

- E is in Period 3 of the Periodic Table.
- E has a lower electrical conductivity than Mg.
- An atom of E has a half-filled subshell in its ground state.
- E forms an acidic oxide on exposure to air.

What is E?

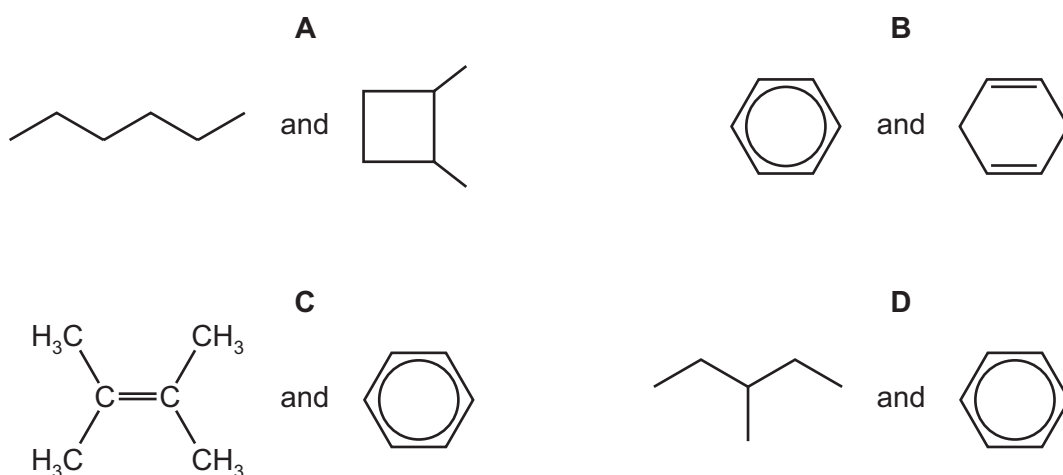
A Na

B Si

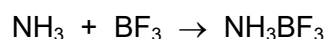
C P

D Cl

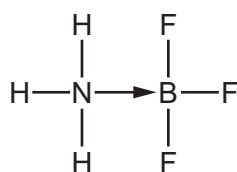
17 In which pair of molecules do both molecules contain six carbon atoms in the same plane?



18 A molecule of ammonia reacts with a molecule of boron trifluoride.



The product has the structure shown.



How do the H–N–H and F–B–F bond angles change during the reaction?

	H–N–H bond angle	F–B–F bond angle
A	decreases	deceases
B	decreases	increases
C	increases	decreases
D	increases	increases

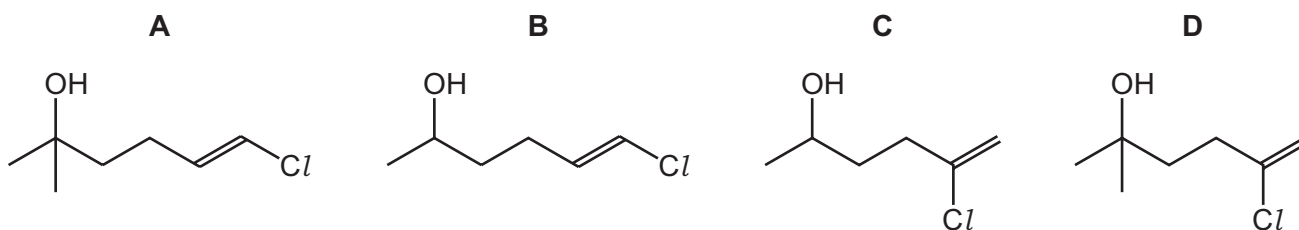
19 Which shows the chemical bonds in order of increasing bond length?

- A $Cl-Cl$ $F-F$ $O=O$ $N\equiv N$
 B $F-F$ $Cl-Cl$ $O=O$ $N\equiv N$
 C $N\equiv N$ $O=O$ $Cl-Cl$ $F-F$
 D $N\equiv N$ $O=O$ $F-F$ $Cl-Cl$

20 Which statement about the bonding in O_2 and N_2 molecules is correct?

- A Both molecules have the same number of electrons in antibonding orbitals.
 B The bond energy in the O_2 molecule is greater than the bond energy in the N_2 molecule.
 C The N_2 molecule has a greater bond order than the O_2 molecule.
 D The N_2 molecule has a greater number of σ bonds than the O_2 molecule.

21 Which compound displays both optical and geometric isomerism?



22 How many peaks would be expected in the proton NMR spectrum of propanone?

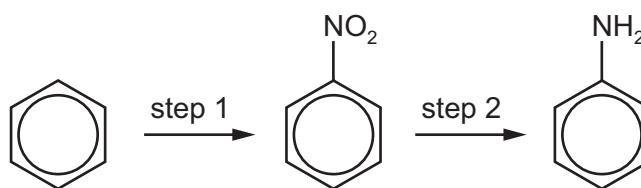
- A 1 B 2 C 3 D 6

23 Magnesium has a HCP structure.

Which row describes the crystal structure in magnesium?

	stacking sequence	coordination number
A	ABAB	8
B	ABAB	12
C	ABCABC	8
D	ABCABC	12

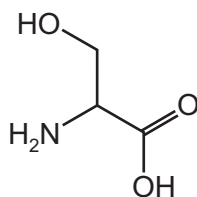
24 Aminobenzene can be prepared in two steps.



Which reagent is needed for each step?

	step 1	step 2
A	conc. H_2SO_4 /conc. HNO_2	NH_3
B	conc. H_2SO_4 /conc. HNO_2	$\text{Sn} + \text{conc. HCl}$
C	conc. H_2SO_4 /conc. HNO_3	NH_3
D	conc. H_2SO_4 /conc. HNO_3	$\text{Sn} + \text{conc. HCl}$

25 The diagram shows a molecule of the amino acid serine.



Which form of serine exists at pH 2?

- A** $\text{H}_3\text{N}^+\text{CH}(\text{CH}_2\text{OH})\text{COOH}$
B $\text{H}_3\text{N}^+\text{CH}(\text{CH}_2\text{OH}_2^+)\text{COOH}$
C $\text{H}_2\text{NCH}(\text{CH}_2\text{OH})\text{COO}^-$
D $\text{H}_2\text{NCH}(\text{CH}_2\text{OH})\text{COOH}_2$

26 The reaction between a bromoalkane, RBr , and hydroxide ions, OH^- , has an $\text{S}_{\text{N}}1$ mechanism.

Which steps and their relative rates describe this mechanism?

- A** $\text{RBr} + \text{OH}^- \rightarrow \text{RBrOH}^-$ (slow)
 $\text{RBrOH}^- \rightarrow \text{ROH} + \text{Br}^-$ (fast)
B $\text{RBr} + \text{OH}^- \rightarrow \text{RBrOH}^-$ (fast)
 $\text{RBrOH}^- \rightarrow \text{ROH} + \text{Br}^-$ (slow)
C $\text{RBr} \rightarrow \text{R}^+ + \text{Br}^-$ (slow)
 $\text{R}^+ + \text{OH}^- \rightarrow \text{ROH}$ (fast)
D $\text{RBr} \rightarrow \text{R}^+ + \text{Br}^-$ (fast)
 $\text{R}^+ + \text{OH}^- \rightarrow \text{ROH}$ (slow)

- 27 Two separate electrolyses were performed and the volumes of gases produced were measured at the same temperature and pressure.

electrolysis 1 Molten copper(II) chloride was electrolysed for three minutes; 10 cm³ of chlorine was collected.

electrolysis 2 Aqueous sulfuric acid was electrolysed for three minutes; 10 cm³ of oxygen was collected.

The current used in electrolysis 1 was a amps.

What was the current used in electrolysis 2?

- A $\frac{a}{2}$ amps B a amps C $2a$ amps D $4a$ amps

- 28 An organic compound Q has the structure (CH₃)₂CCHCOCH₃.

Which types of reaction will Q undergo?

- A nucleophilic addition and electrophilic addition
B nucleophilic addition and nucleophilic substitution
C nucleophilic addition only
D nucleophilic substitution and electrophilic addition

- 29 The ionic model treats ions as hard spheres and is used to calculate expected values for lattice enthalpies.

The experimental lattice enthalpy of which compound should show greatest agreement with the predicted value when the ionic model is used?

- A AlCl₃ B NaCl C AgI D BeI₂

- 30 The standard enthalpy change of combustion of carbon is -394 kJ mol^{-1} .

2.00 g of carbon are completely combusted. The laboratory temperature is 17.0 °C. The temperature of the laboratory does not change significantly during combustion of the carbon.

What is the entropy change of the surroundings, to three significant figures, of this combustion process?

- A $+226 \text{ JK}^{-1}$ B $+1360 \text{ JK}^{-1}$ C $+3860 \text{ JK}^{-1}$ D $+23200 \text{ JK}^{-1}$

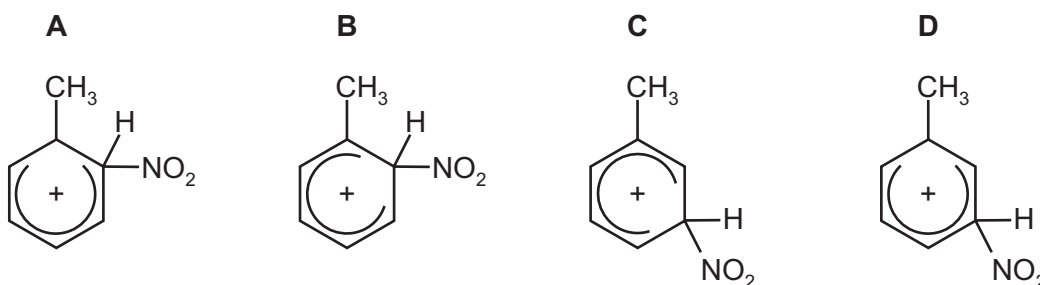
- 31 1,2-diaminoethane, $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$, is a bidentate ligand and forms many complexes with transition elements.

The octahedral complex $[\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2\text{Br}_2]^+$ exists as isomers.

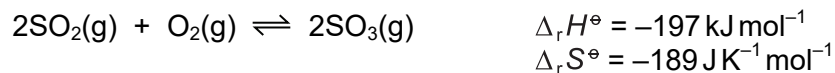
Which type of isomerism can this complex show and what is the total number of isomers?

	type of isomerism	total number of isomers
A	geometric and optical	3
B	geometric and optical	4
C	geometric only	2
D	optical only	2

- 32 What will be the main intermediate ion formed in the nitration of methylbenzene?



- 33 Some thermodynamic data for the reaction of $\text{SO}_2(\text{g})$ and $\text{O}_2(\text{g})$ are given.



T_0 is the temperature, in kelvin, at which the forward reaction becomes spontaneous.

Which row gives the correct expression for this temperature and shows how $\Delta_r G$ changes with increasing T ?

You should assume that $\Delta_r H^\ominus$ and $\Delta_r S^\ominus$ do not change with increasing temperature.

	T_0	change in $\Delta_r G$ with increasing T
A	$\frac{-197000}{-189}$	increases
B	$\frac{-197}{-0.189}$	stays the same
C	$\frac{-197}{0.0189}$	increases
D	$\frac{197000}{-189}$	decreases

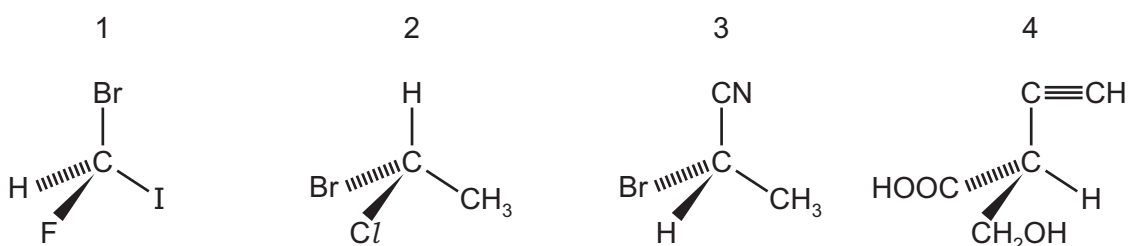
34 One repeating unit of a condensation polymer is shown.



Which monomers are used to form this polymer?

- A** HOCH₂CH₂COOH only
B HOOCCH₂CH₂COOH and HOCH₂CH₂OH
C HOCCOOH and HOCH₂CH₂CH₂CH₂OH
D HOOCCH₂COOH and HOCH₂CH₂CH₂OH

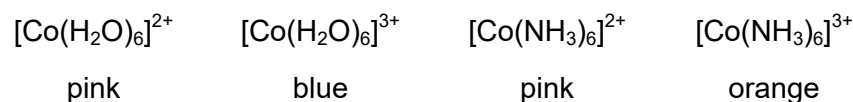
35 Four 3-dimensional structures of optically active compounds are shown.



Which compounds are optical R isomers?

- A** 1, 3 and 4 **B** 1 and 4 only **C** 1 only **D** 2 only

36 The colours of four complex ions containing cobalt are given.



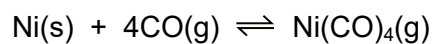
When an aqueous solution of $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ is left to stand in air for several minutes, no observable change occurs.

When an aqueous solution of $[\text{Co}(\text{NH}_3)_6]^{2+}$ is left to stand in air for several minutes, the pink solution gradually turns orange.

Which statement accounts for these observations?

- A** $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ reacts with O₂ in the air to form $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$.
B Cobalt(III) is more stable in air than cobalt(II) when bound to NH₃ ligands.
C H₂O oxidises cobalt(II) to cobalt(III).
D NH₃ oxidises cobalt(II) to cobalt(III).

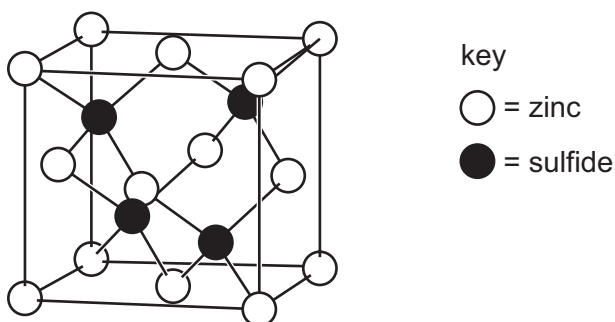
37 Solid nickel reacts with carbon monoxide gas to form a compound.



What is the effect of increasing the concentration of CO(g) ?

- A The concentration of $\text{Ni(CO)}_4\text{(g)}$ decreases.
- B The mass of Ni(s) decreases.
- C The mass of Ni(s) increases.
- D The value of K_c increases.

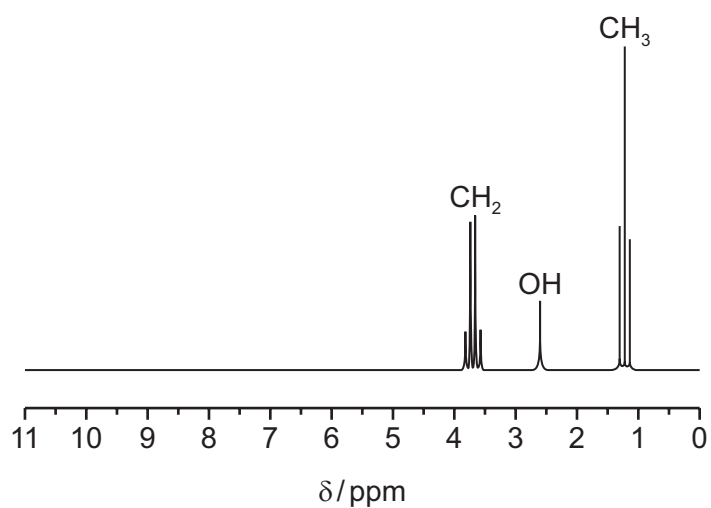
38 A unit cell of zinc blende is shown.



Which statement about zinc blende is correct?

- A Each ion has local octahedral geometry.
- B The anions occupy all of the tetrahedral holes present.
- C The coordination number of the sulfide is 4.
- D The coordination number of the zinc is 2.

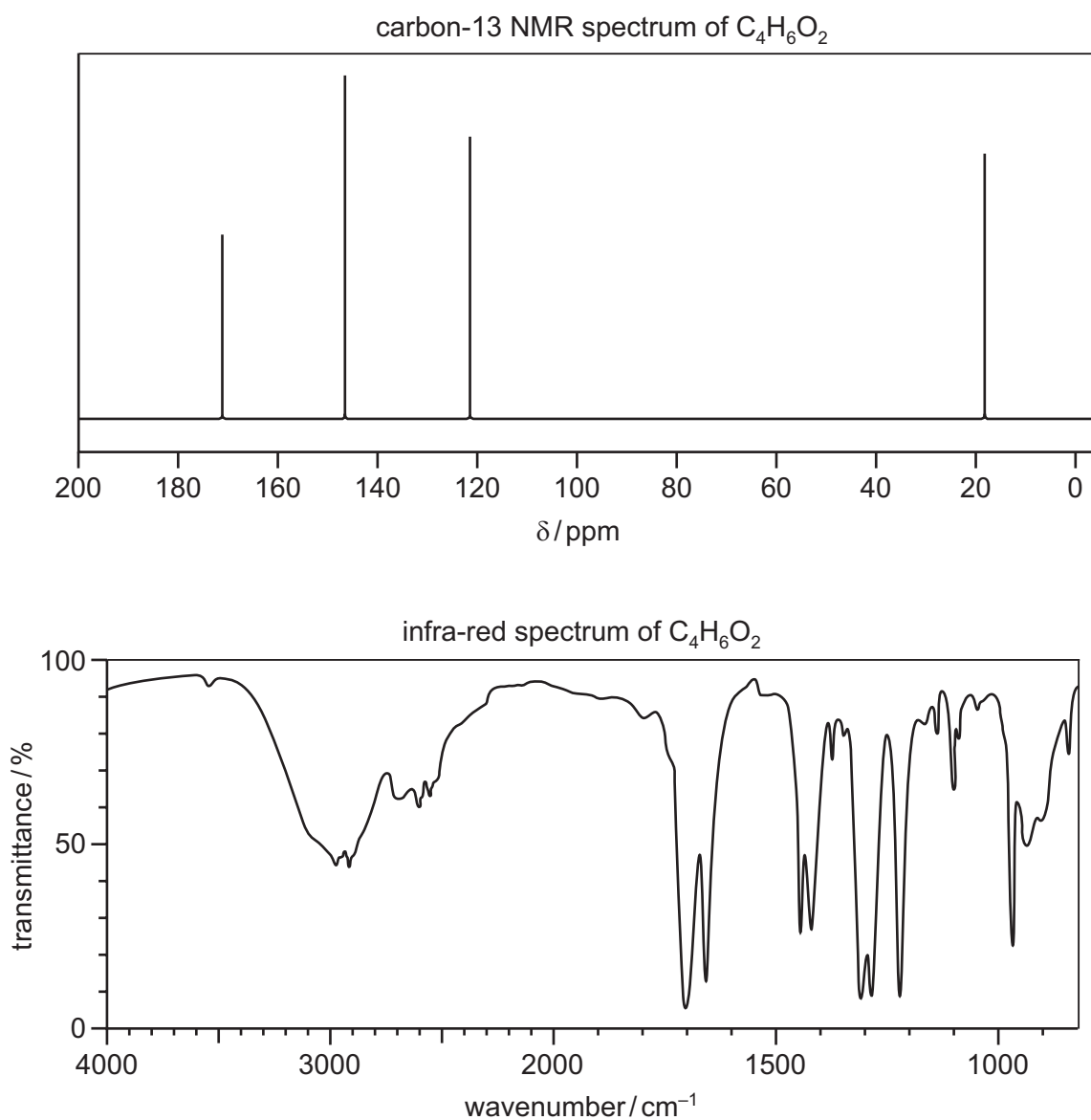
39 The proton NMR spectrum of ethanol is shown.



What will happen to the spectrum when D_2O is added to the ethanol sample?

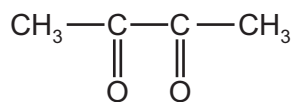
- A There is no change.
- B The CH_2 signal disappears.
- C The CH_3 signal disappears.
- D The OH signal disappears.

40 The diagrams show the carbon-13 NMR and infra-red spectra of a compound of formula $C_4H_6O_2$.

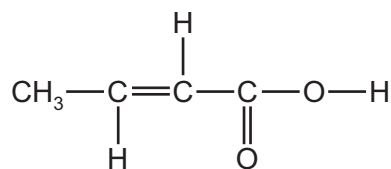


What is the compound?

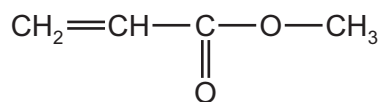
A



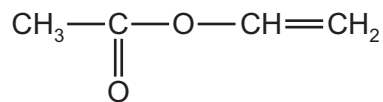
B



C



D



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