Analysis

Question Paper

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Analysis
Booklet	Question Paper

Time Allowed: **49 minutes**

Score: **/41**

Percentage: **/100**

Grade Boundaries:

Qualitative and Quantitative

1. Iodine is far less soluble in water than it is in aqueous potassium iodide, where it forms the complex ion I_3^-. For this reason, reactions involving aqueous iodine are often carried out in potassium iodide solution.

   Which equation describes the quantitative determination of iodine in the presence of excess potassium iodide?

   A $I_2 + 2SO_4^{2-} \rightarrow 2I^- + S_2O_8^{2-}$

   B $2I^- + 2S_2O_3^{2-} \rightarrow I_2 + S_4O_6^{2-}$

   C $I_3^- + 2SO_4^{2-} \rightarrow 3I^- + S_2O_8^{2-}$

   D $I_3^- + 2S_2O_3^{2-} \rightarrow 3I^- + S_4O_6^{2-}$

2. In a famous experiment, the German chemist Wöhler heated an inorganic salt and produced urea, $CO(NH_2)_2$, as the **only** product.

   The original inorganic salt, on heating with aqueous NaOH, produced a gas which turned damp red litmus paper blue.

   What is the formula of the anion in the original inorganic salt?

   A CNO^- **B** CN^- **C** CO_3^{2-} **D** NH_2^-

3. Copper(II) ions react with iodide ions to release iodine as shown in the following equation.

$$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$$

   The iodine released can be determined by titration using a standardised solution of sodium thiosulfate. The equation for this reaction is shown below.

$$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$

   25.00 cm^3 of a solution containing copper(II) ions was treated with excess iodide ions. The resulting iodine required 26.50 cm^3 of sodium thiosulfate solution of concentration 0.150 mol dm^{-3} for complete reaction.

   What was the concentration of copper(II) ions in the solution used?

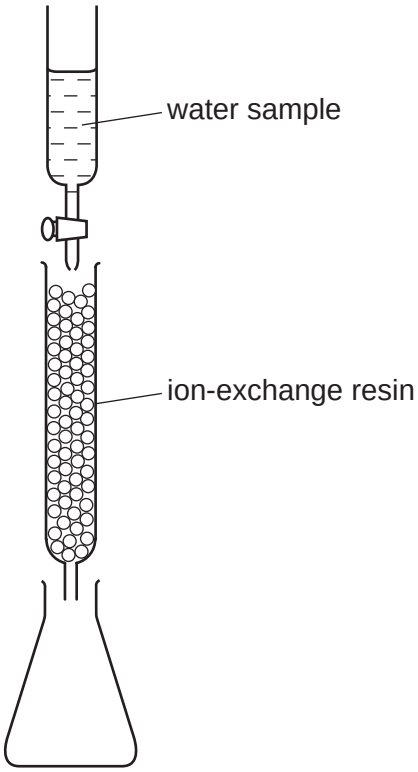
   A 0.0795 mol dm^{-3}

   B 0.142 mol dm^{-3}

   C 0.159 mol dm^{-3}

   D 0.318 mol dm^{-3}

4. The concentration of calcium ions in a sample of natural water can be determined by using an ion-exchange column as shown in the diagram.



A 50.0 cm^3 sample of water containing dissolved calcium sulfate was passed through the ion-exchange resin. Each calcium ion in the sample was exchanged for two hydrogen ions. The resulting acidic solution collected in the flask required 25.0 cm^3 of 1.00×10^{-2} mol dm^{-3} potassium hydroxide for complete neutralisation.

What was the concentration of the calcium sulfate in the original sample?

A 2.50×10^{-3} mol dm^{-3}

B 1.00×10^{-2} mol dm^{-3}

C 2.00×10^{-2} mol dm^{-3}

D 4.00×10^{-2} mol dm^{-3}

5. A gravimetric analysis of a sample of an iron ore was carried out.

0.5873 g of ore was dissolved in perchloric acid to oxidise the iron to Fe^{3+}. The resultant solution was filtered to remove solid impurities and made basic to precipitate the Fe^{3+} as a hydrated hydroxide. The precipitate was filtered and heated to produce 0.3174 g of Fe_2O_3.

Which percentage of iron did the ore contain?

A 18.90 % **B** 37.80 % **C** 54.04 % **D** 64.71 %

6. A large excess of aqueous silver nitrate is added to aqueous barium chloride and the precipitate removed by filtration.

What are the most abundant ions in the filtrate?

A Ag^+, Ba^{2+} and NO_3^-

B Ag^+ and NO_3^- only

C Ba^{2+}, NO_3^- and Cl^-

D Ba^{2+} and NO_3^- only

7. A chemist has samples of solutions of aluminium nitrate and lead(II) nitrate.

Which reagent will **not** be able to distinguish clearly between these two substances? (All reagents are soluble in water.)

A HCl **B** KI **C** NaOH **D** Na_2SO_4

8. 25.00 cm^3 of a solution of acidified iron(II) sulfate, $FeSO_4$, were titrated with 0.0200 mol dm^{-3} potassium manganate(VII). The mean titre was 27.40 cm^3.

The equation for the reaction is shown.

$$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$$

What is the concentration of iron(II) sulfate solution?

A 4.38×10^{-3} mol dm^{-3}

B 2.19×10^{-2} mol dm^{-3}

C 9.12×10^{-2} mol dm^{-3}

D 1.10×10^{-1} mol dm^{-3}

9. 12.5 cm^3 of 0.0500 mol dm^{-3} sodium hydroxide is added to 25.0 cm^3 of 0.100 mol dm^{-3} hydrochloric acid.

   Which concentration of hydrochloric acid remains in the reaction mixture?

   A 0.0019 mol dm^{-3}

   B 0.0333 mol dm^{-3}

   C 0.0500 mol dm^{-3}

   D 0.0750 mol dm^{-3}

10. Which mixture of gaseous oxygen and nitrogen would occupy 0.12 dm^3 at room temperature and pressure?

   A 0.032 g O_2 and 0.084 g N_2

   B 0.096 g O_2 and 0.028 g N_2

   C 0.096 g O_2 and 0.056 g N_2

   D 0.096 g O_2 and 0.084 g N_2

Mass Spectrometry

11. The mass spectrum of CH_2F_2 would **not** contain a peak at which m/z value?

A 14 **B** 19 **C** 38 **D** 52

12. Which does **not** represent a process that produces a detectable ion in a mass spectrometer?

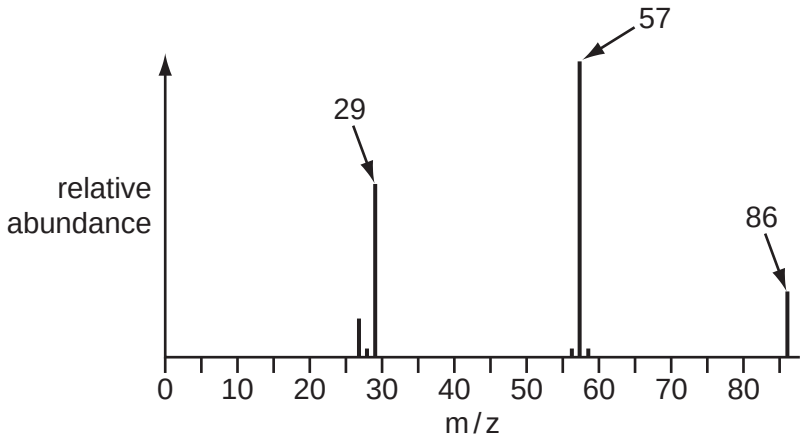
A $C_3H_6(g) + H^+(g) \rightarrow C_3H_7^+(g)$

B $CH_3COCl(g) + e^- \rightarrow CH_3CO^+(g) + Cl^-(g) + e^-$

C $Cl_2(g) + e^- \rightarrow Cl\bullet(g) + Cl^-(g)$

D $He(g) + e^- \rightarrow He^+(g) + 2e^-$

13. The diagram shows a simplified mass spectrum for pentan-3-one.



Which equation represents the process that produces the particle responsible for the peak at m/z 57?

A $CH_3CH_2COCH_2CH_3^{\bullet +} \rightarrow CH_3CH_2CO^+ + {}^{\bullet}CH_2CH_3$

B $CH_3CH_2COCH_2CH_3^{\bullet +} \rightarrow CH_3CH_2CO^{\bullet} + {}^{+}CH_2CH_3$

C $CH_3CH_2COCH_2CH_3^{\bullet +} \rightarrow CH_3CH_2CH_2CH_2^{\bullet} + {}^{+}CHO$

D $CH_3CH_2COCH_2CH_3^{\bullet +} \rightarrow CH_3CH_2CH_2CH_2^+ + {}^{\bullet}CHO$

14. In a time-of-flight mass spectrometer, in which order do the fragments arrive at the detector?

	1st	2nd	3rd
A	CO_2^+	CH_3CO^+	$CH_3CH_2NH_3^+$
B	CH_3CO^+	CO_2^+	$CH_3CH_2NH_3^+$
C	$CH_3CH_2NH_3^+$	CH_3CO^+	CO_2^+
D	$CH_3CH_2NH_3^+$	CO_2^+	CH_3CO^+

15. Which molecule gives large peaks in its mass spectrum at m/z = 29 and m/z = 43?

A $CH_2CHCH(CH_3)_2$

B $CH_3CH_2CH(CH_3)_2$

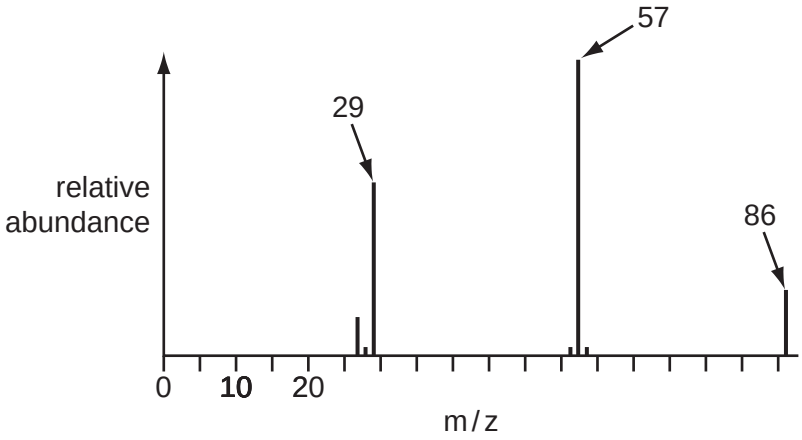
C $CH_3CH_2COOCH_2CH_3$

D CH_3COOCH_3

16. The mass spectrum of CH_2F_2 would **not** contain a peak at which m/z value?

A 14 **B** 19 **C** 38 **D** 52

17. The diagram shows a simplified mass spectrum for pentan-3-one.



Which equation represents the process that produces the particle responsible for the peak at m/z 57?

A $CH_3CH_2COCH_2CH_3^{\bullet+} \rightarrow CH_3CH_2CO^+ + {}^{\bullet}CH_2CH_3$

B $CH_3CH_2COCH_2CH_3^{\bullet+} \rightarrow CH_3CH_2CO^{\bullet} + {}^{+}CH_2CH_3$

C $CH_3CH_2COCH_2CH_3^{\bullet+} \rightarrow CH_3CH_2CH_2CH_2^{\bullet} + {}^{+}CHO$

D $CH_3CH_2COCH_2CH_3^{\bullet+} \rightarrow CH_3CH_2CH_2CH_2^{+} + {}^{\bullet}CHO$

Electronic Spectroscopy

18. Why does the atomic emission spectrum of hydrogen have fewer lines than that of helium?

A H atoms, unlike He atoms, can dimerise to H_2.

B Hydrogen has fewer electrons.

C Hydrogen has fewer protons.

D There are no electron-electron interactions in H atoms.

19. Which description of the emission spectrum of the hydrogen atom is correct?

A a series of lines that are evenly spaced

B a series of lines that converge towards higher frequencies

C a series of lines that converge towards lower energies

D a series of lines that converge towards lower frequencies

20. Which statement about electronic spectroscopy is **not** correct?

A Higher electron shells in hydrogen become closer together in energy.

B In the atomic emission line spectrum for hydrogen, the convergence limit represents the electron breaking free from the hydrogen atom.

C The energy of a transition is inversely proportional to the frequency of the photon that is absorbed or emitted.

D In the hydrogen atom, the subshells within each quantum shell all have the same energy.

21. When a small sample of sodium chloride is introduced into a Bunsen burner flame a bright yellow colouration is observed.

What causes this colouration?

A The electrons in the chlorine atoms absorb energy.

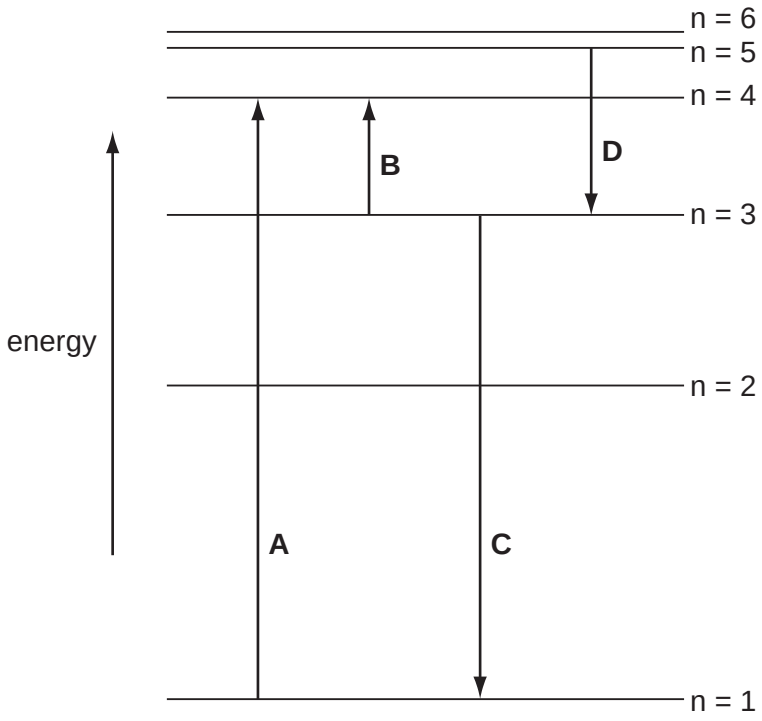
B The electrons in the chlorine atoms emit energy.

C The electrons in the sodium atoms absorb energy.

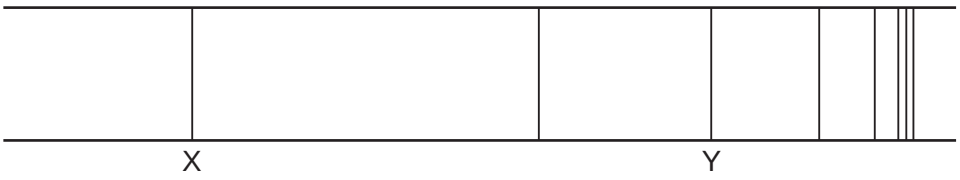
D The electrons in the sodium atoms emit energy.

22. The diagram shows the energy levels within the hydrogen atom with some transitions between the energy levels included.

Which transition will have the highest frequency in the **emission** spectrum of the hydrogen atom?



23. The diagram shows part of a simplified emission spectrum of hydrogen.



Which statement about the lines X and Y is correct?

A The energy of line Y is greater than the energy of line X but the frequencies are the same.

B The energy of line Y is lower than the energy of line X.

C The frequency of line Y is lower than the frequency of line X.

D X and Y are caused by transitions to the same energy level.

Infra Red

24. Compound **X** has a M_r of 58 and an infra-red spectrum that shows a strong absorbance at $3350\,cm^{-1}$.

What is compound **X**?

A prop-2-en-1-ol

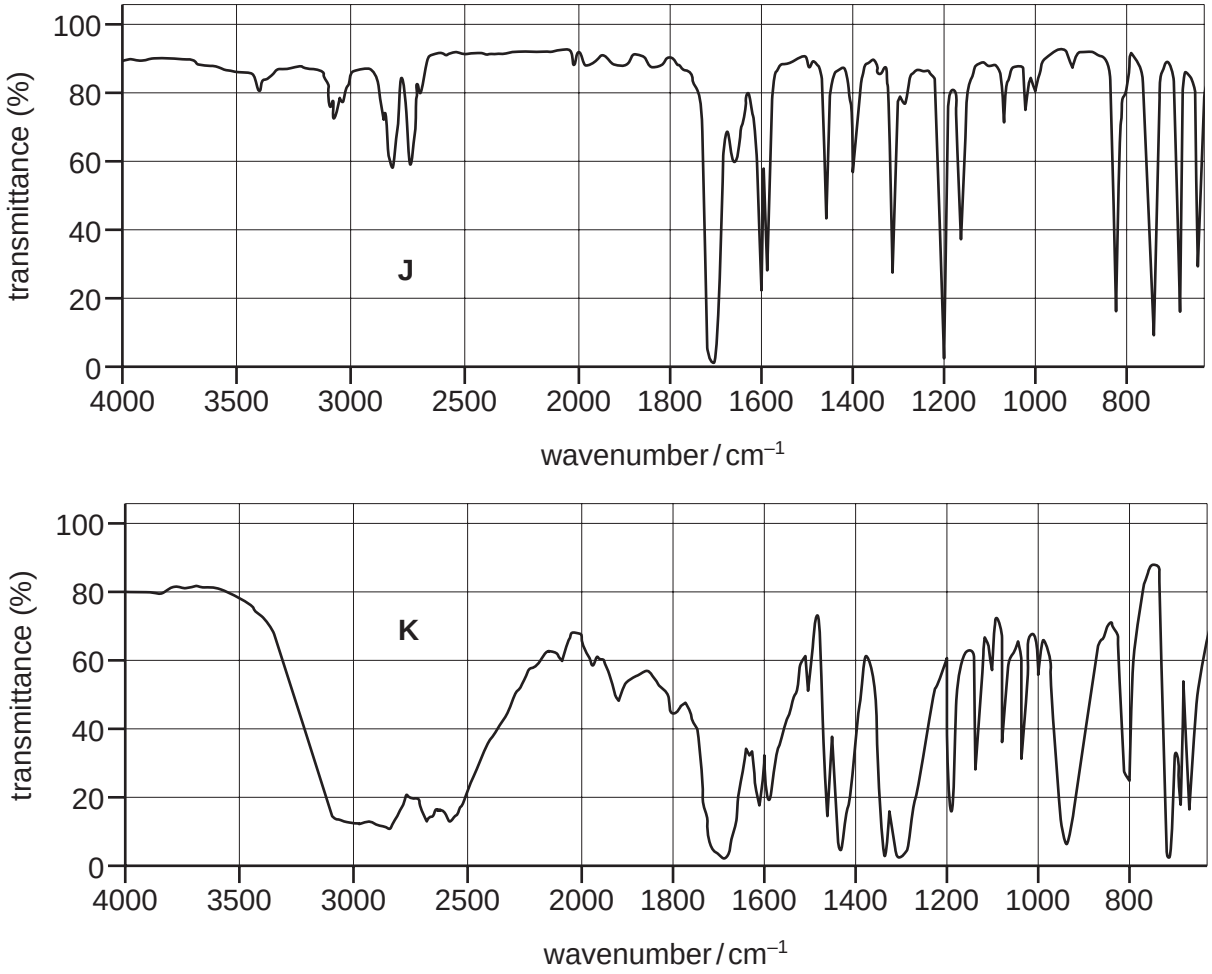
B propanal

C propan-1-ol

D propanone

25. A sample of organic liquid **J** was placed on a watch-glass and left exposed to the atmosphere. A few days later a new substance **K** had been formed.

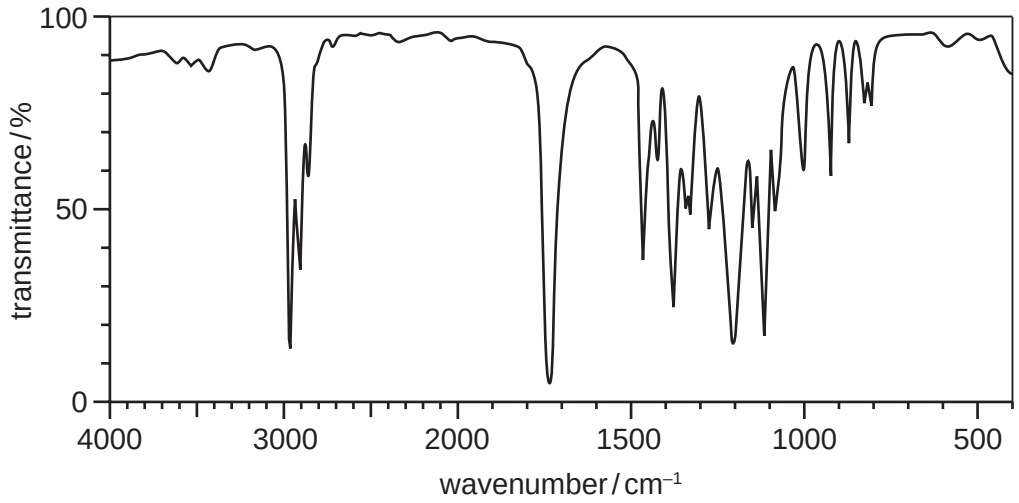
The infra-red spectra of **J** and **K** are given.



To which class of compounds do **J** and **K** belong?

	J	K
A	alcohol	carboxylic acid
B	alcohol	ketone
C	aldehyde	alcohol
D	aldehyde	carboxylic acid

26. The infra-red spectrum of compound **Q** is shown.



To which class of compound does **Q** belong?

A alkanes

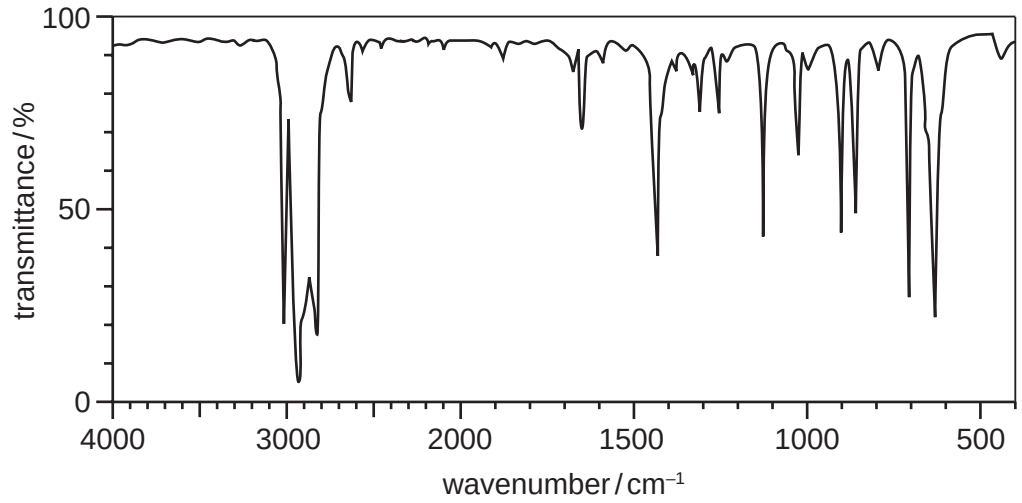
B carboxylic acids

C esters

D halogenoalkanes

27. A solution of chlorocyclohexane and sodium hydroxide was refluxed.

The organic product of this reaction had the infra-red spectrum shown.



Which statement about this reaction is correct?

A Cyclohexanol is formed in an elimination reaction.

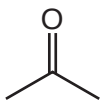
B Cyclohexanol is formed in a hydrolysis reaction.

C Cyclohexene is formed in an elimination reaction.

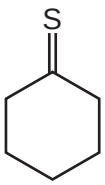
D Cyclohexene is formed in a hydrolysis reaction.

28. Which molecule has an odd number of peaks in its ^{13}C NMR spectrum?

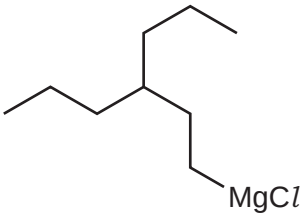
A



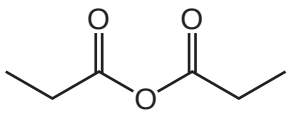
B



C

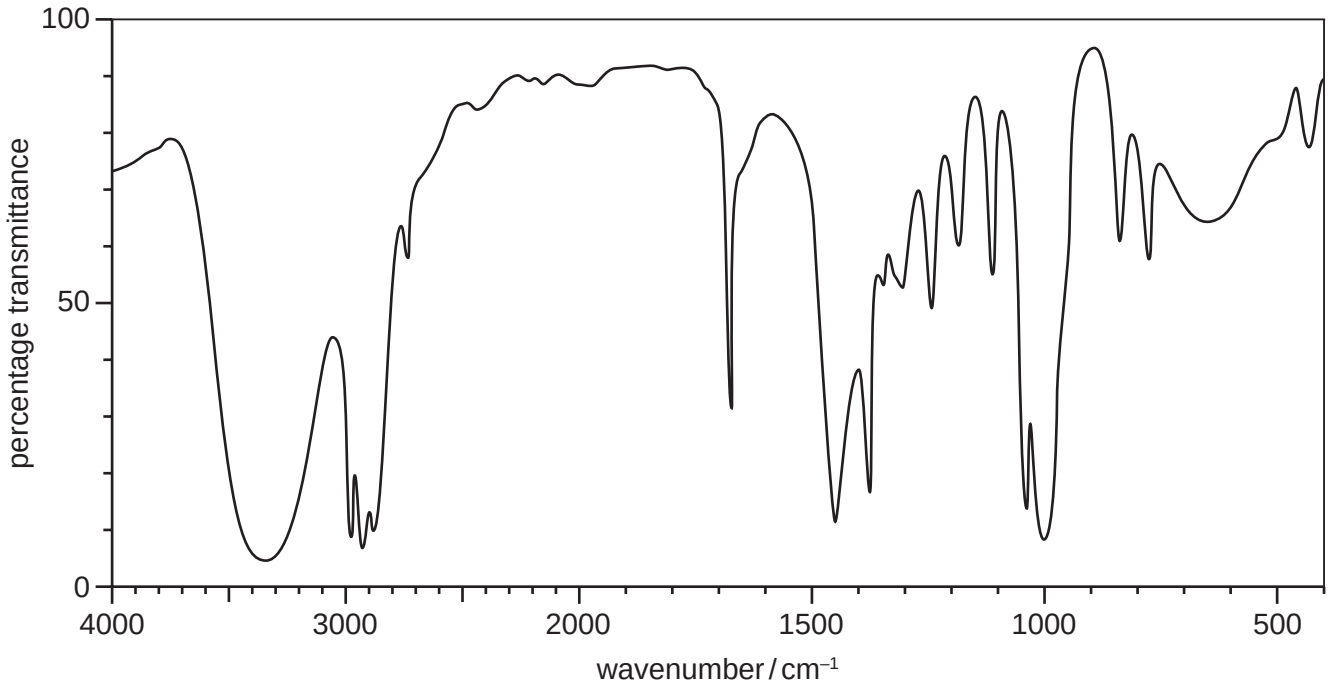


D



29. A compound has the molecular formula $C_5H_{10}O$.

The diagram shows the infra-red spectrum of the compound.



What is the structural formula of the compound?

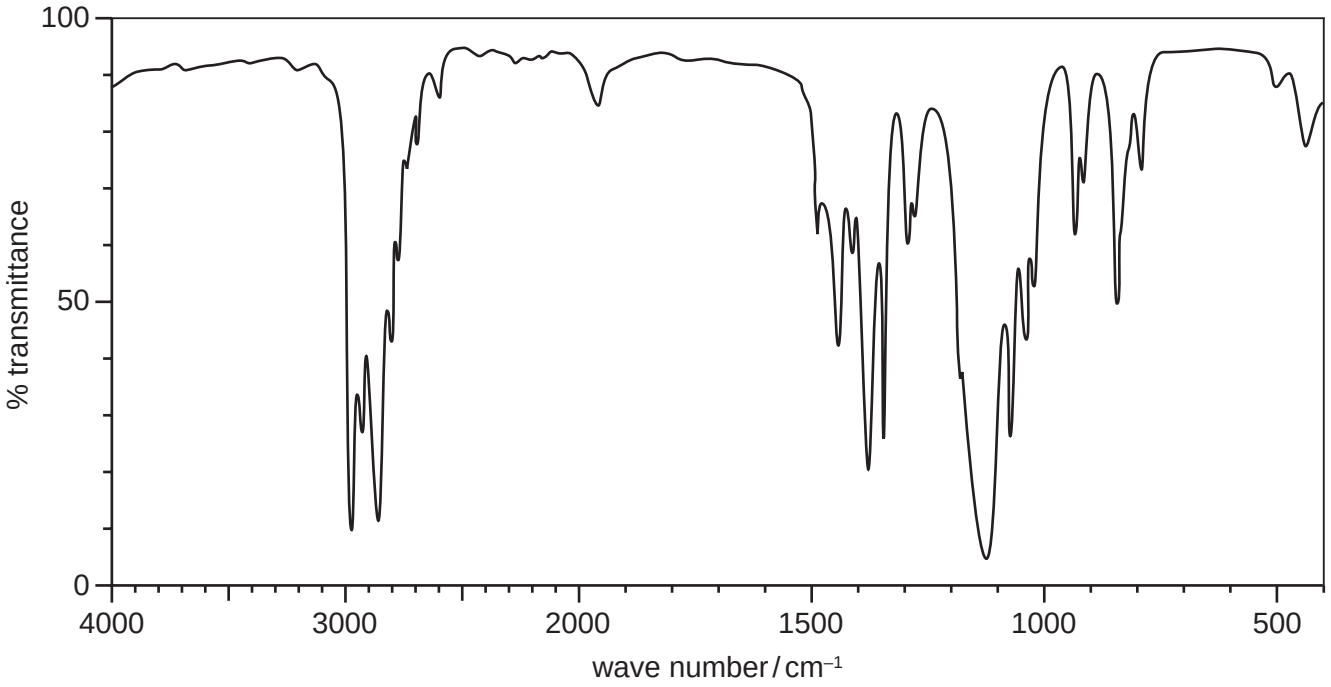
A $(CH_3)_2CHOCHCH_2$

B $CH_3CH_2CH_2CH_2CHO$

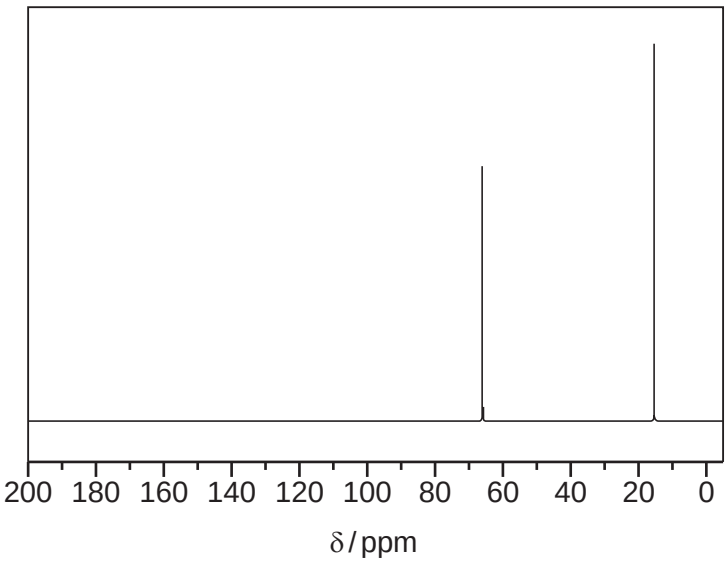
C $CH_3CH_2CH_2COCH_3$

D $CH_3C(CH_3)CHCH_2OH$

30. The infra-red spectrum of a compound of molecular formula $C_4H_{10}O$ is shown below.



The ^{13}C NMR spectrum for the same compound is shown below.



What is the compound?

A butan-1-ol [$HOCH_2CH_2CH_2CH_3$]

B diethyl ether [$CH_3CH_2OCH_2CH_3$]

C 1-methoxypropane [$CH_3OCH_2CH_2CH_3$]

D 2-methylpropan-2-ol [$(CH_3)_3COH$]

31. In the absence of reference spectra, infra-red spectroscopy can most easily be used to distinguish between

A 1-chloropropane and 1-bromopropane.

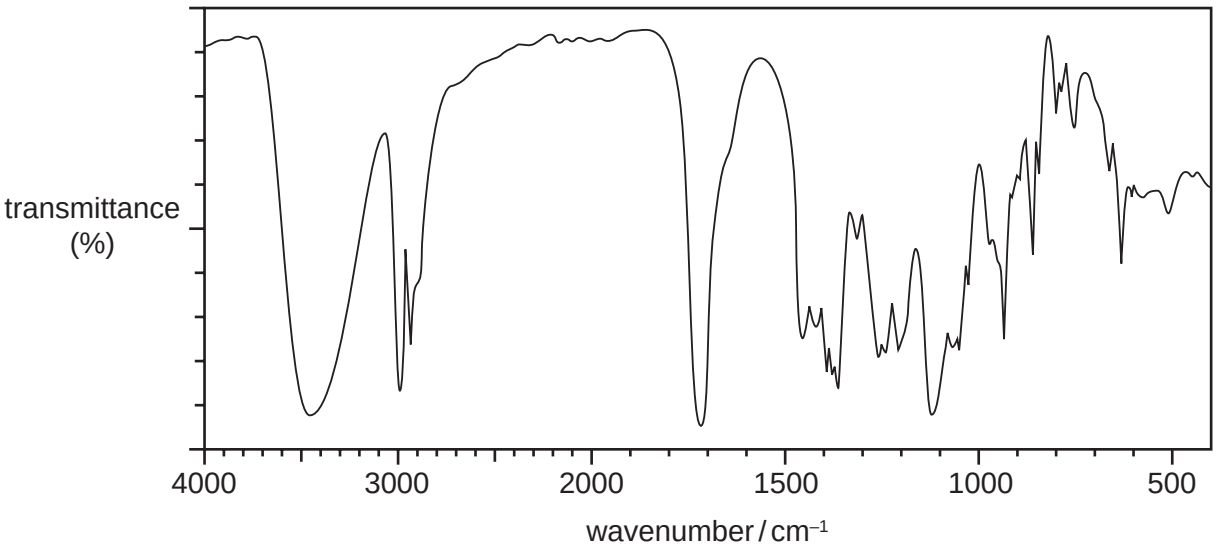
B cis but-2-ene and trans but-2-ene.

C ethanol and ethanal.

D propan-2-ol and propan-1-ol.

32. An organic compound has the empirical formula C_2H_4O.

The diagram shows the infra-red spectrum of the compound.



What is the structural formula of this compound?

A CH_3CHO

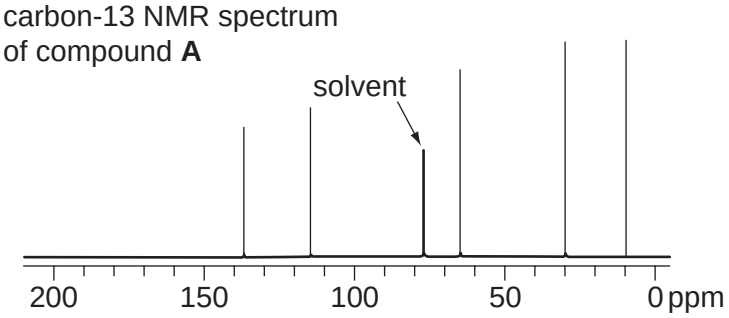
B $C_3H_7CO_2H$

C $HCO_2C_3H_7$

D $CH_3COCH(OH)CH_3$

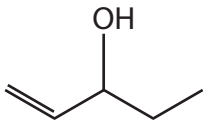
13C-NMR

33. Compound **A** has the formula $C_5H_{10}O$. Its carbon-13 NMR spectrum is shown below.

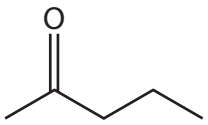


Which of the following structures is consistent with the NMR spectrum?

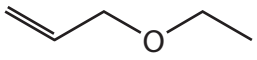
A



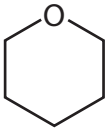
B



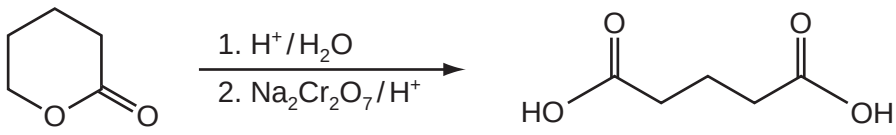
C



D



34. How many carbon-13 NMR signals are given by the organic reactant and product in the following reaction?



	reactant	product
A	3	2
B	3	3
C	5	2
D	5	3

35. Which isomer of bromobutanol, C_4H_9OBr, reacts with aqueous sodium hydroxide to give an organic product that has only two peaks in its ^{13}C NMR spectrum?

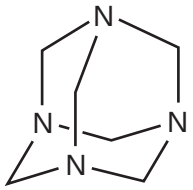
A 1-bromobutan-1-ol

B 3-bromobutan-1-ol

C 2-bromobutan-2-ol

D 3-bromobutan-2-ol

36. Hexamine is a crystalline white solid that is used as an antibiotic and as solid fuel by campers.



The four nitrogen atoms lie at the corners of a tetrahedron.

How many signals are there in the ^{13}C NMR spectrum of hexamine?

A 1 **B** 2 **C** 4 **D** 6

37. The ^{13}C NMR spectrum of a compound with formula $C_4H_8O_2$ shows peaks at 15 ppm, 20 ppm, 60 ppm and 175 ppm.

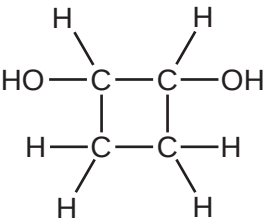
What is the structure of the compound?

A $HOCH_2CHCHCH_2OH$

B $HCOOCH(CH_3)_2$

C $CH_3COOCH_2CH_3$

D



38. Which isomer of $C_4H_8Cl_2$ has the same number of chiral carbon atoms in its molecule as it has peaks in its ^{13}C NMR spectrum?

A 1,2-dichlorobutane

B 1,3-dichlorobutane

C 2,2-dichlorobutane

D 2,3-dichlorobutane

39. A structural isomer of $C_5H_{11}OH$ has a significant peak in its mass spectrum with an m/z value of 31.

Its ^{13}C NMR spectrum shows four different peaks.

What is the isomer?

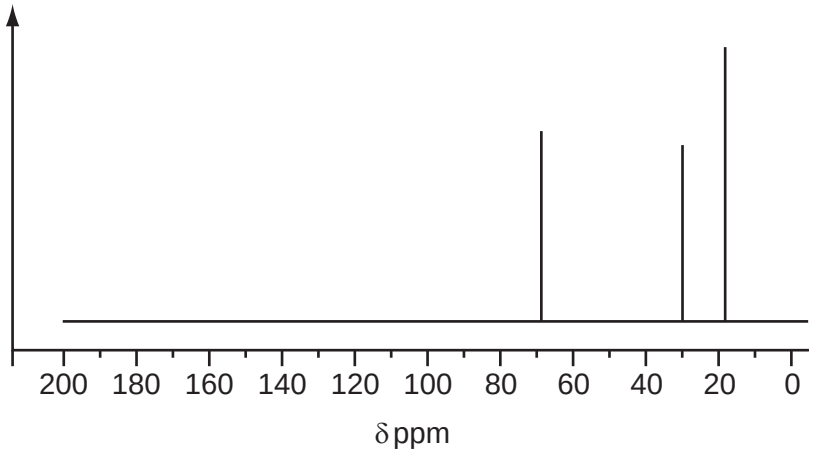
A 3-methylbutan-1-ol

B 3-methylbutan-2-ol

C pentan-1-ol

D pentan-2-ol

40. The diagram shows the ^{13}C NMR spectrum of an alcohol of formula $C_4H_{10}O$.



What is the alcohol?

A butan-1-ol

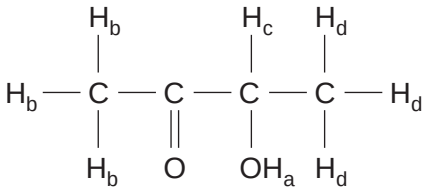
B butan-2-ol

C 2-methylpropan-2

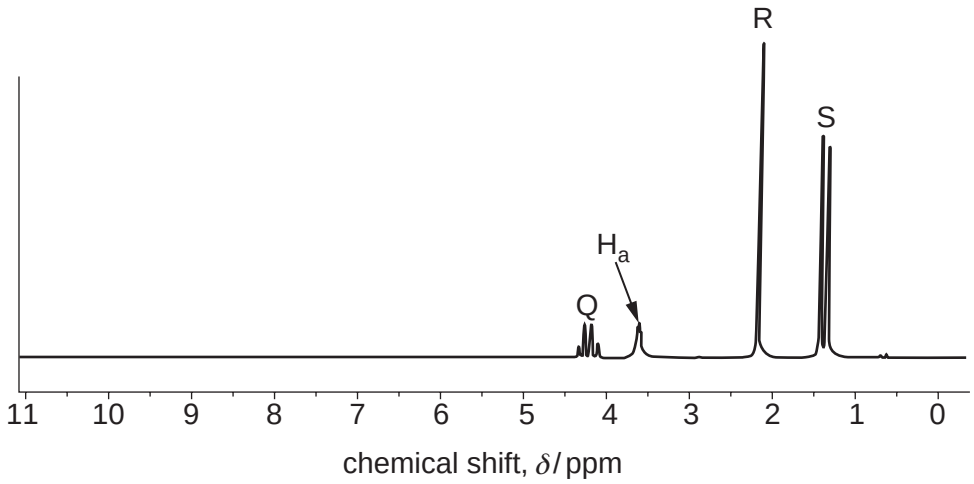
D 2-methylpropan-1

Other 12 Spin Nuclei

41. The different types of proton in an organic compound are labelled below.



The ^1H NMR spectrum of this compound is shown. The peak at 3.6 ppm has been labelled to show the proton responsible for the absorption.



Which protons are responsible for the lettered peaks Q, R and S?

peak	Q	R	S
A	H_c	H_d	H_b
B	H_c	H_b	H_d
C	H_d	H_b	H_c
D	H_b	H_c	H_d