UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CHEMISTRY **9791/01**

Paper 1 Part A Multiple Choice **May/June 2011**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

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 separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any working should be done in this booklet.

This document consists of **15** printed pages and **1** blank page.

1 The table shows the successive ionisation energies for an element Q.

	1st	2nd	3rd	4th
ionisation energy / kJ mol^{-1}	418	3070	4600	5860

What is the likely formula of the oxide of Q?

A QO **B** Q_3O_2 **C** Q_2O **D** Q_2O_3

2 How many neutrons are present in 0.13 g of ^{13}C?
[L = the Avogadro constant]

A 0.06 L **B** 0.07 L **C** 0.13 L **D** 0.91 L

3 Phosphorus sulfide, P_4S_3, is used in small amounts in the tips of matches. On striking a match this compound burns to produce an oxide of phosphorus in the +5 oxidation state and an oxide of sulfur in the +4 oxidation state.

How many moles of oxygen gas are needed to burn one mole of P_4S_3 in this way?

A 6 **B** 7.5 **C** 8 **D** 16

4 Four elements, W, X, Y and Z, are in the potassium to krypton period with consecutive atomic numbers. The table shows the number of unpaired electrons in each atom in its ground state.

element	W	X	Y	Z
unpaired electrons	2	1	0	1

In which group of the Periodic Table is element W?

A 4 **B** 10 **C** 14 **D** 16

5 When the N_2^+ ion is formed from N_2 a σ bonding electron is removed.

Which statement is correct?

A The bond order decreases so N_2^+ has a stronger, shorter bond than N_2.

B The bond order decreases so N_2^+ has a weaker, longer bond than N_2.

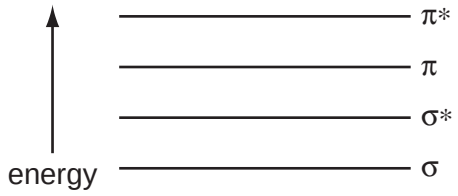
C The bond order increases so N_2^+ has a stronger, shorter bond than N_2.

D The bond order increases so N_2^+ has a weaker, longer bond than N_2.

6 The carbon atoms in ethene are bonded through σ and π bonds. When atomic orbitals overlap they form bonding (σ and π) and antibonding (σ* and π*) orbitals.

What is the correct order of energies of the σ and π orbitals in an ethene molecule?

A



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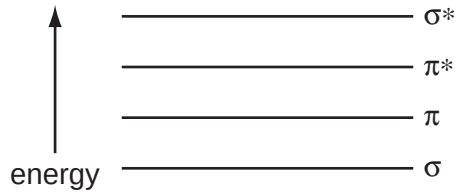

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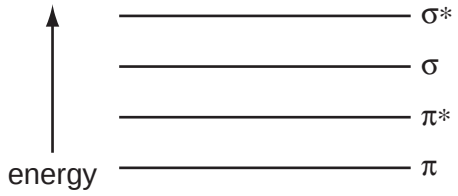

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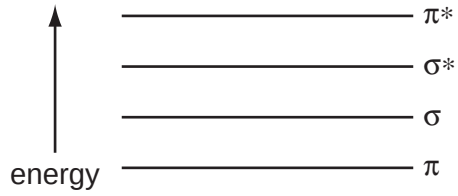


7 Cyanogen, $(CN)_2$, is a colourless, toxic gas with a pungent smell. Its molecule contains a single C–C bond.

Which feature of the cyanogen molecule is **not** correct?

A Both carbon atoms are at a carboxylic acid functional group level.

B The molecule contains four π bonds.

C The molecule contains four lone pairs of electrons.

D The molecule is linear.

8 In which pair of molecules are the values of the bond angles the closest?

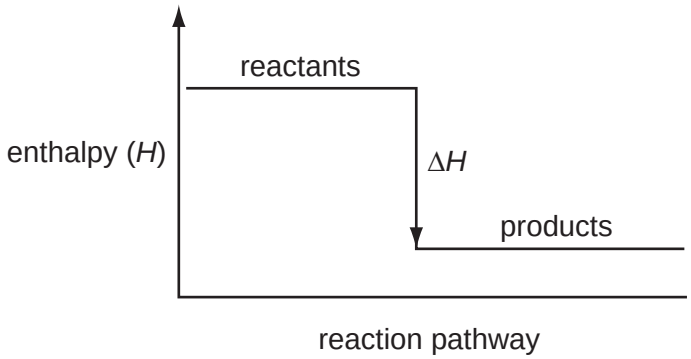
A BF_3 and NH_3

B C_2H_4 and BF_3

C H_2O and C_2H_4

D CH_4 and H_2O

9 Which enthalpy change could **not** be correctly represented by the enthalpy diagram shown?



A standard enthalpy change of atomisation

B standard enthalpy change of combustion

C standard enthalpy change of hydration

D standard enthalpy change of neutralisation

10 Molecule **X** is made up from two elements from period 3 of the Periodic Table. One of the elements has the highest **melting** point and the other element has the lowest **melting** point (excluding argon) in the period.

What is the formula of molecule **X**?

A $AlCl_3$ **B** Al_2S_3 **C** $SiCl_4$ **D** SiS_2

11 Which set of solid elements contains a simple molecular structure, a giant covalent (macromolecular) structure and a giant metallic structure?

A Mg, P, S **B** P, Si, C **C** S, P, Si **D** S, Si, Al

12 The oxide and chloride of an element **R** are separately mixed with water. The two resulting solutions have the same effect on litmus paper.

What is element **R**?

A aluminium

B magnesium

C phosphorus

D sodium

13 Chemists studying the nitrogen cycle in the ocean need to consider N_2, NH_4^+, N_2O, NO_3^- and NO_2^-.

What is the order of increasing oxidation number of nitrogen for these species?

A $NH_4^+ \rightarrow NO_3^- \rightarrow NO_2^- \rightarrow N_2O \rightarrow N_2$

B $NH_4^+ \rightarrow N_2 \rightarrow N_2O \rightarrow NO_2^- \rightarrow NO_3^-$

C $NO_3^- \rightarrow NO_2^- \rightarrow N_2O \rightarrow N_2 \rightarrow NH_4^+$

D $N_2 \rightarrow N_2O \rightarrow NO_2^- \rightarrow NO_3^- \rightarrow NH_4^+$

14 At 900 °C, $CaCO_3$ decomposes producing CO_2 and the metal oxide.

At 1100 °C, $CaSO_4$ decomposes producing SO_3 and the metal oxide.

Which statement explains the greater thermal stability of $CaSO_4$?

A $CaCO_3$ has a higher lattice energy than $CaSO_4$.

B CO_3^{2-} ions are more easily polarised than SO_4^{2-}.

C The charge density of CO_3^{2-} is greater than that of SO_4^{2-}.

D The CO_2 molecule is smaller than SO_3.

15 The great reactivity of fluorine is largely due to the low energy of the F–F bond.

Which statement best accounts for the weak F–F bond?

A The F–F bond is weak because of repulsion between the non-bonding electrons.

B The F–F bond is weak because of the short length of the bond.

C The F–F bond is weak because of the small nuclear charge of the fluorine atom.

D The F–F bond is weak because of the small size of the fluorine atom.

16 Sulfuric acid is involved in reactions X, Y and Z.

X $2NaBr + 2H_2SO_4 \longrightarrow Na_2SO_4 + Br_2 + SO_2 + 2H_2O$

Y $C_2H_5OH + CH_3COOH \xrightarrow{H_2SO_4} CH_3COOCH_2CH_3 + H_2O$

Z $2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$

What is the best description of the action of sulfuric acid in each of these reactions?

	X	Y	Z
A	acid	catalyst	oxidising agent
B	acid	dehydrating agent	oxidising agent
C	dehydrating agent	oxidising agent	acid
D	oxidising agent	catalyst	acid

17 Sulfur is converted to SF_6 by fluorine, to SCl_2 by chlorine and to S_2Br_2 by bromine.

Which trend does this information best provide evidence for?

A the trend in bond energy: $F_2 < Cl_2 > Br_2$

B the trend in electronegativity: F > Cl > Br

C the trend in first ionisation energy: F > Cl > Br

D the trend in oxidising ability: $F_2 > Cl_2 > Br_2$

18 Sodium thiosulfate reduces iodine to iodide ions.

In this reaction, how many moles of electrons are supplied per mole of the thiosulfate ions?

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

19 Three chemical reactions involving hydrogen peroxide, H_2O_2, are listed.

reaction 1 $H_2O_2 + 2HI \rightarrow 2H_2O + I_2$

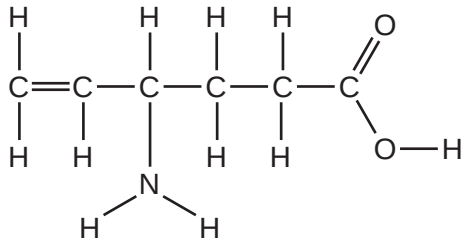
reaction 2 $5H_2O_2 + 2KMnO_4 + 3H_2SO_4 \rightarrow 5O_2 + 2MnSO_4 + 8H_2O + K_2SO_4$

reaction 3 $2H_2O_2 \rightarrow 2H_2O + O_2$

Which row identifies the reaction in which the oxygen of hydrogen peroxide is oxidised, is reduced and disproportionates?

	oxidised	reduced	disproportionates
A	reaction 1	reaction 2	reaction 3
B	reaction 2	reaction 1	reaction 3
C	reaction 2	reaction 3	reaction 1
D	reaction 3	reaction 1	reaction 2

20 The diagram shows the molecular structure of Vigabatrin®, a compound used in the treatment of epilepsy.



Which types of stereoisomerism are present in the Vigabatrin® molecule?

A geometric and optical

B geometric only

C optical only

D none

21 Lactic acid builds up in muscles when there is a deficiency of oxygen. Part of the reaction sequence is shown.

$$HOCH_2CH(OH)CHO \rightarrow CH_3COCOOH \rightarrow CH_3CH(OH)COOH$$

glyceraldehyde pyruvic acid lactic acid

Which statement is correct?

A All three molecules involved have a carbon atom at the carbonyl functional group level.

B All three molecules involved have a chiral carbon atom.

C Both steps in the reaction sequence involve oxidation.

D In the reaction sequence, one of the carbon atoms increases then decreases its functional group level.

22 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?

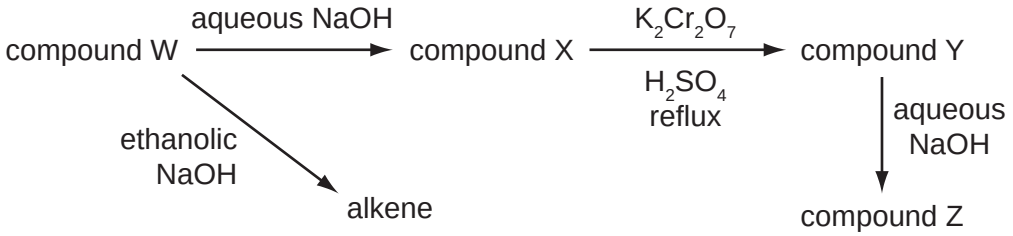
A 1,2-dichlorobutane

B 1,3-dichlorobutane

C 2,2-dichlorobutane

D 2,3-dichlorobutane

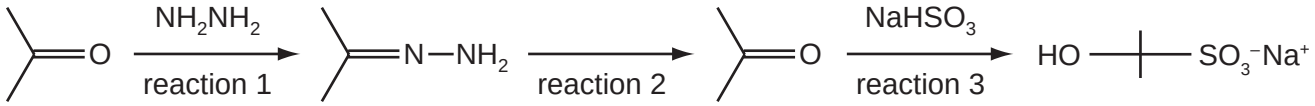
23 The flow chart shows a series of reactions.



Which class of compound are W, X, Y and Z?

	W	X	Y	Z
A	halogenoalkane	primary alcohol	aldehyde	carboxylic acid
B	halogenoalkane	primary alcohol	carboxylic acid	salt of carboxylic acid
C	primary alcohol	aldehyde	carboxylic acid	salt of carboxylic acid
D	primary alcohol	halogenoalkane	aldehyde	carboxylic acid

24 The diagram shows a reaction sequence.



How can the three reactions be classified?

	reaction 1	reaction 2	reaction 3
A	addition	hydrolysis	reduction
B	addition	oxidation	reduction
C	condensation	hydrolysis	addition
D	condensation	oxidation	addition

25 The alkanes used to be known as the paraffin hydrocarbons - paraffin meaning 'lack of affinity' (i.e. unreactive).

Which statement is the best explanation of the 'lack of affinity' in alkanes?

A The atoms are arranged tetrahedrally around each carbon atom.

B The intermolecular forces are van der Waals forces.

C There are no significant dipole moments in C–H and C–C bonds.

D There is free rotation about C–C single bonds.

26 Four isomers of $C_3H_6OCl_2$ are separately subjected to hydrolysis using aqueous sodium hydroxide.

Which isomer produces an organic product with a different molecular formula than the other three isomers?

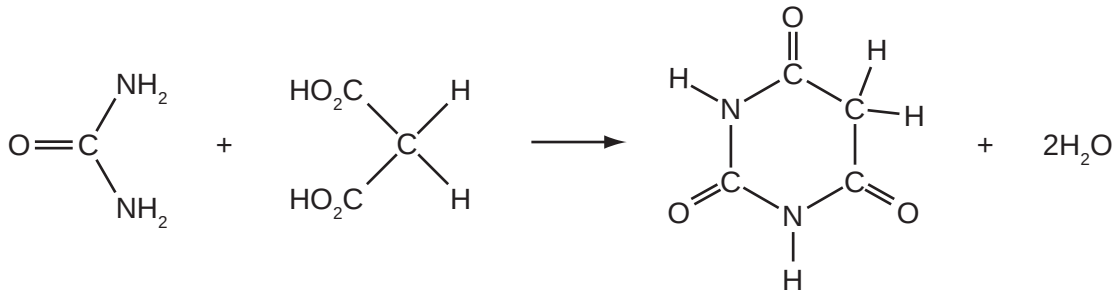
A $CH_3CCl_2CH_2OH$

B $CH_2ClCHClCH_2OH$

C $CH_2ClCH_2CH(OH)Cl$

D $CHCl_2CH_2CH_2OH$

27 Barbituric acid, the basis for synthesising barbiturates, can be made by the reaction shown.

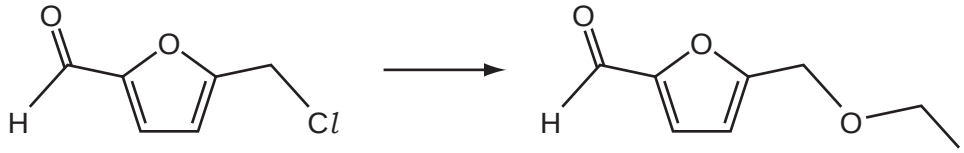


urea malonic acid barbituric acid

In this reaction, how many carbon atoms change their functional group level?

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

28 Huge research efforts are going into biofuel production. Scientists have managed to break down cellulose into 5-(chloromethyl)furfal and convert it into 5-(ethoxymethyl)furfal, potentially useful in biofuel production.



5-(chloromethyl)furfal 5-(ethoxymethyl)furfal

Which reagent is required for this transformation?

A chloroethane

B ethanol

C ethene

D water

29 Which functional group **cannot** be turned into an alcohol in a single reaction?

A alkene

B carbonyl

C halogenoalkane

D nitrile

30 The compound $C_4H_6O_2$ gives butter its distinctive flavour.

It reacts with hydrogen cyanide to produce the compound $C_6H_8N_2O_2$ but does not react with Tollens' reagent.

What is the structural formula of this compound in butter?

A CH_3COCH_2CHO

B $CH_3COCOCH_3$

C $CH_3COCH{=}CHOH$

D $CH_2{=}CHCOCH_2OH$

31 A bromine-containing organic compound, **T**, undergoes an elimination reaction when treated with hot ethanolic sodium hydroxide solution.

What is **T**?

A CH_3Br

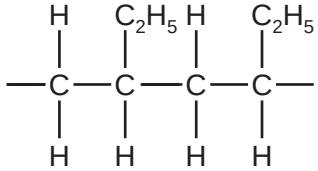
B C_2Br_6

C $(CH_3)_2C{=}CBr_2$

D $CH_3CH_2CBr_3$

32 An alcohol, **X**, can be dehydrated producing a hydrocarbon.

Polymerisation of this hydrocarbon gives the polymer shown.



What is **X**?

A 2-methylpropan-1-ol

B butan-1-ol

C ethanol

D propan-1-ol

33 Titanium is used to replace arthritic hip joints that have become too painful. The final step in its extraction is shown.

reaction 1 $TiCl_4 + 4Na \rightarrow Ti + 4NaCl$

$M_r(TiCl_4) = 189.9$; $A_r(Na) = 23.0$; $A_r(Ti) = 47.9$

A research chemist decides to replace the titanium(IV) chloride with titanium(IV) bromide. The new equation is shown.

reaction 2 $TiBr_4 + 4Na \rightarrow Ti + 4NaBr$

$M_r(TiBr_4) = 367.5$; $A_r(Na) = 23.0$; $A_r(Ti) = 47.9$

What will be the effect of substituting bromine for chlorine on the atom economy of the process where Ti is the only utilised product?

A Reaction 1 has a higher atom economy than reaction 2 by 6.6 %.

B Reaction 1 has a higher atom economy than reaction 2 by 12.2 %.

C Reaction 1 has a lower atom economy than reaction 2 by 6.6 %.

D Reaction 1 has a lower atom economy than reaction 2 by 12.2 %.

34 A solid salt dissolved on being warmed with an excess of aqueous sodium hydroxide without any gas being evolved.

A colourless solution was produced.

What is the salt?

A ammonium nitrate

B chromium(III) nitrate

C magnesium nitrate

D zinc nitrate

35 In the analysis of an oxide of nitrogen, 0.10 mol of the oxide were reacted with excess hydrogen under suitable conditions.

$$N_xO_y \xrightarrow{H_2(g)} xNH_3 + yH_2O$$

3.6 g of water were formed in this reaction, while the ammonia produced required 100 cm^3 of 1.0 $mol\,dm^{-3}$ $HCl(aq)$ for neutralisation.

What is the formula of the oxide of nitrogen analysed?

A N_2O **B** NO **C** NO_2 **D** N_2O_5

36 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}

37 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

38 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.

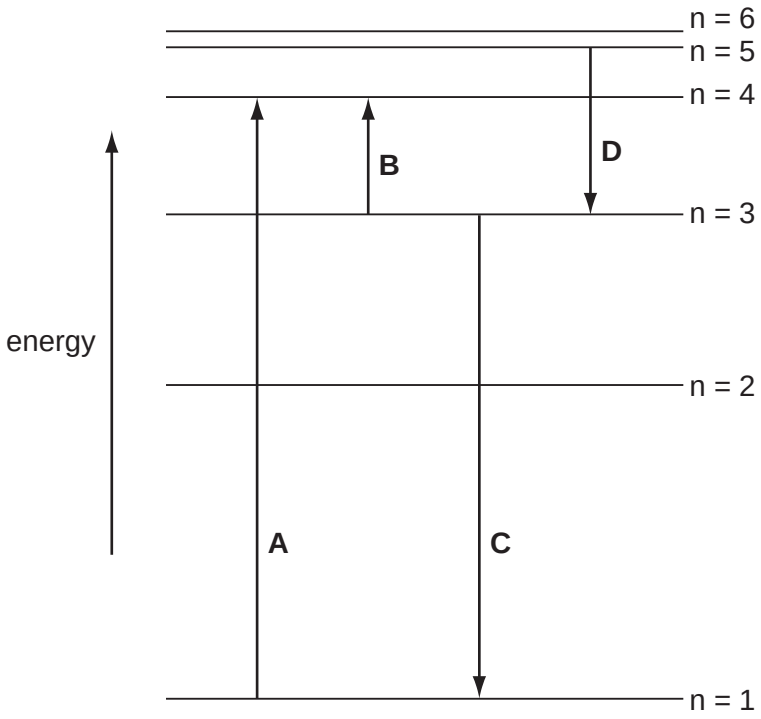
B The electrons in the chlorine atoms emit energy.

C The electrons in the sodium atoms absorb energy.

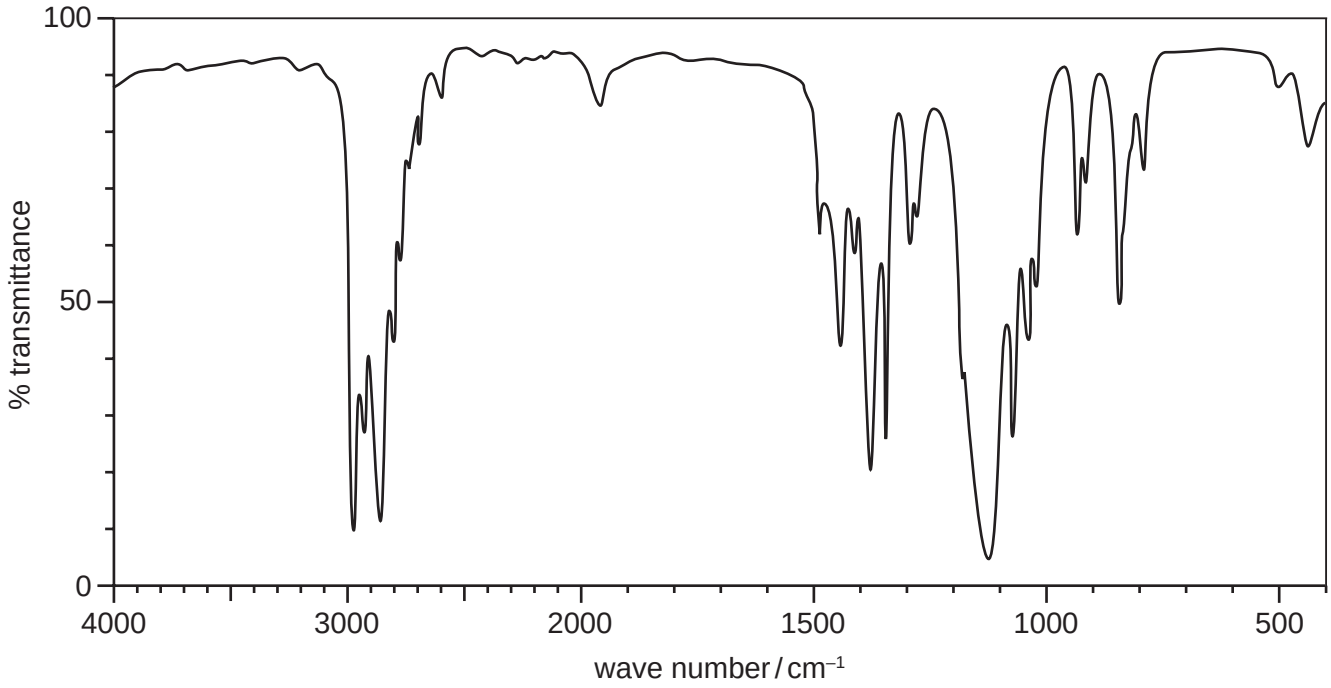
D The electrons in the sodium atoms emit energy.

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

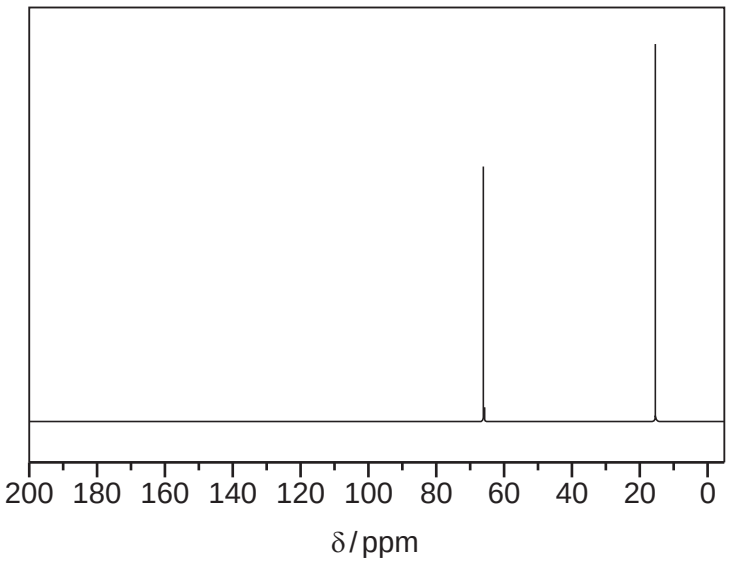
Which transition will have the highest frequency in the **emission** spectrum of the hydrogen atom?



40 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 [$(CH_3)_3COH$]

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