



**CHEMISTRY**

**9791/01**

Paper 1 Part A Multiple Choice

**May/June 2013**

**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.

**DO NOT WRITE IN ANY BARCODES.**

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.

Electronic calculators may be used.

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



- 1 Nuclear theories predict the number of protons and the number of neutrons that give especially stable nuclei. These numbers are known as the nuclear magic numbers. These numbers include

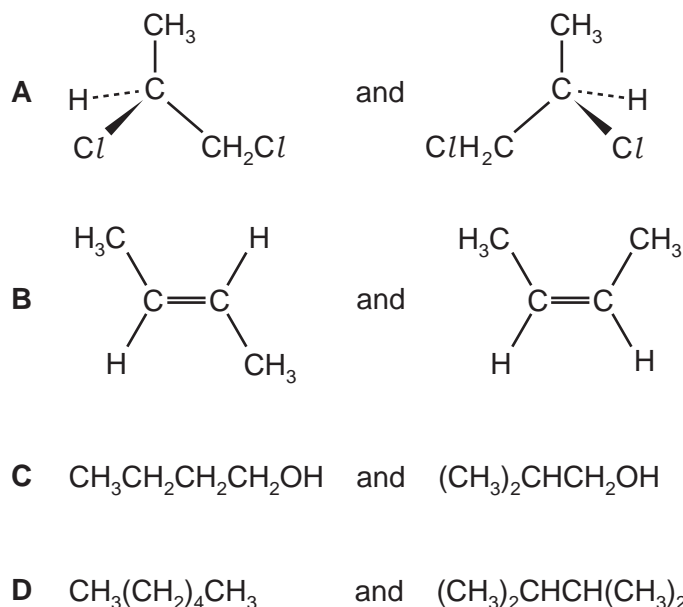
2, 8, 20, 28, 50, 82, 126.

The most stable nuclei are the 'doubly magic' ones that have a magic number of protons and a magic number of neutrons.

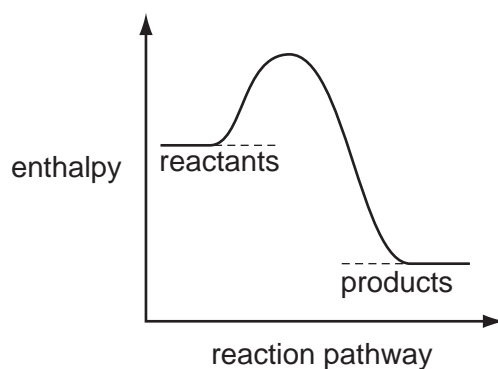
Using this theory, which isotope is the most stable?

- A  ${}^2\text{He}$                       B  ${}^8\text{Be}$                       C  ${}^{40}\text{Ca}$                       D  ${}^{210}\text{Pb}$

- 2 In which pair do the isomers have identical boiling points?



- 3 Which enthalpy change could **never** be correctly represented by the following enthalpy diagram?



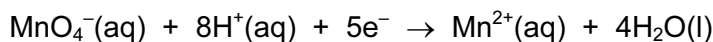
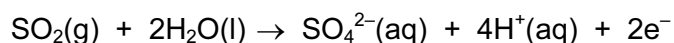
- A standard enthalpy change of combustion  
 B standard enthalpy change of formation  
 C standard enthalpy change of hydration  
 D standard enthalpy change of vaporisation

- 4 When iron reacts with aqueous iron(III) ions, iron(II) ions are formed as the only product.

A final mixture, after the reaction has taken place, contains equal numbers of moles of  $\text{Fe}^{2+}(\text{aq})$  and  $\text{Fe}^{3+}(\text{aq})$ . Assuming the reaction has gone to completion, how many moles of  $\text{Fe}(\text{s})$  and  $\text{Fe}^{3+}(\text{aq})$  were in the starting mixture?

	moles of $\text{Fe}(\text{s})$	moles of $\text{Fe}^{3+}(\text{aq})$
<b>A</b>	1	2
<b>B</b>	1	3
<b>C</b>	1	5
<b>D</b>	2	3

- 5 Sulfur dioxide gas is converted into sulfate ions when it is bubbled into a solution containing aqueous manganate(VII) ions.



How will the pH of the reaction mixture change as sulfur dioxide is bubbled at constant rate into a well-stirred solution of manganate(VII) ions until its colour just fades?

- A** a decrease  
**B** a decrease then an increase  
**C** an increase  
**D** an increase then a decrease
- 6 Which compound is composed of a cation and anion(s) that do **not** contain the same number of electrons as each other?
- A** LiH                      **B** NaOH                      **C**  $\text{NH}_4\text{F}$                       **D**  $\text{TiCl}_3$
- 7 Which statement about an element in the Periodic Table is correct?

- A** Magnesium is a metalloid, has a giant structure and is a good conductor of electricity.  
**B** Silicon is a metalloid, has a simple molecular structure and is a semi-conductor of electricity.  
**C** Sodium is a metal, has a giant structure and is a good conductor of electricity.  
**D** Sulfur is a non-metal, has a giant structure and is a poor conductor of electricity.

- 8 A covalent molecule contains
- 14 electrons,
  - one lone pair of electrons,
  - two  $\pi$  bonds.

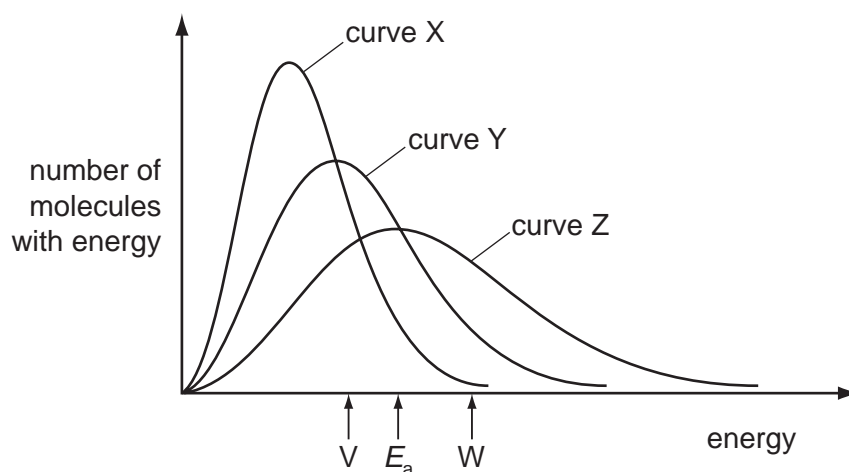
What is the molecule?

- A  $C_2H_4$       B HCN      C  $H_2O_2$       D  $N_2$

- 9 Which value is essential to calculate the lattice energy of the compound NaH?

- A electron affinity of hydrogen  
 B electron affinity of sodium  
 C first ionisation of hydrogen  
 D second ionisation energy of sodium

- 10 The curve Y and the value  $E_a$  represent the distribution of energies of the molecules and the activation energy for an uncatalysed gaseous reaction.

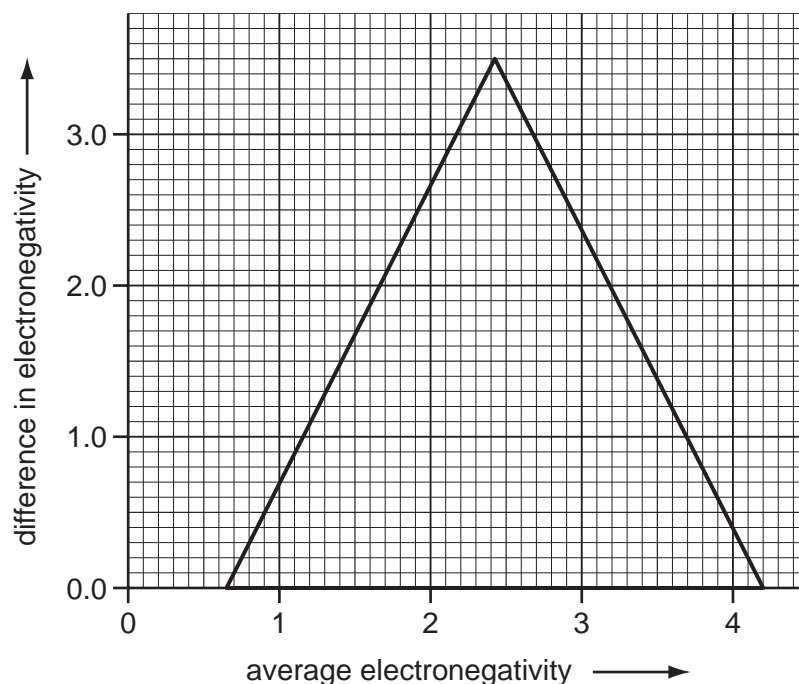


What is a possible outcome if the reaction is catalysed?

- A The distribution of energies will be given by curve X and the activation energy by value V.  
 B The distribution of energies will be given by curve Y and the activation energy by value V.  
 C The distribution of energies will be given by curve Y and the activation energy by value W.  
 D The distribution of energies will be given by curve Z and the activation energy by value W.

- 11 Recent research has investigated ferrosilicon, FeSi, whose unusual electronic behaviour can be switched on and off with magnets.

element	electronegativity
Fe	1.8
Si	1.9



Using the van Arkel triangle and electronegativity values, which type of bonding is present in ferrosilicon?

- A covalent
  - B ionic
  - C metallic
  - D semi-metallic
- 12 An element X in Period 3 is a metalloid and semiconductor and has a chloride which reacts with water to form an acidic solution.

An element Y has an atomic number one **less** than element X.

What is a property of the oxide of element Y?

- A It is a gas at room temperature.
- B It is amphoteric.
- C It is covalent.
- D Its formula is  $YO_2$ .

13 In the compound  $\text{Co}(\text{ClO}_3)_2$ , the  $\text{Cl}$  atom has an oxidation state of +5.

How many  $d$ -orbital electrons are present in the cobalt ion in this compound?

- A 5                      B 7                      C 8                      D 9

14 The information relates to element Z.

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

What is Z?

- A Na                      B Si                      C P                      D Cl

15 The polyoxometallate  $\text{W}_{72}\text{Mn}_{12}\text{Si}_7\text{O}_{268}^{40-}$  was recently identified in a crystal garden.

Which row gives oxidation states of tungsten and manganese that are consistent with this formula?

	oxidation state of tungsten	oxidation state of manganese
A	+3	+2
B	+3	+3
C	+6	+2
D	+6	+3

16 Desulfurisation plants remove  $\text{SO}_2$  from power station emission gases by washing the gases with calcium hydroxide solution.

What is the main product **initially** formed in the reaction that occurs?

- A CaS                      B  $\text{CaSO}_3$                       C  $\text{CaSO}_4$                       D  $\text{Ca}(\text{HSO}_4)_2$

17 Fluorine has anomalous properties in Group 17.

Which statement is correct?

- A Fluorine is intensely coloured.  
 B HF is a strong acid.  
 C The F–F bond is unusually weak.  
 D The melting point of fluorine is high.

- 18 Addition of warm concentrated sulfuric acid,  $\text{H}_2\text{SO}_4$ , to crystals of sodium halides gives the following observations.

halide	observations
NaF	evolution of a colourless gas which etches a damp glass rod
NaCl	evolution of a choking colourless gas which produces a white cloud in contact with ammonia vapour
NaBr	evolution of a brown vapour and of pungent fumes which turn potassium dichromate(VI) paper green
NaI	evolution of a purple vapour and a gas smelling of rotten eggs

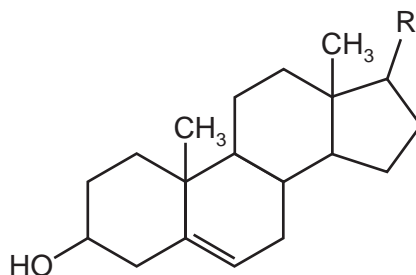
Which statements are consistent with the observations?

	hydrogen halide is produced in all four reactions	sulfuric acid is acting as a reducing agent in all four reactions	sulfur dioxide and hydrogen sulfide are reduction products of sulfuric acid	
<b>A</b>	✓	✗	✓	key ✓ = true ✗ = false
<b>B</b>	✓	✓	✗	
<b>C</b>	✗	✗	✓	
<b>D</b>	✗	✓	✗	

- 19 Which type of formula will show butanone and butanal as different compounds?

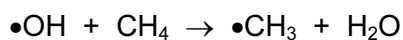
	empirical	molecular	structural	skeletal	
<b>A</b>	✗	✗	✗	✓	key ✓ = shows difference ✗ = shows no difference
<b>B</b>	✗	✗	✓	✓	
<b>C</b>	✗	✓	✓	✓	
<b>D</b>	✓	✓	✓	✓	

- 20 Cholesterol is the most common steroid alcohol. It has a molecular formula of  $C_{27}H_{46}O$  and has the structure shown.



How many carbon atoms are in the hydrocarbon group R?

- A 7                      B 8                      C 9                      D 10
- 21 Ethoxyethane,  $C_2H_5OC_2H_5$ , is the most well known of a class of compounds called ethers. Ethers have the general formula  $R_1-O-R_2$  where  $R_1$  and  $R_2$  are hydrocarbon groups.
- What is the lowest number of carbon atoms a non-cyclic ether molecule needs to have a chiral carbon atom?
- A 4                      B 5                      C 6                      D 7
- 22 Methane is a greenhouse gas but is destroyed in the troposphere by the action of hydroxyl radicals.

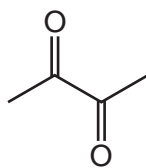


Which statement about this reaction is correct?

- A The reaction involves heterolytic fission and  $\sigma$  bond formation.
- B The reaction involves homolytic fission and  $\sigma$  bond formation.
- C The reaction involves homolytic fission and  $\pi$  bond formation.
- D The total number of electrons in the two reacting species is 20.



23 The diagram shows butane-2,3-dione, a butter-flavoured molecule.



The two carbonyl groups in the molecule are reduced to alcohols.

How many chiral centres are there in the product, and what is the molecular formula of the product?

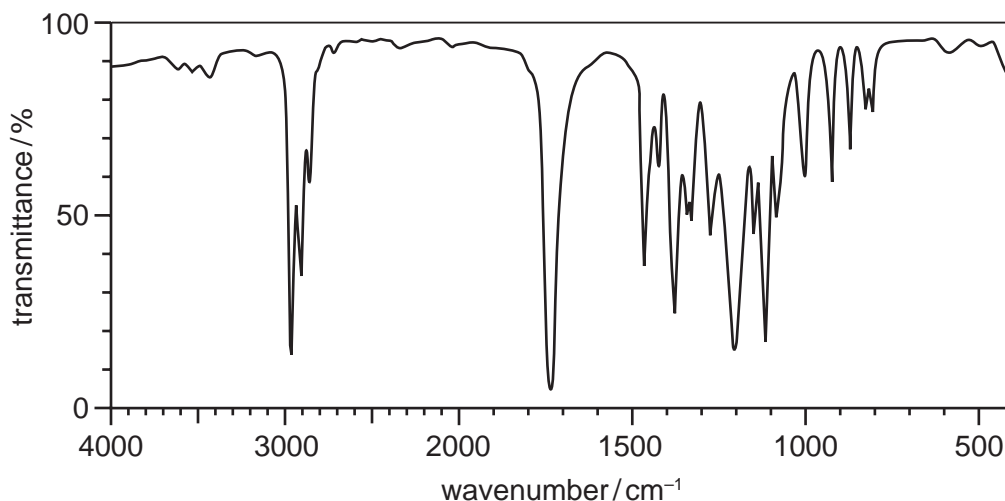
	number of chiral centres	molecular formula of the product
<b>A</b>	0	$C_4H_8O_2$
<b>B</b>	0	$C_4H_{10}O_2$
<b>C</b>	2	$C_4H_8O_2$
<b>D</b>	2	$C_4H_{10}O_2$

24 The molecule  $H_2NCH_2CN$  has been detected in interstellar space.

What is the functional group level of the CN carbon, and what is the hydrolysis product of this molecule?

	functional group level of CN carbon	hydrolysis product
<b>A</b>	alcohol	$HOCH_2CH_2OH$
<b>B</b>	alcohol	$H_2NCH_2CO_2H$
<b>C</b>	carboxylic acid	$HOCH_2CH_2OH$
<b>D</b>	carboxylic acid	$H_2NCH_2CO_2H$

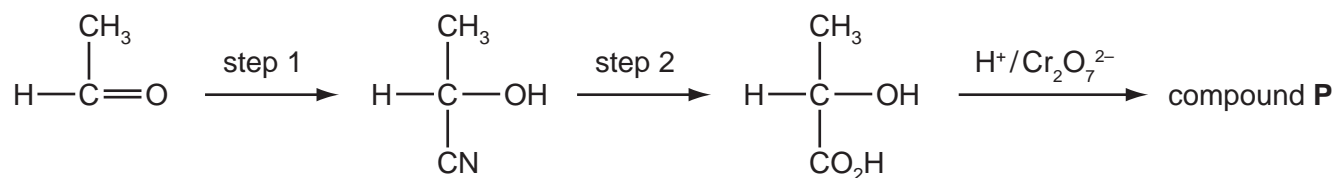
25 The infra-red spectrum of compound **Q** is shown.



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

- A alkanes
- B carboxylic acids
- C esters
- D halogenoalkanes

26 The diagram shows a reaction scheme.

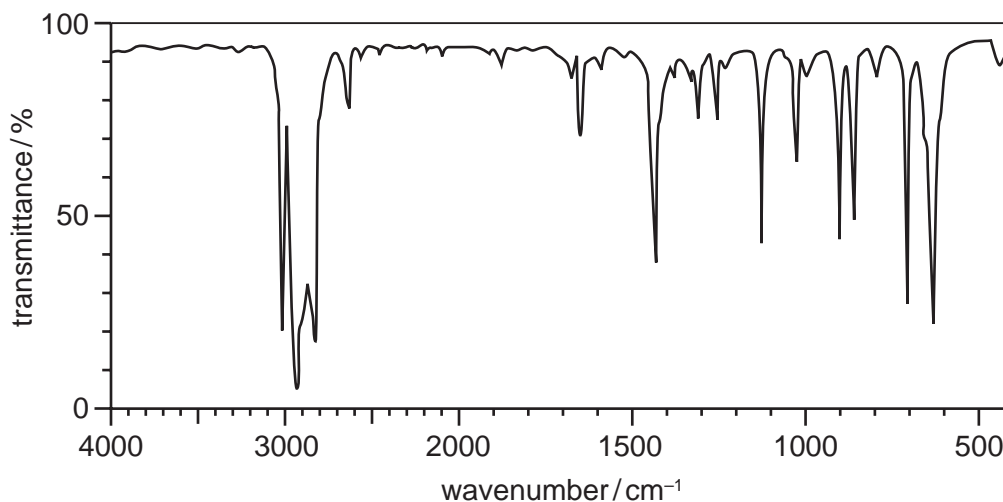


Which statement about this reaction scheme is **not** correct?

- A Step 1 involves addition.
- B Step 2 involves hydrolysis.
- C **P** contains two carbon atoms with the same functional group level.
- D **P** has the molecular formula  $\text{C}_3\text{H}_4\text{O}_3$ .

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 reagent reacts with ethanal to give an organic product **without** a  $\pi$  bonded carbon atom?

- A acidified dichromate(VI) ions
- B bisulfite ions
- C hydrogen cyanide
- D Tollens' reagent

29 Ethanoic acid forms a double molecule or dimer of molecular formula  $C_4H_8O_4$ .

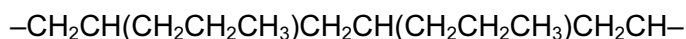
This dimer contains an 8-membered ring containing two hydrogen bonds.

How many carbon, hydrogen and oxygen atoms are present in this ring?

	C	H	O
<b>A</b>	2	2	4
<b>B</b>	2	4	2
<b>C</b>	4	0	4
<b>D</b>	4	2	2

- 30 Certain polymers are added to engine oil to improve its viscosity.

A portion of the chain of one such polymer is shown.



A molecule of this polymer contains 40 carbon atoms.

How many monomer units are incorporated in one molecule of this polymer?

- A 4                      B 5                      C 8                      D 10

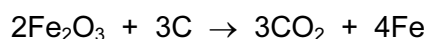
- 31 A carbonyl compound, **X**, with the molecular formula  $\text{C}_5\text{H}_{10}\text{O}$  can be oxidised with a  $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$  mixture to form 3-methylbutanoic acid.

**X** can be reduced by  $\text{NaBH}_4$  to form an alcohol, **Y**.

What is the structure of compound **Y**?

- A  $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}$   
 B  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$   
 C  $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{OH})\text{CH}_3$   
 D  $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$

- 32 Iron can be extracted from the ore haematite,  $\text{Fe}_2\text{O}_3$ , using carbon.

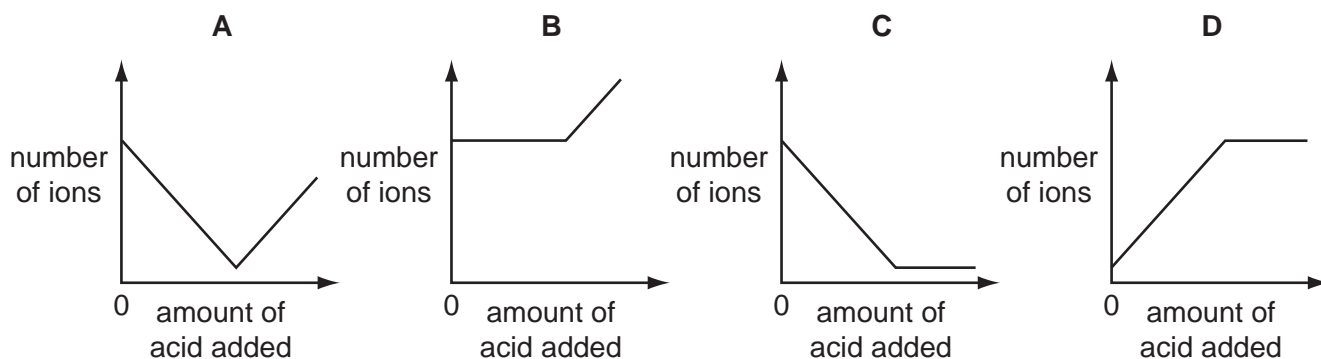


What is the atom economy for this process where iron is the only utilised product?

- A 15.7%              B 32.5%              C 35.0%              D 62.8%

- 33 Dilute sulfuric acid was added to aqueous barium hydroxide until the acid was present in excess.

How will the total number of ions present in solution in the reacting mixture vary?



- 34 In a famous experiment, the German chemist Wöhler heated an inorganic salt and produced urea,  $\text{CO}(\text{NH}_2)_2$ , as the **only** product.

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

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

- A  $\text{CNO}^-$       B  $\text{CN}^-$       C  $\text{CO}_3^{2-}$       D  $\text{NH}_2^-$

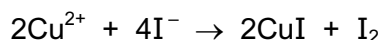
- 35 A powder was known to be either a single sodium halide or a mixture of two sodium halides.

A sample of the powder was dissolved in water and aqueous silver nitrate added. A precipitate was formed, which, on addition of excess aqueous ammonia, partly dissolved leaving a yellow solid.

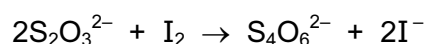
What did the powder consist of?

- A NaBr only  
 B NaI only  
 C a mixture of NaCl and NaBr  
 D a mixture of NaCl and NaI

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



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

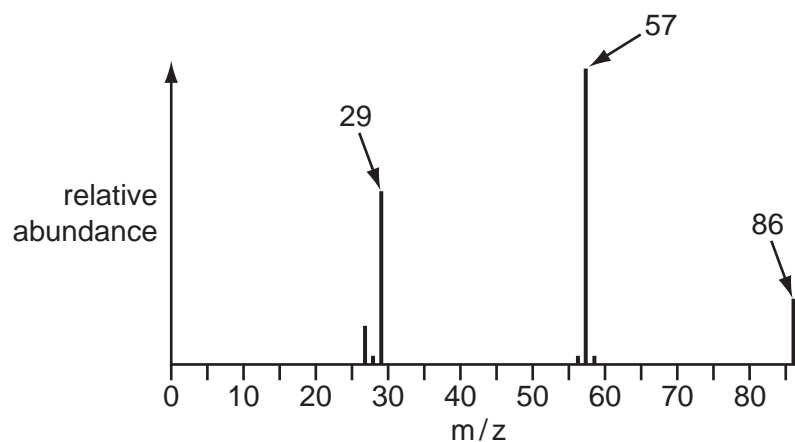


$25.00\text{ cm}^3$  of a solution containing copper(II) ions was treated with excess iodide ions. The resulting iodine required  $26.50\text{ cm}^3$  of sodium thiosulfate solution of concentration  $0.150\text{ mol dm}^{-3}$  for complete reaction.

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

- A  $0.0795\text{ mol dm}^{-3}$   
 B  $0.142\text{ mol dm}^{-3}$   
 C  $0.159\text{ mol dm}^{-3}$   
 D  $0.318\text{ mol dm}^{-3}$

37 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?

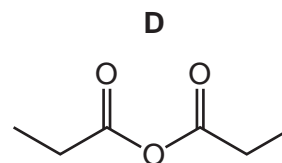
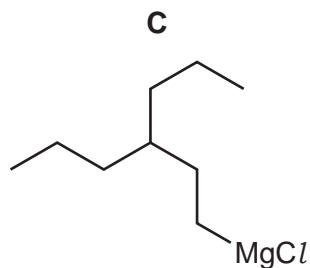
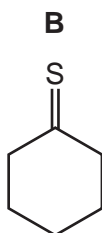
- A**  $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3^{\bullet+} \rightarrow \text{CH}_3\text{CH}_2\text{CO}^+ + \bullet\text{CH}_2\text{CH}_3$   
**B**  $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3^{\bullet+} \rightarrow \text{CH}_3\text{CH}_2\text{CO}^\bullet + \text{}^+\text{CH}_2\text{CH}_3$   
**C**  $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3^{\bullet+} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2^\bullet + \text{}^+\text{CHO}$   
**D**  $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3^{\bullet+} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2^+ + \bullet\text{CHO}$

38 In hydrogen atoms, the four electron transitions below result in the emission of photons of different frequencies.

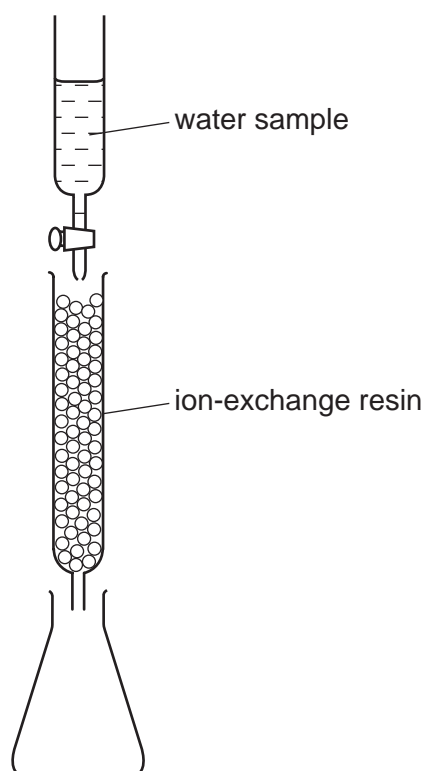
Which transition results in the emission of a photon of the highest frequency?

- A**  $3s \rightarrow 2p$       **B**  $4p \rightarrow 3s$       **C**  $5p \rightarrow 4d$       **D**  $6d \rightarrow 5p$

39 Which molecule has an odd number of peaks in its  $^{13}\text{C}$  NMR spectrum?



- 40 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  $50.0\text{cm}^3$  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  $25.0\text{cm}^3$  of  $1.00 \times 10^{-2}\text{mol dm}^{-3}$  potassium hydroxide for complete neutralisation.

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

- A  $2.50 \times 10^{-3}\text{mol dm}^{-3}$
- B  $1.00 \times 10^{-2}\text{mol dm}^{-3}$
- C  $2.00 \times 10^{-2}\text{mol dm}^{-3}$
- D  $4.00 \times 10^{-2}\text{mol dm}^{-3}$

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