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**CHEMISTRY**

**9701/41**

Paper 4 Structured Questions

**May/June 2014**

**2 hours**

Candidates answer on the Question Paper.

Additional Materials:      Data Booklet

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

**Section A**

Answer **all** questions.

**Section B**

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

**For Examiner's Use**

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| <b>8</b>     |  |
| <b>Total</b> |  |

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## Section A

Answer **all** the questions in the spaces provided.

- 1 (a) (i) State how the melting point and density of iron compare to those of calcium.

melting point of iron: .....

density of iron: .....

- (ii) Explain why these differences occur.

melting point: .....

.....

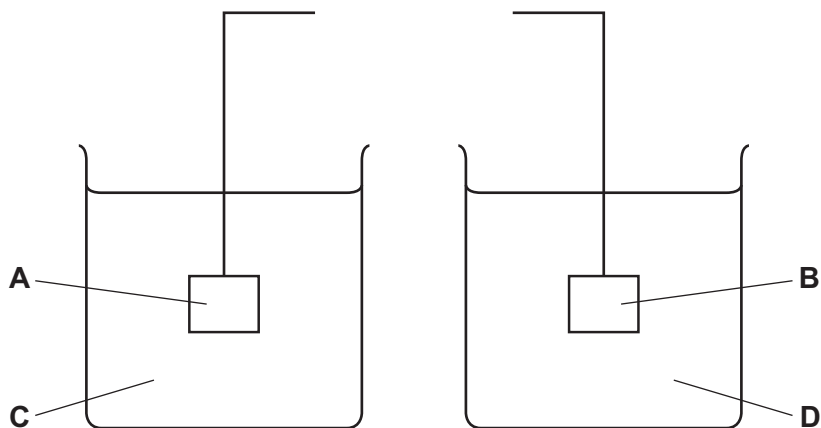
density: .....

.....

[4]

- (b) The following diagram shows the apparatus used to measure the standard electrode potential,  $E^\circ$ , of a cell composed of a Cu(II)/Cu electrode and an Fe(II)/Fe electrode.

- (i) Finish the diagram by adding components to show the complete circuit. Label the components you add.



- (ii) In the spaces below, identify or describe what the four letters **A-D** represent.

**A** .....

**B** .....

**C** .....

**D** .....

- (iv) Predict how the size of the overall cell potential would change, if at all, as the concentration of solution **C** is increased.  
Explain your reasoning.

(c) The iron(II) complex *ferrous bisglycinate hydrochloride* is sometimes prescribed, in capsule form, to treat iron deficiency or anaemia.

18.1 cm<sup>3</sup> of KMnO<sub>4</sub> solution were required to reach the end point.

$$5\text{Fe}^{2+} + \text{MnO}_4^- + 8\text{H}^+ \rightarrow 5\text{Fe}^{3+} + \text{Mn}^{2+} + 4\text{H}_2\text{O}$$

- (i) Describe how you would recognise the end point of this titration.

- (ii) Calculate

- the number of moles of  $\text{Fe}^{2+}$  in the capsule,
- the mass of iron in the capsule,
- the molar mass of the iron(II) complex, assuming 1 mol of the complex contains 1 mol of iron.

[Total: 16]

**[Turn over**

2 The ions of transition elements form *complexes* by reacting with *ligands*.

(a) (i) State what is meant by the terms:

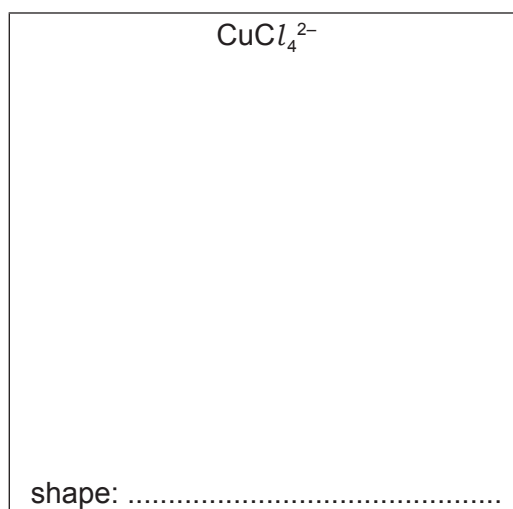
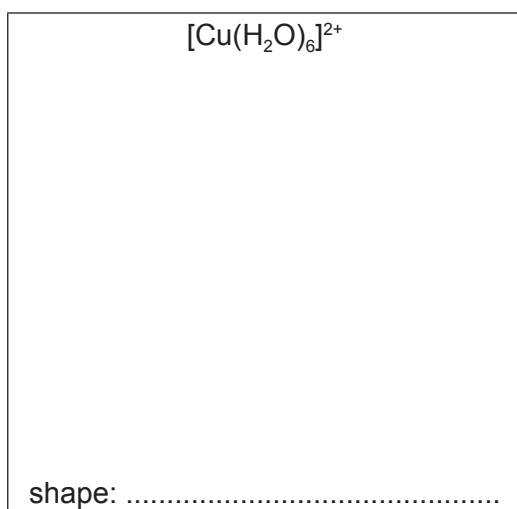
*complex*, .....

.....

*ligand*. .....

.....

(ii) Two of the complexes formed by copper are  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  and  $\text{CuCl}_4^{2-}$ .  
Draw three-dimensional diagrams of their structures in the boxes and name their shapes.

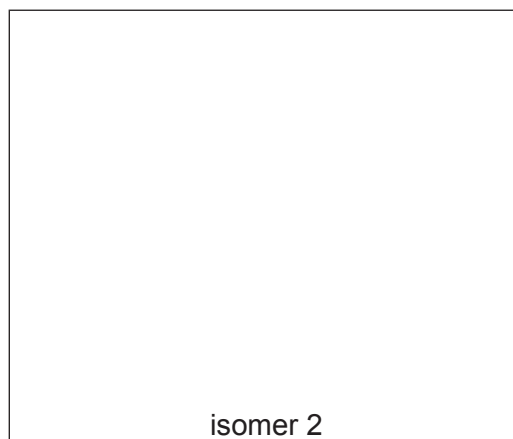
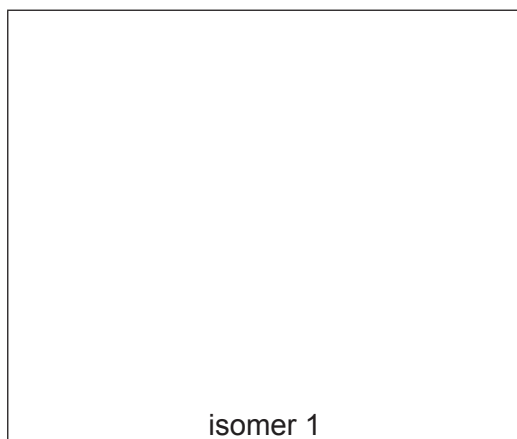


(iii) Platinum forms square-planar complexes, in which all four ligands lie in the same plane as the Pt atom.

There are two isomeric complexes with the formula  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ .

Suggest the structures of the two isomers, and, by comparison with a similar type of isomerism in organic chemistry, suggest the type of isomerism shown here.

Structures of isomers:



Type of isomerism: .....

[7]

(b) Copper forms two series of compounds, one containing copper(II) ions and the other containing copper(I) ions.

(i) Complete the electronic structures of these ions.

Cu(II) [Ar] .....

Cu(I) [Ar] .....

(ii) Use these electronic structures to explain why

copper(II) salts are usually coloured,

.....  
.....  
.....  
.....

copper(I) salts are usually white or colourless.

.....  
.....

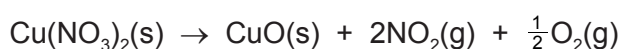
[5]

- (c) Copper(I) oxide and copper(II) oxide can both be used in the ceramic industry to give blue, green or red tints to glasses, glazes and enamels.

The table lists the  $\Delta H_f^\ominus$  values for some compounds.

| compound                      | $\Delta H_f^\ominus / \text{kJ mol}^{-1}$ |
|-------------------------------|-------------------------------------------|
| $\text{Cu}_2\text{O(s)}$      | -168.6                                    |
| $\text{CuO(s)}$               | -157.3                                    |
| $\text{Cu(NO}_3)_2\text{(s)}$ | -302.9                                    |
| $\text{NO}_2\text{(g)}$       | +33.2                                     |

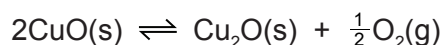
- (i) Copper(II) oxide can be produced in a pure form by heating copper(II) nitrate. Use suitable  $\Delta H_f^\ominus$  values from the table to calculate the  $\Delta H^\ominus$  for this reaction.



$$\Delta H^\ominus = \dots\dots\dots \text{kJ mol}^{-1}$$

- (ii) Copper(I) oxide can be produced from copper(II) oxide.

- Use suitable  $\Delta H_f^\ominus$  values from the table to calculate  $\Delta H^\ominus$  for the reaction.



$$\Delta H^\ominus = \dots\dots\dots \text{kJ mol}^{-1}$$

- Hence suggest whether a low or a high temperature of oxidation would favour the production of copper(I) oxide. Explain your reasoning.

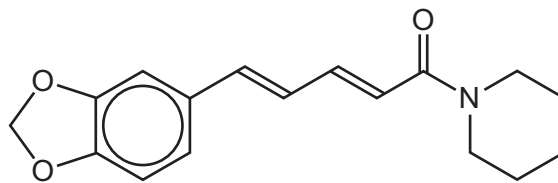
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[4]

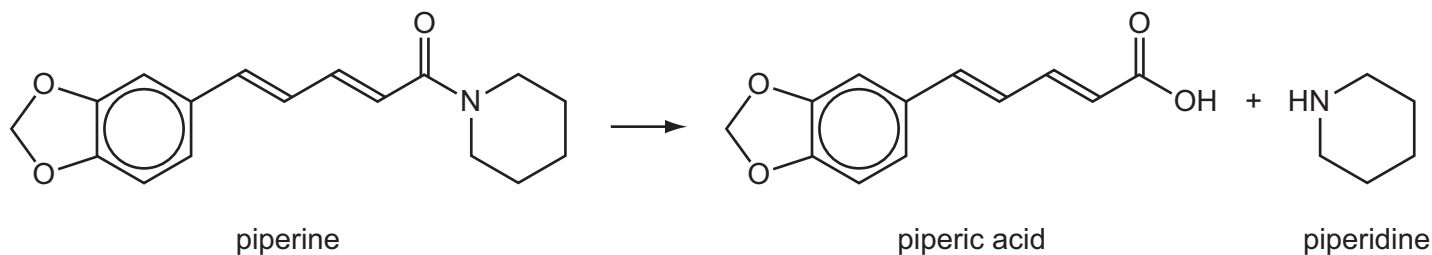
[Total: 16]

- 3 Piperine is the compound responsible for the hot taste of black pepper.



piperine

Piperine is an amide and can be broken down as follows:



- (a) Suggest reagents and conditions for this reaction.

..... [1]

- (b) (i) How many stereoisomers are there with the same structural formula as piperic acid (including piperic acid itself)?

.....

- (ii) Draw the skeletal structure of a stereoisomer of piperic acid, different to the one shown above.

- (iii) Suggest structures for the compounds that would be formed when piperic acid is treated with an **excess** of hot concentrated acidified  $\text{KMnO}_4$ .

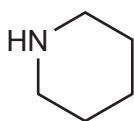
[4]

(c) (i) Write the expression for  $K_w$ .

.....

(ii) Use your expression and the value of  $K_w$  in the *Data Booklet* to calculate the pH of  $0.150 \text{ mol dm}^{-3} \text{ NaOH(aq)}$ .

(iii) The pH of a  $0.150 \text{ mol dm}^{-3}$  solution of piperidine is 11.9.



piperidine

Suggest why this answer differs from your answer in (c)(ii).

.....

.....

(iv) How would you expect the basicity of piperidine to compare to that of ammonia? Explain your reasoning.

.....

.....

[5]

(d)  $20.0\text{ cm}^3$  of  $0.100\text{ mol dm}^{-3}$   $\text{HCl}$  was slowly added to a  $10.0\text{ cm}^3$  sample of  $0.150\text{ mol dm}^{-3}$  piperidine. The pH was measured throughout the addition.

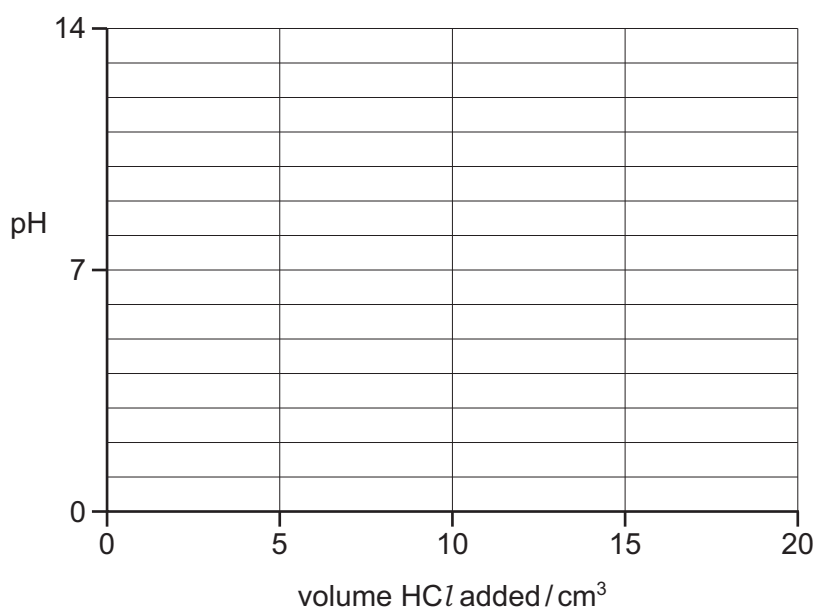
(i) Calculate the number of moles of  $\text{HCl}$  remaining at the end of the addition.

moles of  $\text{HCl}$  = .....

(ii) Hence calculate the  $[\text{H}^+]$  and the pH at the end of the addition.

pH = .....

(iii) On the following axes, sketch how the pH will change during the addition of a total of  $20.0\text{ cm}^3$  of  $0.100\text{ mol dm}^{-3}$   $\text{HCl}$ . Mark clearly where the end point occurs.



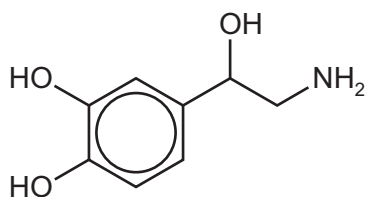
(iv) From the following list of indicators, put a tick in the box by the side of the indicator most suitable for this titration.

| indicator | pH at which colour changes | place <b>one tick only</b> in this column |
|-----------|----------------------------|-------------------------------------------|
| A         | 0 - 1                      |                                           |
| B         | 3 - 4                      |                                           |
| C         | 11 - 12                    |                                           |
| D         | 13 - 14                    |                                           |

[6]

[Total: 16]

- 4 Noradrenaline is a hormone and neurotransmitter, which is released during stress to stimulate the heart and increase blood pressure.

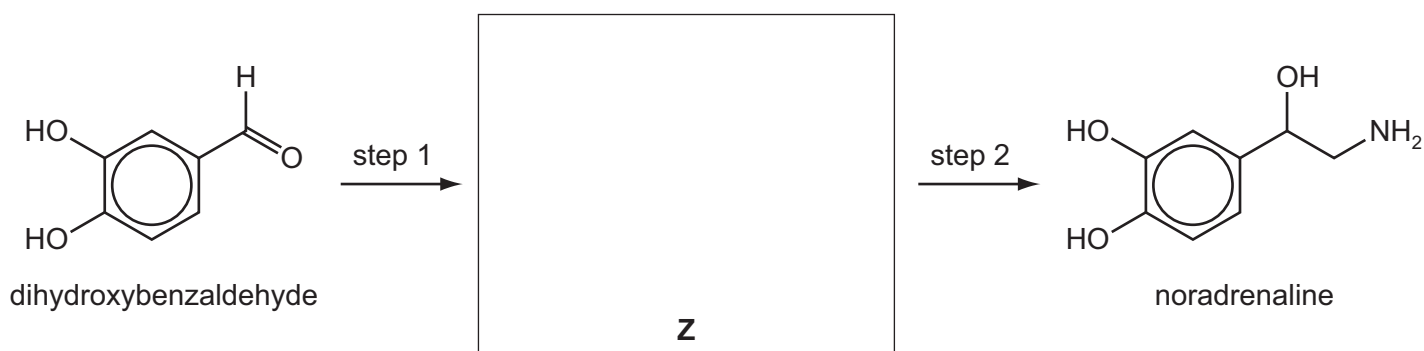


noradrenaline

- (a) State the **names** of **three** functional groups in the noradrenaline molecule.

.....  
 .....  
 ..... [3]

- (b) (i) Consider the following two-stage synthesis of noradrenaline from dihydroxybenzaldehyde.



- Draw the structure of the intermediate **Z** in the box.
- Suggest reagents for steps 1 and 2.

step 1 .....

step 2 .....

(ii) Dihydroxybenzaldehyde reacts with  $\text{Br}_2(\text{aq})$ .

- Describe what you would see during this reaction.

.....

- Draw the structure of the product.

[5]

(c) Draw the structures of the products when noradrenaline is reacted with

(i) dilute  $\text{NaOH}(\text{aq})$ ,

(ii) dilute  $\text{HCl}(\text{aq})$ ,

(iii) an excess of ethanoyl chloride,  $\text{CH}_3\text{COCl}$ .

[4]

(d) Name the **new** functional groups formed in the reaction in (c)(iii).

.....

..... [2]

[Total: 14]

5 The two compounds **V** and **W** are isomers with the molecular formula  $C_4H_8O$ , and show the following properties and reactions.

- Both compounds react with sodium metal, and both decolourise bromine water.
- Compound **V** forms a yellow precipitate with alkaline aqueous iodine, whereas compound **W** does not.
- When reacted with cold  $KMnO_4(aq)$ , both **V** and **W** produce the same neutral compound **X**,  $C_4H_{10}O_3$ .
- Both **V** and **W** exist as pairs of stereoisomers.

(a) Suggest which functional groups are responsible for the reactions with

(i) sodium,

.....

(ii) bromine water,

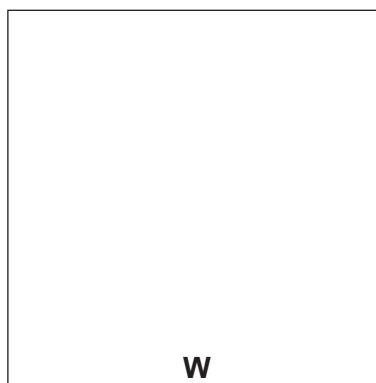
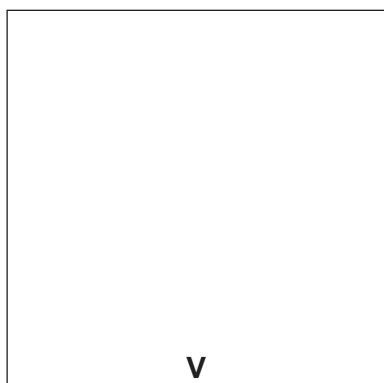
.....

(iii) alkaline aqueous iodine.

.....

[3]

(b) Suggest structures for **V** and **W**.

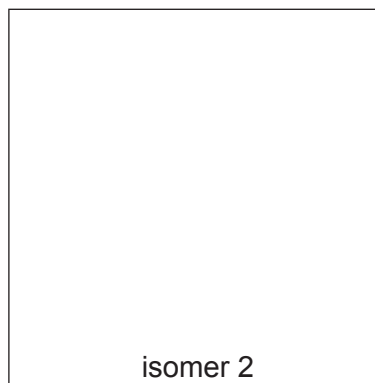
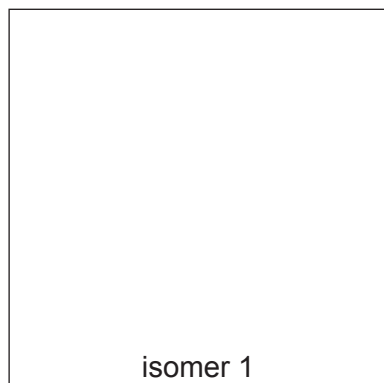


[2]

- (c) State the type of stereoisomerism shown by compound **V** and draw the structures of the stereoisomers.

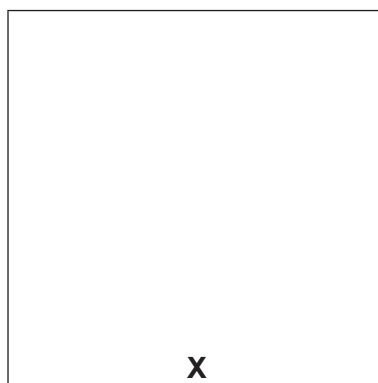
type of stereoisomerism .....

structures of stereoisomers



[2]

- (d) Suggest the structure of the neutral compound **X**.



[1]

[Total: 8]

## Section B

Answer **all** the questions in the spaces provided.

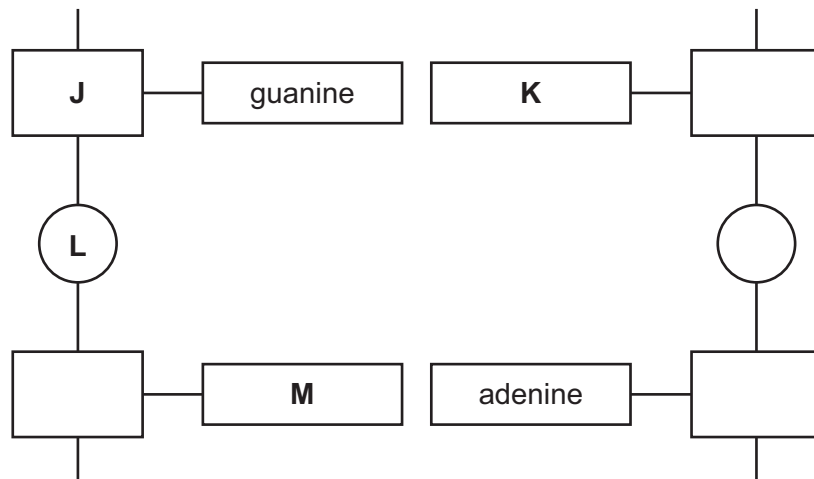
- 6** Proteins and deoxyribonucleic acid, DNA, are two important polymers that occur within living organisms.

- (a)** Proteins have a number of 'levels' of bonding: primary, secondary and tertiary.  
Complete the table to indicate the level of bonding responsible for the features described.

| feature                      | level of bonding |
|------------------------------|------------------|
| formation of $\alpha$ -helix |                  |
| formation of disulfide bonds |                  |
| formation of ionic bonds     |                  |
| linking amino acids          |                  |

[3]

- (b)** The diagram shows part of a DNA molecule. Study the diagram and give the correct names for the blocks labelled **J**, **K**, **L** and **M**.



| block letter | name |
|--------------|------|
| <b>J</b>     |      |
| <b>K</b>     |      |
| <b>L</b>     |      |
| <b>M</b>     |      |

[4]

(c) The DNA molecule is formed from two polymer strands which are held together until DNA replication occurs.

(i) What type of bonding holds the strands together?

.....

(ii) Explain why this type of bonding allows the base pairs within the strands to separate during replication at normal body temperature.

.....

.....

[2]

(d) In the polymer RNA, the identities of two of the blocks, **J**, **K**, **L** or **M**, are different.

For **one** of these blocks that are different, give its correct name in DNA and in RNA.

DNA: .....

RNA: .....

[1]

[Total: 10]

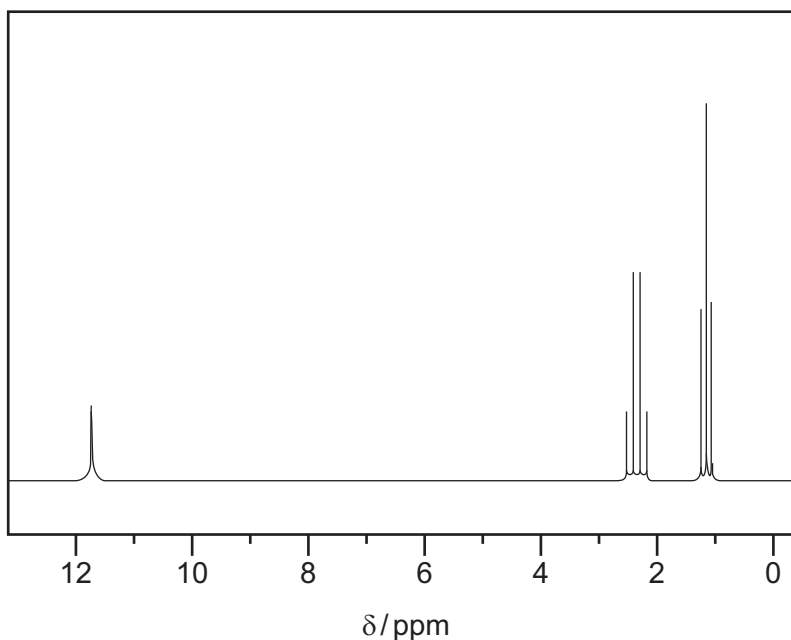
7 The combination of mass spectroscopy and NMR spectroscopy provides a powerful method of analysis for organic compounds.

- (a) The mass spectrum of a compound **G** contains  $M$  and  $M+1$  peaks in the ratio of their heights of 74 : 2.5.

Use these data to calculate the number of carbon atoms present in **G**. Show your working.

[2]

- (b) The NMR spectrum of compound **G** is shown.



- (i) Use the *Data Booklet* and your knowledge of NMR spectroscopy to identify the type of proton responsible for each of the three absorptions.

| $\delta$ /ppm | type of proton |
|---------------|----------------|
| 1.1           |                |
| 2.2           |                |
| 11.8          |                |

- (ii) The addition of  $D_2O$  causes one of these absorptions to disappear. Explain why this happens and state which absorption is affected.

.....

.....

(iii) Draw the structural formula of **G**.

[6]

(c) Several structural isomers of **G** exist.

(i) Draw the structural formula of an isomer of **G** with only two absorptions in its NMR spectrum.

(ii) Use the *Data Booklet* to suggest where these absorptions would occur.

| peak | $\delta$ /ppm |
|------|---------------|
| 1    |               |
| 2    |               |

[3]

[Total: 11]

- 8 (a) Many common drugs are taken orally, but some medications, such as those based on protein molecules, are injected to prevent them being broken down in the digestive system.

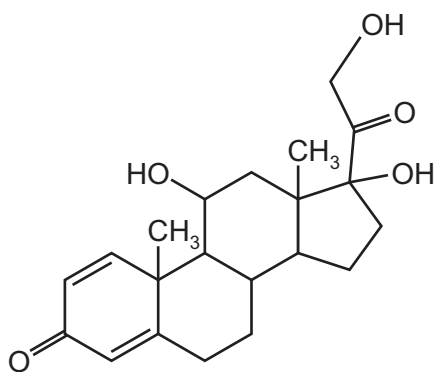
(i) **Name** a functional group present in drug molecules that might be broken down by acid in the stomach.

.....

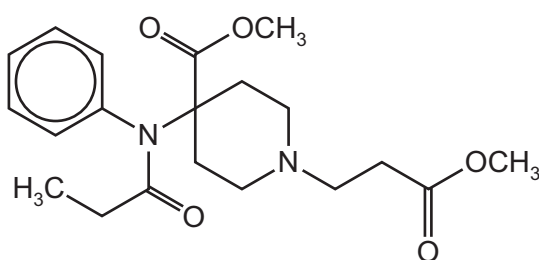
(ii) State the *type of reaction* that would cause such a breakdown.

.....

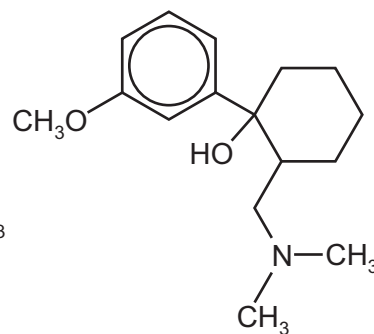
(iii) Which **one** of the following compounds would **not** be suitable to be taken orally?



**A**



**B**



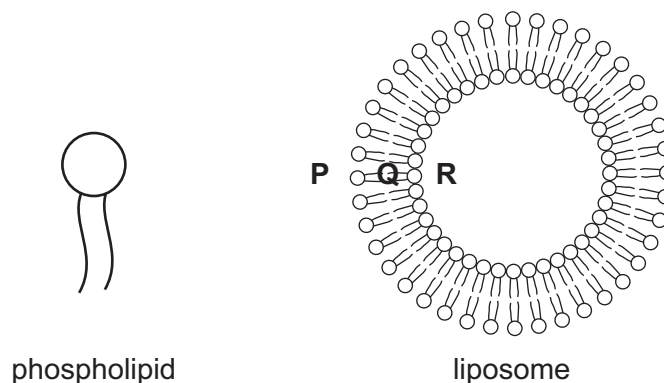
**C**

compound .....

(iv) On the structure of your chosen compound in (iii), circle **all** the functional groups that might be broken down by acid.

[5]

- (b) One way of protecting drug molecules that are taken orally is to enclose them in liposomes. These are artificially created spheres made from phospholipids which have an ionic phosphate 'head' and two hydrocarbon 'tails'.



- (i) State and explain in which location, **P**, **Q** or **R**, a hydrophobic drug could be carried.

.....

.....

- (ii) By considering the nature of the functional groups in **A**, **B** and **C**, explain why these drugs can be carried at position **R** in the liposome.

.....

.....

[2]

- (c) Another method of protecting drug molecules is to 'trap' them inside gold nano-cages. When they reach the site where they are needed, such as a tumour, the drug is released by exposing the site to infra-red radiation.

- (i) Suggest the size of the nano-cages **in metres**.

.....

- (ii) Suggest why infra-red, rather than higher frequency radiation is used.

.....

.....

[2]

[Total: 9]

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**CHEMISTRY**

**9701/42**

Paper 4 Structured Questions

**May/June 2014**

**2 hours**

Candidates answer on the Question Paper.

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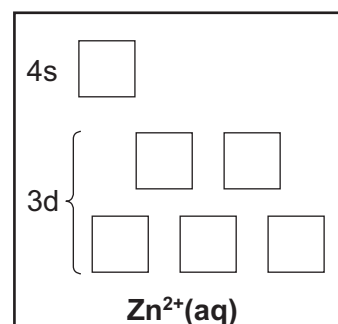
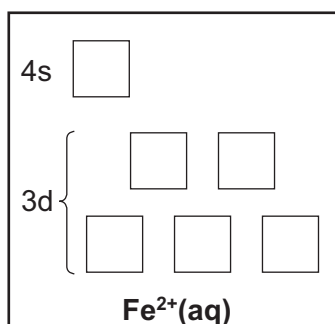
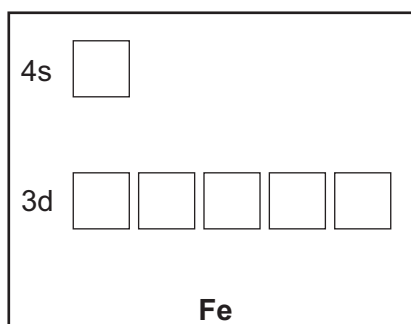
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## Section A

Answer **all** the questions in the spaces provided.

- 1 (a) (i) On the diagrams below, show the outer electron arrangements of the atoms and ions indicated. (Use the symbol  $\uparrow\downarrow$  to represent a pair of electrons in an orbital.)



- (ii) Use the above diagrams to explain why Fe<sup>2+</sup>(aq) ions are coloured, whereas Zn<sup>2+</sup>(aq) ions are colourless.

.....

.....

.....

.....

[4]

- (b) When concentrated HCl is added to a solution of Cu<sup>2+</sup>(aq) ions, the solution turns yellow.

- (i) State the formula of the species responsible for the yellow colour and name the *type of reaction* that has occurred.

.....

.....

- (ii) Ammonia can react as a base or as a ligand.  
Describe the colour changes that occur when NH<sub>3</sub>(aq) is **gradually** added, with stirring, to the yellow solution, until the NH<sub>3</sub>(aq) is in excess.  
Identify the **three** ions or compounds responsible for the new colours.

.....

.....

.....

.....

.....

.....

[7]

(c) When aqueous solutions of KI and  $\text{K}_2\text{S}_2\text{O}_8$  are mixed almost no reaction occurs, but when a few drops of  $\text{Fe}^{2+}(\text{aq})$  or  $\text{Fe}^{3+}(\text{aq})$  are added, iodine,  $\text{I}_2(\text{aq})$ , is produced at a steady rate.

(i) Write an equation for the overall reaction.

.....

(ii) State the precise role of the iron ions during this reaction.

.....

(iii) By means of equations or otherwise, explain why the presence of *either*  $\text{Fe}^{2+}$  *or*  $\text{Fe}^{3+}$  is able to speed up the reaction.

.....

.....

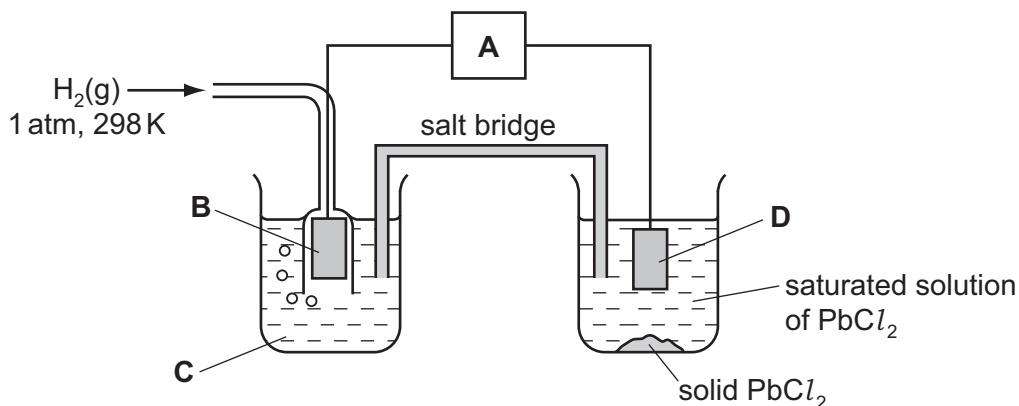
.....

[3]

[Total: 14]

- 2 Lead(II) chloride,  $\text{PbCl}_2$ , can be used in the manufacture of some types of coloured glass.

$\text{PbCl}_2$  is only sparingly soluble in water. The  $[\text{Pb}^{2+}]$  in a saturated solution of  $\text{PbCl}_2$  can be estimated by measuring the cell potential,  $E_{\text{cell}}$ , of the following cell.



- (a) In the spaces below, identify what the four letters **A-D** in the above diagram represent.

**A** ..... **B** .....  
**C** ..... **D** .....

[4]

- (b) In a saturated solution of  $\text{PbCl}_2$ ,  $[\text{PbCl}_2(\text{aq})] = 3.5 \times 10^{-2} \text{ mol dm}^{-3}$ .

- (i) The  $E^\circ$  for the  $\text{Pb}^{2+} / \text{Pb}$  electrode is  $-0.13 \text{ V}$ . Predict the potential of the right-hand electrode in the diagram above. Indicate this by placing a tick in the appropriate box in the table below.

| electrode potential / V | place <b>one tick only</b> in this column |
|-------------------------|-------------------------------------------|
| -0.17                   |                                           |
| -0.13                   |                                           |
| -0.09                   |                                           |
| 0.00                    |                                           |

Explain your answer.

.....  
 .....

- (ii) Write an expression for the solubility product,  $K_{sp}$ , of  $PbCl_2$ .

.....

- (iii) Calculate the value of  $K_{sp}$ , including units.

$$K_{sp} = \text{..... units .....}$$

[5]

- (c) The behaviours of  $PbCl_2$  and  $SnCl_2$  towards reducing agents are similar, but their behaviours towards oxidising agents are very different.

- (i) Illustrate this comparison by quoting and comparing relevant  $E^\circ$  values for the two metals and their ions. Explain what the relative  $E^\circ$  values mean in terms of the ease of oxidation or reduction of these compounds.

.....

.....

.....

.....

.....

.....

- (ii) Writing a balanced molecular or ionic equation in each case, suggest a reagent to carry out each of the following reactions.

the reduction of  $PbCl_2$

.....

the oxidation of  $SnCl_2$

.....

[5]

- (d) (i) Write an equation to represent the lattice energy of  $\text{PbCl}_2$ . Show state symbols.

.....

- (ii) Use the following data, together with appropriate data from the *Data Booklet*, to calculate a value for the lattice energy of  $\text{PbCl}_2$ .

|                                                           |   |                            |
|-----------------------------------------------------------|---|----------------------------|
| electron affinity of chlorine                             | = | $-349 \text{ kJ mol}^{-1}$ |
| enthalpy change of atomisation of lead                    | = | $+195 \text{ kJ mol}^{-1}$ |
| enthalpy change of formation of $\text{PbCl}_2(\text{s})$ | = | $-359 \text{ kJ mol}^{-1}$ |

lattice energy = .....  $\text{kJ mol}^{-1}$

- (iii) How might the lattice energy of  $\text{PbCl}_2$  compare to that of  $\text{PbBr}_2$ ? Explain your answer.

.....

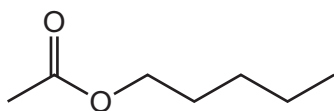
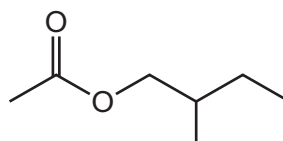
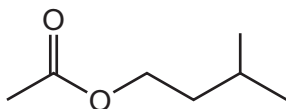
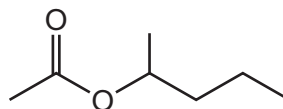
.....

.....

[6]

[Total: 20]

- 3 The following four isomeric esters with the molecular formula  $C_7H_{14}O_2$  are used as artificial flavours in drinks and sweets to give a pear, banana or plum taste to foodstuffs.

**A****B****C****D**

- (a) In each of the spaces below, write one or more of the letters **A-D**, as appropriate.

- (i) Which of these compounds can exist as optical isomers?

.....

- (ii) On hydrolysis, which of these compounds produce(s) a secondary alcohol?

.....

[3]

- (b) The hydrolysis of all these compounds produces ethanoic acid,  $CH_3CO_2H$ , as one of the products.

State the reagents and conditions needed for this hydrolysis.

..... [1]

(c) The acid dissociation constant,  $K_a$ , of ethanoic acid is  $1.75 \times 10^{-5} \text{ mol dm}^{-3}$ .

(i) Explain why this value of  $K_a$  is

- much larger than that of ethanol,  $\text{CH}_3\text{CH}_2\text{OH}$ ,

.....  
.....

- smaller than that of chloroethanoic acid,  $\text{ClCH}_2\text{CO}_2\text{H}$ .

.....  
.....

(ii) Calculate the pH of a  $0.100 \text{ mol dm}^{-3}$  solution of ethanoic acid.

[4]

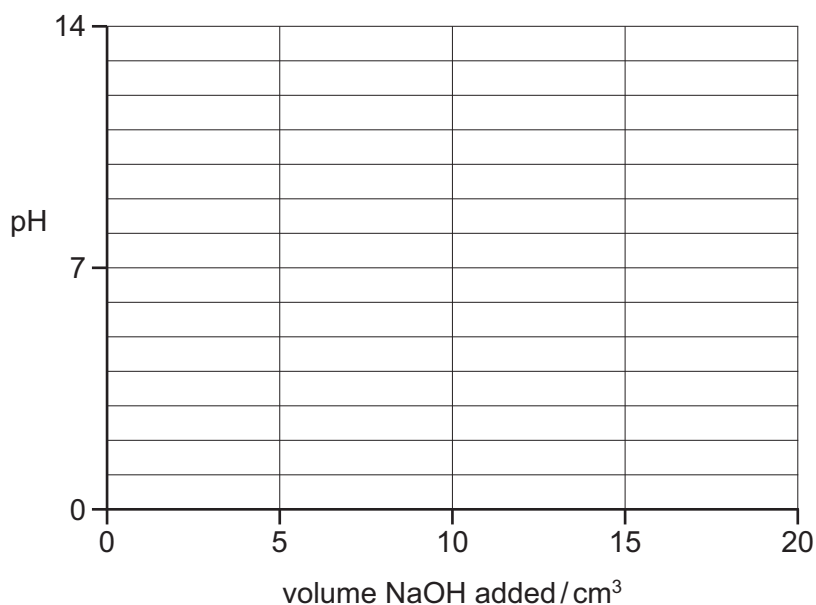
(d)  $20.0 \text{ cm}^3$  of  $0.100 \text{ mol dm}^{-3}$  NaOH were slowly added to a  $10.0 \text{ cm}^3$  sample of  $0.100 \text{ mol dm}^{-3}$  ethanoic acid, and the pH was measured throughout the addition.

(i) Calculate the number of moles of NaOH remaining at the end of the addition.

(ii) Calculate the  $[\text{OH}^-]$  at the end of the addition.

(iii) Using the expression  $K_w = [\text{H}^+][\text{OH}^-]$  and your value in (ii), calculate  $[\text{H}^+]$  and the pH of the solution at the end of the addition.

- (iv) On the following axes, sketch how the pH will change during the addition of a total of  $20.0 \text{ cm}^3$  of  $0.100 \text{ mol dm}^{-3}$  NaOH. Mark clearly where the end point occurs.



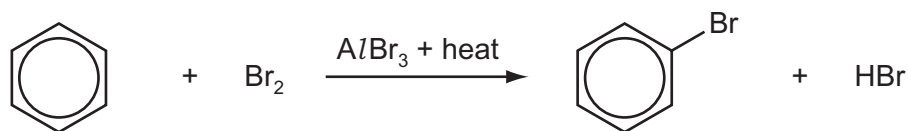
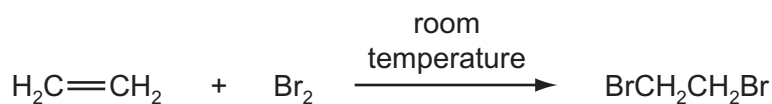
- (v) From the following list of indicators, put a tick in the box by the side of the indicator you consider most suitable for this titration.

| indicator        | pH at which colour changes | place <b>one tick only</b> in this column |
|------------------|----------------------------|-------------------------------------------|
| malachite green  | 0 - 1                      |                                           |
| thymol blue      | 1 - 2                      |                                           |
| bromophenol blue | 3 - 4                      |                                           |
| thymolphthalein  | 9 - 10                     |                                           |

[7]

[Total: 15]

- 4 Both ethene and benzene react with bromine.



- (a) What *type of reaction* is the reaction of bromine with

- (i) ethene,

.....

- (ii) benzene?

.....

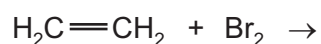
[1]

- (b) Write an equation to show the formation of the electrophile during the reaction between bromine and benzene.

..... [1]

- (c) Each of these reactions involves an intermediate.

- (i) Draw the structure of the intermediate in each reaction.



- (ii) Suggest why the product of the reaction between bromine and benzene, bromobenzene, is still unsaturated.

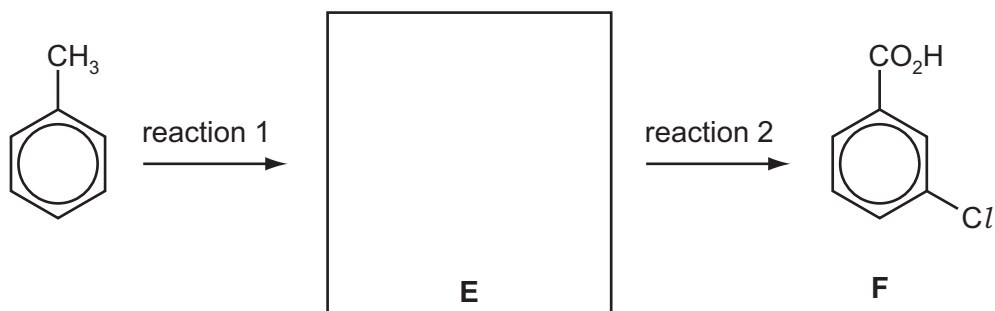
.....

[3]

- (d) When methylbenzene is nitrated, 4-nitromethylbenzene is formed, but when benzoic acid is nitrated, 3-nitrobenzoic acid is produced.

Consider the following synthesis of 3-chlorobenzoic acid, **F**, from methylbenzene. Use the information given above to suggest

- the structure of the intermediate **E**,
- the reagents and conditions needed for reactions 1 and 2.



reagents and conditions for reaction 1

.....

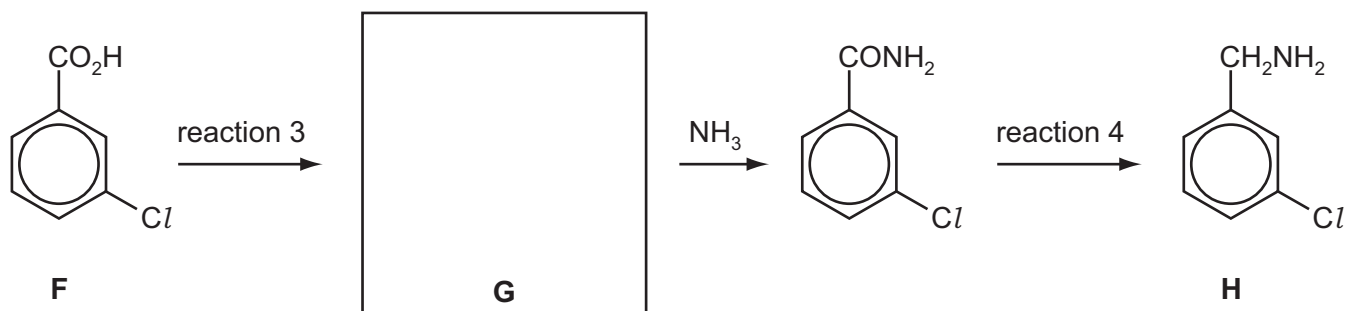
reagents and conditions for reaction 2

.....

[3]

- (e) Consider the following synthesis of 3-chlorophenylmethanamine, **H**, from **F**. Suggest

- the structure of the intermediate **G**,
- the reagents for reactions 3 and 4.



reagents for reaction 3

.....

reagents for reaction 4

.....

[3]

[Total: 11]

- 5 Although now remembered for his music, the Russian composer Alexander Borodin was a chemist. He is credited with the discovery of the *aldol reaction*, a product of which is compound **J**. **J** shows the following properties:

- its molecular formula is  $C_4H_8O_2$ ,
- it is neutral,
- it reacts with sodium metal,
- it reacts with Fehling's solution,
- it does not react with aqueous bromine.

(a) Suggest which functional groups are responsible for the reactions with

(i) sodium,

.....

(ii) Fehling's solution.

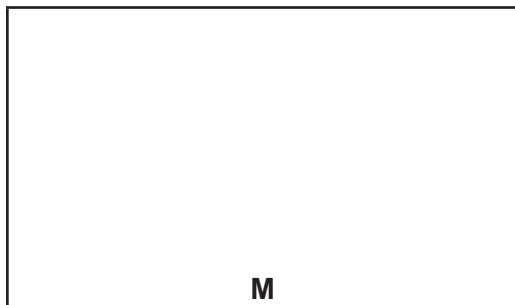
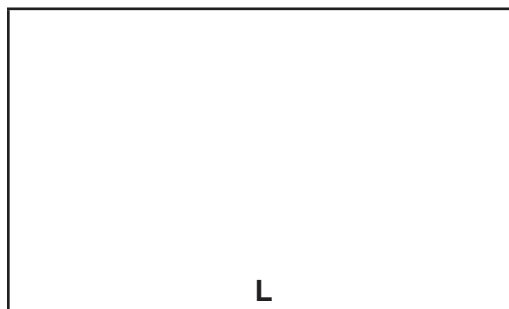
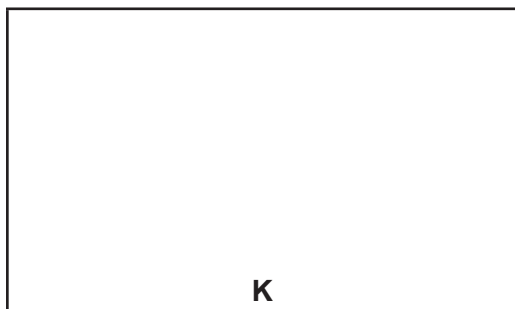
.....

[2]

(b) The result of the bromine test shows a functional group is absent from compound **J**. Suggest the identity of this functional group.

..... [1]

(c) In the boxes below, draw three possible **straight-chain** structures for **J** that fit the above results, and that are structural isomers of each other.



[3]

(d) Compound **J** reacts with alkaline aqueous iodine to give a pale yellow precipitate.

(i) Which functional group does this reaction show that **J** contains?

.....

(ii) Which of your three structures **K**, **L** or **M** contains this group and is therefore **J**?

.....

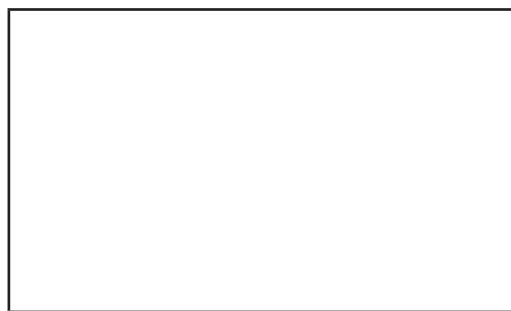
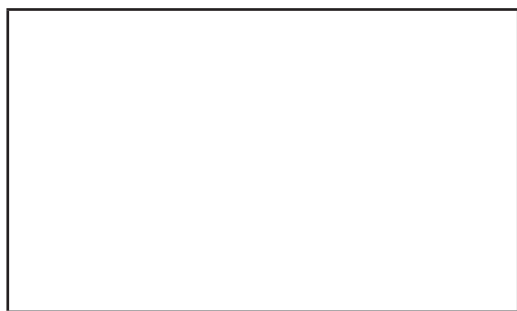
[2]

(e) Compound **J** exists as stereoisomers.

(i) Name the type of stereoisomerism shown by **J**.

.....

(ii) Draw two structures of **J** to illustrate this stereoisomerism.



[2]

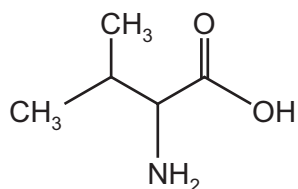
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## Section B

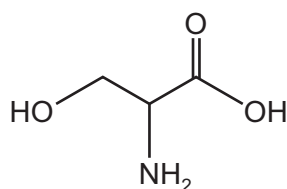
Answer **all** the questions in the spaces provided.

6 This question looks at the formation and breakdown of protein chains in the body.

- (a) Proteins are formed from chains of amino acid monomers joined together. The structures of two amino acids, valine and serine are shown.



valine (val)



serine (ser)

- (i) Draw the structure of the dipeptide val-ser, showing the peptide bond in displayed form.

- (ii) What *type of reaction* has taken place in order to form this dipeptide?

.....

- (iii) Identify the other molecule produced in this reaction.

.....

[4]

- (b) Both DNA and RNA are involved in protein synthesis.

Complete the table to show **three** differences between the structures of DNA and RNA.

|   | DNA | RNA |
|---|-----|-----|
| 1 |     |     |
| 2 |     |     |
| 3 |     |     |

[3]

- (c) In protein synthesis, sections of the DNA are copied by mRNA and this, in turn, is read by the ribosome in order to assemble the amino acids for the new protein chain. Each group of three bases codes for one amino acid, with some amino acids having several codes. The codes are summarised in the table.

|     |               |     |     |     |      |     |      |
|-----|---------------|-----|-----|-----|------|-----|------|
| UUU | phe           | UCU | ser | UAU | tyr  | UGU | cys  |
| UUC | phe           | UCC | ser | UAC | tyr  | UGC | cys  |
| UUA | leu           | UCA | ser | UAA | stop | UGA | stop |
| UUG | leu           | UCG | ser | UAG | stop | UGG | trp  |
| CUU | leu           | CCU | pro | CAU | his  | CGU | arg  |
| CUC | leu           | CCC | pro | CAC | his  | CGC | arg  |
| CUA | leu           | CCA | pro | CAA | gln  | CGA | arg  |
| CUG | leu           | CCG | pro | CAG | gln  | CGG | arg  |
| AUU | ile           | ACU | thr | AAU | asn  | AGU | ser  |
| AUC | ile           | ACC | thr | AAC | asn  | AGC | ser  |
| AUA | ile           | ACA | thr | AAA | lys  | AGA | arg  |
| AUG | met/<br>start | ACG | thr | AAG | lys  | AGG | arg  |
| GUU | val           | GCU | ala | GAU | asp  | GGU | gly  |
| GUC | val           | GCC | ala | GAC | asp  | GGC | gly  |
| GUA | val           | GCA | ala | GAA | glu  | GGA | gly  |
| GUG | val           | GCG | ala | GAG | glu  | GGG | gly  |

In general the amino acid chains start with the code AUG, and end with one of the three 'stop' codes shown in the table.

- (i) Use the abbreviations to show the sequence of amino acids in the peptide for the base sequence shown.

– AUGCUAACACCGGAGUAA –

.....

- (ii) Sometimes an error can occur in the base sequence.

What are these errors called?

.....

- (iii) This type of error can lead to the formation of a protein with a different structure from the original, as in *sickle cell anaemia*. In this case the amino acid glutamic acid (glu) is replaced by valine (val) in the protein as a result of one base being changed in a three base code.

Use the table to suggest the change of base that causes this.

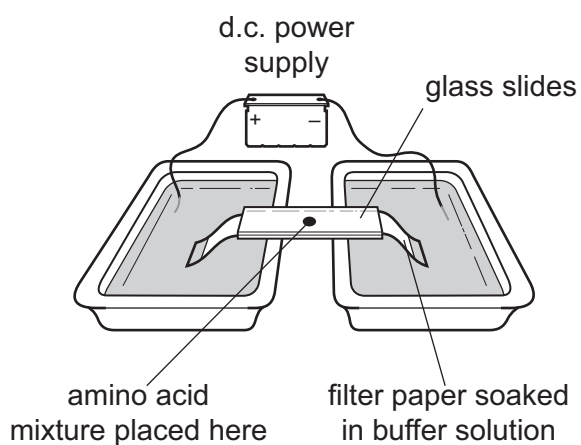
.....

[3]

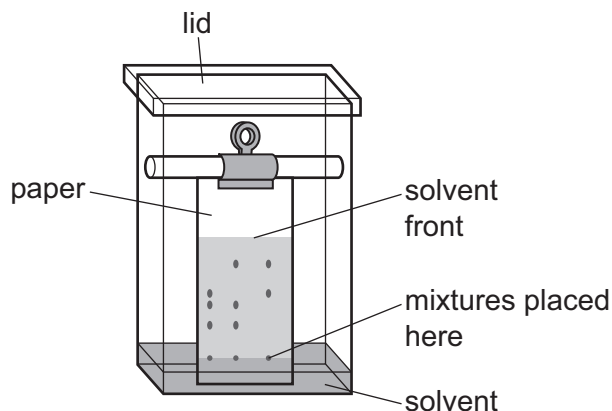
[Total: 10]

- 7 Modern methods of chemical analysis often rely on the interpretation of data gathered from instrumental techniques.

- (a) Electrophoresis and paper chromatography can both be used to separate amino acids from a mixture obtained from polypeptides.



electrophoresis



paper chromatography

In each case, give **one** property of the amino acids that causes their separation.

electrophoresis .....

.....

paper chromatography .....

.....

[2]

- (b) Amino acids are colourless.

How are the positions of the different amino acids made visible so that measurements can be made?

.....

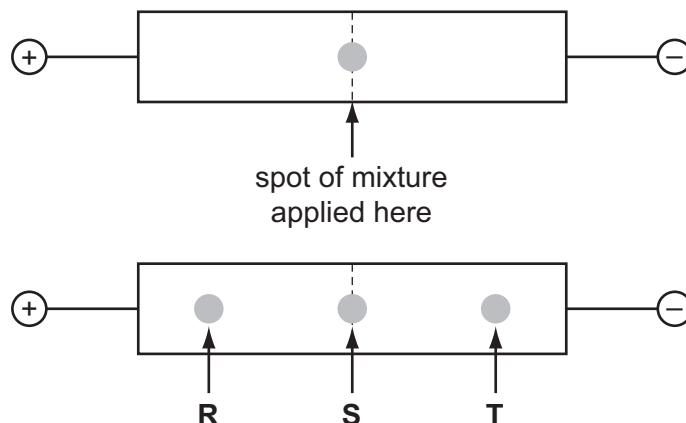
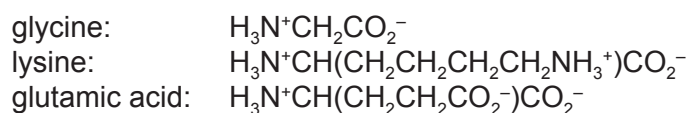
..... [1]

- (c) Which **measurements** need to be made in order to identify individual amino acids in paper chromatography?

.....

..... [1]

- (d) The diagram shows the results of electrophoresis on a mixture of the amino acids glycine, lysine and glutamic acid at pH 7.0. The structures of the amino acids at pH 7.0 are shown.



Identify the amino acids responsible for the spots labelled **R**, **S** and **T**.

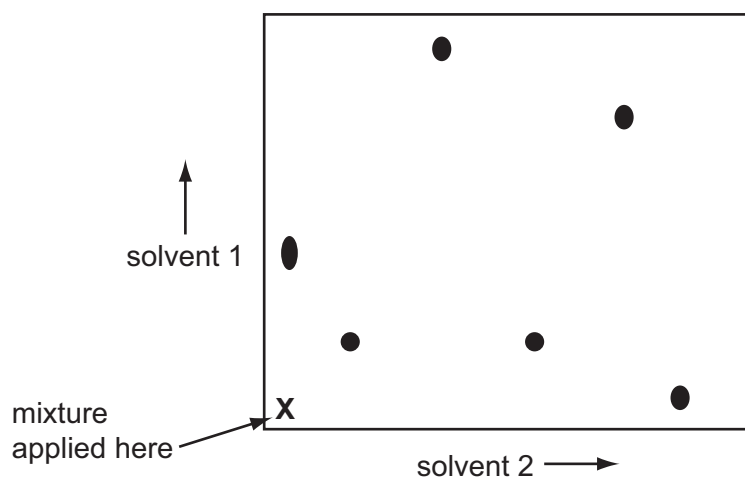
**R** .....

**S** .....

**T** .....

[3]

- (e) This diagram shows the results of two-way paper chromatography of a mixture of amino acids.



To answer these questions you need to indicate clearly on the diagram above as directed in the questions.

- Put a **U** next to the amino acid that travelled furthest in solvent 2.
- Put a ring around the **two** amino acids that were **not** separated in solvent 1.
- Put a **W** next to the amino acid that was very soluble in **both** solvents.

[3]

[Total: 10]

8 Polymers consist of monomers joined by either addition or condensation reactions.

(a) Name an example of a synthetic addition polymer and a synthetic condensation polymer.

addition polymer .....

condensation polymer .....

[2]

(b) Addition polymers are long-term pollutants in the environment but condensation polymers are often biodegradable.

(i) What *type of reaction* occurs when condensation polymers biodegrade?

.....

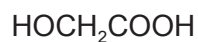
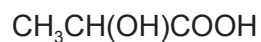
(ii) Identify **two** functional groups that could undergo this type of reaction.

.....

[2]

(c) Petroleum is a non-renewable resource from which a wide range of useful polymers is currently produced. Current polymer research is looking at renewable plant material as a potential source of monomers.

Two monomers obtained from plants are shown.



Draw the displayed formula of the repeat unit of a polymer using **both** monomers.

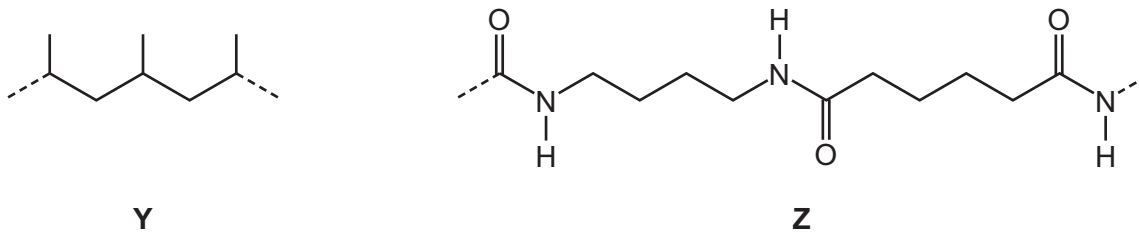
[2]

(d) Monomers obtained from plant sources do not usually form addition polymers. Suggest why this is.

.....

..... [1]

(e) The diagrams show sections of two polymers **Y** and **Z**.



(i) What would be the main force between the chains in each polymer?

**Y** .....

**Z** .....

(ii) Which is likely to be the more hydrophilic of these two polymers? Explain your answer.

.....

.....

[3]

[Total: 10]

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**CHEMISTRY**

**9701/43**

Paper 4 Structured Questions

**May/June 2014**

**2 hours**

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

**Section A**

Answer **all** questions.

**Section B**

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

**For Examiner's Use**

|              |  |
|--------------|--|
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| <b>8</b>     |  |
| <b>Total</b> |  |

This document consists of **19** printed pages and **1** blank page.



## Section A

Answer **all** the questions in the spaces provided.

- 1 (a) (i) State how the melting point and density of iron compare to those of calcium.

melting point of iron: .....

density of iron: .....

- (ii) Explain why these differences occur.

melting point: .....

.....

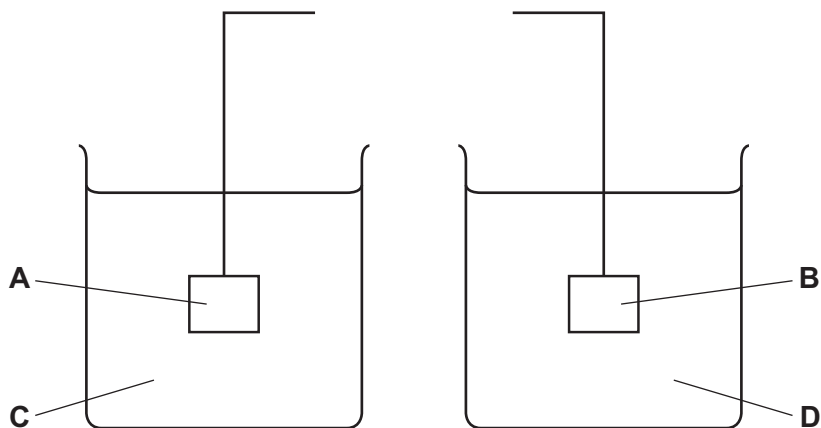
density: .....

.....

[4]

- (b) The following diagram shows the apparatus used to measure the standard electrode potential,  $E^\circ$ , of a cell composed of a Cu(II)/Cu electrode and an Fe(II)/Fe electrode.

- (i) Finish the diagram by adding components to show the complete circuit. Label the components you add.



- (ii) In the spaces below, identify or describe what the four letters **A-D** represent.

**A** .....

**B** .....

**C** .....

**D** .....

- [8]

- 9701/43/M/J/14

2 The ions of transition elements form *complexes* by reacting with *ligands*.

(a) (i) State what is meant by the terms:

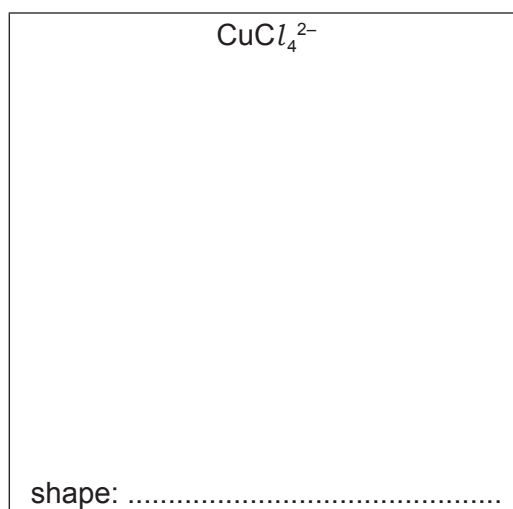
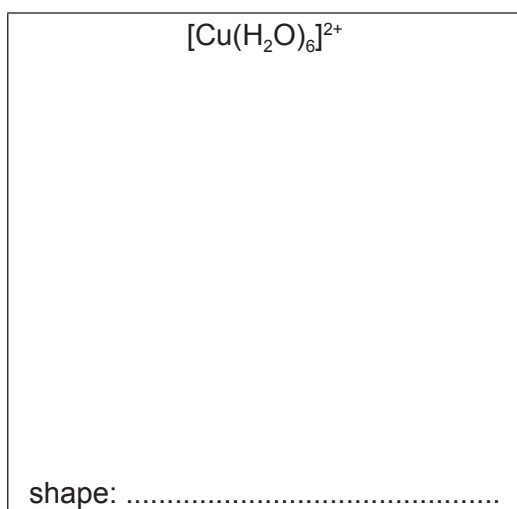
*complex*, .....

.....

*ligand*. .....

.....

(ii) Two of the complexes formed by copper are  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  and  $\text{CuCl}_4^{2-}$ .  
Draw three-dimensional diagrams of their structures in the boxes and name their shapes.

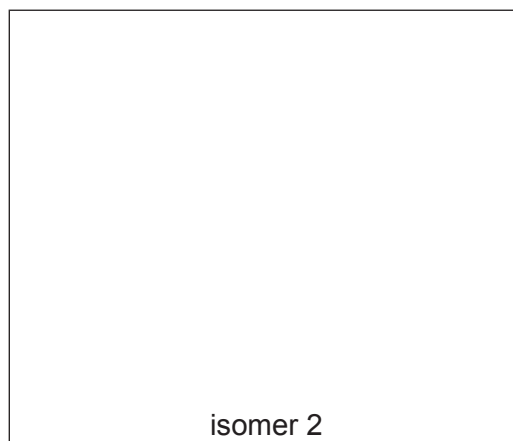
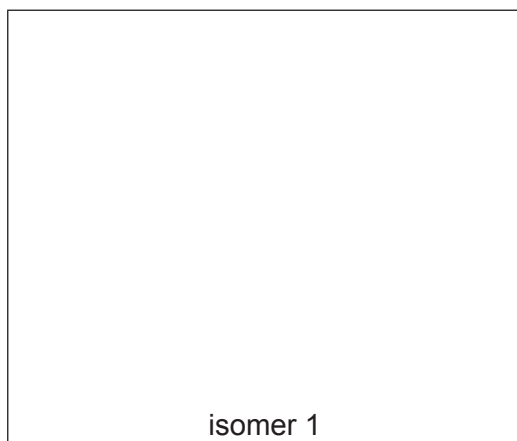


(iii) Platinum forms square-planar complexes, in which all four ligands lie in the same plane as the Pt atom.

There are two isomeric complexes with the formula  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ .

Suggest the structures of the two isomers, and, by comparison with a similar type of isomerism in organic chemistry, suggest the type of isomerism shown here.

Structures of isomers:



Type of isomerism: .....

[7]

(b) Copper forms two series of compounds, one containing copper(II) ions and the other containing copper(I) ions.

(i) Complete the electronic structures of these ions.

Cu(II) [Ar] .....

Cu(I) [Ar] .....

(ii) Use these electronic structures to explain why

copper(II) salts are usually coloured,

.....  
.....  
.....  
.....

copper(I) salts are usually white or colourless.

.....  
.....

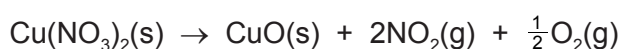
[5]

- (c) Copper(I) oxide and copper(II) oxide can both be used in the ceramic industry to give blue, green or red tints to glasses, glazes and enamels.

The table lists the  $\Delta H_f^\ominus$  values for some compounds.

| compound                      | $\Delta H_f^\ominus / \text{kJ mol}^{-1}$ |
|-------------------------------|-------------------------------------------|
| $\text{Cu}_2\text{O(s)}$      | -168.6                                    |
| $\text{CuO(s)}$               | -157.3                                    |
| $\text{Cu(NO}_3)_2\text{(s)}$ | -302.9                                    |
| $\text{NO}_2\text{(g)}$       | +33.2                                     |

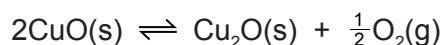
- (i) Copper(II) oxide can be produced in a pure form by heating copper(II) nitrate. Use suitable  $\Delta H_f^\ominus$  values from the table to calculate the  $\Delta H^\ominus$  for this reaction.



$$\Delta H^\ominus = \dots\dots\dots \text{kJ mol}^{-1}$$

- (ii) Copper(I) oxide can be produced from copper(II) oxide.

- Use suitable  $\Delta H_f^\ominus$  values from the table to calculate  $\Delta H^\ominus$  for the reaction.



$$\Delta H^\ominus = \dots\dots\dots \text{kJ mol}^{-1}$$

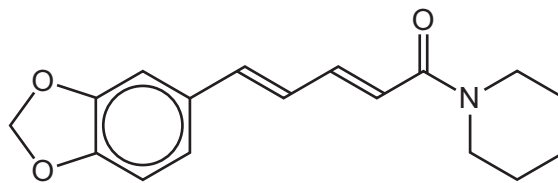
- Hence suggest whether a low or a high temperature of oxidation would favour the production of copper(I) oxide. Explain your reasoning.

.....  
 .....

[4]

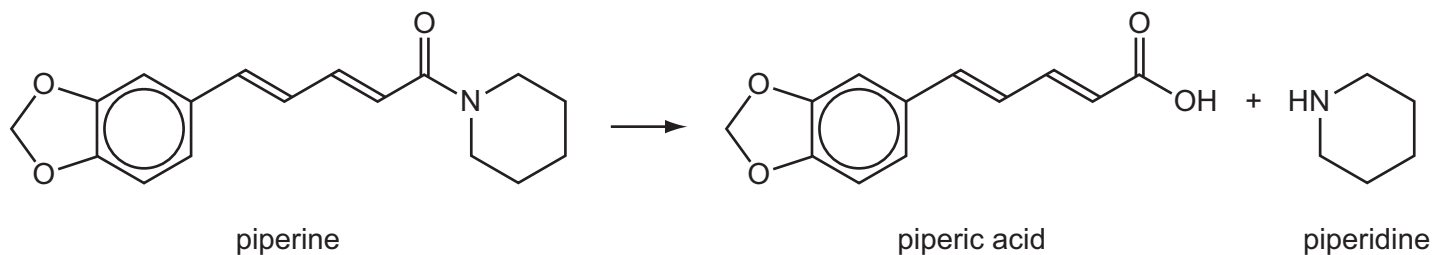
[Total: 16]

- 3 Piperine is the compound responsible for the hot taste of black pepper.



piperine

Piperine is an amide and can be broken down as follows:



- (a) Suggest reagents and conditions for this reaction.

..... [1]

- (b) (i) How many stereoisomers are there with the same structural formula as piperic acid (including piperic acid itself)?

.....

- (ii) Draw the skeletal structure of a stereoisomer of piperic acid, different to the one shown above.

- (iii) Suggest structures for the compounds that would be formed when piperic acid is treated with an **excess** of hot concentrated acidified  $\text{KMnO}_4$ .

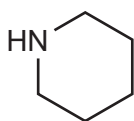
[4]

(c) (i) Write the expression for  $K_w$ .

.....

(ii) Use your expression and the value of  $K_w$  in the *Data Booklet* to calculate the pH of  $0.150 \text{ mol dm}^{-3} \text{ NaOH(aq)}$ .

(iii) The pH of a  $0.150 \text{ mol dm}^{-3}$  solution of piperidine is 11.9.



piperidine

Suggest why this answer differs from your answer in (c)(ii).

.....

.....

(iv) How would you expect the basicity of piperidine to compare to that of ammonia? Explain your reasoning.

.....

.....

[5]

(d)  $20.0\text{ cm}^3$  of  $0.100\text{ mol dm}^{-3}$   $\text{HCl}$  was slowly added to a  $10.0\text{ cm}^3$  sample of  $0.150\text{ mol dm}^{-3}$  piperidine. The pH was measured throughout the addition.

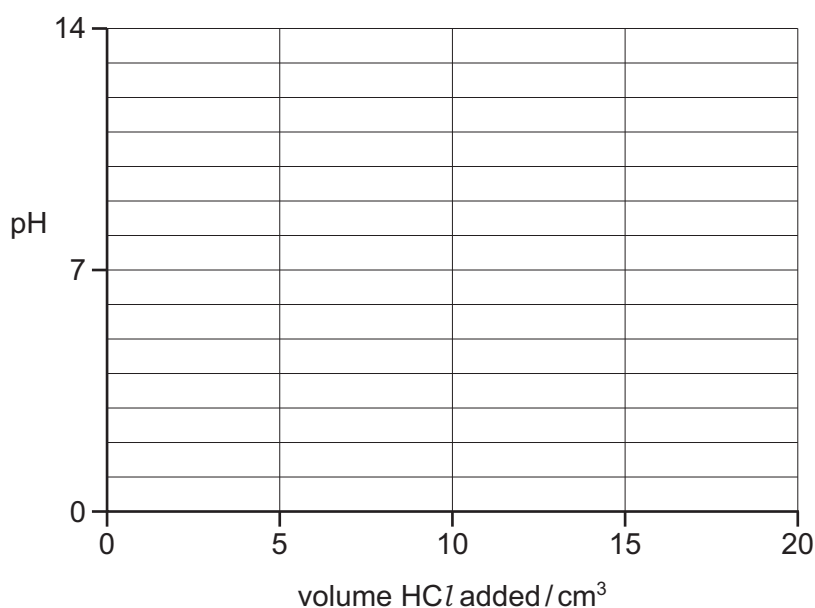
(i) Calculate the number of moles of  $\text{HCl}$  remaining at the end of the addition.

moles of  $\text{HCl}$  = .....

(ii) Hence calculate the  $[\text{H}^+]$  and the pH at the end of the addition.

pH = .....

(iii) On the following axes, sketch how the pH will change during the addition of a total of  $20.0\text{ cm}^3$  of  $0.100\text{ mol dm}^{-3}$   $\text{HCl}$ . Mark clearly where the end point occurs.



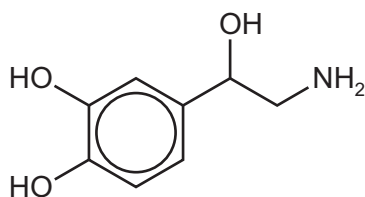
(iv) From the following list of indicators, put a tick in the box by the side of the indicator most suitable for this titration.

| indicator | pH at which colour changes | place <b>one tick only</b> in this column |
|-----------|----------------------------|-------------------------------------------|
| A         | 0 - 1                      |                                           |
| B         | 3 - 4                      |                                           |
| C         | 11 - 12                    |                                           |
| D         | 13 - 14                    |                                           |

[6]

[Total: 16]

- 4 Noradrenaline is a hormone and neurotransmitter, which is released during stress to stimulate the heart and increase blood pressure.

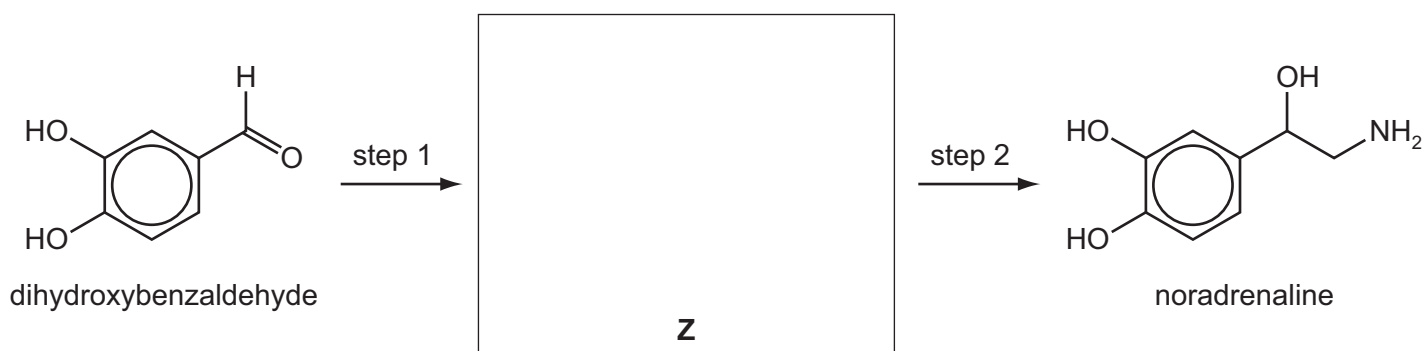


noradrenaline

- (a) State the **names** of **three** functional groups in the noradrenaline molecule.

.....  
 .....  
 ..... [3]

- (b) (i) Consider the following two-stage synthesis of noradrenaline from dihydroxybenzaldehyde.



- Draw the structure of the intermediate **Z** in the box.
- Suggest reagents for steps 1 and 2.

step 1 .....

step 2 .....

(ii) Dihydroxybenzaldehyde reacts with  $\text{Br}_2(\text{aq})$ .

- Describe what you would see during this reaction.

.....

- Draw the structure of the product.

[5]

(c) Draw the structures of the products when noradrenaline is reacted with

(i) dilute  $\text{NaOH}(\text{aq})$ ,

(ii) dilute  $\text{HCl}(\text{aq})$ ,

(iii) an excess of ethanoyl chloride,  $\text{CH}_3\text{COCl}$ .

[4]

(d) Name the **new** functional groups formed in the reaction in (c)(iii).

.....

..... [2]

[Total: 14]

5 The two compounds **V** and **W** are isomers with the molecular formula  $C_4H_8O$ , and show the following properties and reactions.

- Both compounds react with sodium metal, and both decolourise bromine water.
- Compound **V** forms a yellow precipitate with alkaline aqueous iodine, whereas compound **W** does not.
- When reacted with cold  $KMnO_4(aq)$ , both **V** and **W** produce the same neutral compound **X**,  $C_4H_{10}O_3$ .
- Both **V** and **W** exist as pairs of stereoisomers.

(a) Suggest which functional groups are responsible for the reactions with

(i) sodium,

.....

(ii) bromine water,

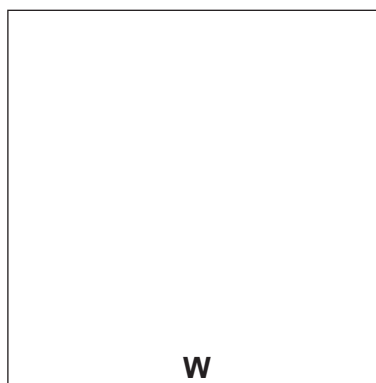
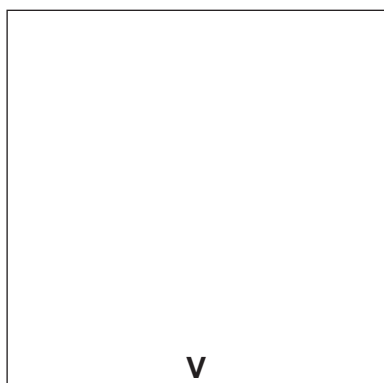
.....

(iii) alkaline aqueous iodine.

.....

[3]

(b) Suggest structures for **V** and **W**.

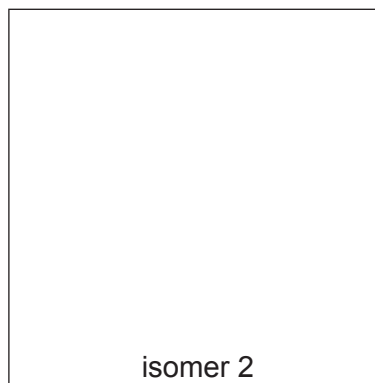
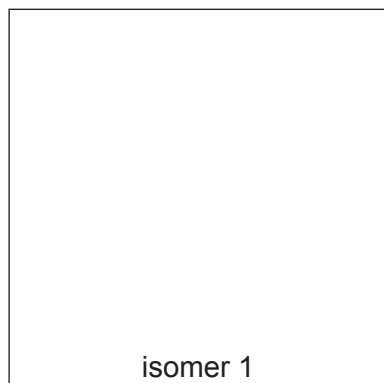


[2]

- (c) State the type of stereoisomerism shown by compound **V** and draw the structures of the stereoisomers.

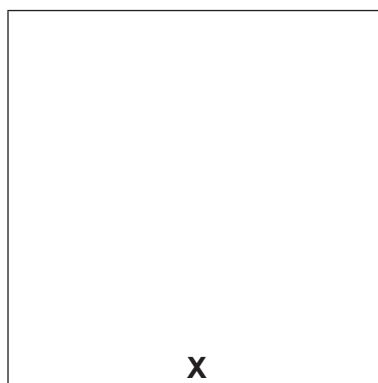
type of stereoisomerism .....

structures of stereoisomers



[2]

- (d) Suggest the structure of the neutral compound **X**.



[1]

[Total: 8]

## Section B

Answer **all** the questions in the spaces provided.

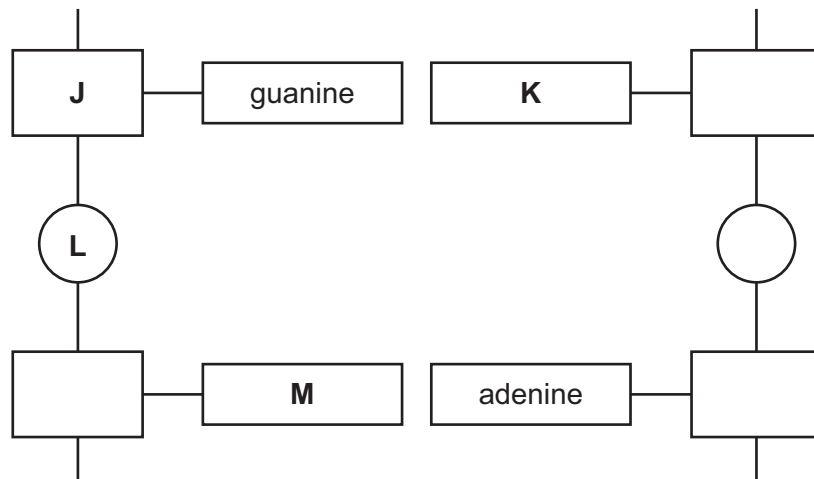
- 6** Proteins and deoxyribonucleic acid, DNA, are two important polymers that occur within living organisms.

- (a)** Proteins have a number of 'levels' of bonding: primary, secondary and tertiary.  
Complete the table to indicate the level of bonding responsible for the features described.

| feature                      | level of bonding |
|------------------------------|------------------|
| formation of $\alpha$ -helix |                  |
| formation of disulfide bonds |                  |
| formation of ionic bonds     |                  |
| linking amino acids          |                  |

[3]

- (b)** The diagram shows part of a DNA molecule. Study the diagram and give the correct names for the blocks labelled **J**, **K**, **L** and **M**.



| block letter | name |
|--------------|------|
| <b>J</b>     |      |
| <b>K</b>     |      |
| <b>L</b>     |      |
| <b>M</b>     |      |

[4]

(c) The DNA molecule is formed from two polymer strands which are held together until DNA replication occurs.

(i) What type of bonding holds the strands together?

.....

(ii) Explain why this type of bonding allows the base pairs within the strands to separate during replication at normal body temperature.

.....

.....

[2]

(d) In the polymer RNA, the identities of two of the blocks, **J**, **K**, **L** or **M**, are different.

For **one** of these blocks that are different, give its correct name in DNA and in RNA.

DNA: .....

RNA: .....

[1]

[Total: 10]

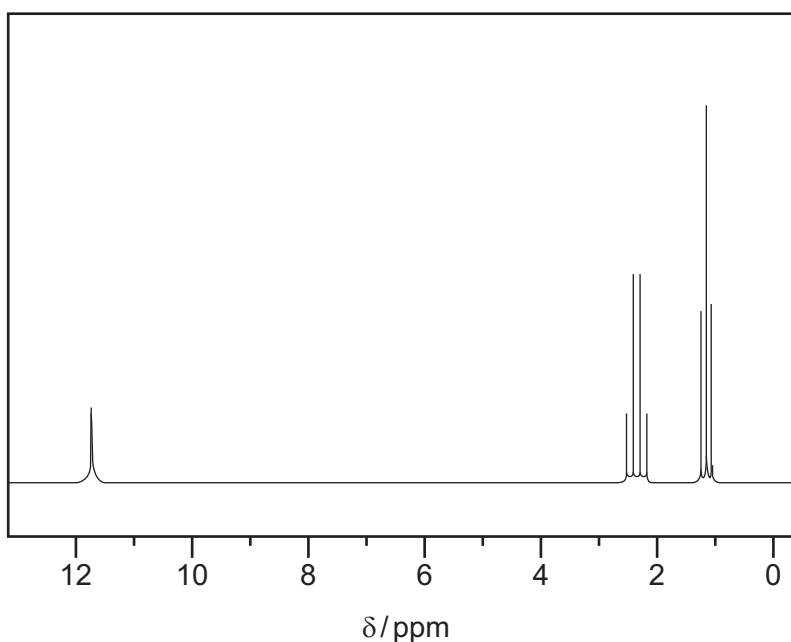
7 The combination of mass spectroscopy and NMR spectroscopy provides a powerful method of analysis for organic compounds.

- (a) The mass spectrum of a compound **G** contains  $M$  and  $M+1$  peaks in the ratio of their heights of 74 : 2.5.

Use these data to calculate the number of carbon atoms present in **G**. Show your working.

[2]

- (b) The NMR spectrum of compound **G** is shown.



- (i) Use the *Data Booklet* and your knowledge of NMR spectroscopy to identify the type of proton responsible for each of the three absorptions.

| $\delta$ /ppm | type of proton |
|---------------|----------------|
| 1.1           |                |
| 2.2           |                |
| 11.8          |                |

- (ii) The addition of  $D_2O$  causes one of these absorptions to disappear. Explain why this happens and state which absorption is affected.

.....

.....

(iii) Draw the structural formula of **G**.

[6]

(c) Several structural isomers of **G** exist.

(i) Draw the structural formula of an isomer of **G** with only two absorptions in its NMR spectrum.

(ii) Use the *Data Booklet* to suggest where these absorptions would occur.

| peak | $\delta$ /ppm |
|------|---------------|
| 1    |               |
| 2    |               |

[3]

[Total: 11]

- 8 (a) Many common drugs are taken orally, but some medications, such as those based on protein molecules, are injected to prevent them being broken down in the digestive system.

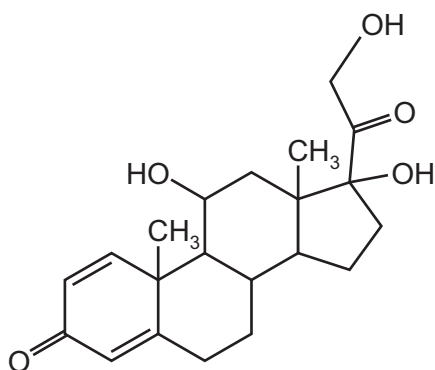
(i) **Name** a functional group present in drug molecules that might be broken down by acid in the stomach.

.....

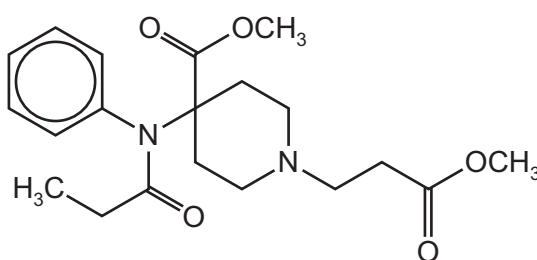
(ii) State the *type of reaction* that would cause such a breakdown.

.....

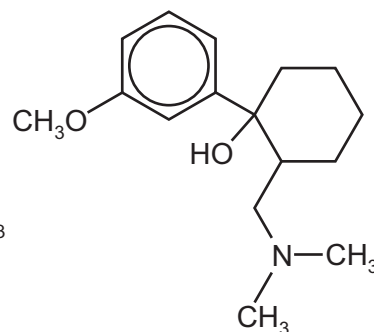
(iii) Which **one** of the following compounds would **not** be suitable to be taken orally?



**A**



**B**



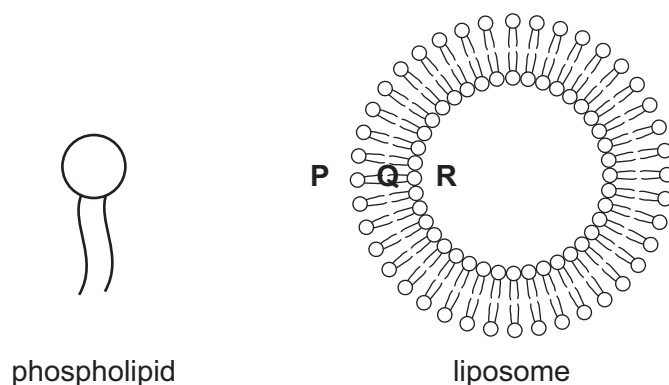
**C**

compound .....

(iv) On the structure of your chosen compound in (iii), circle **all** the functional groups that might be broken down by acid.

[5]

- (b) One way of protecting drug molecules that are taken orally is to enclose them in liposomes. These are artificially created spheres made from phospholipids which have an ionic phosphate 'head' and two hydrocarbon 'tails'.



- (i) State and explain in which location, **P**, **Q** or **R**, a hydrophobic drug could be carried.

.....

.....

- (ii) By considering the nature of the functional groups in **A**, **B** and **C**, explain why these drugs can be carried at position **R** in the liposome.

.....

.....

[2]

- (c) Another method of protecting drug molecules is to 'trap' them inside gold nano-cages. When they reach the site where they are needed, such as a tumour, the drug is released by exposing the site to infra-red radiation.

- (i) Suggest the size of the nano-cages **in metres**.

.....

- (ii) Suggest why infra-red, rather than higher frequency radiation is used.

.....

.....

[2]

[Total: 9]

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