UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/42**

Paper 4 Structured Questions **May/June 2011**

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 a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **all** questions.

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	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

This document consists of **16** printed pages and **4** blank pages.

Section A

For Examiner's Use

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

1 **(a)** Hydrogen fluoride, HF, behaves as a weak acid in water, with $K_a = 5.6 \times 10^{-4}\,\text{mol dm}^{-3}$.

Calculate the pH of a $0.050\,\text{mol dm}^{-3}$ solution of HF.

pH = ...[2]

(b) Gaseous ammonia and hydrogen fluoride react together to give solid ionic ammonium fluoride.

$$NH_3(g) + HF(g) \rightleftharpoons NH_4F(s) \qquad \Delta H = -147\,\text{kJ mol}^{-1}$$

(i) What *type of reaction* is this?

.....

(ii) Draw dot-and-cross diagrams (outer shells only) describing the bonding in the three compounds involved in this reaction.

NH_3	HF	NH_4F

(iii) There are **three** types of bonding in NH_4F.
Give the names of each of the three types, and state where in the compound each type occurs.

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(iv) The reaction between NH_3 and HF is reversible. What conditions of temperature and pressure would favour the **reverse** reaction, i.e. the dissociation of NH_4F? Explain your answer.

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[9]

(c) Many commercial copper and brass polishes contain ammonia. The tarnish that forms on the surface of copper is often copper sulfide, CuS. In the presence of O_2 from the air, NH_3 can combine with this copper sulfide to produce the soluble cuprammonium sulfate, $[Cu(NH_3)_4]SO_4$.

(i) Construct an equation for this reaction.

.....

(ii) State the colour of cuprammonium sulfate solution.

.....

(iii) Describe what you would see if a solution of cuprammonium sulfate was diluted with water. Explain your answer.

.....

.....

[3]

(d) When sulfuric acid is added to $Cu^{2+}(aq)$, no colour change occurs, but when concentrated hydrochloric acid is added to $Cu^{2+}(aq)$, the solution turns yellow-green. The solution reverts to its original colour when it is diluted with water.

Suggest the type of reaction occurring with $HCl(aq)$, suggest what is formed during the reaction, and write an equation for the change.

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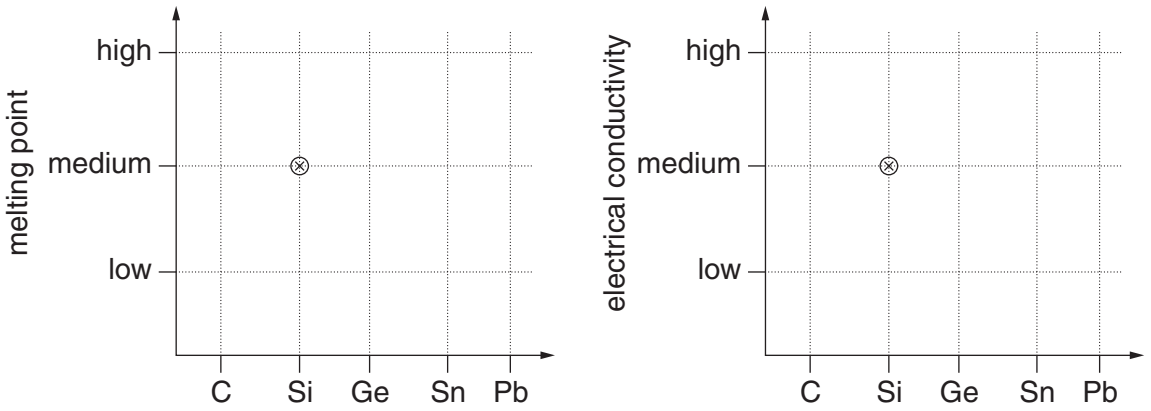
.....[3]

[Total: 17]

[Turn over

2 **(a)** **(i)** On the following grids, plot points showing the variation in the named property of the Group IV elements. Your points should show for each element, whether the melting point/electrical conductivity is 'high', 'medium' or 'low'. The point for silicon has already been plotted in each case.



(ii) Suggest explanations of these trends in terms of the structure and bonding of the Group IV elements.

melting point

.....

.....

electrical conductivity

.....

.....

[6]

(b) Choose **one** reaction to illustrate **each** of the following statements. Write an equation for each of your chosen reactions, and describe what you would see as the reaction is carried out.

(i) PbO is more stable than PbO_2.

.....

.....

(ii) CO is easily oxidised to CO_2.

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(iii) Aqueous $SnCl_2$ is a useful reducing agent.

.....

.....

[4]

[Total: 10]

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For Examiner's Use

3 **(a)** State the relationship between the Faraday constant, F, the charge on the electron, e, and the Avogadro number, L.

.....[1]

(b) If the charge on the electron, the A_r and the valency of copper are known, the value of the Avogadro number can be determined experimentally. This is done by passing a known current for a known time through a copper electrolysis cell, and weighing the mass of copper deposited onto the cathode.

(i) Draw a diagram of suitable apparatus for carrying out this experiment.
Label the following: power supply (with + and – terminals); anode; cathode; and ammeter.
State the composition of the electrolyte.

The following are the results obtained from one such experiment.

current passed through the cell	=	0.500 A
time current was passed through cell	=	30.0 min
initial mass of copper cathode	=	52.243 g
final mass of copper cathode	=	52.542 g

(ii) Use these data and relevant information from the *Data Booklet* to calculate a value of L to **3 significant figures**.

L = ...
[9]

(c) Use relevant information from the *Data Booklet* to identify the substances formed at the anode and at the cathode when aqueous solutions of the following compounds are electrolysed.

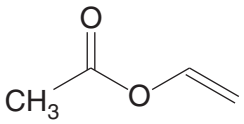
For Examiner's Use

compound	product at anode	product at cathode
AgF		
$FeSO_4$		
$MgBr_2$		

[5]

[Total: 15]

4 **(a)** Polyvinyl acetate, PVA, is a useful adhesive for gluing together articles made from wood, paper or cardboard. The monomer of PVA is ethenyl ethanoate, **B**.

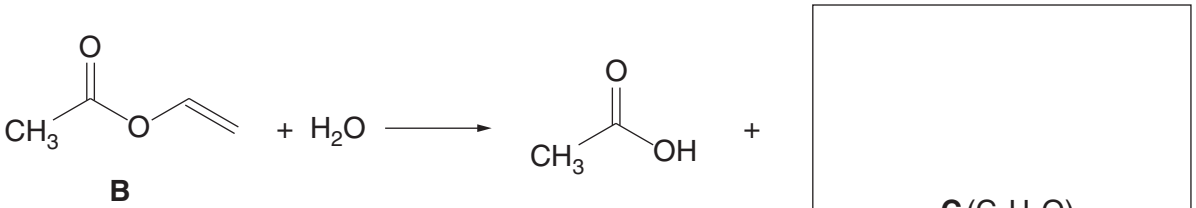


B

PVA is formed from **B** by the process of addition polymerisation.

(i) Draw a section of the PVA molecule containing at least 2 monomer molecules, and identify clearly the repeat unit.

The ester **B** can be hydrolysed in the usual way, according to the following equation.



B **C** (C_2H_4O)

(ii) Use this information to suggest a possible structure for **C** and draw it in the box above.

When substance **C** is extracted from the product mixture, it is found that it does **not** decolourise $Br_2(aq)$, but it **does** form a pale yellow precipitate with alkaline aqueous iodine.

(iii) Suggest a structure for **C** that fits this new information.

(iv) Suggest a confirmatory test for the functional group in the structure you have drawn in **(iii)**. Your answer should include the reagent you would use and the observation you would make.

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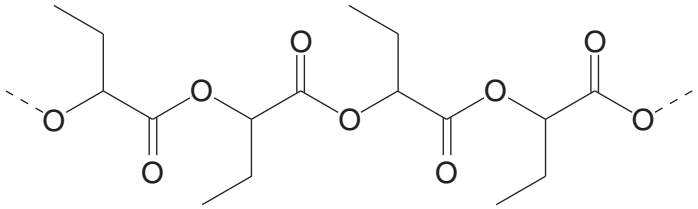
[6]

(b) The following diagram represents a section of another polymer.



D

(i) On the above formula draw brackets, [ ], around the atoms that make up the repeat unit of this polymer.

(ii) Name the functional group in polymer **D**.

.....

(iii) Suggest and draw the structure of the monomer, **E**, that could form this polymer.

(iv) What *type of polymerisation* is involved in making polymer **D** from its monomer?

.....

(v) What is the relationship between the repeat unit of polymer **D** and the repeat unit of PVA?

.....

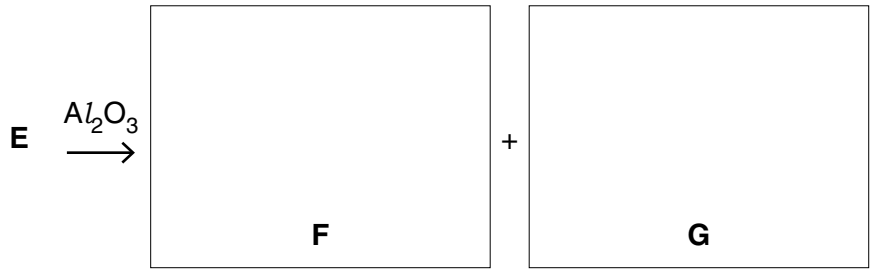
[5]

(c) Monomer **E** exists as two stereoisomers. Heating either isomer with Al_2O_3 gives a mixture of two unsaturated carboxylic acids **F** and **G**, which are stereoisomers of each other.

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

.....

(ii) Suggest structures for **F** and **G**, and name the type of stereoisomerism they show.



type of isomerism .....

[4]

[Total: 15]

5 **(a)** Describe and explain how the acidities of ethanol and phenol compare to that of water.

For Examiner's Use

.....

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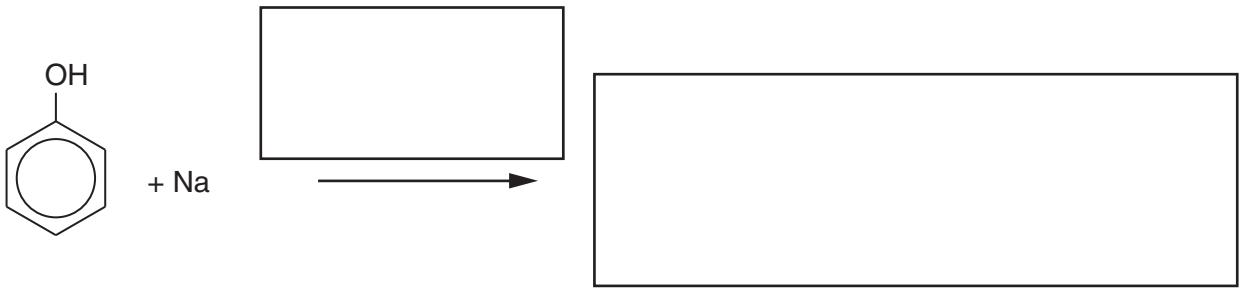
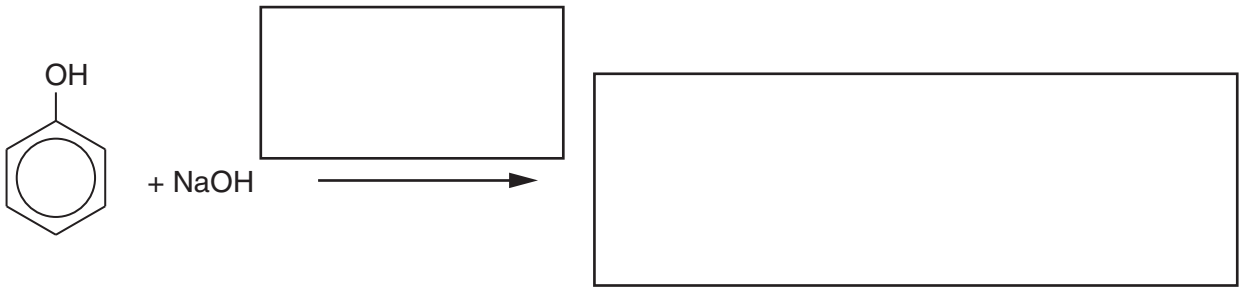
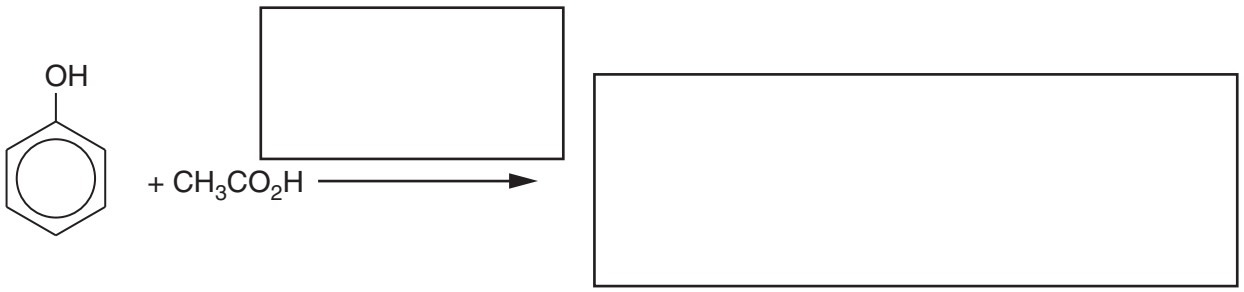
.....

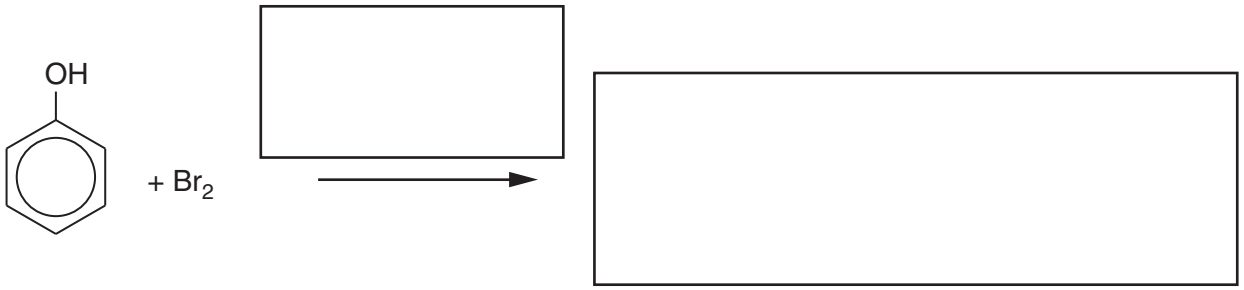
.....[4]

(b) Complete the following equations showing **all** the products of each of these reactions of phenol. Include reaction conditions where appropriate in the boxes over the arrows. If no reaction occurs write ***no reaction*** in the products box.





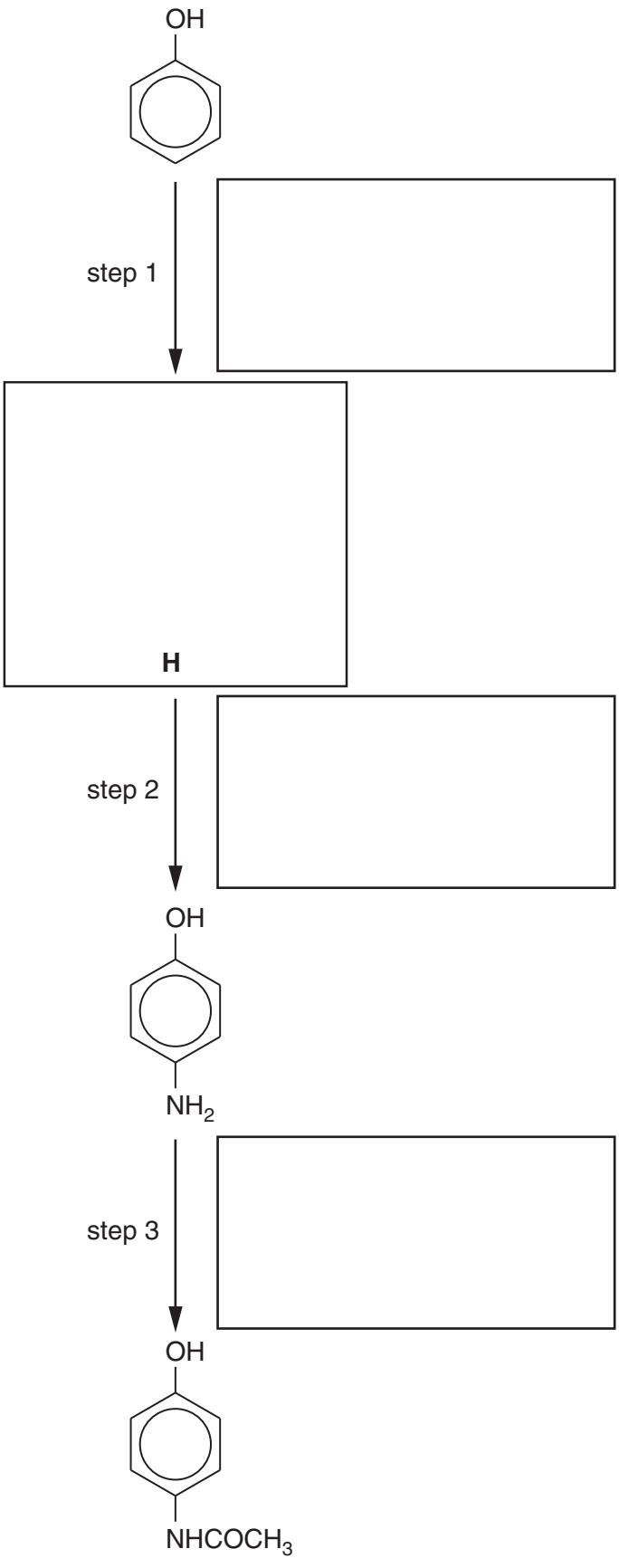




[5]

(c) The analgesic drug paracetamol can be synthesised from phenol by the following route. Suggest reagents and conditions for the each of three steps, and suggest the structure of the intermediate **H**. Write your answers in the boxes provided.

For Examiner's Use



paracetamol

[4]

[Total: 13]

Section B

For Examiner's Use

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

6 Enzymes are protein molecules that are highly efficient in catalysing specific chemical reactions in living organisms.

(a) To work in tissues, enzyme molecules generally need to be water-soluble. What does this tell you about the nature of the side-chains on the exterior of the molecules?

.....

.....[1]

(b) Enzymes function by a substrate molecule interacting with a particular part of the enzyme known as the 'active site'. The substrate is converted into products that are then released, to be replaced by another substrate molecule.

(i) Describe briefly the primary, secondary and tertiary structures of an enzyme.

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(ii) The activity of an enzyme depends upon the tertiary structure of the protein molecule. Explain how the tertiary structure produces an effective active site.

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(iii) Give **two** conditions that can **reduce** the activity of an enzyme, explaining the reason in each case.

I .....

.....

.....

II .....

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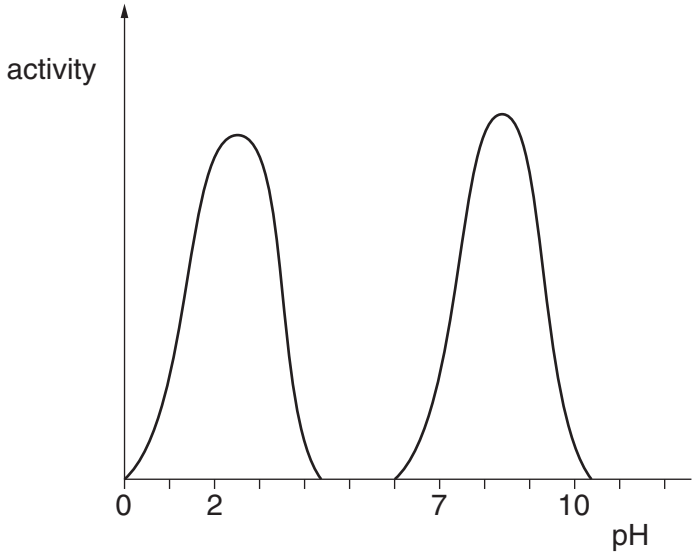
.....

[6]

(c) An individual enzyme operates best at a specific pH. Different enzymes operate best under conditions of different pH. Three enzymes involved in the digestion of food are amylase, pepsin and trypsin.

- Amylase, found in saliva, hydrolyses starch to a mixture of glucose and maltose under approximately neutral conditions.
- Pepsin hydrolyses proteins to peptides in the acid conditions of the stomach.
- Trypsin continues the hydrolysis of peptides to amino acids in the mildly alkaline conditions of the small intestine.

The graph below shows the activity of two of the three enzymes mentioned above.



(i) Label each peak shown with the name of the enzyme responsible, either amylase, pepsin or trypsin.

(ii) On the axes above, sketch the graph that the third enzyme would produce, and label it with the name of that enzyme.

[3]

[Total: 10]

7 The technique of DNA fingerprinting has been one of the most important developments in biochemical analysis in recent times. It has enabled enormous advances to be made in forensic science, medicine and archaeology.

(a) The table shows different stages in the production of a genetic fingerprint. Use the numbers 1 to 6 to put the stages in the correct sequence in the blank column.

stages	process	correct sequence (numbers)
A	place samples on agarose gel	
B	use polymerase chain reaction	
C	label with radioactive isotope	
D	extract DNA	
E	use restriction enzyme	
F	carry out electrophoresis	

[3]

(b) One of the stages above uses a radioactive isotope.

(i) What isotope is used? .....

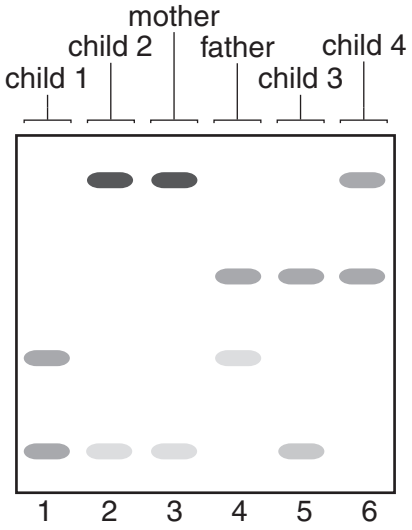
(ii) Why is this isotope chosen?

.....

.....

[2]

(c) The following DNA fingerprints were taken from a family of mother, father and four children.



(i) Are all of the children related to the mother? State the evidence for your answer.

.....

.....

(ii) Which child is unlikely to be related to the father? State the evidence for your answer.

.....

.....

[2]

(d) DNA fingerprinting has been successfully used in archaeological investigations.

(i) Ancient writings were often made on goatskins. Over the centuries these have often become broken into fragments, making reconstruction of the writings almost impossible.

Suggest how the use of DNA fingerprinting might be able to identify which fragments came from a particular skin.

.....

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(ii) Apart from the examples of human remains and goatskins, state one other material that could be investigated using this technique.

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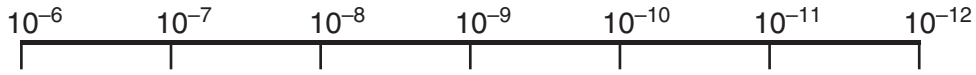
[3]

[Total: 10]

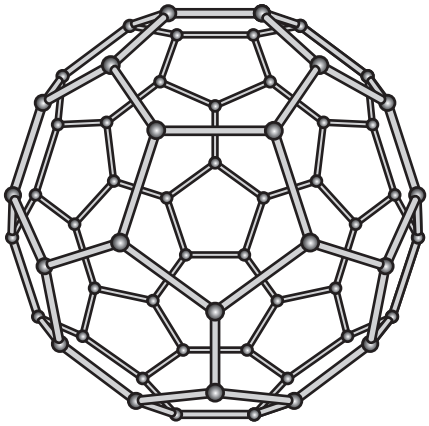
8 Nanotechnology is a fast-developing area of science based on the ability to manipulate materials of very small dimensions.

(a) On the scale shown in metres, mark the upper and lower limits of the range of sizes for nanoparticles.



[2]

(b) One of the most commonly recognised nanoparticles is the 'buckyball', a spherical form of carbon containing 60 carbon atoms. It has been referred to as the third allotrope of carbon.



Diamond and graphite are two other allotropes of carbon. Suggest what is meant by the term *allotrope*.

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.....

.....[2]

(c) Nanoparticles are used to deliver drugs within cells. Suggest what property of nanoparticles enables them to be used in this way. Explain your answer.

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.....[2]

(d) Copper is an important metal that has been used for thousands of years. The problem today is that most of the ores rich in copper compounds have been used up. A century ago ores containing >2% of copper by mass would have been worked; today's mines have to operate at much lower percentages, down to 0.5% of copper by mass.

(i) By what *type of reaction* is the copper present in the ore converted to copper metal?

.....

One of the main ores of copper contains the mineral *chalcopyrite*, $CuFeS_2$.

(ii) Calculate the percentage of copper by mass in *chalcopyrite*.

(iii) If the ore contains 2% of *chalcopyrite* by mass, calculate the mass of copper which can be produced from each tonne of ore.

(iv) Certain bacteria are able to extract copper from the 'spoil' heaps of previously mined copper ore. These bacteria are sprayed onto the spoil heaps in an aqueous solution and the resulting solution containing iron(II) sulfate and copper(II) sulfate is collected in tanks.

Suggest how the copper could be recovered as metal.

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[4]

[Total: 10]

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