UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

7729772231

CHEMISTRY **9701/42**

Paper 4 Structured Questions **October/November 2009**

1 hour 45 minutes

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	
9	
Total	

This document consists of **20** printed pages and **4** blank pages.

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Section A

For Examiner's Use

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

1 **(a)** Describe and explain qualitatively the trend in the solubilities of the sulfates of the Group II elements.

.....

.....

.....

.....[3]

(b) The major ore of barium is barytes, $BaSO_4$. This is very unreactive, and so other barium compounds are usually made from the sulfide, BaS. This is obtained by heating the crushed ore with carbon, and extracting the BaS with water.

$$BaSO_4(s) + 4C(s) \longrightarrow BaS(s) + 4CO(g)$$

When 250 g of ore was heated in the absence of air with an excess of carbon, it was found that the CO produced took up a volume of 140 dm^3 at 450 K and 1 atm.

(i) Calculate the number of moles of CO produced.

.....

(ii) Calculate the number of moles of $BaSO_4$ in the 250 g sample of the ore.

.....

(iii) Calculate the percentage by mass of $BaSO_4$ in the ore.

.....
[4]

For Examiner's Use

(c) (i) Use the following data and data from the *Data Booklet* to construct a Born-Haber cycle and calculate the lattice energy of BaS.

standard enthalpy change of formation of BaS(s)	–460 kJ mol^{-1}
standard enthalpy change of atomisation of Ba(s)	+180 kJ mol^{-1}
standard enthalpy change of atomisation of S(s)	+279 kJ mol^{-1}
electron affinity of the sulfur atom	–200 kJ mol^{-1}
electron affinity of the S^- ion	+640 kJ mol^{-1}

lattice energy = ... kJ mol^{-1}

(ii) Explain whether the magnitude of the lattice energy of BaS is likely to be greater or less than that of BaO.

.....

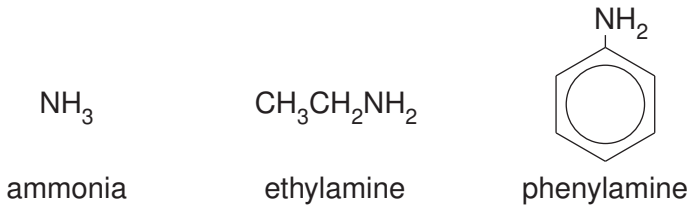
.....

[4]

[Total: 11]

For Examiner's Use

2 **(a)** Describe and explain how the basicities of ammonia, ethylamine and phenylamine differ.



.....

.....

.....

.....[3]

(b) Describe how the use of aqueous silver nitrate and aqueous ammonia can distinguish between aqueous solutions containing chloride, bromide or iodide ions by filling in the following table.

halide	observation when $AgNO_3(aq)$ is added	observation when dilute $NH_3(aq)$ is added	observation when concentrated $NH_3(aq)$ is added
chloride			
bromide			
iodide			

[3]

(c) Silver bromide is sparingly soluble in water.

$$AgBr(s) \rightleftharpoons Ag^+(aq) + Br^-(aq) \qquad K_{sp} = 5 \times 10^{-13}\ mol^2\ dm^{-6}$$

(i) Calculate $[Ag^+(aq)]$ in a saturated aqueous solution of AgBr.

$[Ag^+(aq)]$ = ... $mol\ dm^{-3}$

(ii) State and explain whether AgBr will be less or more soluble in $0.1\ mol\ dm^{-3}$ KBr than it is in pure water.

.....

.....

[2]

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(d) Silver ions form complexes with ammonia and with amines.

For Examiner's Use

$$Ag^+(aq) + 2RNH_2(aq) \rightleftharpoons [Ag(RNH_2)_2]^+(aq)$$

(i) Write an expression for the K_c for this reaction, and state its units.

K_c = ... units .....

K_c has the numerical value of 1.7×10^7 when R = H.

(ii) Using your expression for K_c calculate the $[NH_3(aq)]$ needed to change the $[Ag^+(aq)]$ in a 0.10 mol dm^{-3} solution of silver nitrate to the value that you calculated in **(c)(i)**.

$[NH_3(aq)]$ = ... mol dm^{-3}

(iii) Explain whether you would expect the K_c for the reaction where R = C_2H_5 to be greater or less than that for the reaction where R = H.

.....

.....

[5]

[Total: 13]

For Examiner's Use

3 Iron metal and its compounds are useful catalysts in certain reactions.

(a) **Apart from its catalytic activity**, state **two** properties of iron or its compounds that show that it is a transition element.

.....

.....[2]

(b) You are provided with a solution of $KMnO_4$ of known concentration in a burette.
Outline how you could use this solution to find out the concentration of $Fe^{2+}(aq)$ in a solution. You should include relevant equations for any reactions you describe.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

(c) For each of the following equations, write the oxidation number of the element printed **in bold** underneath its symbol, and balance the equation by adding appropriate numbers before each species.

(i) ..... $\mathbf{Mn}O_4^-$ + ... $\mathbf{S}O_2$ + ... $H_2O \rightarrow$ ..... $\mathbf{Mn}^{2+}$ + ... $\mathbf{S}O_4^{2-}$ + ... H^+

oxidation numbers: ....

(ii) ..... $\mathbf{Cr}_2O_7^{2-}$ + ... $\mathbf{N}O_2$ + ... $H^+ \rightarrow$ ..... $\mathbf{Cr}^{3+}$ + ... $\mathbf{N}O_3^-$ + ... H_2O

oxidation numbers: ....

[6]

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(d) Outline the role that Fe^{3+} ions play in catalysing the reaction between iodide ions and peroxydisulfate(VI) ions.

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

.....

.....

.....[2]

[Total: 14]

For Examiner's Use

4 **(a)** What is meant by the term *bond energy*?

.....

.....[2]

(b) Describe and explain what is observed when a red-hot wire is plunged into separate samples of the gaseous hydrogen halides HC*l* and HI.
How are bond energy values useful in interpreting these observations?

.....

.....

.....

.....[3]

(c) The following reaction occurs in the gas phase.

$$3F_2(g) + Cl_2(g) \longrightarrow 2ClF_3(g), \qquad \Delta H_r^{\ominus} = -328\,\text{kJ mol}^{-1}$$

Use these and other data from the *Data Booklet* to calculate the average bond energy of the C*l*-F bond in ClF_3. [2]

[Total: 7]

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5 **(a)** All the carbon atoms in benzene lie in the same plane. This means that they are *coplanar*, but this is not the case with cyclohexane.

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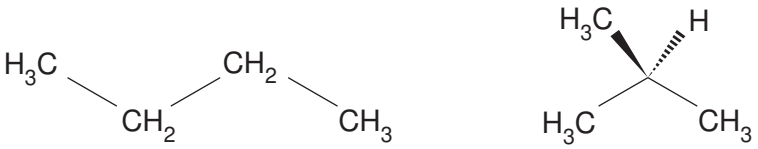
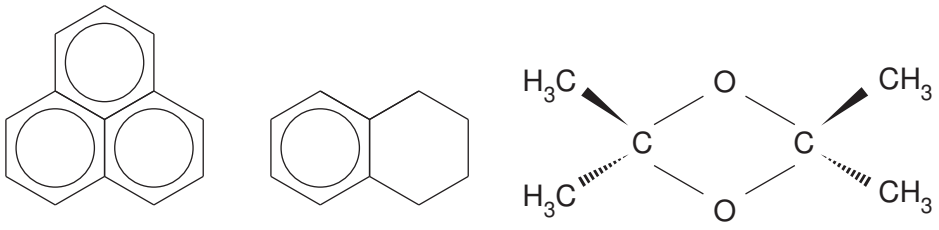
benzene cyclohexane

By rotating the molecule around its several C–C bonds, all the carbon atoms in butane can be made to lie in the same plane, but this is not the case with methylpropane.



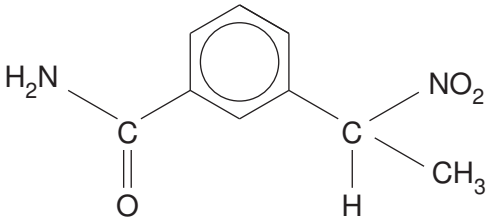
butane methylpropane

By considering the 3-dimensional geometry of the following five molecules, and allowing rotations around C–C bonds, decide whether or not the **carbon atoms** in each molecule **can be arranged** in a coplanar fashion. Then place a tick in the appropriate column in the table below.



A **B** **C**

$CH_3CH(OH)CO_2H$



D **E**

compound	all carbon atoms can be coplanar	not all carbon atoms can be coplanar
A		
B		
C		
D		
E		

[3]

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(b) Methylbenzene can react with chlorine under different conditions to give the monochloro derivatives **F** and **G**.

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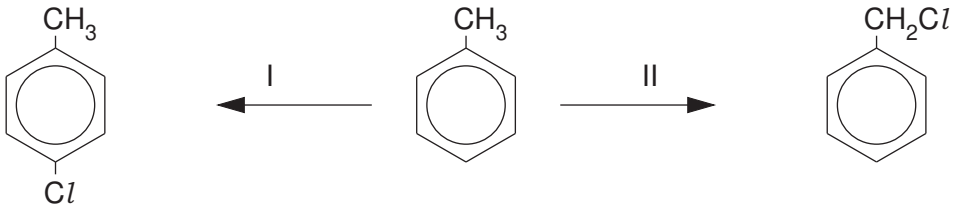

F **G**

Suggest reagents and conditions for each reaction.

reaction I

.....

reaction II

.....[2]

(c) Benzyl benzoate is a constituent of many perfumery products, and has also been used in the treatment of the skin condition known as scabies. It can be made from methylbenzene by the following route, which uses one of the chlorination reactions from **(b)**.

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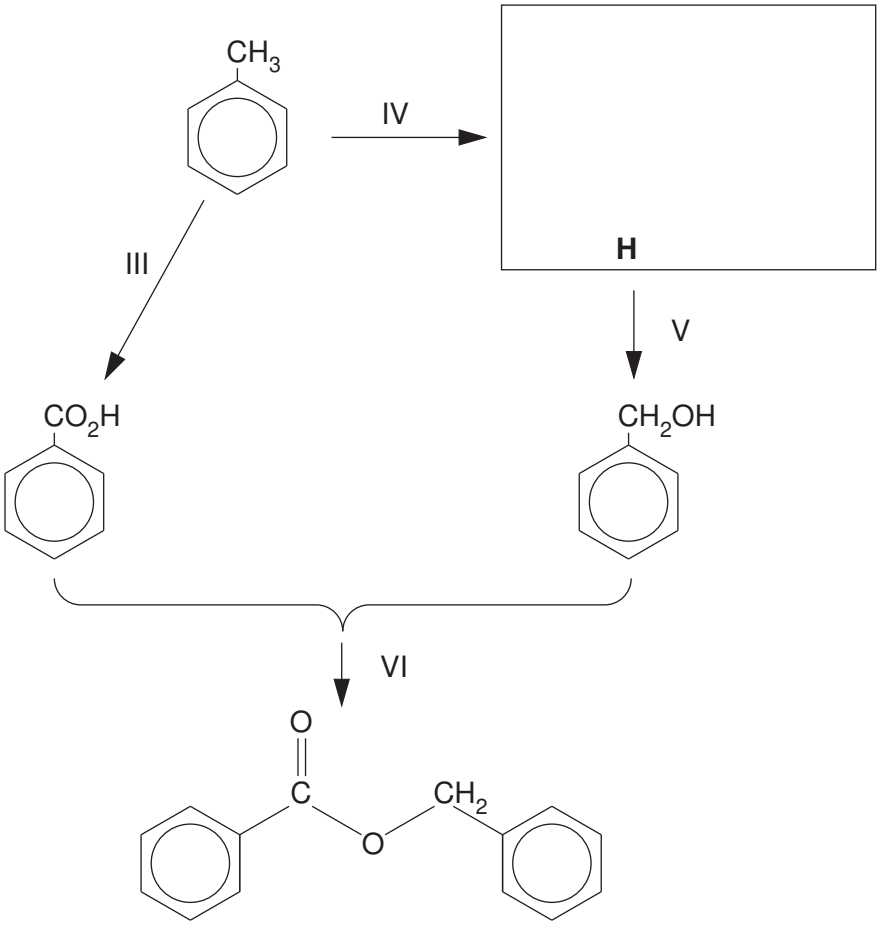

benzyl benzoate

(i) Draw the structural formula of the intermediate **H** in the box above.

For Examiner's Use

(ii) Suggest reagents and conditions for each reaction.

reaction III

.....

reaction V

.....

reaction VI

.....

(iii) State the type of reaction occurring during

reaction III,

.....

reaction V.

.....

[6]

[Total: 11]

6 Compounds **J** and **K** are isomers with the molecular formula $C_5H_{11}NO$, and they contain the same functional group.

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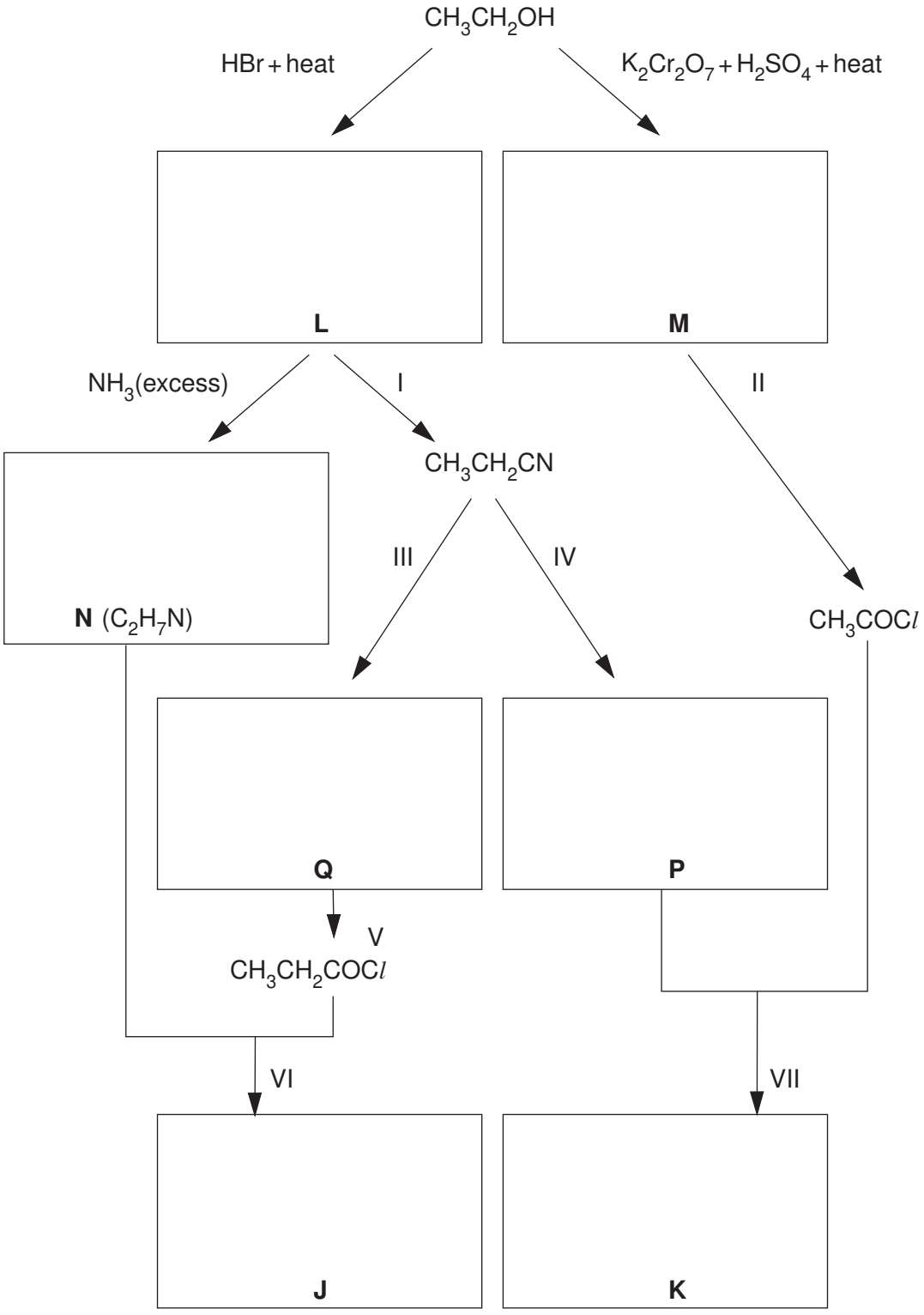
They may both be obtained from ethanol by the following routes.



(a) Draw the structural formulae of the lettered compounds **J** to **Q** in the boxes above. [7]

(b) Suggest reagents and conditions for the following.

For Examiner's Use

reaction I

.....

reaction II

.....

reaction IV

.....[3]

(c) What *type of reaction* is occurring in

reaction IV,

.....

reaction VI?

.....[2]

(d) **(i)** Name the functional group that is common to compounds **J** and **K**.

.....

(ii) Name the functional group that is common to compounds **N** and **P**.

.....[2]

[Total: 14]

Section B

For Examiner's Use

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

7 **(a)** Explain, using diagrams where appropriate, the types of interaction responsible for the primary, secondary and tertiary structure of a protein.

primary structure

.....

.....

.....

secondary structure

.....

.....

.....

tertiary structure

.....

.....

.....[6]

(b) Enzymes are particular types of protein molecule. Explain briefly how enzymes are able to help to break down molecules in the body.

For Examiner's Use

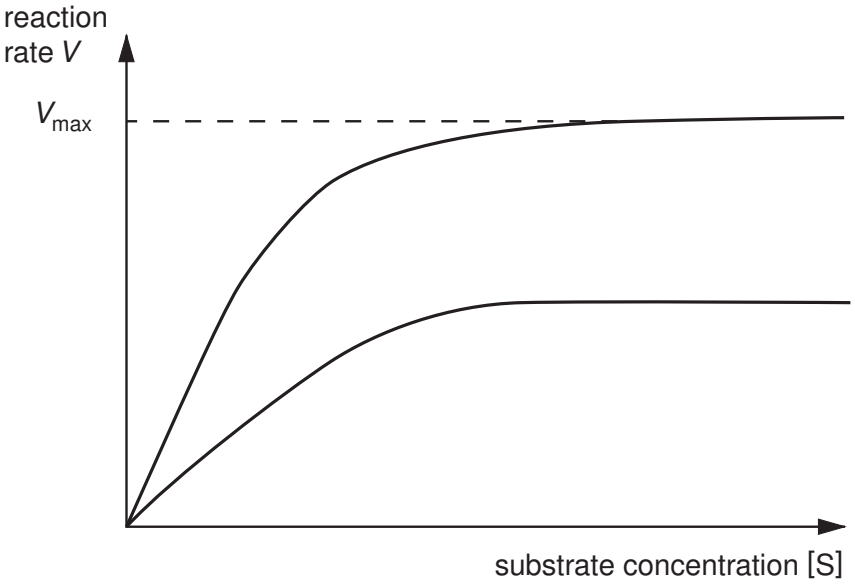
.....

.....

.....

.....[2]

(c) The graph below shows the effect of inhibition on an enzyme-catalysed reaction.



State the type of inhibition shown, giving a reason to support your answer.

type of inhibition .....

reason .....

.....[2]

[Total: 10]

8 The residues from organohalogen pesticides are known to be a major cause of the decline in numbers of different birds of prey in many countries. These residues are concentrated in birds at the top of food chains.

For Examiner's Use

(a) Analysis of the bodies of birds of prey show that the pesticide residues accumulate in the fatty tissues of the birds. This is because of the high partition coefficient between the fat in the tissues and water found in blood.

Explain what is meant by the term *partition coefficient*.

.....

.....

.....[2]

(b) A particular pesticide has a partition coefficient of 8.0 between the solvent hexane and water. If a 25 cm^3 sample of water containing 0.0050 g of the pesticide is shaken with a 25 cm^3 sample of hexane, calculate the mass of pesticide that will dissolve in the hexane layer.

[2]

(c) Compounds used as pesticides may contain bromine or chlorine.

(i) What would be the difference in the ratio of the M: M+2 peaks if the pesticide contained one chlorine rather than one bromine atom?

.....

(ii) If a given pesticide contains **two** chlorine atoms per molecule, deduce the relative heights of the M, M+2 and M+4 peaks.

[3]

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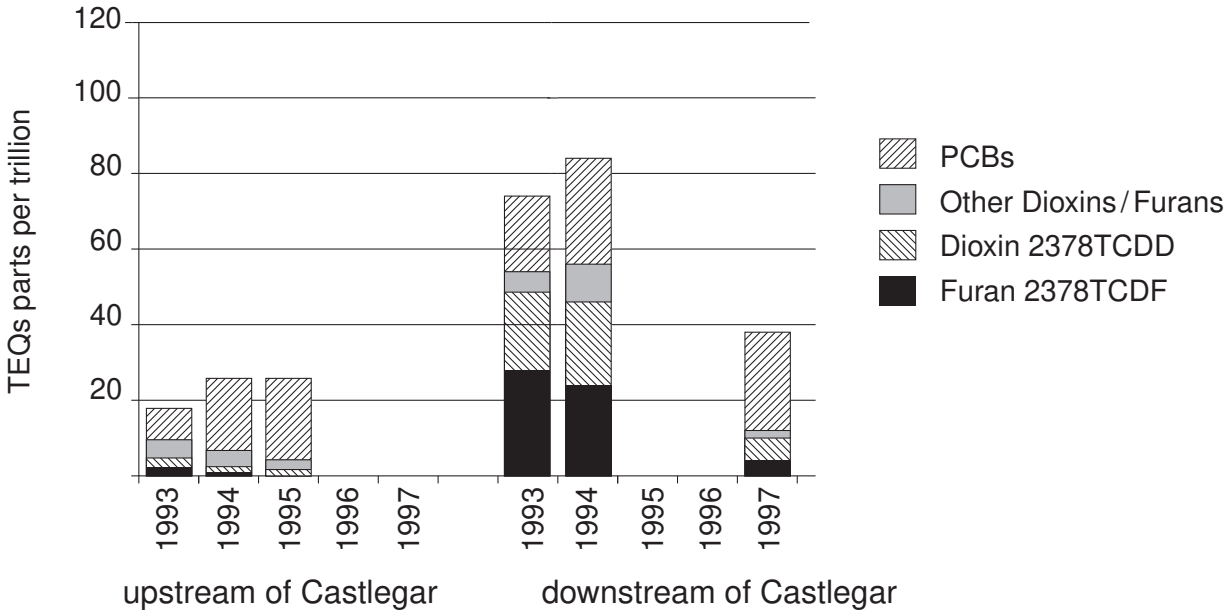
(d) The following graph shows the occurrence of pesticide residues in the eggs of fish-eating birds of prey upstream and downstream of a paper mill at Castlegar on the Columbia River in Canada.

For Examiner's Use

Columbia River Basin



PCBs, the dioxin 2378TCDD, and the furan 2378TCDF all come from chemicals containing chlorine.

(i) Suggest which compounds are present directly as a result of the paper mill.

.....

(ii) By studying the data for 1994, suggest which chemical(s) come from sources other than the paper mill.

.....

(iii) Compare the downstream data for 1994 with that for 1997. Suggest what might be responsible for the change.

.....

(iv) A molecule of 2378TCDD contains four chlorine atoms. How many molecular ion peaks would this compound show in its mass spectrum?

.....

[4]

[Total:11]

9 **(a)** Put the following items in order of **increasing** size. Use the number 1 to indicate the smallest and 3 to indicate the largest.

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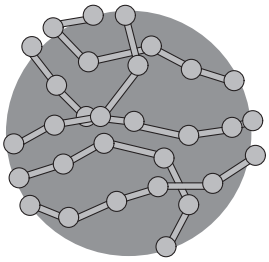
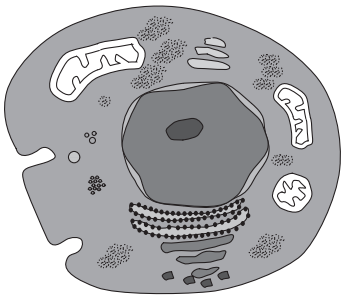
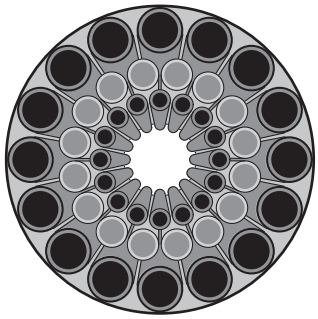




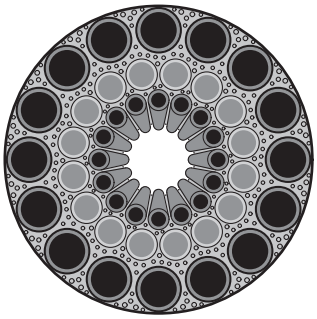
length of DNA molecule in a chromosome	nanosphere diameter	cell diameter

[2]

(b) Nanotechnology has an increasing range of uses across a number of fields including sport. For example, golf clubs are now being made using nanomaterials.



cross-section of normal golf club shaft



cross-section of golf club shaft with nanomaterial fill

Use the diagrams above and your knowledge of nanomaterials to suggest **two** properties of the new shafts. Explain your answers.

(i) .....

.....

.....

(ii) .....

.....

.....

[2]

For Examiner's Use

(c) A mixture of nano-sized particles of tungsten and vanadium(IV) oxide can be applied to the surface of windows and reflects heat whilst letting all light in the visible range through.

Suggest how this variable reflective property is possible using nano-sized particles.

.....

.....

.....[2]

(d) Although silver is well-known as a precious metal, its medicinal properties have been used for hundreds of years. In ancient Greece silver was used to purify water and until the development of antibiotics, silver was important in the treatment of large wounds.

(i) What property of silver makes it useful for jewellery?

.....

(ii) Suggest the property of silver that makes it useful in the treatment of large wounds.

.....

(iii) Suggest why nano-sized silver particles are more useful in treating wounds.

.....

.....

[3]

[Total: 9]

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