THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

CHEMISTRY (SALTERS)

Chemistry of Materials

2849/01

Candidates answer on the Question Paper
A calculator may be used for this paper

OCR Supplied Materials:
- *Data Sheet for Chemistry (Salters)* (inserted)

Other Materials Required:
- Scientific calculator

Thursday 21 January 2010
Afternoon

Duration: 1 hour 30 minutes

OCE/12005

2849901

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **90**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry (Salters)*.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.

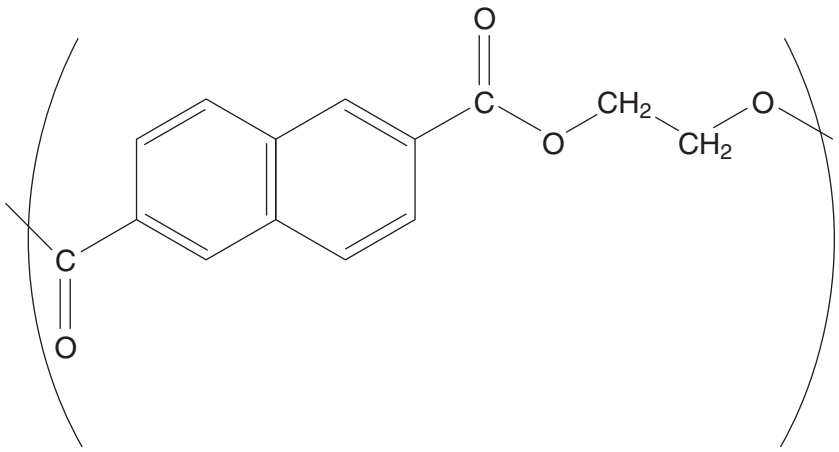
Examiner's Use Only:			
1			
2			
3			
4			
5			
6			
Total			

DC (KN) 12005/5

Answer **all** the questions.

1 Chemists have developed a new polyester which can be used for producing returnable bottles. The polymer is known as **PEN**.

(a) The repeating unit for **PEN** is given below.



(i) Draw a ring around the ester group in the repeating unit above. **[1]**

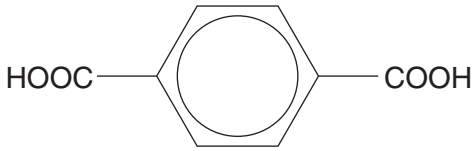
(ii) One of the monomers from which **PEN** is made is ethane-1,2-diol.

Draw the **full** structural formula of ethane-1,2-diol.

[1]

(b) Non-returnable drinks bottles are often made from another polymer, **PET**. This produces a huge problem for waste disposal. However, this polymer cannot be used to make returnable bottles.

(i) **PET** is a polymer made from ethane-1,2-diol and **compound A**.



compound A

Draw the **skeletal** formula of the repeating unit of **PET**.

[2]

(ii) **PET** cannot be used to make returnable bottles because its glass transition temperature, T_g, is too low. The glass transition temperature of a polymer is the temperature at which it changes from being flexible to becoming brittle.

Explain why lowering the temperature of a polymer below its T_g causes it to become brittle.

.....

.....

.....

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

(iii) **PEN** has a higher T_g and melting temperature than **PET**.

Assume both polymers have similar average relative molecular masses.

Suggest why **PEN** has a higher melting temperature than **PET**.

.....

.....

..... **[2]**

(c) Plastic waste is often disposed of by burial in the ground.

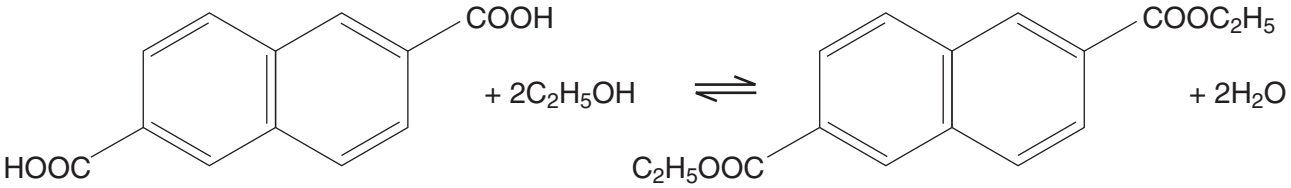
Suggest **one** other method for the disposal of plastic waste and explain an advantage of this method.

.....

.....

..... **[2]**

(d) Industrially, **PEN** is made starting from a diester of compound **B**. The diester is produced when compound **B** reacts with ethanol according to the equation below.



compound B **compound C**

(i) Write the expression for the equilibrium constant, K_c, for this reaction. Use **B** and **C** in your expression to represent the diacid and the diester.

[2]

(ii) Describe and explain the effect of **decreasing** the temperature on the equilibrium constant, K_c, for this reaction. The forward reaction is exothermic.

.....

.....

..... **[2]**

[Total: 15]

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2 Chemists in Australia have developed batteries for the large-scale storage of electricity.

The batteries, known as vanadium redox batteries, are made from two half-cells.

These half-cells contain solutions of compounds of the transition metal vanadium.

(a) The following reaction can occur in one of the half-cells, **D**.

$$VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$$

(i) Give the oxidation state of the vanadium in VO_2^+.

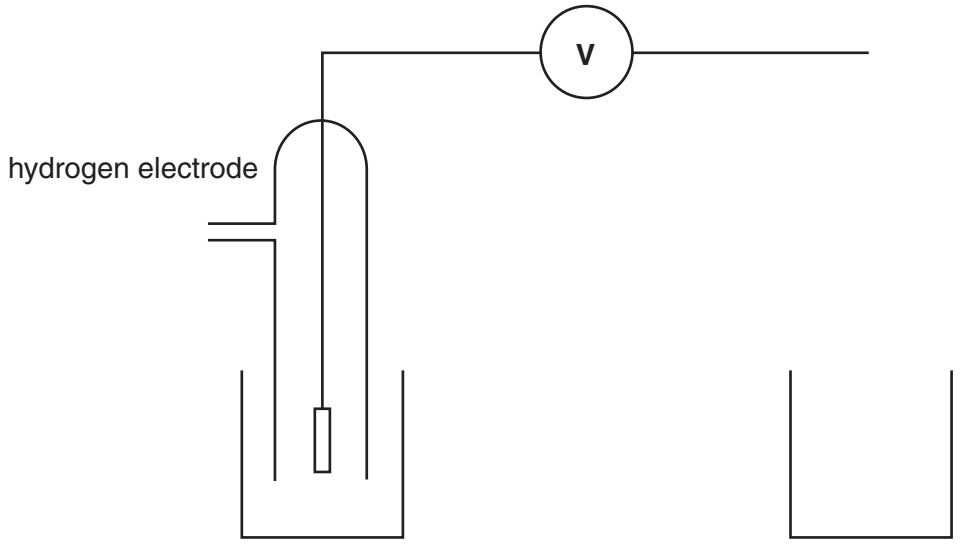
..... **[1]**

(ii) The standard electrode potential, $E^\ominus$, of half-cell **D** is +1.00 V.

Complete the diagram below to show the apparatus used to measure this $E^\ominus$ value.

Label the electrodes and solutions used and any other apparatus you include.

State the temperature and concentration of the solutions involved.



[5]

(b) The solution in the other half-cell, **E**, is a mixture of V^{2+} ions and V^{3+} ions. The standard electrode potential for this half-cell is –0.26 V.

(i) Calculate the $E^{\ominus}_{cell}$ value for the cell (consisting of half-cells **D** and **E**) used in the vanadium redox battery.

$E^{\ominus}_{cell}$ = ...V **[1]**

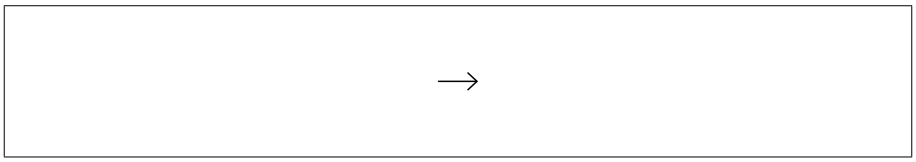
(ii) Which half-cell forms the negative electrode?

Explain your answer.

.....

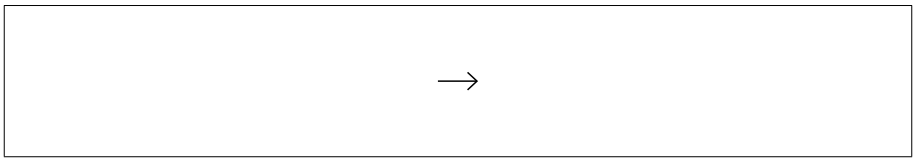
..... **[1]**

(c) **(i)** Give the half-equation (ion-electron equation) for the reaction involving V^{2+} and V^{3+} ions that occurs in half-cell **E** when the cell is delivering a current.



[1]

(ii) Construct an equation for the overall reaction occurring in the vanadium redox battery.



[2]

(d) In aqueous solutions, V^{3+} ions form complex ions which have a green colour.

Explain why a green solution looks green.

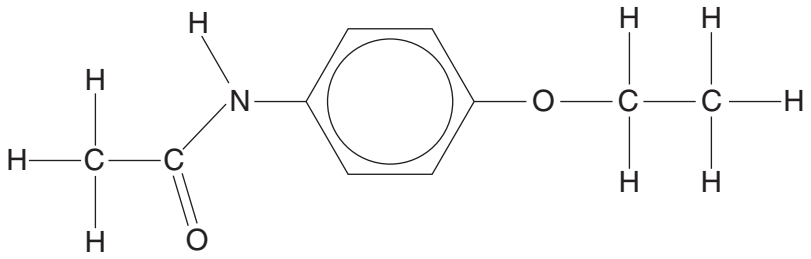
.....

.....

..... **[2]**

[Total: 13]

3 Phenacetin is a medicine that reduces the symptoms of a fever. It is sometimes used as a substitute for aspirin for people who suffer from stomach disorders. Like aspirin, it is a solid.



phenacetin

(a) In this question, one mark is available for the quality of spelling, punctuation and grammar.

An impure sample of phenacetin can be purified by recrystallisation, using ethanol as the solvent.

Describe how you would carry out the recrystallisation in the laboratory to obtain a pure sample of phenacetin.

.....

.....

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.....

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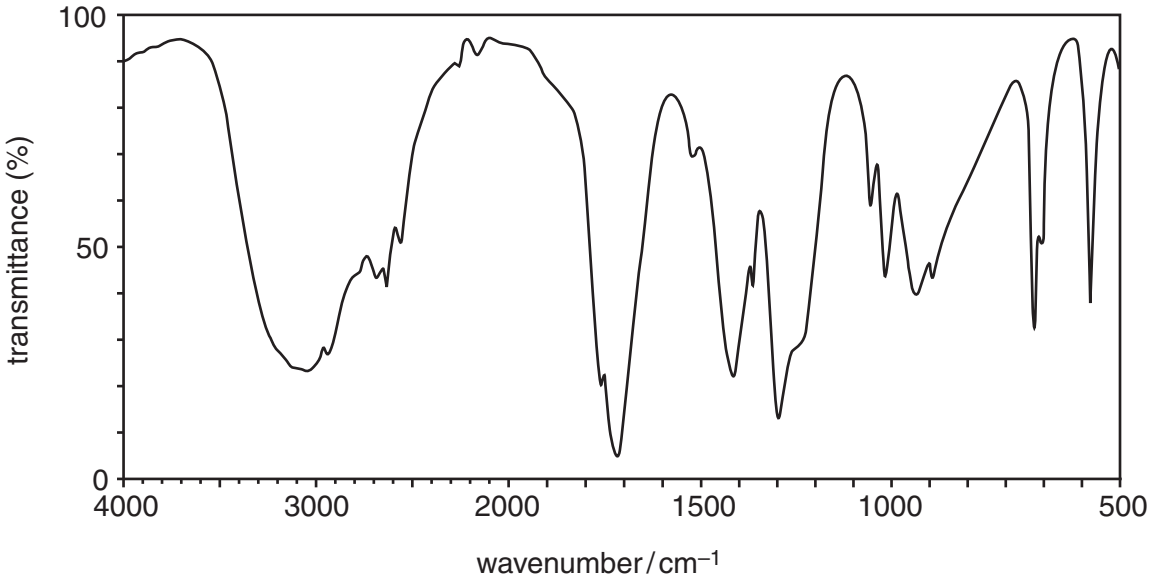
.....

.....

..... **[6]**

Quality of Written Communication **[1]**

(b) A stored sample of phenacetin is damp. Hydrolysis has taken place which has caused impurities to form. The infrared spectrum of one of the impurities, **X**, is shown on the next page.



(i) Use the *Data Sheet*, together with the information above, to identify the functional group in **X**. Give your reasoning by identifying the key peaks in the spectrum and the bond to which each peak corresponds.

reasoning: .....

.....

.....

.....

functional group: ..... **[3]**

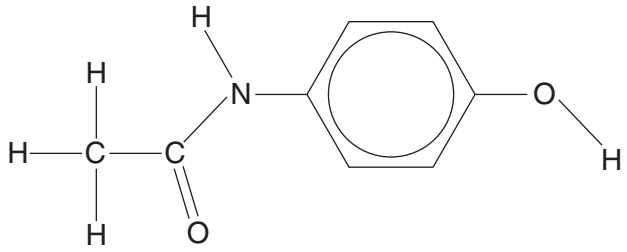
(ii) The M_r of **X** is 60. Draw the **full** structural formula of **X**.

[2]

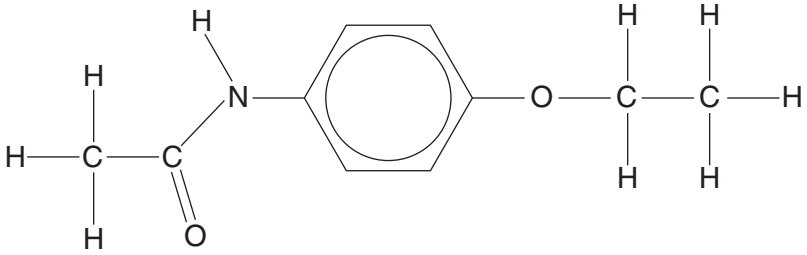
(iii) 3.00 g of **impure** phenacetin contains 0.010 mol phenacetin. Calculate the percentage by mass of phenacetin in the impure sample.
A_r: H, 1.00; C, 12.0; N, 14.0; O, 16.0

percentage purity = ...% **[3]**

(c) Acetaminophen is a related compound with similar medicinal properties to phenacetin.



acetaminophen



phenacetin

(i) A student was asked to devise a chemical test to distinguish between acetaminophen and phenacetin. He added a little of each compound to a fresh sample of neutral aqueous iron(III) chloride.

State the colour of aqueous iron(III) chloride.

.....

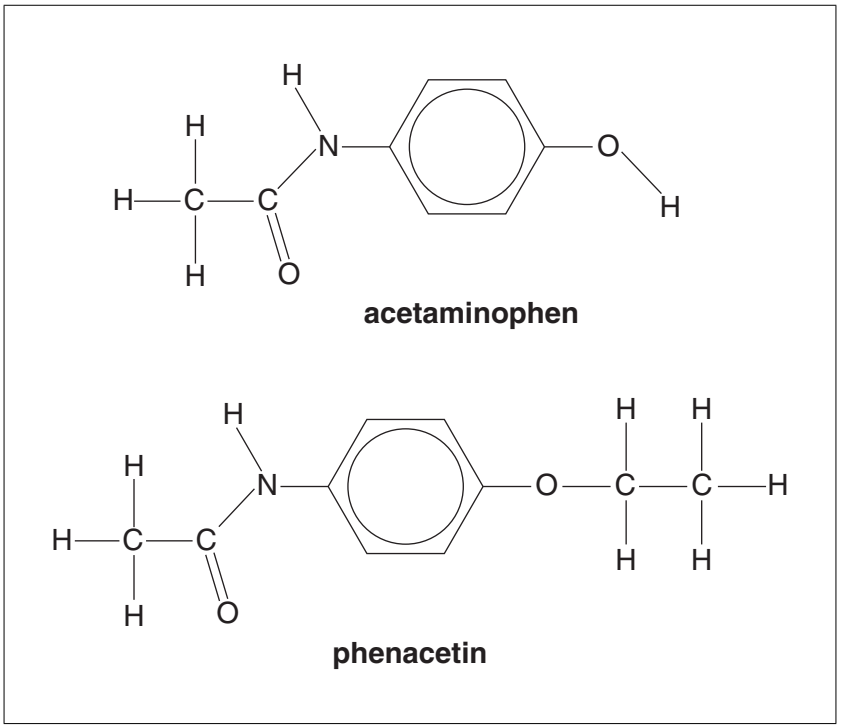
In the table below describe the expected results of the test on each compound.

compound	observations on adding to aqueous iron(III) chloride
acetaminophen	
phenacetin	

[3]

(ii) Another way of distinguishing between samples of acetaminophen and phenacetin is to compare their n.m.r. spectra.

Use the *Data Sheet* to help you describe how the two n.m.r. spectra differ.
Give the chemical shifts of the peaks that **differ** in the two spectra, indicating the relative intensity of the peaks **where appropriate**.



acetaminophen

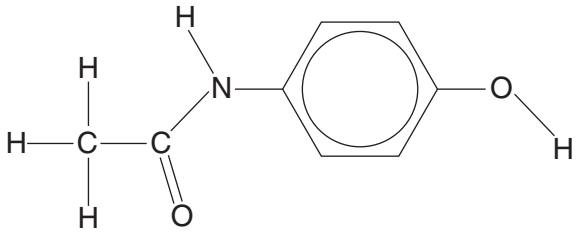
phenacetin

chemical shifts for **acetaminophen** only	type of proton	relative intensity

chemical shifts for **phenacetin** only	type of proton	relative intensity

[5]

(d) Acetaminophen dissolves readily without hydrolysis in cold dilute aqueous sodium hydroxide.



acetaminophen

(i) **Name** the functional group present in acetaminophen responsible for its solubility in sodium hydroxide solution.

..... **[1]**

(ii) Draw the structure of the organic species formed in the sodium hydroxide solution.

[2]

[Total: 26]

4 Steels containing large amounts of chromium and nickel were first developed in the early part of the 20th century. Statues and structures made from these steels are as shiny today as when they were first constructed.

(a) Describe **one** property, other than appearance, that steels have as a result of containing chromium and nickel.

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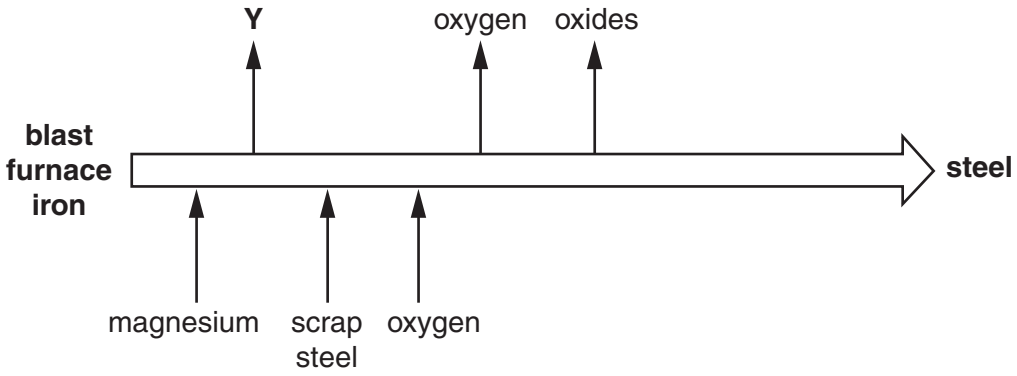
..... **[1]**

(b) The flow diagram below shows some of the processes involved in making steel.



(i) Identify **Y**.

..... **[1]**

(ii) Other than recycling materials, what important role does adding scrap steel serve?

..... **[1]**

(iii) Name **two** elements which are removed by direct oxidation with gaseous oxygen.

..... **[1]**

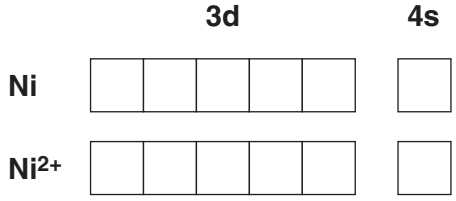
(c) Indicate, by ticking the appropriate boxes, whether the following statements about the process of rusting are true or false.

statement	true	false
Iron is reduced.		
Iron(II) ions are oxidised.		
Electrons move through the water in the cell that is set up.		
Iron(II) ions form a brown precipitate in the presence of hydroxide ions.		

[2]

(d) The amount of nickel in steel can be analysed by using a colorimeter. The nickel is converted to nickel(II) ions in solution by oxidation with nitric acid.

(i) By drawing arrows in the appropriate boxes, complete the outer electron structures for Ni and Ni^{2+}.

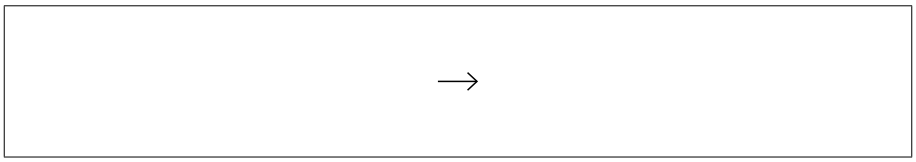


[2]

(ii) Use the two half-equations below to construct an overall equation for the reaction between nickel and nitric acid.

$$Ni^{2+} + 2e^- \rightarrow Ni$$

$$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$$



[2]

(e) In aqueous solution, nickel(II) ions have the formula $[Ni(H_2O)_6]^{2+}$.

Dilute solutions of Ni(II) ions are pale in colour.

Dimethylglyoxime, a **bidentate** ligand, can be added to dilute nickel(II) solutions to produce an intensely red-coloured complex.

(i) The red complex can be represented by $[Ni(dimethylglyoxime)_2]^{2+}$.

State the coordination number for the following complex ions.

$[Ni(H_2O)_6]^{2+}$ ..... $[Ni(dimethylglyoxime)_2]^{2+}$ ..... **[2]**

(ii) Suggest the shape of each complex ion.

$[Ni(H_2O)_6]^{2+}$ ..... $[Ni(dimethylglyoxime)_2]^{2+}$ ..... **[2]**

[Total: 14]

5 Now that chemists understand the structure of DNA, people can use DNA technology to trace their family histories.

(a) DNA is a polymer made from monomers called nucleotides. A nucleotide consists of a five-carbon sugar joined to a phosphate group and a nitrogen-containing ring structure which is a base.

(i) Explain how organic nitrogen-containing compounds act as bases.

.....

.....

..... **[2]**

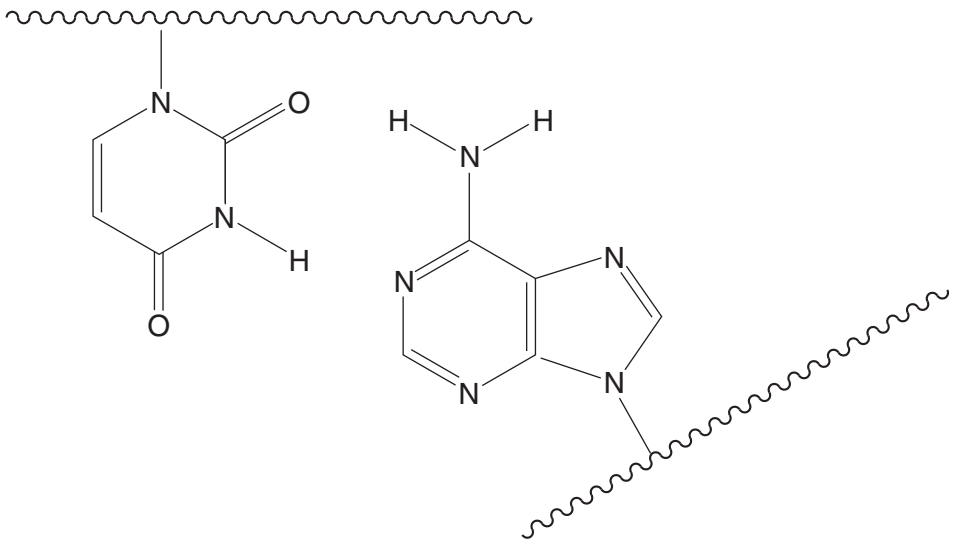
(ii) The polymerisation of nucleotides to form DNA is a condensation reaction.

Identify the other substance formed in this reaction.

..... **[1]**

(iii) DNA is formed from two polynucleotide chains. These chains are held together by interactions between base units on adjacent chains.

On the diagram below, show clearly these interactions. Include any relevant lone pairs and partial charges.



[3]

(iv) What is the shape of a DNA molecule?

..... **[1]**

(b) DNA is used in the synthesis of RNA which carries the code for constructing a protein.

(i) Give **two** differences between DNA and RNA molecules.

.....

..... **[2]**

(ii) Outline how DNA is able to replicate genetic information.

.....

.....

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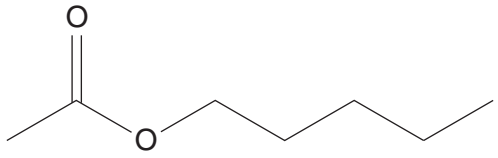
..... **[2]**

[Total: 11]

6 Pear oil is an artificial flavouring containing compound **P**. The structure of **P** is shown below.



compound **P**

(a) **Name** compound **P**.

..... **[2]**

(b) Compound **P** can be made by the reaction shown below.

$$\text{acid} + \text{alcohol} \rightleftharpoons \text{compound } \mathbf{P} + \text{water}$$

In an experiment, the acid and alcohol are heated together under reflux. At equilibrium the concentration of the acid is found to be 1.06 mol dm^{-3}, and the concentration of the alcohol is also found to be 1.06 mol dm^{-3}.

The equilibrium constant for the reaction, K_c, is 4.15 at the temperature at which the concentrations are measured.

(i) Calculate the concentration of compound **P** present at equilibrium. Give your answer to an **appropriate** number of significant figures.

answer = ... mol dm^{-3} **[4]**

(ii) A student repeated the experiment using the same initial quantities. During the experiment she noticed that there was a problem with the apparatus. The water in the condenser had stopped flowing and there was a smell of pears coming from the top of the condenser.

Suggest the effect, if any, that this problem would have on:

- the concentrations of the reactants in the flask
- the equilibrium constant.

Explain your answers.

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.....

..... **[4]**

(iii) The acid and alcohol react together very slowly.

Name a reagent that is added to the mixture so that equilibrium is reached faster.

..... **[1]**

[Total: 11]

END OF QUESTION PAPER

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