Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

ADVANCED GCE

F334

CHEMISTRY B (SALTERS)

Chemistry of Materials

WEDNESDAY 27 JANUARY 2010: Morning
DURATION: 1 hour 30 minutes

SUITABLE FOR VISUALLY IMPAIRED CANDIDATES

Candidates answer on the Question Paper

A calculator may be used for this paper

OCR SUPPLIED MATERIALS:

Data Sheet for Chemistry B (Salters) **(inserted)**

OTHER MATERIALS REQUIRED:

Scientific calculator

READ INSTRUCTIONS OVERLEAF

DC (SLM/SW) MEP10142 23751/1

INSTRUCTIONS TO CANDIDATES

- **Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes on the first page.**
- **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.**
- **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.**
-  **Where you see this icon you will be awarded marks for the quality of written communication in your answer.**

  This means for example you should:

  - **ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;**
  - **organise information clearly and coherently, using specialist vocabulary when appropriate.**
- **You may use a scientific calculator.**
- **A copy of the *Data Sheet for Chemistry B (Salters)* is provided as an insert with this question paper.**
- **You are advised to show all the steps in any calculations.**
- **The total number of marks for this paper is 90.**

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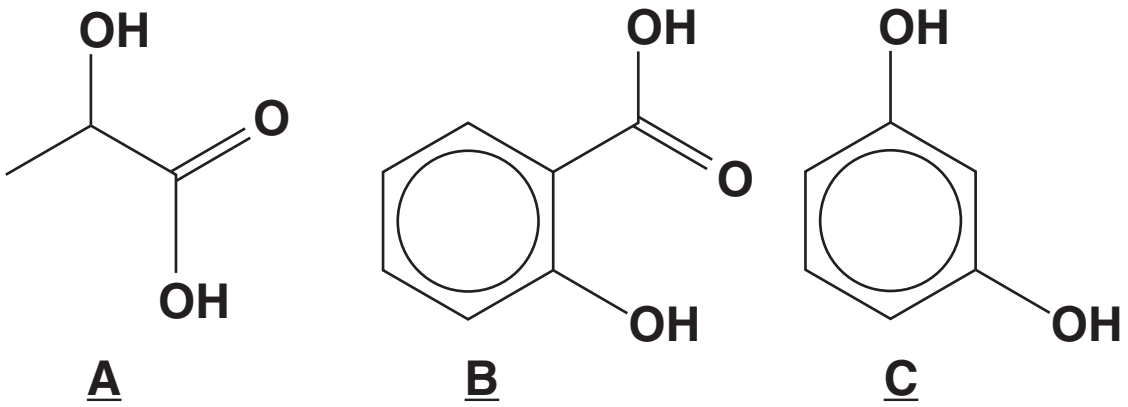
Answer ALL the questions.

1 A chemical peel is a solution used to improve and smooth the texture of facial skin by removing its damaged outer layers. Jessener's Peel contains compounds A, B and C, whose structures are shown below.



(a) Give the systematic name of compound A.

_____ **[2]**

(b) Compound A exists as two enantiomers.

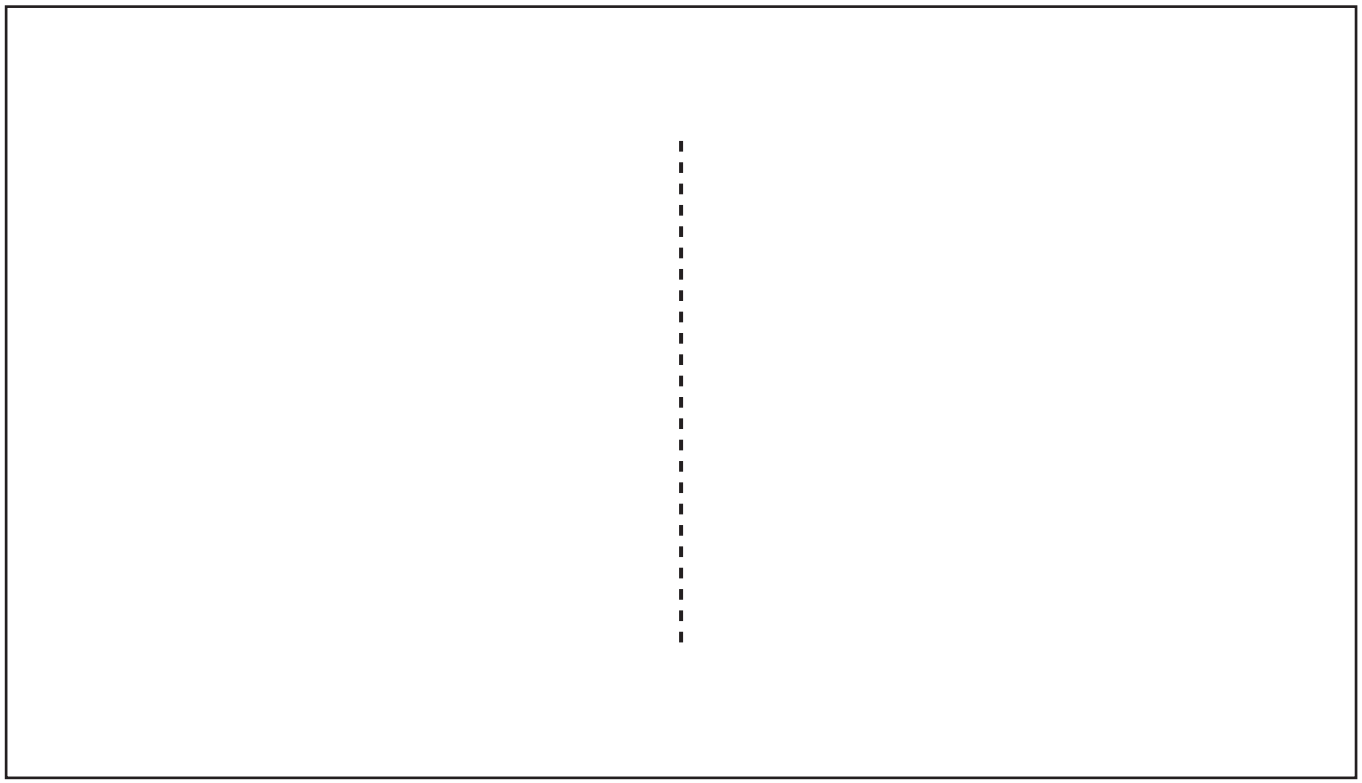
(i) Explain the term *enantiomers*.

_____

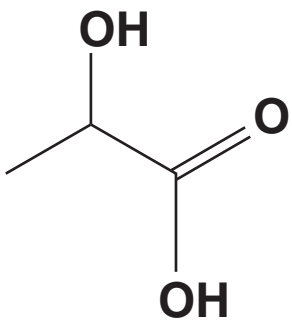
_____

_____ **[2]**

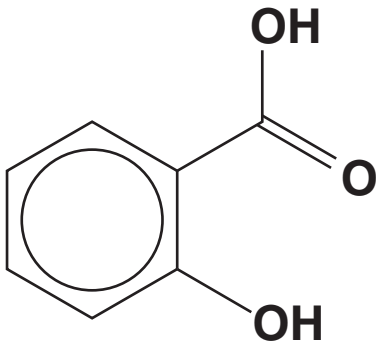
(ii) In the box below, draw 3-dimensional structures to represent these enantiomers of compound A.



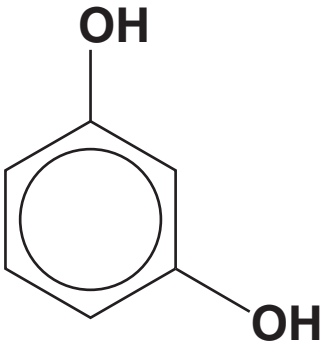
[2]



A



B



C

(c) A student is provided with three solutions P, Q and R.

Each of these solutions contains one of the compounds A, B or C dissolved in water.

She performs two chemical tests on each solution P, Q and R. Her results are given in the table below.

TEST	P	Q	R
addition of neutral iron(III) chloride solution	purple solution	yellow-brown solution	purple solution
addition of sodium carbonate solution	no reaction	fizzing	fizzing

(i) Identify which compound, A, B or C, is present in each of the solutions P, Q and R.

P contains _____

Q contains _____

R contains _____ [1]

(ii) Give a reason for each of your answers in (i).

P _____

_____

_____

Q _____

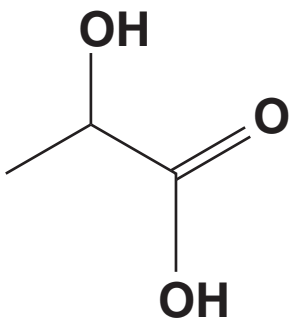
_____

_____

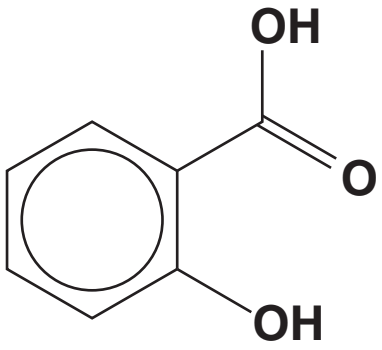
R _____

_____

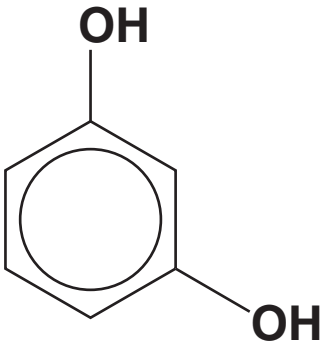
_____ **[3]**



A



B



C

(d) Compounds A, B and C can also be identified using infrared spectroscopy. The infrared spectrum of one of these compounds is shown opposite.

Identify the compound and provide TWO pieces of evidence from the spectrum to support your answer.

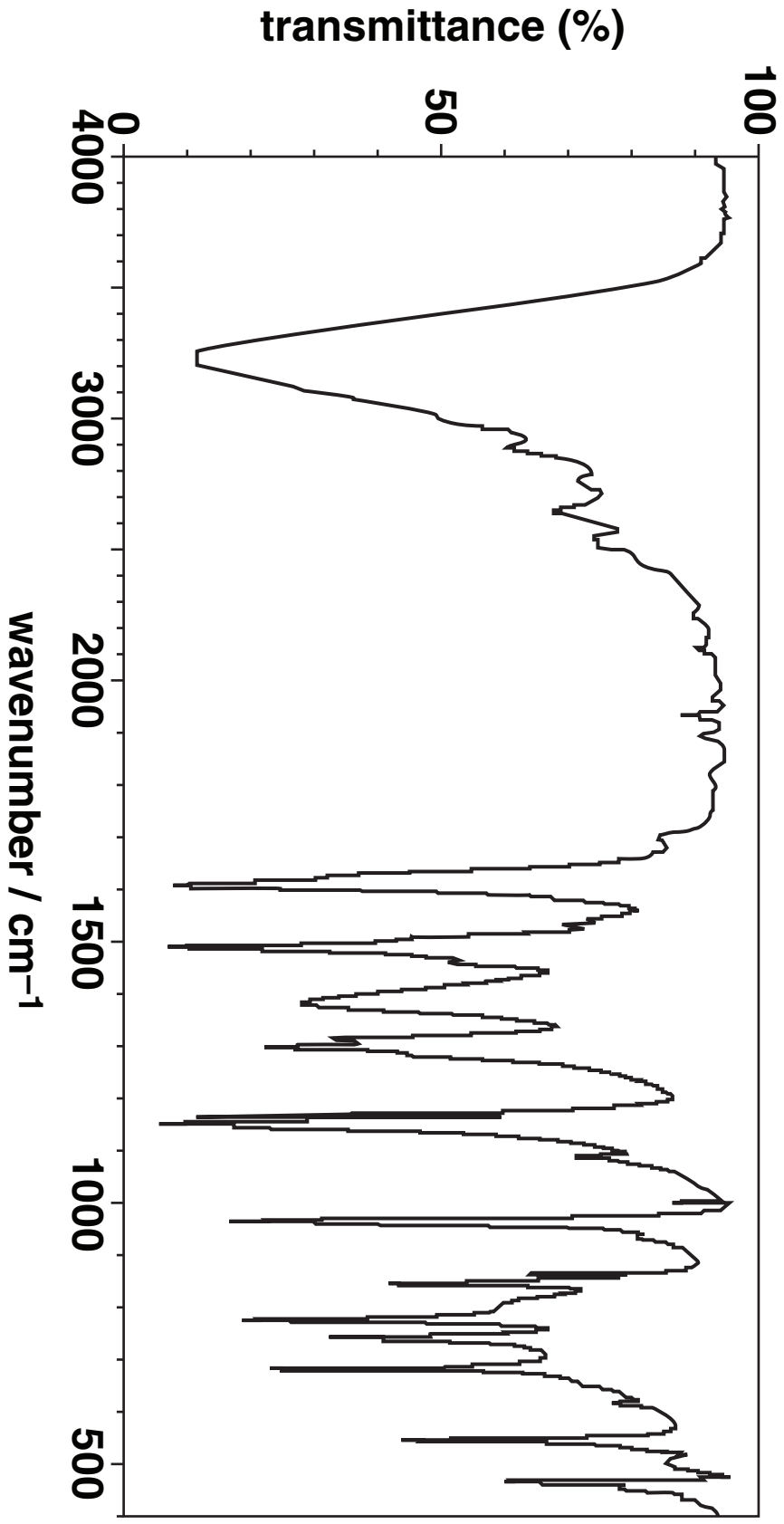
_____

_____

_____

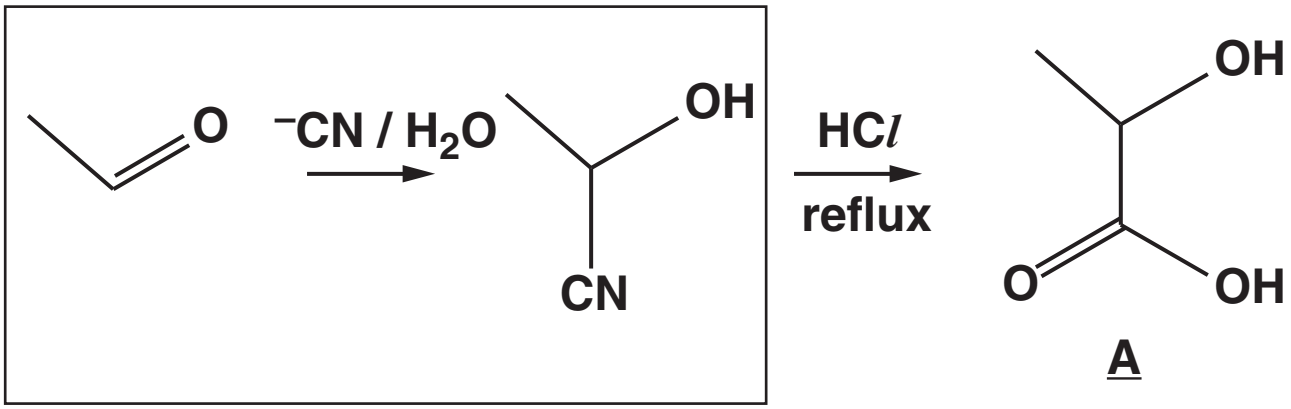
_____

_____ **[3]**


transmittance (%)
0
50
100
4000
3000
2000
1500
1000
500
wavenumber / cm−1

(e) Compound A can be synthesised from ethanal in a two-stage reaction.

STAGE 1 **STAGE 2**



A

(i) Identify, by underlining TWO words from the list below, the type of mechanism for the reaction in STAGE 1.

ADDITION

CONDENSATION

ELECTROPHILIC

ELIMINATION

NUCLEOPHILIC

RADICAL

SUBSTITUTION **[2]**

(ii) In the first step of <u>STAGE 1</u> the cyanide ion attacks the ethanal.

Draw the mechanism for this step using appropriate 'curly arrows' and bond polarities.

Draw the structure of the resultant ion.

[4]

(iii) The rate equation for the reaction of ethanal with cyanide ion <u>AND WATER</u> is shown below.

$$\text{Rate} = k\,[CH_3CHO]\,[CN^-]$$

Explain how the rate equation supports a multi-step mechanism for the reaction in <u>STAGE 1</u>.

_____

_____

_____

_____

_____

_____ **[3]**

(f) (i) Compare the relative atom economies of the following reactions. No calculations are needed.

REACTION 1.1

$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$

REACTION 1.2

$CH_3CH(OH)CN + 2H_2O \rightarrow CH_3CH(OH)COOH + NH_3$

_____

_____

_____ **[2]**

(ii) Many such reactions are used industrially for synthesising compounds.

Why is it important that these reactions have high atom economy?

_____

_____

_____

_____ **[2]**

[Total: 26]

2 An aqueous solution of iron(III) chloride is sometimes used by coin collectors to identify the dates of badly worn 'nickel' coins. Nickel coins are made from an alloy of copper and nickel. The iron(III) chloride solution reacts with the surface of the coin highlighting the date.

(a) Use appropriate data from the table below to describe and explain the reaction occurring between iron(III) chloride solution and the copper in the coin.

You should give an ionic equation for the reaction occurring. State symbols are not required.

HALF-REACTION	$E^{\ominus}$/V
$Fe^{2+} + 2e^{-} \rightarrow Fe$	–0.44
$Cu^{2+} + 2e^{-} \rightarrow Cu$	+0.34
$Fe^{3+} + e^{-} \rightarrow Fe^{2+}$	+0.77

_____

_____

_____

_____

ionic equation

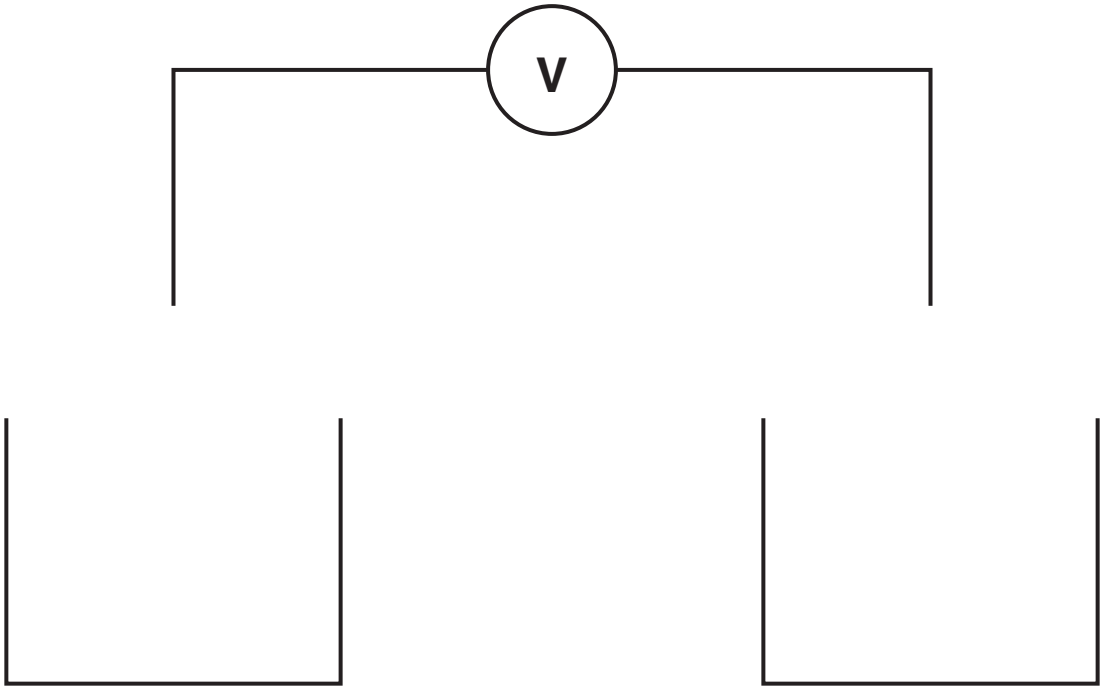
$\longrightarrow$

[3]

(b) (i) Complete the diagram below that shows how the $E^{\ominus}_{cell}$ value of an electrochemical cell using the following two half-reactions is measured under standard conditions.

HALF-REACTION	$E^{\ominus}$/V
$Cu^{2+} + 2e^{-} \rightarrow Cu$	+0.34
$Fe^{3+} + e^{-} \rightarrow Fe^{2+}$	+0.77

Label the electrodes and solutions used and state the conditions required.



conditions _____

_____ **[5]**

(ii) Calculate the $E^{\ominus}_{cell}$ value for the electrochemical cell in (i).

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

(c) The amount of copper in a 'nickel' coin can be determined by the following method.

STAGE 1

A weighed coin is dissolved in concentrated nitric acid to form $Cu^{2+}(aq)$ ions.
The solution is made up to 250 cm^3 in a volumetric flask.

STAGE 2

An excess of potassium iodide solution is added to a 25.0 cm^3 portion of the $Cu^{2+}(aq)$ solution.

A white solid and iodine are produced.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$$

STAGE 3

The amount of iodine formed is found by titration with a standard sodium thiosulfate solution.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^{-}(aq)$$

(i) Name the white solid formed in STAGE 2.

_____ **[1]**

(ii) An impure copper coin with a mass of 3.47 g was analysed using the three stages above.

A titre of 20.5 cm^3 of 0.200 mol dm^{-3} sodium thiosulfate solution was needed to react with the iodine formed in <u>STAGE 2</u> of the process.

Calculate the percentage of copper in the coin. Give your answer to an <u>APPROPRIATE</u> number of significant figures.

answer = _____ % [6]

(d) The amount of Cu^{2+} ions in aqueous solution can also be determined by colorimetry.

(i) State the colour of Cu^{2+} ions in water and explain why the solution has this colour.

In your answer you should use technical terms spelled correctly.

_____

_____

_____ **[2]**

(ii) Addition of concentrated hydrochloric acid to a solution of Cu^{2+} ions in water causes a change in the colour of the solution.

Name the type of reaction that has occurred and give the formula of the product containing the copper.

type of reaction _____

formula of product containing the copper

_____**[2]**

(iii) Describe how colorimetry is used to determine the concentration of Cu^{2+} ions in an aqueous sample.

In your answer you should indicate how experimental results lead to the required value.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ **[6]**

[Total: 26]

3 Britain has one of the largest DNA databases in the world. Genetic material is taken from all people arrested by the police.

(a) DNA is a polymer formed from nucleotide monomers. A nucleotide consists of a phosphate unit covalently bonded to a deoxyribose molecule which is bonded to a base.

(i) Use the information on the *Data Sheet* to draw a structure of the organic product formed when a phosphate unit combines with a molecule of deoxyribose.

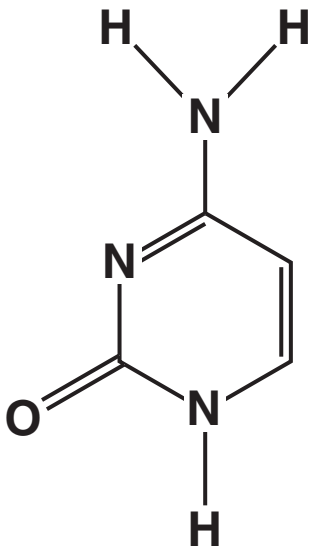
[2]

(ii) For the reaction in (i), identify the other product and give the name of the <u>TYPE</u> of polymerisation reaction involved.

_____ **[1]**

(iii) Cytosine can be joined to deoxyribose.

On the structure below, <u>CIRCLE</u> the atom to which deoxyribose is bonded in DNA.



[1]

(iv) Cytosine can behave as a base. Explain this by considering its chemical structure.

_____

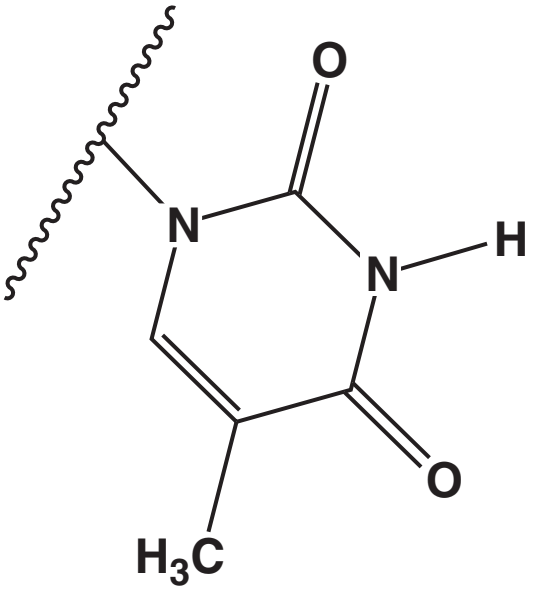
_____

_____ **[2]**

(b) A base on one strand of DNA, hydrogen bonds with a base on another strand of DNA.

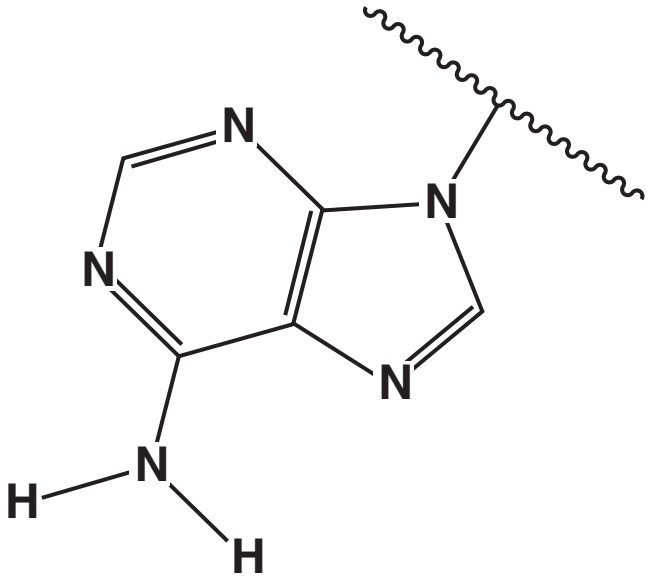
Complete the diagram below to show <u>ALL</u> the hydrogen bonds formed between thymine and adenine. For <u>ONE</u> of the hydrogen bonds, show all partial charges and the relevant lone pair.

<u>PHOSPHATE–SUGAR 'BACKBONE'</u>



<u>THYMINE</u>

<u>PHOSPHATE–SUGAR 'BACKBONE'</u>



<u>ADENINE</u>

[3]

(c) In the early 1950s, X-ray crystallography helped scientists show that a strand of DNA has a helical form. Pauling proposed a model for DNA consisting of three intertwined helical strands with the phosphate groups on the inside of the coil and the bases on the outside. Shortly afterwards, Watson and Crick published their proposal, our present model for DNA.

Describe how the model we use today is different from Pauling's model.

_____

_____

_____

_____

_____

_____

_____ **[3]**

(d) Many members of the general public believe that the DNA 'fingerprints' of the innocent should be removed from the DNA database. Others disagree with this view.

Suggest a reason for each of the two differing viewpoints.

_____

_____

_____

_____

_____ **[2]**

[Total: 14]

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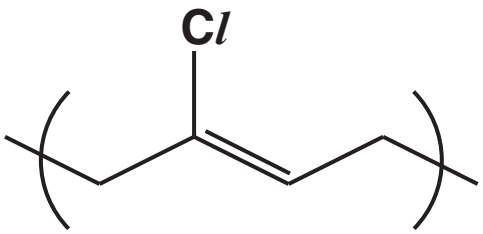
PLEASE TURN OVER FOR QUESTIONS 4 AND 5

4 The polymers neoprene and nylon-6 are waterproof, elastic and highly resistant to abrasion.
These properties make them suitable for the manufacture of outdoor garments.

(a) Complete the table by drawing the structure of the monomer of neoprene and the repeating unit for nylon-6.

POLYMER	MONOMER	REPEATING UNIT
neoprene	2-chloro-1,3-butadiene	
nylon-6	$HOOC—(CH_2)_5—NH_2$	

[2]

(b) In the POLYMER chains of neoprene, 90% of the double bonds are in a *trans* arrangement.

(i) Explain why NEOPRENE can form *cis* and *trans* isomers.

_____

_____

_____

_____ **[2]**

(ii) Describe AND explain the effect on the crystallinity of neoprene of changing the composition of the double bonds to 50% of *trans* and 50% of *cis*.

_____

_____

_____

_____ **[2]**

(c) Materials made from nylon-6 can absorb moisture but those made from neoprene cannot.

- **Explain these observations.**

- **Describe the effect of water absorption on the chain arrangement in nylon-6 and thus on its glass transition temperature (T_g).**

_____

_____

_____

_____

_____

_____

_____

_____ **[4]**

(d) Nylon-6 is hydrolysed by heating under reflux with aqueous sodium hydroxide.

Draw the structural formula of the organic product of this reaction.

[2]

[Total: 12]

5 The water from wells in some rural areas smells of rotten eggs due to the presence of hydrogen sulfide from decaying vegetable and animal matter. The smell can be removed by the addition of dilute aqueous potassium manganate(VII).

(a) (i) Balance the equation below for the reaction removing the 'rotten egg' smell.

$$\_\_\_\_ H_2S + \_\_\_\_ MnO_4^- + 2H^+ \longrightarrow$$
$$\_\_\_\_ MnO_2 + \_\_\_\_ S + 4H_2O$$

[1]

(ii) Give the oxidation state of Mn in MnO_2.

oxidation state of Mn = _____ [1]

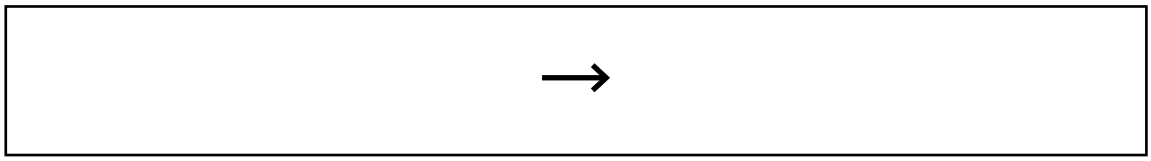
(b) The potassium manganate(VII) will also remove any iron(II) ions, which are often present in water from wells, converting them to Fe(III).

A student added some drops of potassium manganate(VII) solution to a sample of water from a well containing iron(II) ions. He then added excess sodium hydroxide solution and observed a red-brown precipitate.

(i) Name the precipitate.

_____ [1]

(ii) Give the ionic equation for the formation of the precipitate. Include state symbols.



[2]

(c) Potassium manganate(VII) reacts with acidified ethanedioate ions, $C_2O_4^{2-}$.

A student determined the rate of this reaction using colorimetry. In the experiment, he used concentrations of ethanedioate and acid which were greatly in excess of the manganate(VII) concentration. He also added a small amount of $Mn^{2+}(aq)$ as a catalyst. He used his results to plot the graph opposite.

(i) Explain why the student was able to assume that in his experiment only the concentration of the manganate(VII) effectively changed during the reaction.

_____

_____

_____ **[1]**

(ii) Use the graph to determine the order of the reaction with respect to the manganate(VII) concentration. Show your working and give your reasoning.

_____

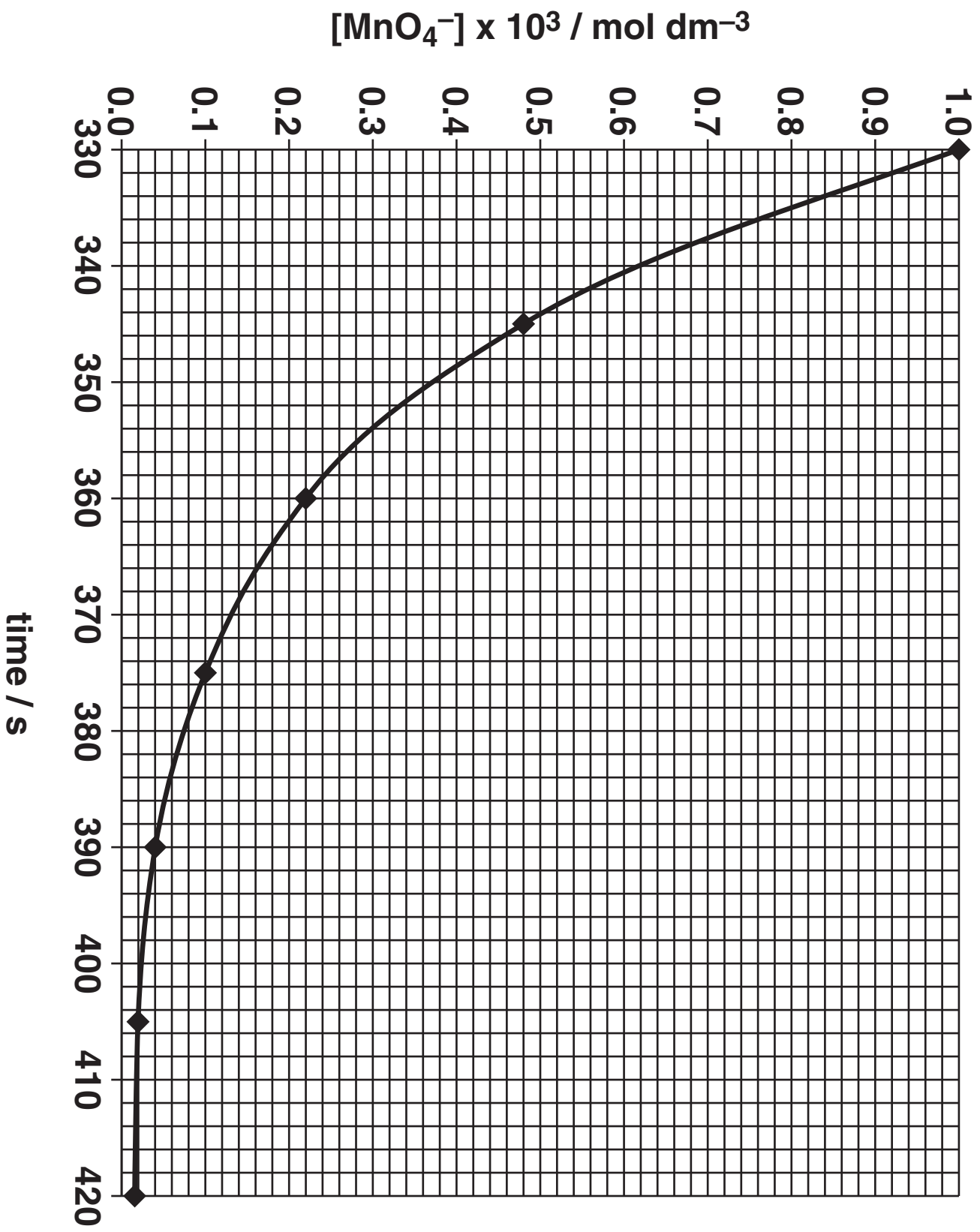
_____

_____

_____

_____

_____ **[3]**


[MnO4−] x 10^3 / mol dm−3
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
time / s
330
340
350
360
370
380
390
400
410
420

(iii) By drawing arrows in the appropriate boxes complete the outer electron structure for Mn^{2+}.

3d					4s

[1]

(d) Describe and explain another experimental method, other than colorimetry, which the student could use to follow the rate of the reaction of potassium manganate(VII) with acidified ethanedioate given below.

$$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

_____

_____

_____

_____ [2]

[Total: 12]

END OF QUESTION PAPER

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