

**Advanced GCE
CHEMISTRY B (SALTERS)**

F334 QP

Unit F334: Chemistry of Materials

Specimen Paper

Candidates answer on the question paper.

Time: 1 hour 30
minutes

Additional Materials:
Data Sheet for Chemistry B (Salters) (Inserted)
Scientific calculator

Candidate
Name

Centre
Number

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Candidate
Number

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INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

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.
- 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**.

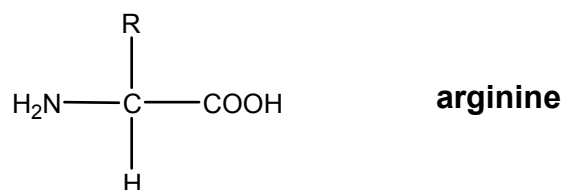
FOR EXAMINER'S USE

Qu.	Max.	Mark
1	21	
2	22	
3	14	
4	24	
5	9	
TOTAL	90	

This document consists of **14** printed pages, **2** blank pages and a *Data Sheet for Chemistry B (Salters)*.

Answer **all** the questions.

- 1 A Japanese firm has marketed a range of clothes called 'amino jeans'. The garments are impregnated with arginine. The arginine softens and moisturises the wearer's legs. A simplified structure of arginine is shown below. R represents a carbon chain containing functional groups.



- (a) What is the name for the group of compounds to which arginine belongs?

..... [1]

- (b) Arginine is often used as a salt made by reacting arginine with hydrochloric acid.

Complete the equation below to show the **ions** formed.



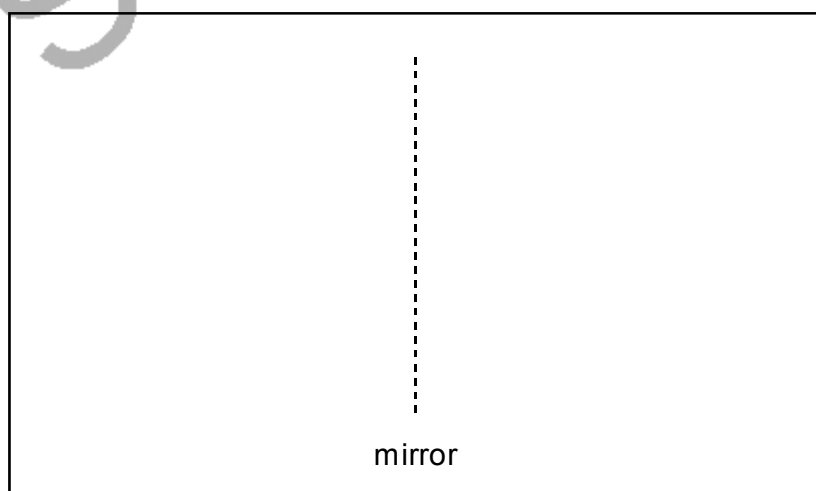
[3]

- (c) Arginine forms two enantiomers.

- (i) What structural feature causes arginine to have enantiomers?

..... [1]

- (ii) On the diagram below, draw the **three dimensional** structures of the two enantiomers to show how they are related.



[2]

- (ii) When arginine is at a low concentration, the enzyme catalysed reaction is first-order with respect to arginine **and** first-order with respect to the enzyme.


Write down the rate equation for this reaction and give the units of the **rate constant**.

rate equation:

units of rate constant [3]

- (iii) At high concentrations of arginine, the order of the reaction with respect to arginine becomes zero.

Describe a mechanism for this enzyme catalysed reaction which explains why the order of reaction depends on the concentration of arginine.

 In your answer you should make clear how the explanation matches the description.

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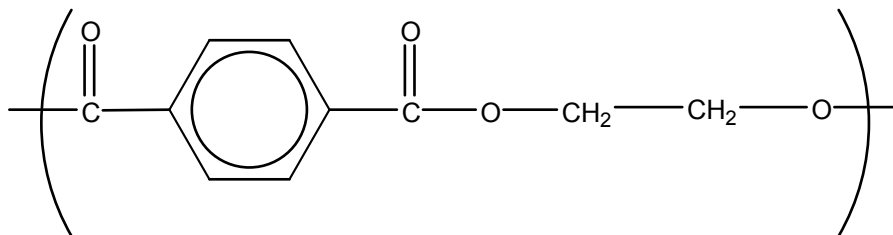
[4]

[Total: 21]

SPECIMEN

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

(a) PET is a polyester. The repeating unit for PET is given below.



Draw a ring around the ester group in the repeating unit above.

[1]

(b) Plastic waste is often buried for disposal.

Give **two** other methods which are used to deal with plastic waste and explain a different advantage for each method.

.....

.....

.....

.....

.....

.....

.....

[4]

(c) PET is not used to make returnable bottles because its glass transition temperature, T_g , is too low.

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

.....

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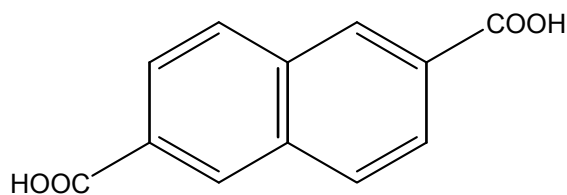
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[3]

[Turn over

- (d) Chemists have developed a new polyester which can be used for producing returnable bottles. It can be made from ethane-1,2-diol, $\text{HOCH}_2\text{CH}_2\text{OH}$, and compound **A**. The structure of compound **A** is shown below. The polymer is known as PEN.



compound A

- (i) Draw the skeletal formula of the repeating unit of PEN.

[2]

- (ii) **PEN** has a higher melting temperature than PET.

Assume both polymers have similar average relative molecular masses.

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

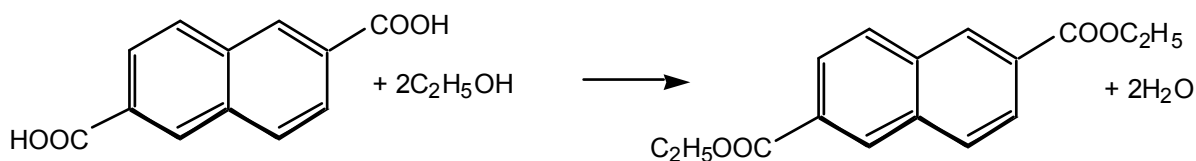
.....
.....
..... [2]

- (iii) Explain how the infrared spectra of compound **A** and **PEN** would differ in **one** significant respect. Use the *Data Sheet* to look up any relevant absorbances you need.

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

(e) Industrially, **PEN** is made by reacting a diester of compound **A** with ethane-1,2-diol.

The diester is made by reacting compound **A** with ethanol according to the equation below.



compound A

(i) What other chemical is added to an acid and alcohol mixture and what conditions are used to make an ester in the laboratory?

.....
 [2]

(ii) Classify the reaction in which **PEN** is made by underlining one of the following reaction types.

addition

condensation

elimination

rearrangement

[1]

(iii) Explain, using ideas of atom economy, why the polymerisation reactions in which PET and PEN are formed are less environmentally friendly than those in which poly(ethene) is made.

.....

 [3]

(iv) Compound **A** and its diester can be distinguished by thin-layer chromatography.

A spot of a mixture of the two is run on a TLC plate.

Draw a diagram of the resulting TLC plate showing the located spots.

Explain how you would measure the R_f values of the spots.

[2]

[Total: 22]

[Turn over

3 Groundwater usually contains iron compounds and therefore water from wells will contain significant amounts of iron compounds. The main problem with household water containing iron compounds is the staining it causes to laundry, porcelain and plumbing fittings.

(a) Water containing iron in an oxidation state of +2 is known as 'clear water' since it appears colourless. However, on leaving the tap it may become coloured and it is then referred to as 'red water'. 'Red water' contains iron(III) compounds.

(i) Give the formula of the complex ion which causes the 'red' colour.

..... [1]

(ii) What causes the colour change when clear water leaves the tap?

.....

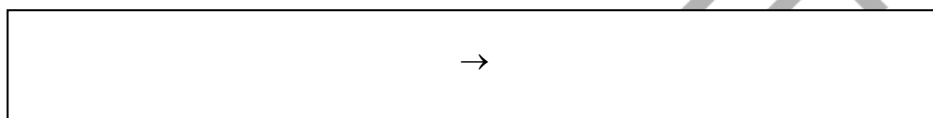
.....

..... [2]

(iii) If the 'red water' is made slightly alkaline, for example by adding sodium hydroxide solution, a red-brown precipitate will form.

Write an ionic equation for the formation of the red-brown precipitate.

Include state symbols.



[3]

(b) 'Iron stains' contain iron(III) compounds and can be removed using a variety of products available in the supermarket. One commonly used chemical is ethanedioic acid. It is used in stain removers as the disodium salt.

(i) Draw the full structural formula of the ethanedioate ion, $C_2O_4^{2-}$.

[1]

(ii) Name the type of reaction that occurs when ethanedioate ions in aqueous solution react with 'red water' to form green $[Fe(C_2O_4)_3]^{3-}$ ions.

..... [1]

(iii) Explain why a green substance looks green.

.....

.....

.....

..... [2]

(c) Iron stains can be removed by adding a solution of a suitable reducing agent.

Use the data in the table below to identify a reducing agent which can reduce iron(III) ions under standard conditions. Explain your answer and write an equation for the reaction that occurs.

half-reaction	E^\ominus / V
$\text{SO}_4^{2-} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{SO}_3^{2-} + \text{H}_2\text{O}$	-0.93
$\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$	+0.44
$2\text{H}^+ + \text{O}_2 + 2\text{e}^- \rightarrow \text{H}_2\text{O}_2$	+0.68

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[4]

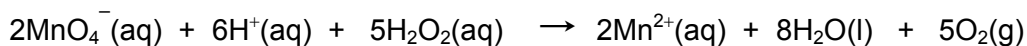
[Total: 14]

[Turn over

(ii) 25.0 cm³ of a concentrated solution of hydrogen peroxide is diluted to 250 cm³.

10.0 cm³ of this diluted H₂O₂ reacted with exactly 17.2 cm³ of 0.0200 mol dm⁻³ MnO₄⁻ solution.

The equation for the reaction taking place is given below.



Calculate the concentration of the **concentrated** H₂O₂ solution.

Give your answer to an **appropriate number** of significant figures.

concentration = mol dm⁻³

[4]

(iii) The concentration of the hydrogen peroxide solution used for treating paintings must not be greater than 3.0%. Assume this means 3.0 g of H₂O₂ in 100 cm³ of solution.

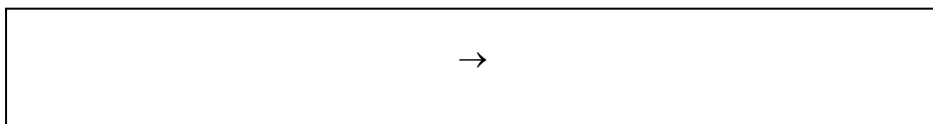
Is the undiluted solution of H₂O₂ suitable to be used for treating paintings?

Show your working.

[2]

(c) Restorers of paintings are instructed to make up the solutions of hydrogen peroxide in a polythene bottle with pure water rather than tap water. Traces of transition metal ions, such as Fe²⁺, present in tap water, can catalyse the decomposition of hydrogen peroxide.

(i) Write the equation for the decomposition of hydrogen peroxide into water and oxygen. Give the state symbols.



[1]

[Turn over

- (ii) The decomposition of hydrogen peroxide is a redox reaction.

Explain how $\text{Fe}^{2+}(\text{aq})$ ions can catalyse a redox reaction in aqueous solution.

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

- (iii) A solution of hydrogen peroxide stored in a glass bottle at room temperature was found to be completely decomposed after two weeks.

Describe an experimental procedure you could use to measure the oxygen produced when hydrogen peroxide decomposes.

Show how you would use your results to find the initial rate of the reaction.

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

- (iv) The reaction is found to be first-order with respect to hydrogen peroxide with a rate constant of $2.0 \times 10^{-6} \text{ s}^{-1}$ at 298 K.

Calculate the rate of decomposition of a 2.0 mol dm^{-3} hydrogen peroxide solution at 298 K.

rate of decomposition = $\text{mol dm}^{-3} \text{ s}^{-1}$

[2]

[Total: 24]

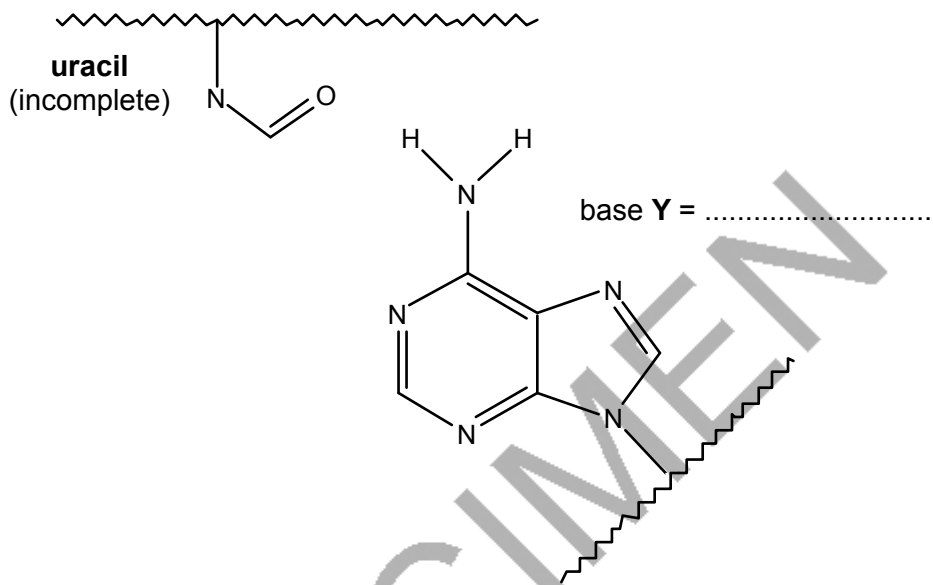
5 Now that chemists have unlocked the significance of the DNA structure and developed experimental methods, DNA technology is being used by people tracing their family histories.

DNA is a polymer made from monomers called nucleotides.

Nucleotides consist of a base joined to a sugar joined to a phosphate group.

(a) (i) DNA is formed from two polynucleotide chains. These chains are held together by hydrogen bonds between base units on adjacent chains. On the diagram below:

- use the *Data Sheet* to name the base **Y** and complete the structure of uracil;
- show clearly the hydrogen bonds between the bases including any relevant lone pairs and partial charges.



[4]

(ii) On the diagram of the base **Y** above, circle the atom which enables it to act as a base. Explain how the atom acts as a base.

.....
 [3]

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

..... [1]

(b) The model of DNA discussed in (a) was first described by Watson and Crick in 1953. Before 1953, several other models of DNA had been published by other scientists.

Suggest a reason why, after 50 years, scientists are still using Watson and Crick's model for DNA.

.....
 [1]

[Total: 9]

Paper Total [90]

SPECIMEN

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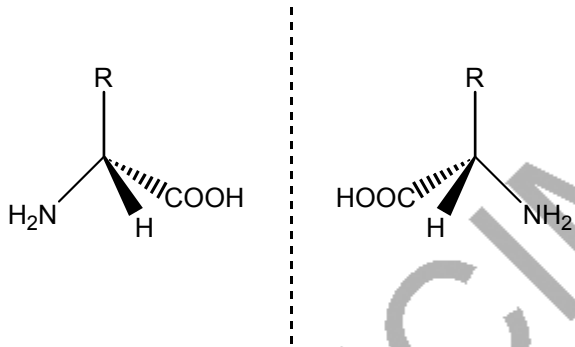
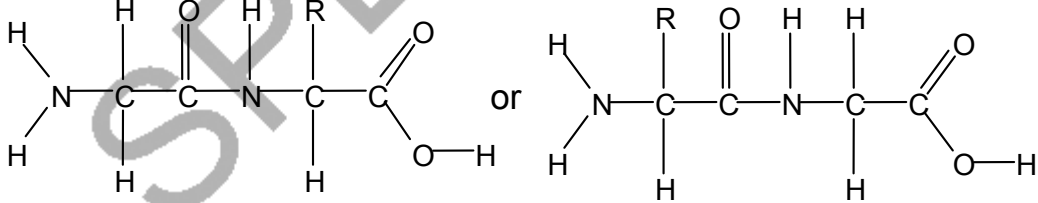
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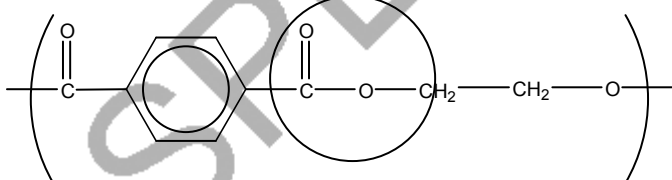
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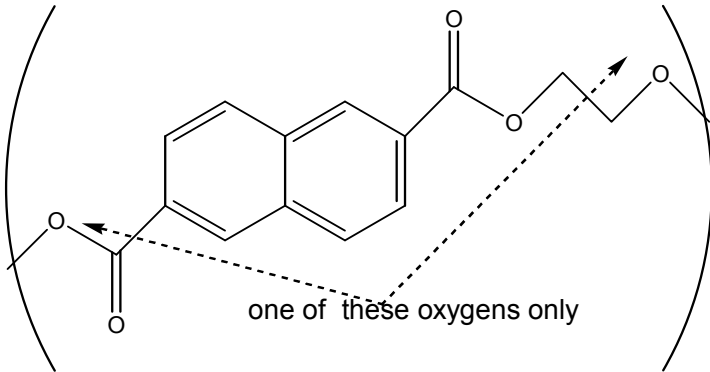
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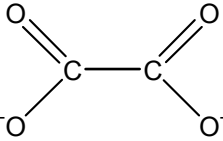
The maximum mark for this paper is **90**.

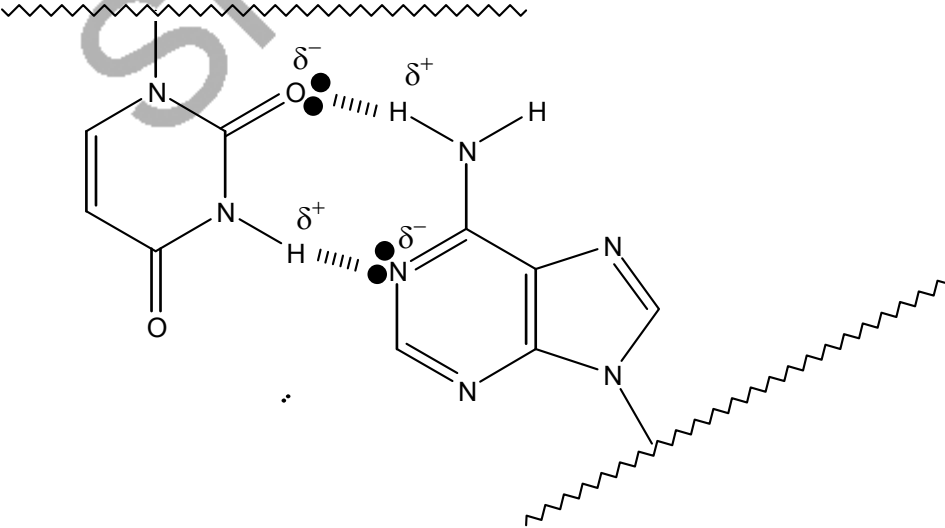
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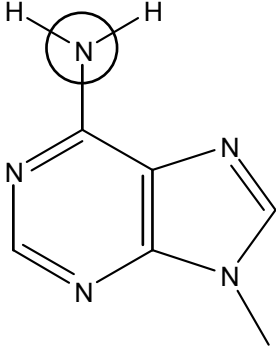
Question Number	Answer	Max Mark
1(a)	Amino acids (1).	[1]
(b)	$ \begin{array}{c} \text{R} \\ \\ ^+\text{H}_3\text{N}-\text{C}-\text{COOH} \\ \\ \text{H} \end{array} + \text{Cl}^- $ <p>1 mark for structure of organic ion and 1 mark for charge on amino group (2); 1 mark for chloride ion alone (1).</p>	[3]
(c)(i)	Asymmetric carbon atom / chiral centre (<i>carbon atom</i>) / carbon bonded to/ with AW 4 different atoms/groups (1).	[1]
(ii)	 <p>Correct 3D structural formula for one enantiomer(1); Mirror images (1).</p>	[2]
(d)	 <p>1 mark for one COOH group and one NH₂ group structure in molecule (1); 1 mark for rest correct for either structure (1).</p>	[2]

Question Number	Answer	Max Mark
(e)(i)	<p>One mark each for points in bold and then any two others up to a total of 5 marks:</p> <p>Reaction/AW takes place at active site; active sites have specific shapes / enzyme contains hole or cleft with specific shape; due to the tertiary structure of the enzyme / way it folds; only one of the enantiomers will fit in the active site AW; interactions between arginine and active site weaken bonds; activation energy is lowered; high temperatures cause intramolecular bonds to break and active site is lost; at low temperatures rate is slow since activation energy is not often reached.</p>	[5]
(ii)	<p>Rate = $k \times [\text{arginine}] \times [\text{enzyme}]$ 1 mark for [arginine] and [enzyme] (1); 1 mark for rest correct (1); $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$ (1) allow any order for units.</p>	[3]
1(e)(iii)	<p>At low [arginine]: rate determining step/ slow step involves 1 molecule of arginine and 1 enzyme molecule forming complex (1); QWC hence first order* (1) At high [arginine]: rds does not involve arginine/rds is breakdown of complex (1) since all enzyme sites are occupied and [complex] is constant (1). QWC relation of one of these two mpts to zero order* [1] *score either one of these.</p>	[4]
Total		[21]
2(a)	 <p>(1); allow without the C within the ring.</p>	[1]
(b)	<p>Burning/combustion (1); Energy produced can be used/reducing landfill (1).</p>	[4]
(c)	<p>recycling AW(1); oil resources saved AW/reducing landfill (1).</p>	[3]
(c)	<p>(Below T_g) chains do not have enough energy (may describe in terms of vibration or motion of chains) (1); to move over/slide over one another (1); force applied to change shape of polymer will cause 'frozen' chains to break AW (1).</p>	[3]

Question Number	Answer	Max Mark
(d)(i)	 <p data-bbox="710 533 1045 566">one of these oxygens only</p> <p data-bbox="300 622 715 696">Ester linkage correct (1); rest correct (1) <i>ignore brackets.</i></p>	[2]
(ii)	Intermolecular bonds between chains are greater/stronger NOT 'MORE' (1); chains are able to get closer (because of the flat ring system) (1).	[2]
(iii)	O–H group present in compound A (1); will give absorbance at 2500-3200 (cm ⁻¹) (1)	[2]
(e)(i)	Conc. sulfuric acid / c. H ₂ SO ₄ (1); Heat/warm (under reflux)/reflux (1).	[2]

Question Number	Answer	Max Mark
(ii)	Condensation	[1]
(iii)	PET/PEN are formed by condensation reactions whereas polythene are formed by addition reactions (1); condensation reactions lead to wasted products because elimination reactions occur (1); addition reactions use all reactant atoms (1).	[3]
(iv)	TLC plate showing two dots (1); R_f = distance moved by spot/distance moved by solvent front (1)	[2]
Total		[22]
3(a)(i)	$[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ (1).	[1]
(ii)	Oxidation of Fe(II) ions/Fe(II) ion loses electron/ Fe(II) converted to Fe(III) (1); by oxygen/air (1).	[2]
(iii)	$\text{Fe}^{3+}(\text{aq}) + 3\text{OH}^{-}(\text{aq}) \rightarrow \text{Fe}(\text{OH})_3(\text{s})$ correct formula for $\text{Fe}(\text{OH})_3$ (1); balanced equation as above (1) <i>ignore spectator ions if balanced</i> ; correct state symbols (1).	[3]
(b)(i)	 (1).	[1]
(ii)	Ligand exchange/complex formation/ligand substitution/Ligand displacement (1).	[1]
(iii)	particular frequencies/wavelengths of light/radiation in visible region absorbed (1); hence colour transmitted is light NOT absorbed,(in this case green/ complementary colour is seen (1).	[2]
(c)	SO_3^{2-} (1); E^\ominus for half-reactions are more negative than E^\ominus for $\text{Fe}^{2+}/\text{Fe}^{3+}$ half-reaction / electrons will flow to Fe^{3+} (1). $2\text{Fe}^{3+} + \text{SO}_3^{2-} + \text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 2\text{H}^+ + 2\text{Fe}^{2+}$ reactants and products correct (1); balanced (1).	[4]
Total		[14]
4(a)	$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}$ correct formulae of substances (1); balanced correctly with electrons on left (1).	[2]
(b)(i)	Use of <u>pipette</u> for measuring <u>hydrogen peroxide</u> (1); use of <u>burette</u> for <u>manganate(VII)</u> (1) QWC award mark only if spelling of burette is correct; (Use of burette & pipette but with solutions switched is 1 mark only)	

Question Number	Answer	Max Mark
(b)(i) cont'd	addition of sulfuric acid (1) <i>NOT hydrochloric/nitric acid</i> ; to <u>conical flask</u> with hydrogen peroxide (1); slow addition at end point/dropwise/drop by drop/slowly/carefully (1); to pink/purple colour (if reverse addition then allow colourless but NOT pink) (1); repeat to give at least two concordant/consistent readings (1).	[7]
(ii)	Moles of $\text{MnO}_4^- = (17.2/1000) \times 0.0200$ (1); moles of $\text{H}_2\text{O}_2 = 2.5 \times (17.2/1000) \times 0.0200$ (1) <i>ecf</i> , mark is for the 2.5 ratio concentration of undiluted = $2.5 \times (17.2/1000) \times 0.0200 \times (1000/10.0) \times 10$ (1); concentration $0.860 \text{ mol dm}^{-3}$ (1) <i>ecf but answer must be to 3 sig. figs.</i>	[4]
(iii)	M_r of $\text{H}_2\text{O}_2 = 34$ (1); mass of H_2O_2 in 100 cm^3 of water = $34 \times 0.86 \times 100/1000 = 2.9 \text{ g}$ <i>or</i> max moles of H_2O_2 allowed in 100 cm^3 of water = $3.0/34 = 0.088 \text{ mol}$ therefore YES (1) <i>ecf from (iii) and M_r of H_2O_2.</i>	[2]
(c)(i)	$2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$ <i>formulae correct, balanced and state symbols correct</i> (1).	[1]
(ii)	Fe^{2+} can reduce/lose electrons to one reactant to form a product and Fe^{3+} (1); Fe^{3+} can then oxidise/gain electrons from a reactant to reform Fe^{2+} (1); both reactions are faster than the uncatalysed reaction/ E_a for both is lower AW (1).	[3]
(iii)	Measure volume of oxygen by syringe/over water (1); plot graph of volume of O_2 v time (1); find gradient at time = 0 (1).	[3]
(iv)	Rate of decomposition = $k \times [\text{H}_2\text{O}_2]$ (1); $= 2.0 \times 10^{-6} (\times 5.0) \text{ mol dm}^{-3} \text{ s}^{-1} = 4.0 \times 10^{-6} \text{ mol dm}^{-3} \text{ s}^{-1}$ <i>ecf</i> (1).	[2]
5(a)(i)	 <p>one mark for both hydrogen bonds (1); one mark for both lone pairs (1); partial charges correct (1);</p>	

Question Number	Answer	Max Mark
5(a)(i) cont'd	If only one interaction shown but all three components are correct then give 2 marks out of 3; Y= adenine and uracil completed correctly (1); sugar = deoxyribose (1).	[4]
(ii)	 <p>Lone pair of electrons on N (1); can accept proton/hydrogen ion/H⁺ (1).</p>	[3]
(iii)	<u>Double helix</u> (1).	[1]
(b)	It explains all the known facts about DNA/ it helps predict facts/properties/reactions which can be tested and shown to be correct (1).	[1]
	Total	[9]
	Paper Total	[90]

Assessment Objectives Grid (includes QWC)

Question	AO1	AO2	AO3	Total
1(a)	1			1
1(b)	3			3
1(c)(i)	1			1
1(c)(ii)	2			2
1(d)		2		2
1(e)(i)	4	1		5
1(e)(ii)			3	3
1(e)(iii)		4		4
2(a)	1			1
2(b)	4			4
2(c)	3			3
2(d)(i)		2		2
2(d)(ii)		2		2
2(d)(iii)		2		2
2(e)(i)			2	2
2(e)(ii)		1		1
2(e)(iii)		3		3
2(e)(iv)			2	2
3(a)(i)	1			1
3(a)(ii)		2		2
3(a)(iii)	3			3
3(b)(i)		1		1
3(b)(ii)	1			1
3(b)(iii)	2			2
3(c)(i)		2		2
3(c)(ii)		2		2
4(a)		2		2
4(b)(i)			7	7
4(b)(ii)			4	4
4(b)(iii)			2	2
4(c)(i)		1		1
4(c)(ii)		3		3
4(c)(iii)			3	3
4(c)(iv)		2		2
5(a)(i)		4		4
5(a)(ii)	3			3
5(a)(iii)	1			1
5(b)			1	1
Totals	30	36	24	90