OXFORD CAMBRIDGE AND RSA EXAMINATIONS

A2 GCE

F334/01

CHEMISTRY B (SALTERS)

Chemistry of Materials

WEDNESDAY 10 JUNE 2015:

Afternoon

DURATION: 1 hour 30 minutes
plus your additional time allowance

MODIFIED ENLARGED 24pt

Candidate forename		Candidate surname	

Centre number						Candidate number				

Candidates answer on the Question Paper.

OCR SUPPLIED MATERIALS:
Data Sheet for Chemistry B (Salters)
Loose sheet for question 4

OTHER MATERIALS REQUIRED:
Scientific calculator

READ INSTRUCTIONS OVERLEAF

DC (LK/FD) 5335776577 111413/1

INSTRUCTIONS TO CANDIDATES

The Inserts will be found inside this document.

Write your name, centre number and candidate number in the boxes on the first page. Please write clearly and in capital letters.

Use black ink. HB pencil may be used for graphs and diagrams only.

Answer ALL the questions.

Read each question carefully. Make sure you know what you have to do before starting your answer.

Write your answer to each question in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.

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.

A loose sheet showing a diagram for Question 4 is provided as an Insert.

You are advised to show all the steps in any calculations.

The total number of marks for this paper is 90.

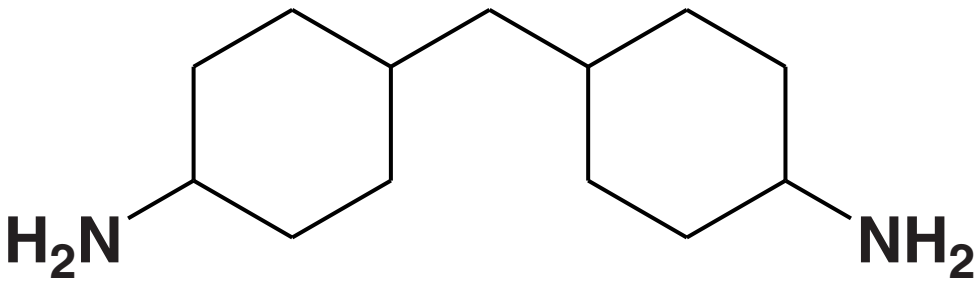
Any blank pages are indicated.

Answer ALL the questions.

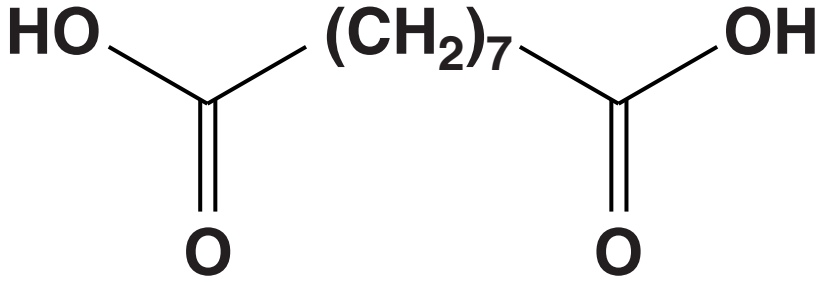
1 Silk is a natural protein fibre. Early attempts to make a substitute 'silk' included the use of a polyester and a polymer called Qiana.

Qiana is made from two monomers, compound A and AZELAIC ACID. Their structures are shown below.

COMPOUND A



AZELAIC ACID



(a) (i) Compound A, a diamine, can be synthesised from its corresponding dichloro compound.

Give the reagent that is used in the laboratory to change a dichloroalkane into a diamine.

_____ **[1]**

(ii) Compound A is a base.

Explain why the amine groups in compound A show basic properties.

_____

_____ **[2]**

(b) Qiana is a condensation polymer.

(i) Underline TWO words from the list below which best describe a condensation reaction.

addition

elimination

neutralisation

rearrangement

redox

substitution

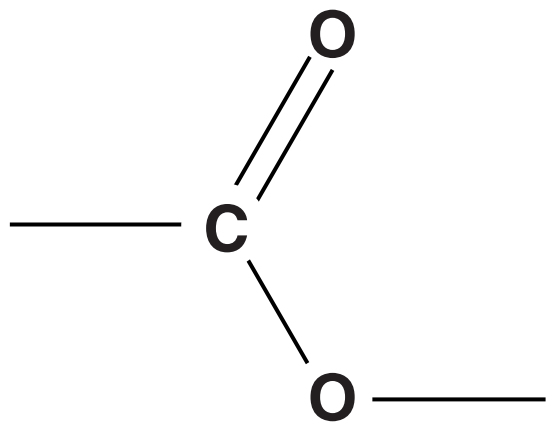
[1]

(ii) Draw the structure of the linkage formed when a molecule of compound A and a molecule of azelaic acid react together.

[1]

(c) **Polyesters can form hydrogen bonds with water molecules.**

On the diagram below, show how a water molecule can hydrogen bond to the ester linkage. Include any relevant partial charges and lone pairs.



[2]

(d) **The problem with clothes made from polyester is that they do not absorb water nearly as well as silk or Qiana. So sweating is a problem when wearing garments made solely from polyester.**

Suggest a reason why Qiana is better at absorbing water than polyester.

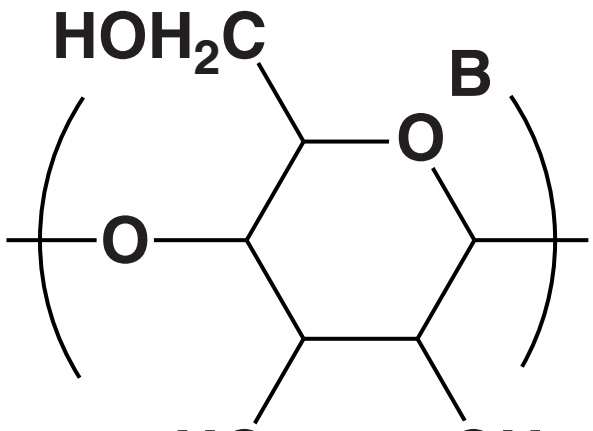
_____

_____ **[1]**

[TOTAL: 8]

2 **Film, used to make motion pictures, consists of a light-sensitive emulsion supported on a 'film base'. The film base is made from a polymer. Most of the polymers were based on cellulose. The repeating unit for cellulose is given below.**

cellulose repeating unit



(a) (i) Name the functional group labelled B in the structure of cellulose.

_____ **[1]**

(ii) CIRCLE a secondary alcohol group on the structure of cellulose shown above. [1]

(iii) **Cellulose is made by condensation reactions of a single monomer.**

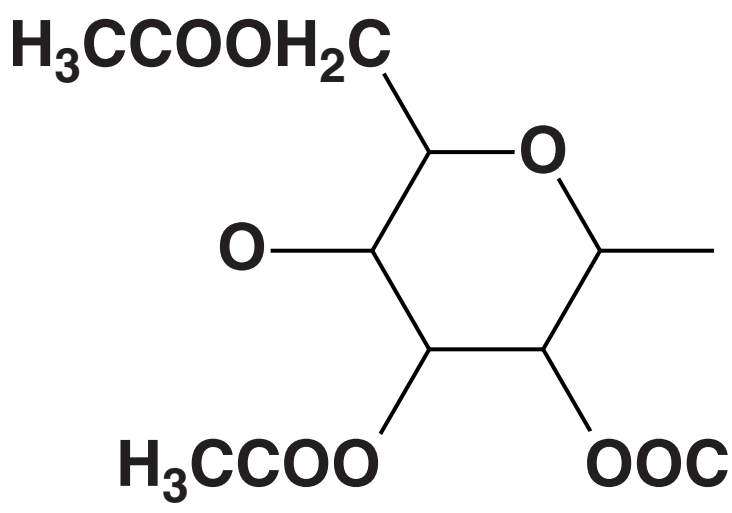
Give the FULL structural formula of the monomer from which cellulose is formed.

[2]

(b) **Some data about the polymers used as a film base are summarised in the table given below. All of the polymers are transparent and flexible at room temperature.**

Name	Cellulose nitrate	Cellulose triethanoate	Polyester
Approximate year introduced	1889	1923	1970s
Action when heated	extremely flammable	melts, does not burn	melts, does not burn
Stability to decomposition at room temperature	can break down explosively	breaks down in warm humid conditions giving off choking vapours	stable
Tensile strength	medium	medium	high

cellulose triethanoate repeating unit



(i) **Give the systematic name for the 'choking vapours' given off when cellulose triethanoate is hydrolysed.**

_____ **[1]**

(ii) **Name all the types of intermolecular bonds between polymer chains in cellulose triethanoate and those in polyester polymers.**

cellulose triethanoate _____

_____

polyesters _____

_____ **[2]**

(iii) **All polyesters have the same linkage.**

Explain what causes different polymers with the same linkage to have different strengths.

_____

_____ **[2]**

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(c) **Cellulose nitrate and cellulose triethanoate films are stored in freezers to slow their breakdown. Under these conditions, however, they tend to shatter.**

Explain this tendency to shatter.

_____

_____

_____

_____ **[3]**

(d) **As well as cellulose triethanoate, cellulose diethanoate can be used for film. Infrared spectroscopy can be used to distinguish between these two films.**

Give evidence from the infrared spectrum opposite to identify which of these two film bases was used.

Explain your answer.

_____

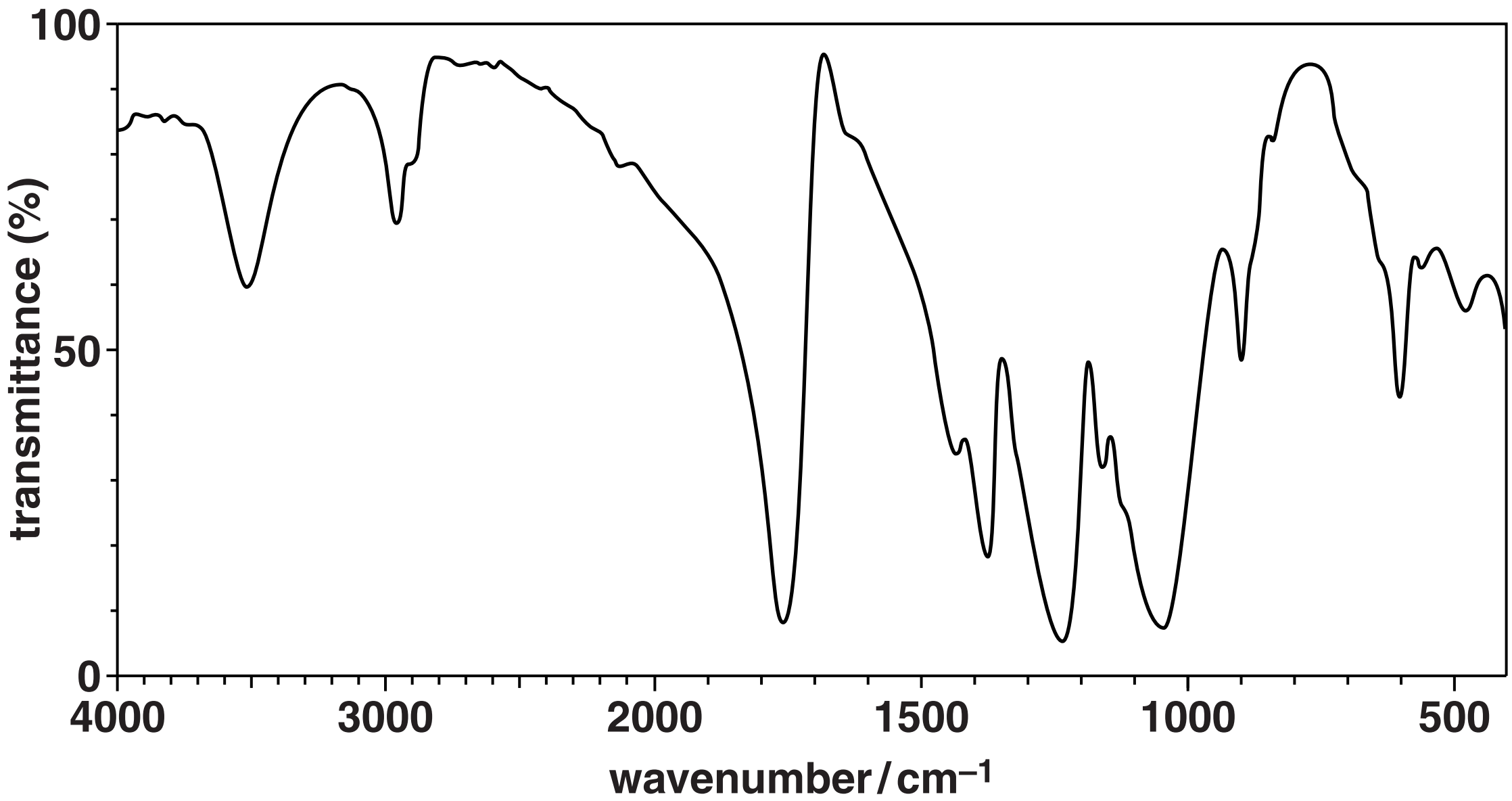
_____

_____

_____ **[2]**

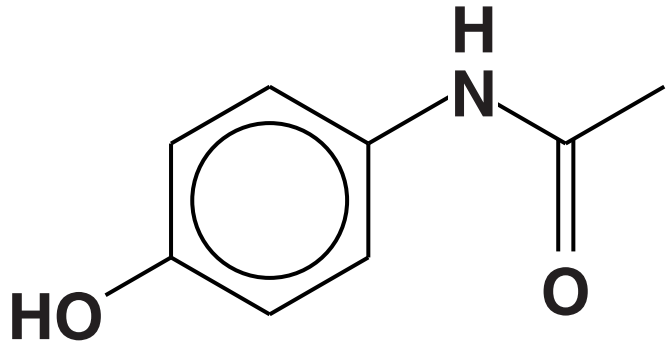
[TOTAL: 14]

13

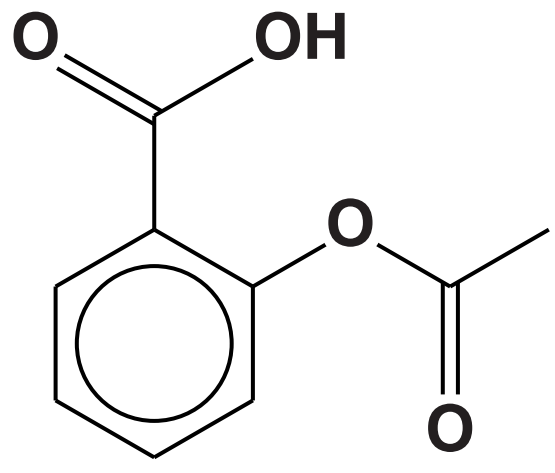

100
50
0
transmittance (%)
4000
3000
2000
1500
1000
500
wavenumber / cm⁻¹

3 Disprin Extra is a medicine containing the active compounds C and D.

COMPOUND C



COMPOUND D



(a) Give TWO chemical tests that will distinguish between compounds C and D.

Choose ONE chemical test that gives a positive result for C and ONE that gives a positive result for D.

Test for C _____

_____

Observations _____

_____

Test for D _____

_____

Observations _____

_____

[4]

(b) Heating a few Disprin Extra tablets under reflux with hydrochloric acid (aqueous) produces a mixture. Two aromatic compounds can be isolated from the mixture.

(i) Draw structural formulae for the two aromatic compounds.

[2]

(ii) **Describe how a student would use thin-layer chromatography to show that a mixture from the hydrolysis of Disprin Extra contains both aromatic compounds.**

[6]

(c) **Disprin Extra tablets have to be stored in a cool dry place. Compound D hydrolyses slowly in moist air at room temperature.**

A student studies how the rate of the hydrolysis in water varies with the concentration of D at 37 °C and a pH of 7.0. The student measures the concentration of D at different time intervals. Some of the results obtained are given below.

time / hours	concentration of D / mol dm^{-3}
0	5.55×10^{-3}
30	4.96×10^{-3}
100	3.83×10^{-3}
220	2.48×10^{-3}
290	1.92×10^{-3}

(i) **Use data from the table to show, without using a graph, that the rate of hydrolysis is first order with respect to D.**

Give your reasoning.

_____

_____

_____ **[3]**

(ii) Calculate the AVERAGE RATE of reaction over the first 290 hours.

average rate of reaction = _____ $mol\,dm^{-3}\,hr^{-1}$ [1]

(iii) Under the conditions of the experiment the rate equation is

$rate = k \times [D]$

The rate of reaction after 30 hours is $4.96 \times 10^{-9}\,mol\,dm^{-3}\,s^{-1}$

Calculate the rate constant.

Give the units of the rate constant.

k = _____ units _____ [2]

(d) Medicines C and D were the result of several years of research to maximise their therapeutic effect and minimise adverse side effects.

(i) Suggest a modification chemists might make to the structures of medicines to make them more effective.

_____

_____ **[1]**

(ii) Explain how combinatorial chemistry can speed up this process.

_____

_____ **[1]**

[TOTAL: 20]

4 In 1908, Henry Ford advertised his Model T car by boasting that 'vanadium steel is used throughout the entire car and has superior properties to other steels'.

(a) The flow diagram on the loose sheet outlines one method of extracting vanadium from its ore, VS_4.

(i) NAME a possible toxic gas given off in STEP 1.

_____ **[1]**

(ii) The anion in VS_4 has the formula S_2^{2-}.

Complete the table below giving the oxidation state of vanadium in each of the four vanadium compounds involved in the extraction process.

Compound	Oxidation state of vanadium
VS_4	
$NaVO_3$	
$Na_2V_6O_{16}$	
V_2O_5	

[2]

(iii) In which of steps 1–3 is vanadium involved in a redox reaction?

Give a reason for your answer.

step(s) _____

reason _____

_____ [2]

(iv) $NaVO_3$ forms a yellow solution with water.

Explain, in terms of frequencies, why solutions of transition metal ions are often coloured.

In your answer, you should use appropriate technical terms, spelled correctly.

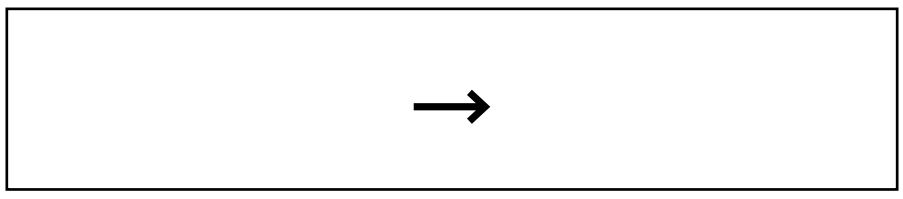
_____

_____

_____

_____ [2]

(v) Give the equation for the reaction in STEP 4. State symbols are not required.



[1]

(b) Vanadium is an expensive resource and it is important that vanadium steels are recycled.

Give ONE reason for adding recycled steel in the steel-making process, other than saving resources.

_____

_____ **[1]**

(c) Some vanadium is used to make compounds for industrial electrochemical batteries.

An industrial 'vanadium battery' uses a half-cell containing V^{2+} and V^{3+} ions with another half-cell using VO_2^+ and VO^{2+} ions.

Some data about vanadium and iodide ions are given below.

TABLE 4.1

half-reaction	$E^{\ominus}$ / V
$V^{3+} + e^- \longrightarrow V^{2+}$	-0.26
$VO^{2+} + 2H^+ + e^- \longrightarrow V^{3+} + H_2O$	+0.34
$I_2 + 2e^- \longrightarrow 2I^-$	+0.54
$VO_2^+ + 2H^+ + e^- \longrightarrow VO^{2+} + H_2O$	+1.00

A student carries out an experiment to find the E_{cell} of a 'vanadium battery'. The student works at room temperature (about 20 °C) and uses approximately 0.1 mol dm^{-3} solutions of each of the ions.

(i) Draw a labelled diagram of the apparatus the student sets up to measure this E_{cell}.

[4]

(ii) Use the data in TABLE 4.1 to calculate a value for this E_{cell}.

E_{cell} = _____ V [1]

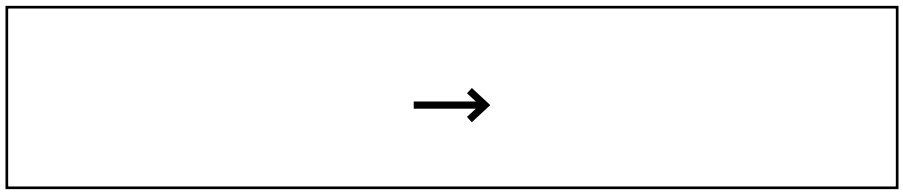
(iii) Give TWO reasons, other than experimental error, why the E_{cell} value that the student measures is different from that calculated in c(ii).

_____

_____

_____ [2]

(iv) **Write an ionic equation for the reaction taking place in the cell in (i) when it is producing a current. State symbols are not required.**



[2]

(v) **The student was going to use a solution of NaI in the salt bridge.**

However, on considering the data in TABLE 4.1 on page 22, the student decided that NaI would react with one of the vanadium ions and so affect the result of the experiment.

Which vanadium ion will NaI react with?

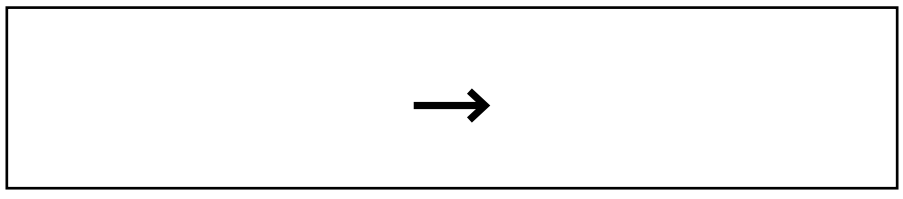
Give your reasoning, including an equation (in the box below) for the reaction taking place.

State symbols are not required.

formula of ion _____

reasoning _____

_____



[2]

(d) The student used a titration method to determine the amount of iron in a piece of vanadium–iron alloy. An outline of the method used is shown below.

STAGE 1.
100 cm^3 of 2.0 mol dm^{-3} sulfuric acid and about 1 g of sodium hydrogencarbonate were added to a conical flask connected to a non-return valve.

STAGE 2.
0.175 g of the wire alloy was added. The mixture was warmed gently until all of the iron in the wire had reacted to form a solution of iron(II) ions.

STAGE 3.
The flask was then cooled and its contents titrated with 0.0216 mol dm^{-3} potassium dichromate(VI).

The student recorded a titre of 23.50 cm^3.

The equation for the reaction between iron(II) ions and dichromate(VI) ions in acid solution is given below.

$$6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \longrightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$$

(i) **Calculate the percentage by mass of iron in the alloy.**

Give your answer to an APPROPRIATE number of significant figures.

percentage = _____ % [5]

(ii) **The non-return valve only allows gases out of the flask. The sodium hydrogencarbonate and the non-return valve are to prevent iron(II) ions being oxidised to iron(III) ions before the end of stage 2.**

Explain how iron(II) could be changed into iron(III) and suggest how sodium hydrogencarbonate and the non-return valve prevent this from occurring.

_____

_____

_____

_____ **[3]**

(e) The student tests another flask at the end of stage 2 for iron(II) ions.

(i) Describe what is seen when excess NaOH is added to an acidified solution of iron(II) ions taken from the flask.

Observations BEFORE addition _____

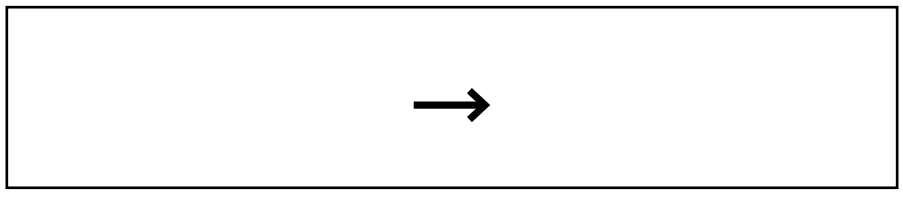
_____

Observations AFTER addition _____

_____

[2]

(ii) Give an ionic equation for the reaction of the iron(II) ions in (i). Include state symbols.



[2]

[TOTAL: 32]

5 **DNA testing or 'genetic fingerprinting' has recently become important to family historians. People pay to have their results in international databases.**

The UK has one of the largest national DNA databases in the world, containing over 6 million records, collected by the police, who are legally allowed to do so. By 2013 some data had to be removed to comply with European law.

(a) Give a reason in each case why people:

choose to have their DNA 'fingerprint' stored

are required to give a DNA sample

after having to give a DNA sample, are allowed to have their data removed.

_____

_____

_____

_____

_____ **[3]**

(b) The structure of DNA is now well-established after Watson and Crick's work in 1953.

In this question refer to the *Data Sheet* for any necessary formulae.

(i) Give the name used to describe a repeating unit in a DNA chain.

_____ **[1]**

(ii) DNA consists of a deoxyribose and phosphate backbone to which four bases are bonded.

Draw the structural formulae of the TWO products formed when one molecule of deoxyribose reacts with a phosphate ion.

[3]

(c) **In a scientific paper in 1953 Watson and Crick wrote 'It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material'.**

Explain:

how the adenine–thymine and guanine–cytosine base pairs are held together, stating the difference between the two different pairs

how the specific pairing 'suggests a copying mechanism' for the replication of DNA.

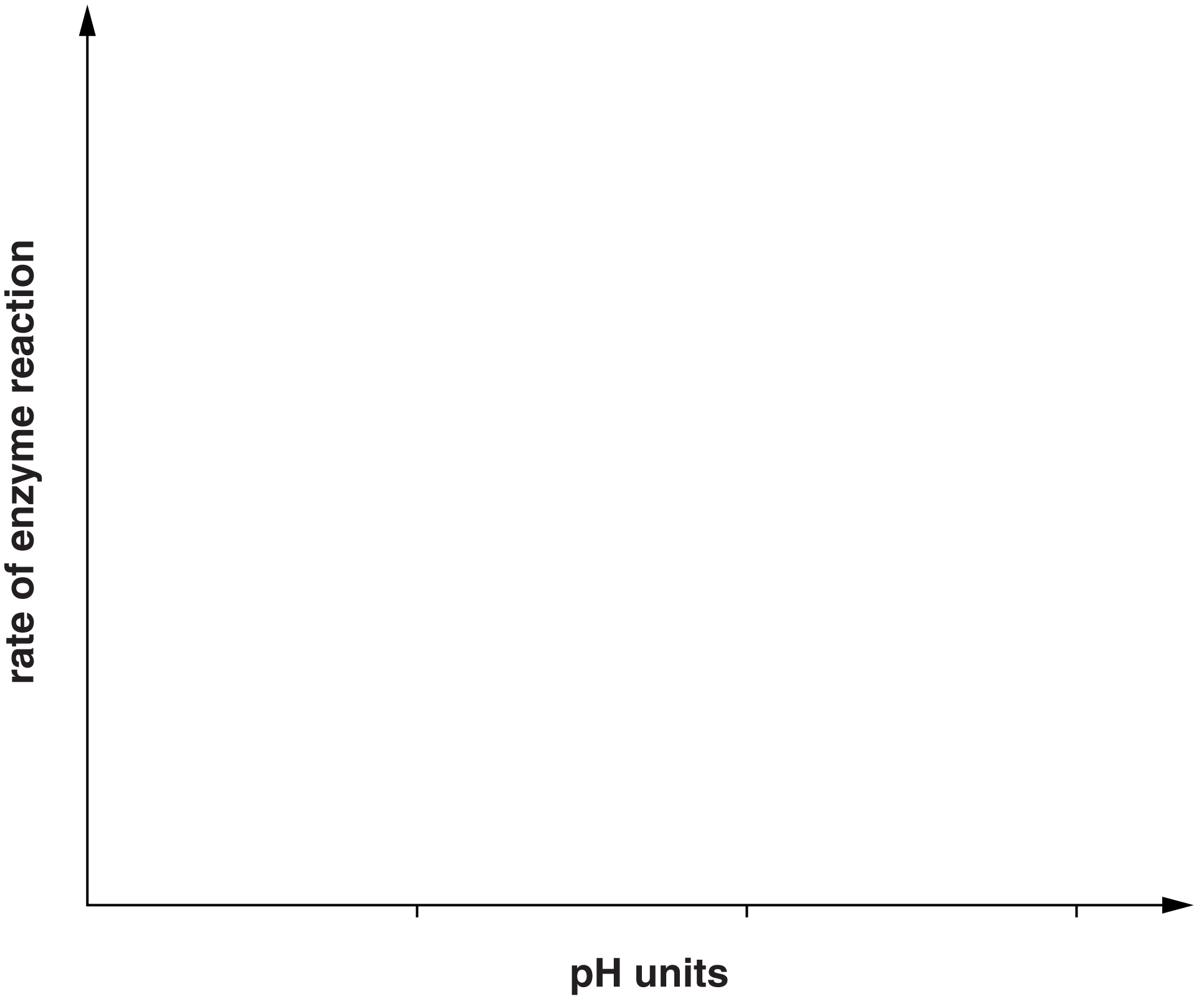
In your answer, you should link the making and breaking of bonds between base pairs to the ability of DNA to replicate itself.

[5]

(d) The copying of DNA is catalysed by enzymes called polymerases.

Draw a curve, using the axes given below, to show how the rate of an enzyme catalysed reaction is affected by pH.

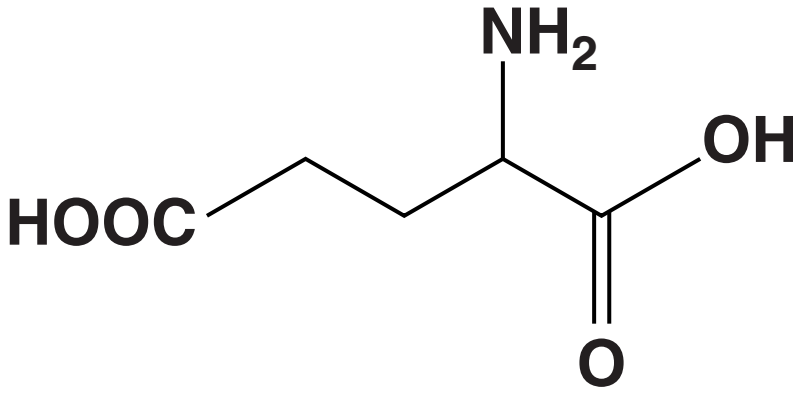
Label the optimum pH for the reaction.



[2]

(e) DNA codes for an amino acid sequence in a protein.

(i) Draw the PART OF A PROTEIN CHAIN formed when two units of the amino acid shown below are joined together.



[1]

(ii) Explain the effect that increasing the pH has on the structure of the part of the protein formed in (i).

_____

_____ **[1]**

[TOTAL: 16]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page. The question number(s) must be clearly shown in the margins.

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