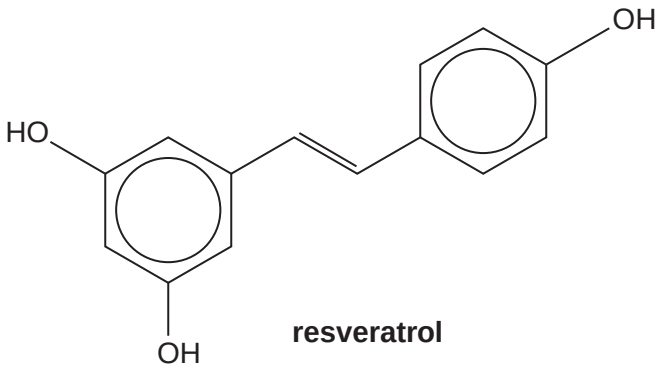
Answer **all** the questions.

1 It is claimed that an ingredient of red wine, resveratrol, has the potential to become a 'wonder drug'. Research suggests that it kills cancer cells and protects the heart and brain.

The structure of resveratrol is shown below.



resveratrol

(a) Give **two** successful outcomes of clinical trials that would be necessary before resveratrol could be marketed as an effective drug.

.....

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

(b) Resveratrol is an *E* isomer.

(i) Draw the structure of the *Z* isomer of resveratrol.

[1]

(ii) Explain why resveratrol and its *Z* isomer show *E/Z* isomerism.

.....

.....

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

(iii) Suggest why the two stereoisomers would be expected to have different activities in the body.

.....

.....

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

(c) Resveratrol is a white solid that can be purified by recrystallisation.

What properties should a solvent have to achieve efficient recrystallisation?

.....

.....

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

(d) Although resveratrol is insoluble in water, it reacts with aqueous sodium hydroxide to form a solution.

(i) Explain why resveratrol reacts with aqueous sodium hydroxide and suggest why the products are soluble in water.

In your answer, you should make it clear how the solubility of a substance depends on its structure.

.....

.....

.....

.....

.....

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

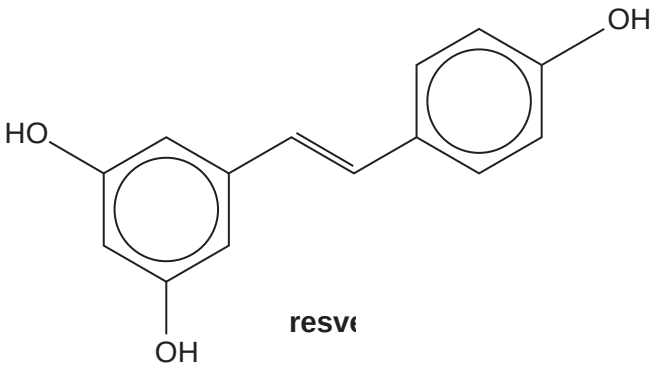
(ii) Using the formula $C_{14}H_{12}O_3$ for resveratrol, write an equation for its reaction with an excess of hydroxide ions.

Show any relevant charges.

$C_{14}H_{12}O_3 \quad + \qquad \rightarrow$

[2]

Turn over



resve

(e) Mass spectrometry can be used to confirm the structure of resveratrol.

The molecular ion peak occurs at mass (*m/z*) 228. There is also a peak at mass 211 and another at mass 93.

(i) Suggest a formula for the chemical species causing the peak in the mass spectrum at mass 93.

[2]

(ii) Suggest a formula for the group of atoms lost from the molecular ion to produce the chemical species causing the peak at mass 211.

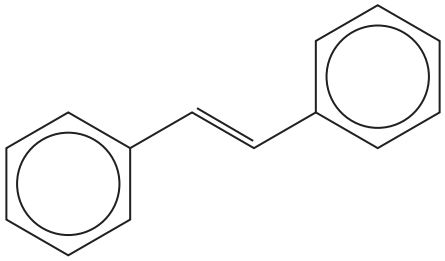
[1]

(f) **One mole** of resveratrol was reacted with **one mole** of ethanoyl chloride.

(i) **Name** the new functional group formed.

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

(ii) Complete the diagram below to show the formula of a possible organic product of this reaction. Show the structure of the new functional group.



[3]

[Total: 22]

2 Water is often purified by treatment with ozone. However, any bromide ions present are converted into bromate ions, BrO_3^-, by the reaction given in **equation 2.1**. Bromate ions are toxic, and so must be removed.

$$Br^- + O_3 \rightarrow BrO_3^- \qquad \textbf{equation 2.1}$$

....

(a) (i) Write the appropriate oxidation states on the dotted lines under **equation 2.1**. **[3]**

(ii) Give the reducing agent in **equation 2.1** and explain your choice using your answers to **(i)**.

reducing agent .....

explanation .....

.....

.....

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

(b) One way of removing toxic bromate ions is to react the bromate ions with iodide ions. The equation for the reaction is given in **equation 2.2**.

$$BrO_3^-(aq) + 6I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l) + Br^-(aq) \qquad \textbf{equation 2.2}$$

The rate of this reaction can be studied in a school laboratory at room temperature.

(i) Suggest how you could follow the rate of this reaction.

In your answer you should state what property you would measure, the substance involved and the method that you would use.

property .....

substance .....

method .....

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

(ii) A student studied the rate of this reaction and obtained the results given in **Table 2.1**.

Table 2.1

expt.	$[BrO_3^-(aq)]$ /mol dm^{-3}	$[I^-(aq)]$ /mol dm^{-3}	$[H^+(aq)]$ /mol dm^{-3}	relative initial rate
1	0.10	0.10	0.10	1
2	0.20	0.10	0.10	1
3	0.20	0.10	0.20	2
4	0.20	0.20	0.10	4

Use the data in **Table 2.1** to find the order of reaction for each reactant.

$BrO_3^-(aq)$ = ... $I^-(aq)$ = ... $H^+(aq)$ = ... **[3]**

(iii) Some errors were made in the experimental work and the correct rate equation is actually as shown below.

$$\text{rate} = k \times [BrO_3^-(aq)] \times [I^-(aq)] \times [H^+(aq)]^2$$

Using correct procedures, the rate of reaction in **experiment 2** was found to be 2.4×10^{-3} mol dm^{-3} s^{-1}.

Use these data and the correct rate equation to calculate a value for the rate constant, *k*, giving its units.

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

rate constant = ... units = ... **[3]**

(iv) The rates of reaction were measured when the amounts of reactants used up were **small** in comparison to the total quantities of reactants present.

Explain why it is necessary to do this.

.....

.....

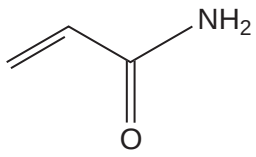
.....

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

[Total: 16]

PLEASE TURN OVER FOR QUESTIONS 3, 4 AND 5

3 Compound **A**, $C_2H_3CONH_2$, is a suspected carcinogen. It has recently been shown to be formed in starchy foods when they are heated at high temperatures such as those involved in frying or roasting. The structure of compound **A** is shown below.



compound **A**

(a) (i) **Name** the functional groups in compound **A**.

.....

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

(ii) Compound **A** can be broken down by hydrolysis in aqueous acid or alkali.

In the appropriate boxes below, complete the equations for the reaction of compound **A** with acid and with alkali.

$C_2H_3CONH_2 + H_2O + H^+ \rightarrow$

$C_2H_3CONH_2 + OH^- \rightarrow$

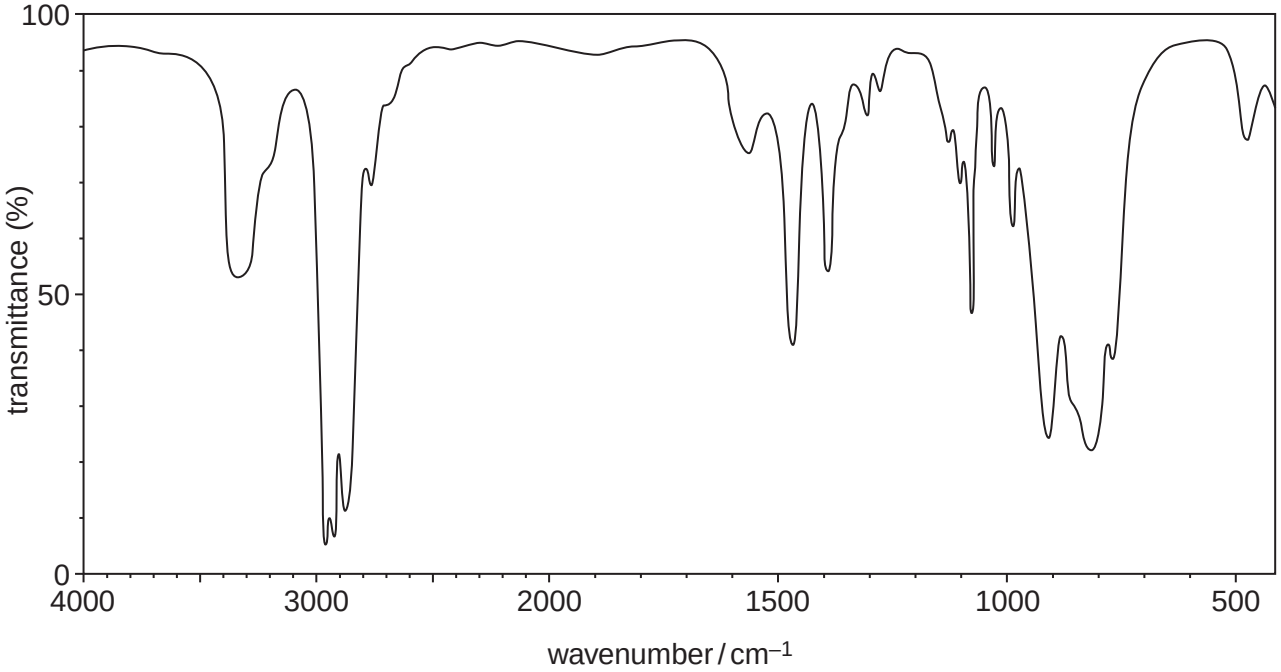
[4]

(b) Compound **A** can be catalytically reduced to compound **B**, $C_3H_7NH_2$.

(i) **Name** compound **B**.

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

(ii) A student attempted the reduction of compound **A**. The infrared spectrum of the product is shown below.



The spectrum shows that the student was successful and that all compound **A** had been reduced.

Give **two** pieces of evidence to justify these conclusions.

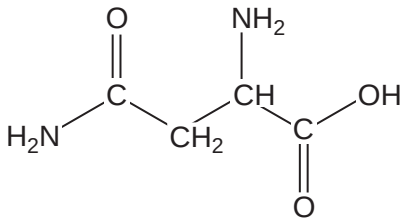
.....

.....

.....

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

(c) Compound **A** is formed when asparagine in food is reduced by sugar. The structure of asparagine is shown below.



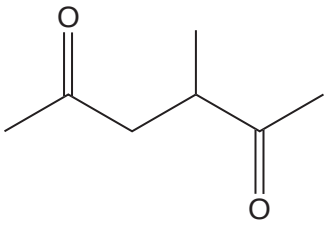
asparagine

(i) Explain why the NH_2 group in asparagine can behave as a base.

.....

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

(ii) Complete the diagram below to show the structure of the zwitterion formed by asparagine.



[1]

(iii) Asparagine can exist as two enantiomers.

Explain the meaning of the term *enantiomers*.

.....

.....

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

(d) Asparagine, Asn, is an important constituent of many proteins.

A codon for asparagine is AAU.

(i) Use information from the *Data Sheet* to give the anticodon of this codon.

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

(ii) Use information from the *Data Sheet* and that given above to answer this part.
In your answer you should use three-letter abbreviations for the amino acids.

Predict the amino acid sequence obtained using mRNA with the following sequence of bases.

GCCAAUGUC

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

[Total: 17]

PLEASE TURN OVER FOR QUESTIONS 4 AND 5

4 'Slush powders', also called superabsorbent polymers, can absorb and retain large amounts of liquid, commonly water. Most 'slush powders' are based on poly(acrylic acid) and its derivatives.

Acrylic acid has the formula $CH_2CHCOOH$.

(a) Draw the full structural formula of the repeating unit of the polymer poly(acrylic acid).

[2]

(b) To be effective as a superabsorbent polymer, the poly(acrylic acid) has to be modified. A modification involves cross-linking the polymer chains.
Two methods can be used to achieve this cross-linking.

(i) **Method 1** uses a co-polymer which has alkene side groups. The unsaturated side groups on different polymer chains can react together to form cross-links.

Name the **type** of reaction that occurs between the unsaturated side-groups.

Explain how the cross-links are formed.

.....

.....

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

(ii) **Method 2** uses reagents which cross-link the polymer chains by forming ester links with the carboxylic acid side groups.

Give the structural formula of a suitable reagent and name the **type** of reaction that occurs when the ester links are formed.

type of reaction..... **[3]**

(iii) **Method 1** has the higher atom economy. Explain why.

.....

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

(c) Another modification of the poly(acrylic acid) involves converting carboxylic acid groups into carboxylate ions.

(i) Name a suitable reagent for converting a carboxylic acid group into a carboxylate ion.

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

(ii) Draw the full structural formula of the carboxylate ion formed from ethanoic acid.

[1]

(iii) Cross-linked poly(acrylic acid) does not dissolve when water is added.
Poly(acrylic) acid without cross-links eventually dissolves when sufficient water is added.

Suggest and explain a reason for this difference in properties.

.....

.....

.....

.....

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

QUESTION 4 CONTINUES ON PAGE 16

(d) A student used a colorimeter to investigate how much water was absorbed by a sample of a super-absorbent polymer. He added 1.0 g of the polymer to a measured volume of water containing a blue dye. The molecules of the blue dye are not absorbed by the polymer.

(i) Explain how the concentration of the blue dye changed with time after the polymer had been added to the water.

.....

.....

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

(ii) The student worked out that the water absorbency of this polymer can be deduced from the change in concentration of the blue dye.

Describe how the student used a colorimeter to find out how the concentration of the blue dye changed when added to the polymer.

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

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.....

.....

.....

.....

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.....

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

(e) One of the most important uses for super-absorbent polymers is in the manufacture of disposable hygiene products such as nappies.

Suggest and explain a reason why it is much easier to recycle the super-absorbent polymers from used nappies than the polymers from a mixture of used packaging.

.....

.....

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

[Total: 20]

5 NiCd rechargeable batteries use the reaction between cadmium and nickel(IV) oxide to produce an electric current. The electrolyte is a concentrated solution of hydroxide ions.

Table 5.1

half-reaction	$E^{\ominus}$/V
$Cd(OH)_2 + 2e^- \rightarrow Cd + 2OH^-$	–0.81
$NiO_2 + 2H_2O + 2e^- \rightarrow Ni(OH)_2 + 2OH^-$	+0.49

(a) (i) Use the data in **Table 5.1** to calculate the $E^{\ominus}_{cell}$ value for the reaction that takes place in a nickel–cadmium cell when it delivers a current.

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

(ii) The voltage of a 'NiCd battery', measured with a high resistance voltmeter, is about 1.2V. Suggest why your answer to **(i)** differs from this value.

.....

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

(iii) A 'NiCd battery' can be recharged by using an electric current to reverse the reaction. Give the equation for the overall reaction occurring when the 'battery' is being recharged.

$\rightarrow$

[1]

(b) NiCd batteries have to be carefully disposed of because cadmium and its compounds are toxic. 'Super-iron' batteries have an iron-based cathode using potassium ferrate, K_2FeO_4, a powerful oxidising agent. When super-iron batteries are used, the reaction produces iron(III) oxide (rust).

Suggest reasons why potassium ferrate has been called a 'green' oxidising agent and why super-iron batteries would be more environmentally friendly to dispose of than NiCd batteries.

.....

.....

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

Turn over

(c) Potassium ferrate can also be used to oxidise NO_2^- ions in the purification of contaminated water. The equation for the reaction is given below.

$$2K_2FeO_4 + 3NO_2^- + 2H_2O \rightarrow Fe_2O_3 + 3NO_3^- + 4KOH$$

The concentration of NO_2^- ions in a sample of impure water is 6.0×10^{-6} mol dm^{-3}.
What is the minimum mass of solid potassium ferrate needed to oxidise all of the NO_2^- ions in **1000 dm^3** of the impure water?

mass of potassium ferrate = ... g **[4]**

(d) When Fe_2O_3 is added to dilute acid, a complex ion having the formula $[Fe(H_2O)_6]^{3+}$ is formed.

(i) Complete the table below about this complex ion.

name of shape of ion	
coordination number of Fe	
colour of ion in water	

[3]

(ii) When an excess of aqueous sodium hydroxide is added to a solution of this complex ion a precipitate forms.

Complete the ionic equation for the formation of this precipitate. Include state symbols.

Fe^{3+} $\rightarrow$

[2]

(iii) Give the outer electron structure for Fe^{3+} by drawing arrows in the appropriate boxes.

	3d					**4s**
Fe^{3+}						

[1]

[Total: 15]

END OF QUESTION PAPER