



## Questions

Q1.

Organic compounds containing nitrogen include amides, amines, amino acids and nitriles.

\* Alanine and glycine are amino acids.

Amino acid	Structure
alanine	
glycine	

Compare and contrast the structures, optical activity and reactions with acids and bases of alanine and glycine.

Include diagrams, structures and equations to illustrate your answer.

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**Q2.**

This is a question about polymerisation.

PLA is a biodegradable polyester which is made from 2-hydroxypropanoic acid,  $\text{CH}_3\text{CH}(\text{OH})\text{COOH}$ .

(i) Draw the two enantiomers of 2-hydroxypropanoic acid.

(2)

(ii) State how separate samples of these two enantiomers could be distinguished in a laboratory.

(1)

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(iii) Biodegradable polyesters break down naturally.

State why this is an advantage.

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**(Total for question = 4 marks)**



**Q3.**

This is a question about the hydrolysis of halogenoalkanes.

The product of the hydrolysis of 2-bromobutane is butan-2-ol. Both molecules are chiral.

State what is meant by the term chiral, using three-dimensional diagrams of the enantiomers of butan-2-ol to illustrate your answer.

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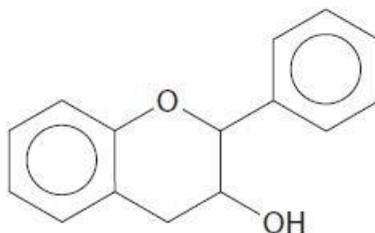
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**(Total for question = 3 marks)**



Q4.

The compound flavan-3-ol is found in tea, fruit and wine.



Clearly label all the chiral carbon atoms in flavan-3-ol.

(Total for question = 1 mark)



Q5.

Answer the questions with a cross in the boxes you think are correct . If you change your mind about an answer, put a line through the box  and then mark your new answer with a cross .

Methyl cinnamate,  $C_{10}H_{10}O_2$ , is a white crystalline solid used in the perfume industry.

Methyl cinnamate undergoes an addition reaction in the dark with bromine.

- (i) Draw the mechanism for the reaction between methyl cinnamate and bromine,  $Br_2$ .  
Include curly arrows, and relevant lone pairs and dipoles.

(4)

- (ii) Deduce the number of optical isomers of the addition product that can exist.

(1)

- A 2  
 B 3  
 C 4  
 D 8

- (iii) When plane-polarised light is passed through an optical isomer, the plane of polarisation is

(1)

- A diffracted  
 B reflected  
 C refracted  
 D rotated

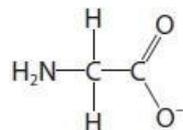
(Total for question = 6 marks)



Q6.

Some organic compounds contain metals.

Glycinate ions are formed from the amino acid glycine.



glycinate ion

- (i) Explain the effect, if any, of an aqueous solution containing glycinate ions on plane-polarised monochromatic light.

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- (ii) A hot aqueous solution of glycine is added to a hot solution of copper(II) ethanoate. When the mixture is cooled, crystals of copper(II) glycinate are formed. Write the equation for this reaction. State symbols are not required.

(2)



(iii) In an experiment, the crystals are filtered, weighed and the percentage yield calculated.

Student 1 obtained a yield of 102.6%.

Student 2 obtained a yield of 56.4%.

The expected yield is 82% and the students carried out the calculation correctly.

Discuss possible reasons for the yields obtained by these students.

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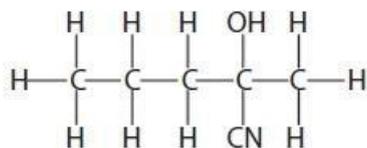
**(Total for question = 8 marks)**



Q7.

This question is about some carbonyl compounds with the molecular formula  $C_5H_{10}O$ .

Pentan-2-one reacts with hydrogen cyanide in the presence of cyanide ions to form 2-hydroxy-2-methylpentanenitrile.



2-hydroxy-2-methylpentanenitrile

(i) Draw the mechanism for the reaction between pentan-2-one and hydrogen cyanide in the presence of cyanide ions.

Include curly arrows and any relevant lone pairs.

(4)

(ii) The product of this reaction, 2-hydroxy-2-methylpentanenitrile, has a chiral centre.

Explain why a racemic mixture of 2-hydroxy-2-methylpentanenitrile is formed in this reaction.

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**(Total for question = 6 marks)**



Q8.

2-bromobutane can react with aqueous hydroxide ions by an  $S_N1$  mechanism.

Explain why the butan-2-ol produced from a single optical isomer of 2-bromobutane, using this mechanism, is **not** optically active.

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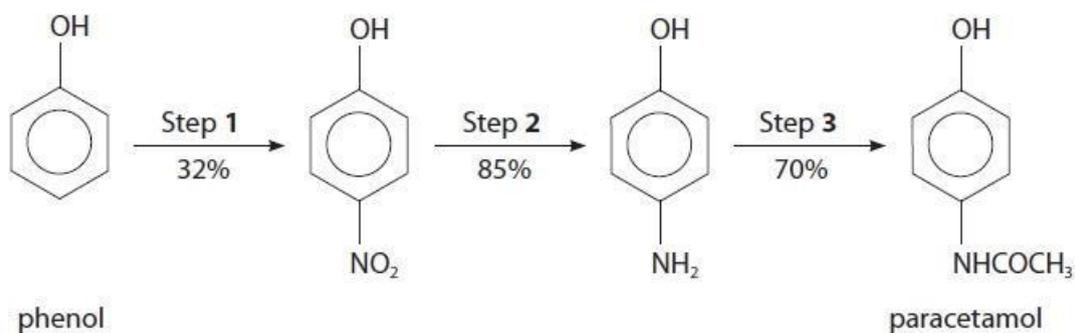
(Total for question = 3 marks)



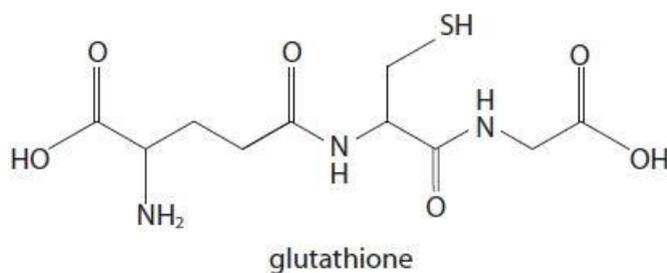
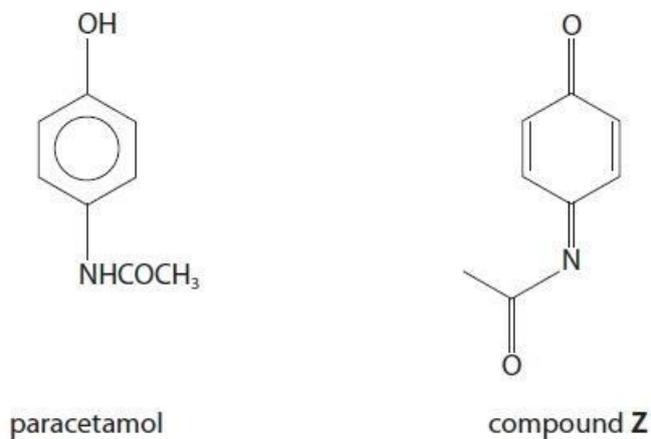
Q9.

Answer the question with a cross in the box you think is correct  . If you change your mind about an answer, put a line through the box  and then mark your new answer with a cross  .

The painkiller paracetamol can be synthesised from phenol in three steps. The percentage yield for each step is shown.



When metabolised in the body, paracetamol forms a toxic compound **Z**. This is then removed in the liver by a reaction with the tripeptide glutathione.





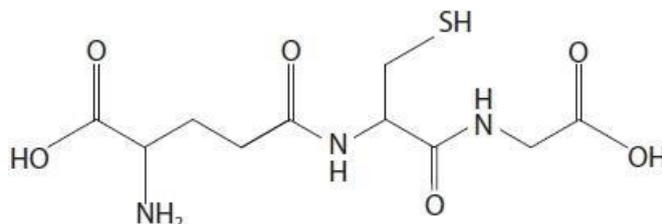
(i) The conversion of paracetamol to compound **Z** is

(1)

- A** addition  
 **B** hydrolysis  
 **C** oxidation  
 **D** reduction

(ii) Draw a circle around each of the chiral carbon atoms in glutathione.

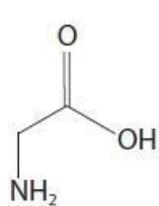
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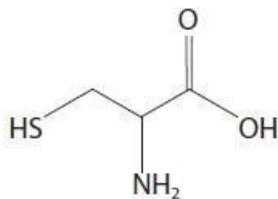
(iii) Glutathione is formed from glycine and two other amino acids.

Which two amino acids combine with glycine to form glutathione?

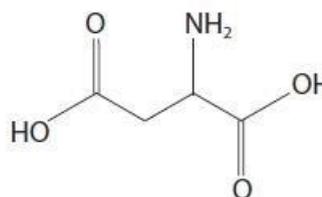
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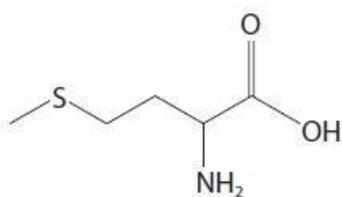
glycine



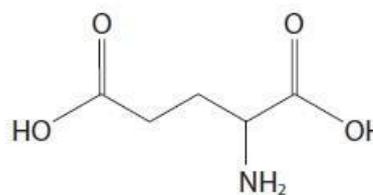
cysteine



aspartic acid



methionine



glutamic acid

- A** aspartic acid and cysteine  
 **B** glutamic acid and cysteine  
 **C** glutamic acid and methionine  
 **D** aspartic acid and methionine

(Total for question = 4 marks)



## Q10.

(a) This question is about the analysis of an unknown carboxylic acid **X** by three students.

The students analyse the mass spectrum of **X** and find that it has a molecular ion peak at  $m/z = 116$ .

The three students each propose a different structural formula for compound **X**.

**Structure 1**  $\text{HOOCCH}=\text{CHCOOH}$

**Structure 2**  $\text{HOCH}_2\text{CH}=\text{CHCH}_2\text{COOH}$

**Structure 3**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$

The students are given the infrared spectrum of **X**.

(i) State **two** wavenumber ranges of the infrared absorptions providing evidence that compound **X** is a carboxylic acid. Include the bonds responsible.

(2)

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(ii) One of the students suggests that this infrared spectrum and the data in the Data Booklet **alone** could be used to identify which of the three proposed structures is **X**.

Show that this student's suggestion is correct. Include relevant infrared data in your answer.

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(b) The students decide to carry out an acid-base titration to obtain further information about compound **X**.

Each student uses solid sodium hydroxide, NaOH, to prepare a solution of concentration  $0.140 \text{ mol dm}^{-3}$ .

Calculate the mass, in grams, of solid sodium hydroxide that each student should weigh out to prepare  $250.0 \text{ cm}^3$  of a  $0.140 \text{ mol dm}^{-3}$  solution.

(2)

(c) Each of the students makes up  $250.0 \text{ cm}^3$  of  $0.140 \text{ mol dm}^{-3}$  sodium hydroxide solution in a volumetric flask and titrates this solution with the same solution of **X** of known concentration.

### Student A

- correctly prepares the  $0.140 \text{ mol dm}^{-3}$  sodium hydroxide solution and pipettes a volume of  $10.0 \text{ cm}^3$  of the solution into a conical flask
- fills a burette with the solution of **X** and carries out a titration
- repeats the procedure until obtaining concordant results
- obtains a mean titre of  $10.20 \text{ cm}^3$ .

### Student B

- dissolves the sodium hydroxide in distilled water and transfers the solution to a volumetric flask
- adds more distilled water to the volumetric flask and mixes the solution
- notices that the volumetric flask has been filled with distilled water several  $\text{cm}^3$  beyond the graduation mark
- realises the mistake, removes the extra solution and discards it
- pipettes  $10.0 \text{ cm}^3$  of the sodium hydroxide solution into a conical flask and titrates this with the solution of **X**.

### Student C

- correctly prepares the  $0.140 \text{ mol dm}^{-3}$  sodium hydroxide solution
- washes a conical flask thoroughly with distilled water and pipettes  $10.0 \text{ cm}^3$  of the sodium hydroxide solution into the wet conical flask
- titrates the contents of the conical flask with the solution of **X**.



(i) Explain how, if at all, Student **B**'s mistake affects the value of the titre.

(2)

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(ii) Explain how, if at all, Student **C**'s use of a wet conical flask affects the value of the titre.

(2)

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(iii) Student **A** uses three pieces of apparatus to measure volumes in this experiment.

- The burette has an uncertainty of  $\pm 0.05 \text{ cm}^3$  for each volume reading
- The volumetric flask has an uncertainty of  $\pm 0.30 \text{ cm}^3$  for the volume
- The pipette has an uncertainty of  $\pm 0.04 \text{ cm}^3$  for the volume

Show by calculation which volume measurement has the lowest percentage uncertainty.

(3)



(d) Student **A** calculates the correct value for the molar mass of compound **X**, using the mean titre of  $10.20 \text{ cm}^3$ . The results indicate that **X** has **structure 1**.

**Structure 1**  $\text{HOOCCH}=\text{CHCOOH}$

**Structure 2**  $\text{HOCH}_2\text{CH}=\text{CHCH}_2\text{COOH}$

**Structure 3**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$

(i) Write the equation for the reaction between **structure 1** and sodium hydroxide solution. State symbols are not required.

(2)

(ii) Deduce the value that would have been obtained for the mean titre if the structural formula of **X** had been **structure 2**.

Justify your answer.

(2)

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(e) The students could have identified the three structures using chemical tests.

Complete the table to show whether or not the suggested structures react with bromine water and when heated with acidified potassium dichromate(VI).

Use a tick (✓) if a reaction occurs.

Use a cross (x) if no reaction occurs.

(2)

Structure	Test with bromine water	Test with acidified potassium dichromate(VI)
$\text{HOOCCH}=\text{CHCOOH}$		
$\text{HOCH}_2\text{CH}=\text{CHCH}_2\text{COOH}$		
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$		

(f) The structure  $\text{HOOCCH}=\text{CHCOOH}$  has two stereoisomers.

(i) Draw the structures of these stereoisomers.

(2)

**E-isomer**

**Z-isomer**

(ii) State why  $\text{HOOCCH}=\text{CHCOOH}$  has *E/Z* isomers.

(2)

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**(Total for question = 24 marks)**



Q11.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box  and then mark your new answer with a cross .

This question is about alcohols and their reactions.

- (i) Some alcohols react with concentrated phosphoric acid to form alkenes.  
What is the type of this reaction?

(1)

- A addition  
 B elimination  
 C oxidation  
 D substitution

- (ii) When butan-2-ol reacts with concentrated phosphoric acid, two stereoisomers are formed.

Explain what is meant by the term stereoisomers.

(2)

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- (iii) Draw the structures and give the names of the two stereoisomers.

(2)

Stereoisomer 1	Stereoisomer 2
Name:	Name:

- (iv) Name this type of stereoisomerism.

(1)

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(Total for question = 6 marks)