GCE A LEVEL CHEMISTRY

S21-A410

Assessment Resource C

Organic Chemistry and Analysis

1. Draw the structure for a compound of formula C_3H_8O that shows an infrared absorption peak between 1000 and 1300 cm^{-1} but no peak between 2500 and 3550 cm^{-1}, other than that at 2800-3100 cm^{-1} corresponding to C—H bonds. Give your reasoning. [2]

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2. *(a)* Give the structure of the organic compound produced when 2-hydroxybenzenecarboxylic acid reacts with ethanoyl chloride. [1]

(b) If the product in *(a)* was contaminated with unreacted 2-hydroxybenzenecarboxylic acid, describe a chemical test that would show its presence. State the reagents used and the observation made. [2]

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3.

(a) Explain why amino acids are amphoteric compounds. [1]

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(b) If an amino acid is treated with methanal, the resulting compound can be titrated against sodium hydroxide solution in a 1:1 ratio.

4.95 g of an amino acid was treated with methanal and the resulting solution made up to 250 cm^3. 25.0 cm^3 of this solution was then titrated with sodium hydroxide of concentration 0.105 mol dm^{-3}. The results are shown in the table below.

Titration	1	2	3	4	5
NaOH(aq) used / cm^3	38.70	35.90	36.00	32.00	36.10

(i) Suggest a practical reason why the reading for titration 1 was too high. [1]

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(ii)   Use appropriate titration values to calculate the relative molecular mass of the amino acid. [5]
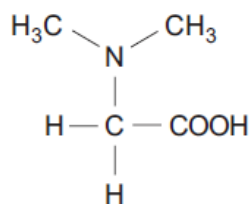
M_r = ...

(iii) Assuming that the amino acid in part (ii) is a straight chain aliphatic α-amino acid deduce its structure. [2]

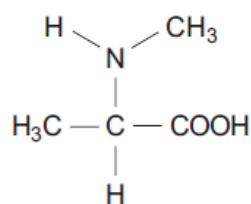(c) The formulae of three amino acids are shown below.

$$H_2N-CH(H)-COOH \quad (CH_3)_2N-CH(H)-COOH \quad CH_3(H)N-C(CH_3)(H)-COOH$$
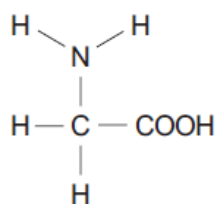
compound **R**   compound **S**   compound **T**

(i) State which of the three compounds could be identified by its ability to rotate the plane of plane polarised light. Give a reason for your answer. [1]

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(ii) State how the infrared absorption spectrum of compounds **S** and **T** would differ from each other in their significant functional group absorption(s). [1]

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(iii) State which of these amino acids would **not** be able to form two **different** dipeptides with either of the other two amino acids. Explain your answer. [1]

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(d) Nylon-11 is a bio-sourced polyamide which is made from castor oil. Undec-10-enoic acid is produced as an intermediate compound. This acid is reacted, under suitable conditions, to give 11-bromoundecanoic acid, which is then treated with ammonia to produce 11-aminoundecanoic acid. Polymerisation of this product gives nylon-11.
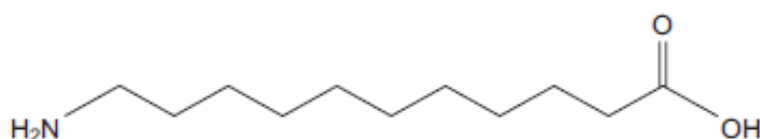

undec-10-enoic acid

HBr

11-bromoundecanoic acid

NH₃
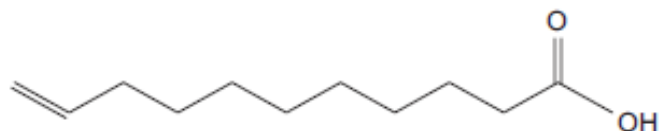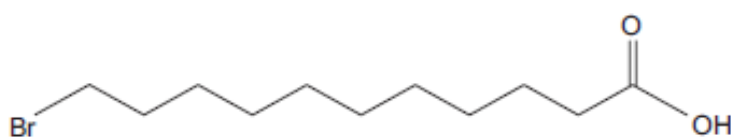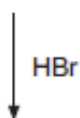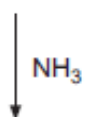
11-aminoundecanoic acid

(i) The addition of hydrogen bromide to undec-10-enoic acid would give 10-bromoundecanoic acid as the major product. Explain why this is the case. [1]

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(ii) The bromo-compound reacts with ammonia to produce 11-aminoundecanoic acid.

One step in the mechanism for this reaction is shown below.
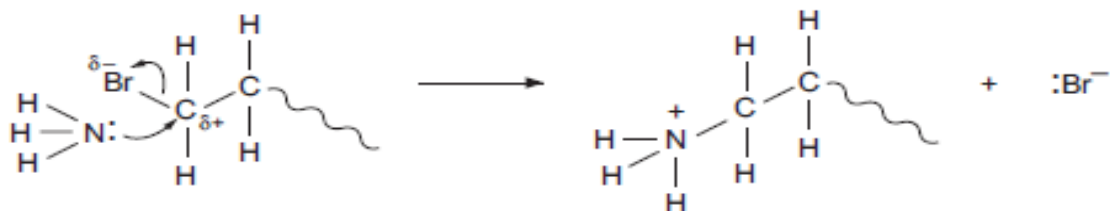
I. Explain how partial charges ($\delta+$ and $\delta-$) arise on the carbon and bromine atoms. [1]

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II. State the role of ammonia in this reaction. [1]

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(iii) Draw the structure of nylon-11, indicating the repeating unit present.

The formula of 11-aminoundecanoic acid is shown below. [1]
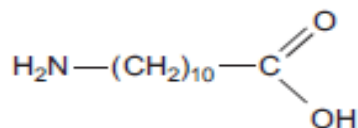
4. *(a)* (i) Describe the structure and bonding in benzene. Explain why benzene is resistant to addition reactions and why its usual mode of reaction is by substitution.

You may include a diagram as part of your answer. [4]

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(ii) Benzene is an example of an aromatic compound. There are a number of other aromatic systems. One of these is pyrrole.

   I. Pyrrole can be made by reacting butan-1,4-dial with ammonia.
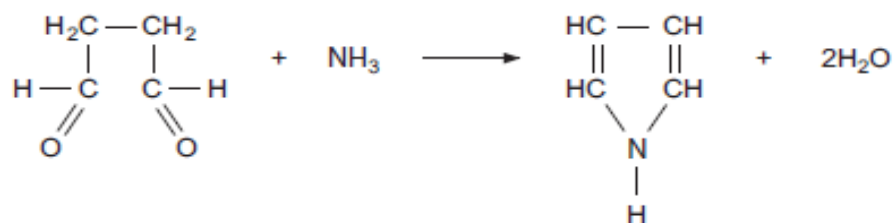
     Calculate the atom economy of this reaction. [2]

Atom economy = ... %

   II. Pyrrole reacts in a similar way to benzene, although it is more reactive.

For example, pyrrole reacts readily with iodine to produce 2,3,4,5-tetraiodopyrrole.
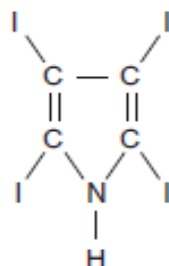
Suggest the balanced equation for the reaction between iodine and pyrrole, leading to 2,3,4,5-tetraiodopyrrole. [1]

(b) Diseases caused by sucking insects are a major problem in hot countries. Extensive research has been carried out to find compounds that are deterrents against these insects. One of the these compounds is DEPA.
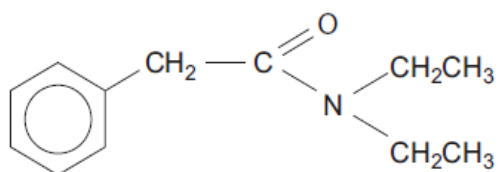
DEPA

(i) In the first stage of a synthesis of DEPA, methylbenzene [M_r 92.1] reacts with chlorine until the increase in mass indicates that (chloromethyl)benzene, $C_6H_5CH_2Cl$ [M_r 126.6] has been produced.

In an experiment 0.430 mol of methylbenzene was used. Calculate the increase in mass that will indicate that the conversion to $C_6H_5CH_2Cl$ is complete. [2]

Increase in mass = ... g

(ii) Suggest a three stage synthesis of phenylethanoic acid ($C_6H_5CH_2COOH$) starting from methylbenzene. In the first stage, methylbenzene reacts with chlorine in a similar way to the reaction of chlorine with methane.

For each stage you should state the reactants and the products as well as any important conditions, relevant equations and the type of reaction or mechanism occurring. [6 QER]

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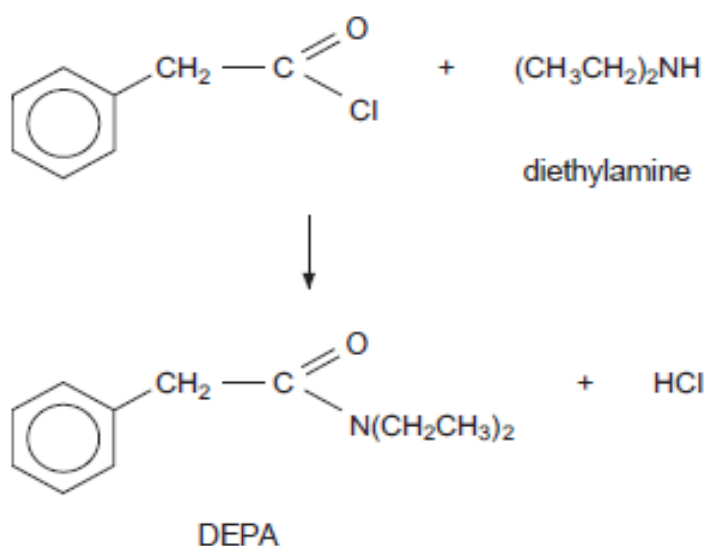
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(iii) The overall yield of phenylethanoic acid, starting from methylbenzene, was 65%.

Calculate the mass of phenylethanoic acid [M_r 136] formed from 0.430 mol of methylbenzene. [1]

Mass = ... g

(iv)   The final stage to make DEPA is shown in the equation below.

A teacher asked some students for suggestions as to how this reaction should be carried out.

I.   One student suggested that the reaction could be carried out using water as the solvent.

Suggest why this method might give a very poor yield of DEPA.   [1]

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II.   Another suggestion was that an excess of diethylamine should be used.

Explain why this method should be used.   [1]

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III.   A further suggestion was that DEPA should be purified by distillation under reduced pressure as DEPA is a liquid with a high boiling temperature.

Explain why this process of separation should be used.   [1]

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