



GCE A LEVEL CHEMISTRY

S21-A410

Assessment Resource D

Organic Chemistry and Analysis

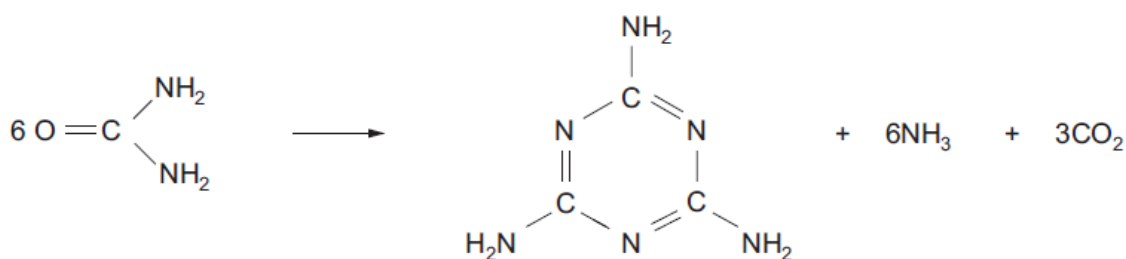
1. An aqueous solution contains sodium benzoate, $C_6H_5COO^-Na^+$, and benzamide, $C_6H_5CONH_2$.

A student was asked to suggest a simple chemical method to produce a solution containing only sodium benzoate and water. He said that he would heat the mixture with aqueous sodium hydroxide.

Explain why this suggestion is correct. [1]

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2. Melamine is made by heating urea.



- (a) Calculate the atom economy of this reaction. [2]

Atom economy = %

- (b) There have been a number of instances of the illegal addition of melamine to baby milk. This addition appears to increase the percentage of protein in the milk, by increasing its nitrogen content.

Calculate the percentage of nitrogen by mass in melamine. [1]

Percentage = %

3. (a) Alkanes react with chlorine to give chloroalkanes.

- (i) Give the equation for the reaction of methylpropane, $(\text{CH}_3)_3\text{CH}$, with chlorine, giving 2-chloro-2-methylpropane as one of the products.

Your answer should show the structures of the reactants and products. [1]

- (ii) The chlorination of methylpropane also produces a number of polychlorinated alkanes.

State how these polychlorinated products are formed. [1]

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- (iii) The formula of methylpropane shows that 9 of the 10 hydrogen atoms are equivalent and therefore there is a greater chance of 1-chloro-2-methylpropane being the principal organic product in the first stage of the chlorination reaction.

However, the main product of this chlorination is 2-chloro-2-methylpropane. Suggest a reason for this compound being the main product. [1]

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- (iv) Another product of this reaction is a hydrocarbon of molecular formula C_8H_{18} , whose high resolution 1H NMR spectrum shows only a singlet at 0.86 ppm.

Suggest a structure for this hydrocarbon, explaining why the spectrum shows a singlet. [2]

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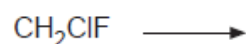
- (v) Methylpropane is replacing CFCs as a domestic refrigerant. While this material is seen as more environmentally friendly, it is very flammable.

Give the equation for the complete combustion of methylpropane. [1]

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- (b) Halogenated alkanes cause environmental problems in the ozone layer by their interaction with UV radiation.

Complete the equation below, which shows the effect of UV radiation on chlorofluoromethane. Explain why these products are formed. [2]



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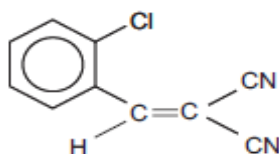
- (c) Methane clathrate is the name given to methane trapped inside ice crystals. The permafrost contains extensive quantities of this material and there are worries that global warming may lead to the uncontrolled emission of vast quantities of methane.

Use the information below to show that the mole ratio of methane to water (ice) in methane clathrate is about 1 : 5.8.

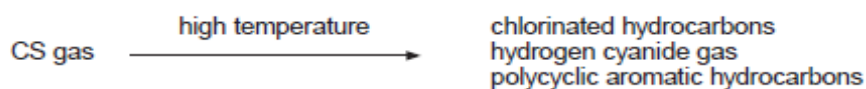
You should assume that methane clathrate is a material consisting of only methane and ice. [4]

- 1 dm³ of methane clathrate gives 168 dm³ of methane measured at 273K and 1 atm pressure
- 1 dm³ of methane clathrate has a mass of 900g

(d) CS gas (actually a solid) is a substance used to quell social unrest.



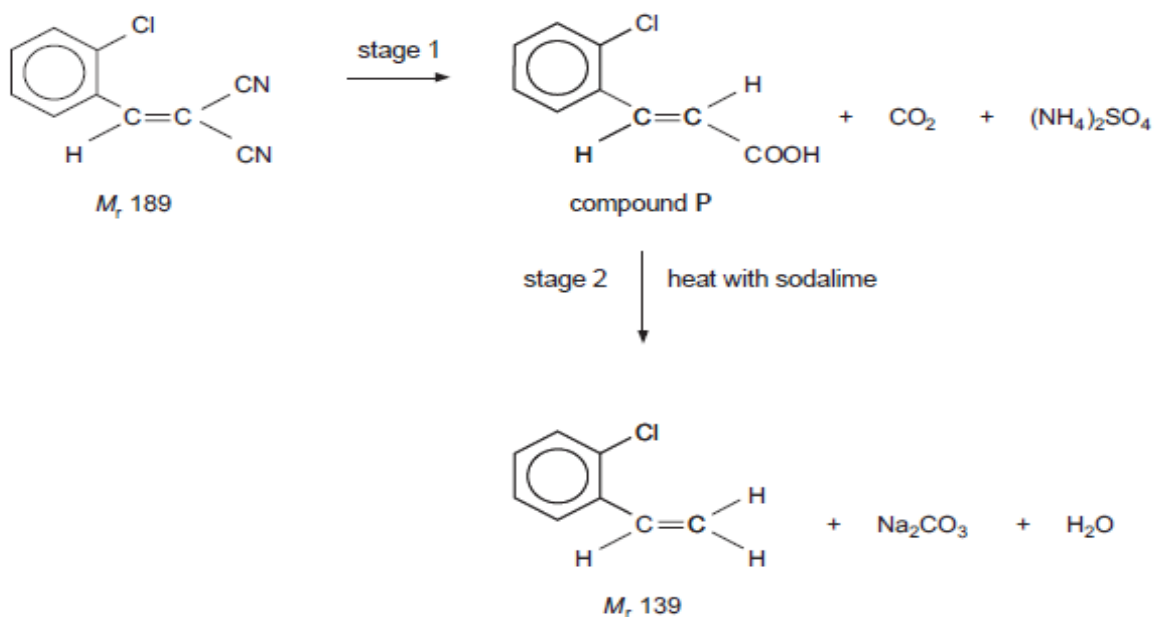
(i) The disposal of surplus stocks of CS gas is a problem which is causing concern. One way is by incineration.



Suggest one reason why this method is seen as an unsatisfactory method of disposal. [1]

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(ii) Another method of disposal is by the conversion of CS gas to (2-chlorophenyl)ethene, ammonium sulfate, carbon dioxide and other products.



I. Stage 1 is an example of a hydrolysis reaction.

State what is meant by this term.

[1]

II. If stage 1 were carried out in the laboratory a mixture would be obtained, containing ammonium sulfate in solution, together with a precipitate of the organic acid.

State how you would obtain pure crystals of the acid from this mixture.

[1]

III. The melting temperature of compound P is 209°C.

State how this figure would change if a sample of compound P were impure.

[1]

IV. State the type of reaction occurring in stage 2.

[1]

V. The yield of compound P in stage 1 was 90.0% and when compound P was converted to (2-chlorophenyl)ethene in stage 2 the yield was 50.0%.

Calculate the overall percentage yield and use your answer to calculate the mass of (2-chlorophenyl)ethene obtained if 75.0 kg of CS gas were destroyed in this way.

Give your answer to an appropriate number of significant figures.

[4]

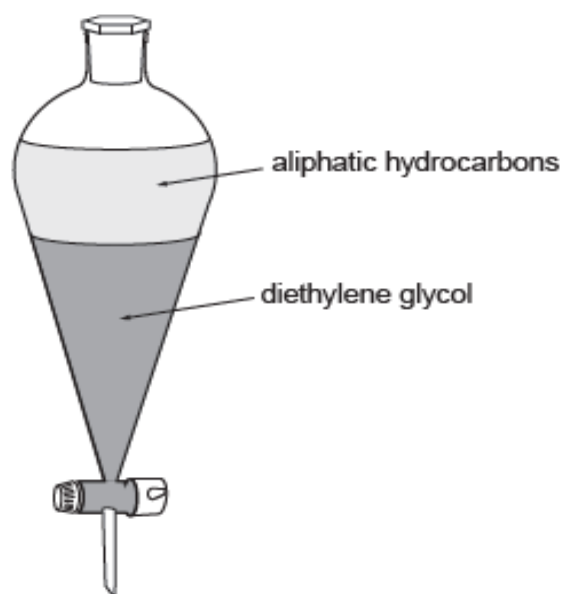
Mass = kg

4. (a) (i) Naphtha, obtained from crude oil (petroleum) contains hexane.

Write the equation for the conversion (reforming) of hexane into benzene and hydrogen. [1]

- (ii) The reforming of naphtha produces a number of other liquid products in addition to benzene.

- I. One method of separating benzene from aliphatic products is to use solvent extraction. Benzene dissolves in diethylene glycol whereas aliphatic hydrocarbons are largely insoluble in this solvent. In the laboratory this can be demonstrated using a separating funnel.



Describe the use of a separating funnel containing the two layers shown above, to obtain a separate sample of the diethylene glycol layer. [1]

- II. The boiling temperatures of benzene and diethylene glycol are 80°C and 245°C respectively.

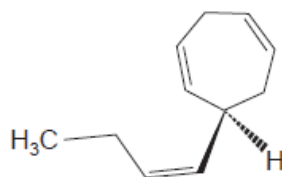
State the name of the technique used to separate these two liquids and state how you could make sure that the risk of fire is reduced to a minimum. [2]

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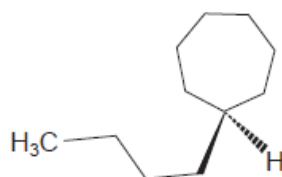
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- (b) Ectocarpene is a hydrocarbon produced by certain algae.



- (i) 4.31 dm^3 of hydrogen, measured at 312 K and at a pressure of $1.01 \times 10^5\text{ Pa}$, was needed to completely react with 8.29 g of ectocarpene to produce compound **G**.



compound **G**

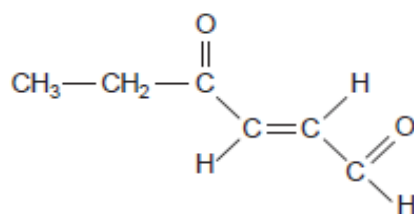
Use this information to confirm that the relative molecular mass of ectocarpene is 148. [4]

- (ii) Find the molecular formula of ectocarpene and deduce the structural formula of an aromatic compound that has the same molecular formula as ectocarpene. [2]

Molecular formula

Structural formula

- (c) A particular insect defends itself by producing a mixture of compounds that contains compound W.



compound W

- (i) Give the structure of the compound obtained when compound W reacts with sodium tetrahydridoborate(III), NaBH₄. [1]

- (ii) Compound W is warmed with Tollens' reagent.

Describe what is seen (if anything) and explain your observation. [2]

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(d) Another insect produces a defensive mixture that contains 2-methylbutanoic acid.

Write the displayed formula of 2-methylbutanoic acid. Give an isomer of this compound that has only three signals in its ^{13}C NMR spectrum, one of which occurs at 160-185 ppm. [2]

Structure of 2-methylbutanoic acid

Structure of the isomer