SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

16 Olive oil is an important edible oil. In many European countries, it is used as an alternative to butter for spreading on bread.

A useful method of comparing fats and oils is to measure their iodine values. An iodine value is the amount of iodine in grams that reacts with 100 g of a fat or oil. This measures the degree of unsaturation of the fat or oil.

The iodine value of olive oil can be determined in the following way.

Add 0.200 g of olive oil to a 250 cm^3 conical flask.

Add 10 cm^3 of solvent to dissolve the oil.

Add 10.0 cm^3 of a solution of iodine monochloride, called Wijs solution.

Stopper the flask and allow to stand in the dark for half an hour.

Add 15 cm^3 of 10% potassium iodide solution and 100 cm^3 of water and shake the mixture.

Titrate the liberated iodine with 0.100 mol dm^{-3} sodium thiosulfate solution. This is the sample titre.

Carry out a blank titration using 10 cm^3 of solvent, 10.0 cm^3 of Wijs solution, 15 cm^3 of 10% potassium iodide solution and 100 cm^3 of water.

(a) For many years, 1,1,1-trichloroethane was used as the solvent for this reaction.

(i) Draw the **displayed** formula for 1,1,1-trichloroethane.

(1)

(ii) Explain why 1,1,1-trichloroethane has a higher boiling temperature than hexane.

(2)

(iii) Suggest why the solvent 1,1,1-trichloroethane is no longer used.

(1)

(b) (i) Iodine monochloride adds more readily than iodine to carbon-carbon double bonds. Using your knowledge of electrophilic addition, suggest why this is so.

(1)

(ii) Complete the formula of the product formed when iodine monochloride, ICl, reacts with oleic acid, $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$, the most abundant unsaturated compound in olive oil.

(1)

$$CH_3(CH_2)_7{-}C{-}C{-}(CH_2)_7COOH$$

(iii) Suggest why the mixture must be kept in the dark.

(1)

(iv) Give the oxidation numbers of iodine in iodine monochloride, iodide ions and iodine.

Write the ionic equation for the reaction between iodide ions and iodine monochloride. State symbols are not required.

(2)

Oxidation number of iodine in

Iodine monochloride .....

Iodide ion .....

Iodine .....

Ionic equation for this reaction

(c) Suggest a suitable indicator for the titration. Give the colour change of the solution at the end point.

(2)

Indicator .....

Colour change from ..... to .....

(d) In the blank titration, 20.0 cm^3 of sodium thiosulfate solution reacted with 10.0 cm^3 of Wijs solution.

(i) Calculate the number of moles of 0.100 mol dm^{-3} sodium thiosulfate that reacted with the **blank** titre.

(1)

(ii) Complete the ionic equation for the reaction between iodine and thiosulfate ions. Include state symbols.

(1)

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow$

(iii) Calculate the number of moles of iodine, I_2, that reacted with the thiosulfate solution in the blank titration.

(1)

(iv) Using your answers to (b)(iv) and (d)(iii), write down the corresponding number of moles of iodine monochloride solution in 10 cm^3 of Wijs solution.

(1)

(v) The number of moles of iodine monochloride left after reacting the Wijs solution with the olive oil sample, calculated from the sample titre, is 3.65×10^{-4} mol.

Use this, and your answer to (d)(iv), to calculate the amount of iodine monochloride that reacted with the sample.

(1)

(vi) Your answer to (d)(v) is equal to the number of moles of iodine that would have reacted with 0.200 g of olive oil.

Calculate the number of moles of iodine that would have reacted with 100 g of olive oil.

(1)

(vii) Calculate the mass of iodine, I_2, that would have reacted with 100 g of olive oil, which is the iodine value for the olive oil.

(1)

(e) Butter contains a smaller percentage of unsaturated molecules than olive oil.

Would the titre value and iodine value for butter be higher, lower or about the same as the values for olive oil?

(1)

Sample titre .....

Iodine value .....

(Total for Question 16 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 80 MARKS