Q1.

Which statement about $(CH_3)_2CHCH_2COOH$ is correct?

A In aqueous solution it reacts with magnesium to form carbon dioxide. ⬭

B It can form hydrogen bonds. ⬭

C It has optical isomers. ⬭

D It has the IUPAC name 2-methylbutanoic acid. ⬭

(Total 1 mark)

Q2.

Which compound is formed when phenyl benzenecarboxylate is hydrolysed under acidic conditions?

A $C_6H_5CH_2OH$ ⬭

B C_6H_5CHO ⬭

C $C_6H_5COCH_3$ ⬭

D C_6H_5COOH ⬭

(Total 1 mark)

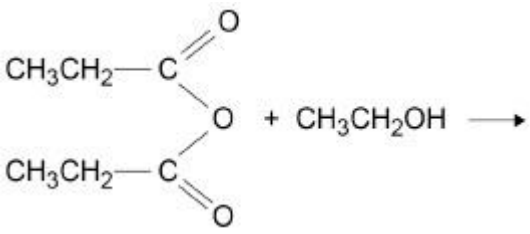
Q3.

This question is about esters including biodiesel.

(a) An ester is formed by the reaction of an acid anhydride with CH_3CH_2OH

Complete the equation. In your answer show clearly the structure of the ester.
Give the IUPAC name of the ester.

Equation



Name of ester

_____

(3)

(b) In a reaction to form biodiesel, one mole of a vegetable oil reacts with an excess of methanol to form two moles of an ester with molecular formula $C_{19}H_{34}O_2$ and one mole of an ester with molecular formula $C_{19}H_{36}O_2$

Draw the structure of the vegetable oil showing clearly the ester links.

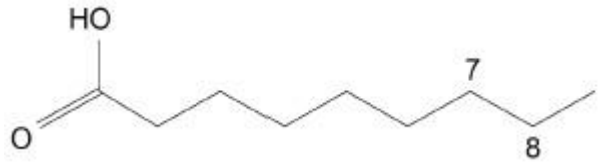
You should represent the hydrocarbon chains in the form C_xH_y where *x* and *y* are the actual numbers of carbon and hydrogen atoms.

(2)

(c) The compound $C_{19}H_{34}O_2$ is the methyl ester of Z,Z-octadeca-9,12-dienoic acid.

Part of the structure of the acid is shown.

Complete the skeletal formula to show the next part of the hydrocarbon chain to carbon atom number 14.
In your answer, show the Z stereochemistry around both C=C double bonds.



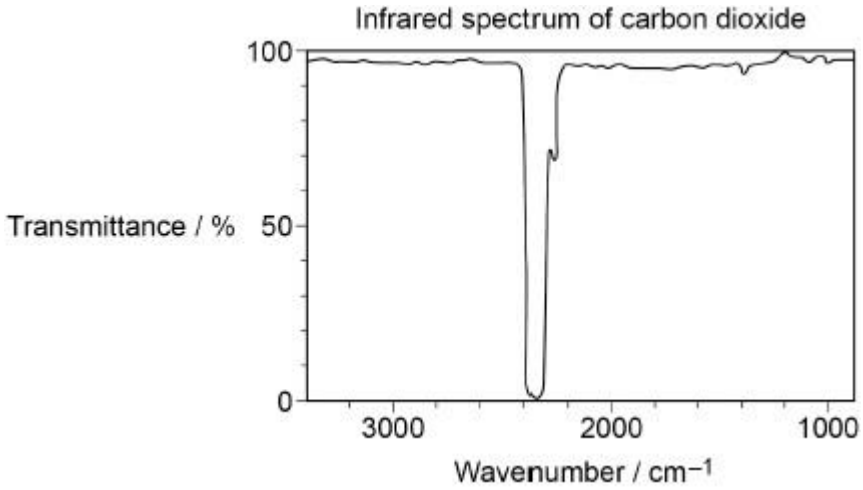
(2)

(d) Give an equation for the complete combustion of the ester $C_{19}H_{34}O_2$

_____

(1)

(e) Combustion of biodiesel produces greenhouse gases such as carbon dioxide that cause global warming.
Part of the infrared spectrum of carbon dioxide is shown in the diagram.



State how the infrared spectrum of carbon dioxide in the diagram above is **not** what you might predict from the data provided in **Table A** in the Data Booklet.

_____

_____

_____

(1)

(f) Explain how carbon dioxide causes global warming.

_____

_____

_____

_____

_____

_____

(2)

(Total 11 marks)

Q4.

Which compound is formed by acid hydrolysis of phenylmethyl ethanoate?

A $C_6H_5CH_2OH$ ⬭

B C_6H_5CHO ⬭

C $C_6H_5COCH_3$ ⬭

D C_6H_5COOH ⬭

(Total 1 mark)

Q5.

Acyl chlorides are useful reagents in synthesis. They react with aromatic compounds and also with alcohols.

(a) CH_3CH_2COCl reacts with benzene in the presence of $AlCl_3$ in an electrophilic substitution reaction.

Give an equation for the reaction of CH_3CH_2COCl with $AlCl_3$ to form the electrophile.
Outline a mechanism for the reaction of this electrophile with benzene.

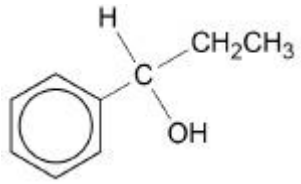
Equation

_____

Mechanism

(4)

(b) The organic product in **part (a)** can be converted into the alcohol shown.



Give the IUPAC name of the alcohol.
Give the reagent needed for this reaction and name the mechanism.

IUPAC name

_____

Reagent

_____

Name of mechanism

_____

(3)

(c) The alcohol shown in **part (b)** reacts with ethanoyl chloride to form an ester.

Describe what would be observed when the alcohol reacts with ethanoyl chloride.
Name the mechanism for the reaction to form the ester.
Draw the structure of the ester.

Observation

_____

_____

Name of mechanism

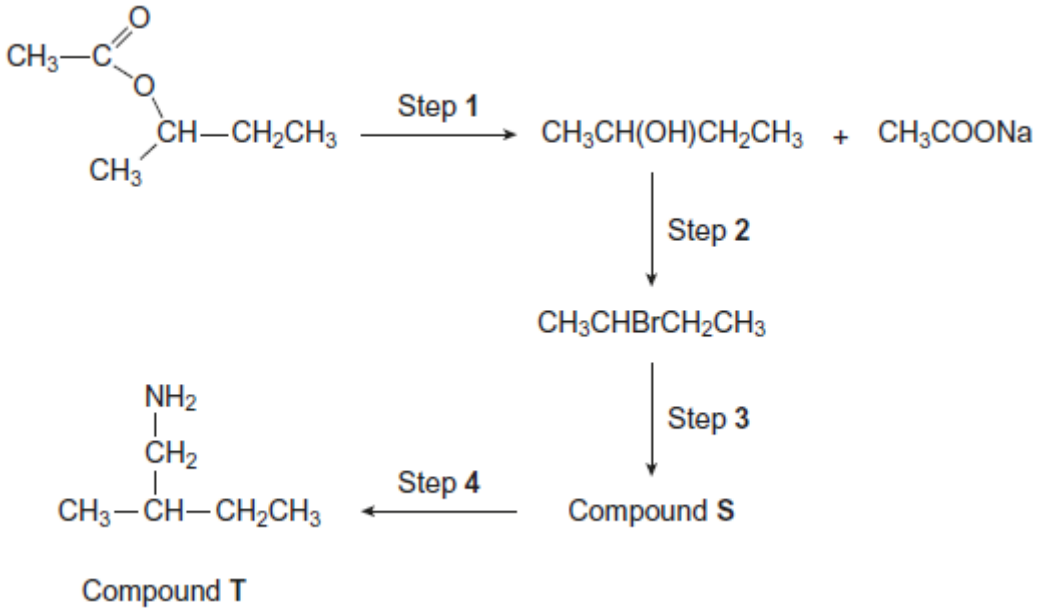
_____

Structure of ester

(3)
(Total 10 marks)

Q6.

A four-step synthesis of compound **T** is shown.



(a) Give the reagent and conditions for Step **1**.
State how you could obtain a sample of the alcohol from the reaction mixture formed in Step **1**.

_____

_____

_____

_____

_____

(3)

(b) Draw the structure of compound **S**.
For each of Steps **3** and **4**, give a reagent and one condition, other than heat.

(5)

(Total 8 marks)

Q7.

Coconut oil contains a triester with three identical R groups.
This triester reacts with potassium hydroxide.

(a) Complete the equation by drawing the structure of the other product of this reaction in the box.

Name the type of compound shown by the formula RCOOK

Give **one** use for this type of compound.

Type of compound _____

Use _____

(3)

(b) The triester in coconut oil has a relative molecular mass, M_r = 638.0
In the equation shown at the start of this question, R represents an alkyl group that can be written as $CH_3(CH_2)_n$

Deduce the value of n in $CH_3(CH_2)_n$
Show your working.

n _____

(3)

(c) A 1.450 g sample of coconut oil is heated with 0.421 g of KOH in aqueous ethanol until all of the triester is hydrolysed.
The mixture is cooled.
The remaining KOH is neutralised by exactly 15.65 cm^3 of 0.100 mol dm^{-3} HCl

Calculate the percentage by mass of the triester (M_r = 638.0) in the coconut oil.

Percentage by mass _____

(6)

(d) Suggest why aqueous ethanol is a suitable solvent when heating the coconut oil with KOH.

Give a safety precaution used when heating the mixture.
Justify your choice.

Reason _____

_____

Safety
precaution _____

_____

Justification _____

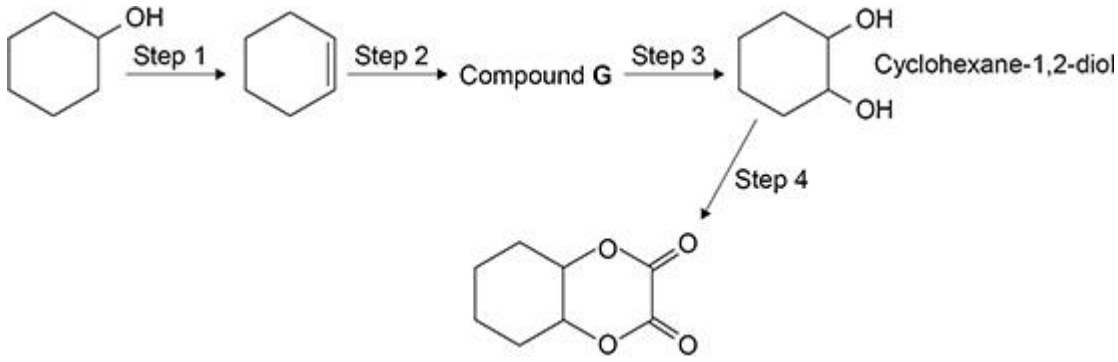
_____

(3)

(Total 15 marks)

Q8.

This question is about making a diester from cyclohexanol.



(a) State the type of reaction in step **1**.

Give the name of the reagent needed for step **1**.

Type of reaction _____

Reagent _____

(2)

(b) State the reagents needed and give equations for step **2** and step **3**.

Show the structure of Compound **G** in your equations.

Step 2 reagent _____

Step 2 equation

_____

Step 3 reagent _____

Step 3 equation

_____

(4)

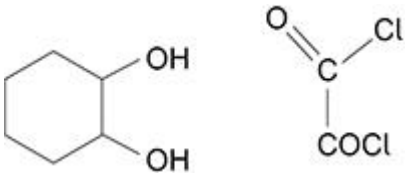
(c) Cyclohexane-1,2-diol reacts with ethanedioyl dichloride.

Give the name of the mechanism for this reaction.

Complete the mechanism to show the formation of **one** ester link in the first step of this reaction.

Mechanism name _____

Mechanism



(5)

(d) Suggest why chemists usually aim to design production methods
- with fewer steps
- with a high percentage atom economy.

Fewer steps _____

_____

_____

High percentage atom economy _____

_____

_____

(2)

(Total 13 marks)

Q9.

Aspirin can be produced by reacting salicylic acid with ethanoic anhydride.
An incomplete method to determine the yield of aspirin is shown.

1. Add about 6 g of salicylic acid to a weighing boat.
2. Place the weighing boat on a 2 decimal place balance and record the mass.
3. Tip the salicylic acid into a 100 cm^3 conical flask.
4. _____
5. Add 10 cm^3 of ethanoic anhydride to the conical flask and swirl.
6. Add 5 drops of concentrated phosphoric acid.
7. Warm the flask for 20 minutes.
8. Add ice-cold water to the reaction mixture and place the flask in an ice bath.
9. Filter off the crude aspirin from the mixture and leave it to dry.
10. Weigh the crude aspirin and calculate the yield.

(a) Describe the instruction that is missing from step **4** of the method.

Justify why this step is necessary.

Instruction

_____

Justification

_____

_____

_____

(2)

(b) Suggest a suitable piece of apparatus to measure out the ethanoic anhydride in step **5**.

_____

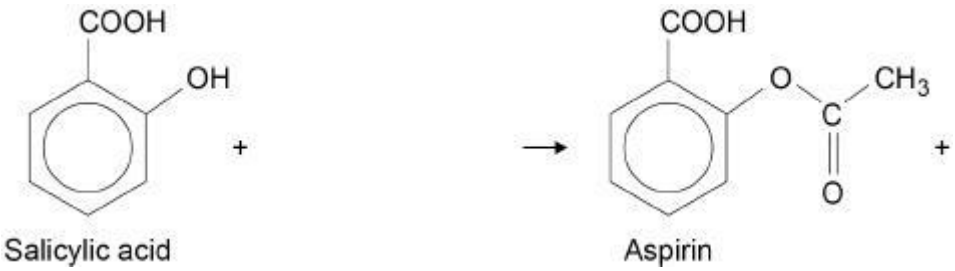
(1)

(c) Identify a hazard of using concentrated phosphoric acid in step **6**.

_____

(1)

(d) Complete the equation for the reaction of salicylic acid with ethanoic anhydride to produce aspirin.



(1)

(e) A 6.01 g sample of salicylic acid (M_r = 138.0) is reacted with 10.5 cm^3 of ethanoic anhydride (M_r = 102.0).
In the reaction the yield of aspirin is 84.1%

The density of ethanoic anhydride is 1.08 g cm^{-3}

Show by calculation which reagent is in excess.

Calculate the mass, in g, of aspirin (M_r = 180.0) produced.

Reagent in excess _____

Mass of aspirin _____ g

(5)

(f) Suggest **two** ways in which the melting point of the crude aspirin collected in step **9** would differ from the melting point of pure aspirin.

Difference 1

_____

_____

Difference 2

_____

_____

(2)

(g) The crude aspirin can be purified by recrystallisation using hot ethanol (boiling point = 78 °C) as the solvent.

Describe **two** important precautions when heating the mixture of ethanol and crude aspirin.

Precaution 1

_____

_____

Precaution 2

_____

_____

(2)

(h) The pure aspirin is filtered under reduced pressure.
A small amount of cold ethanol is then poured through the Buchner funnel.

Explain the purpose of adding a small amount of cold ethanol.

_____

_____

_____

(1)

(i) A sample of the crude aspirin is kept to compare with the purified aspirin.

Describe **one** difference in appearance you would expect to see between these two solid samples.

_____

_____

_____

(1)

(Total 16 marks)

Q10.

Which reaction involves addition-elimination?

A $(CH_3)_2CHBr + KOH \rightarrow CH_3CH=CH_2 + KBr + H_2O$ ⬭

B $CH_3COCl + C_6H_5OH \rightarrow CH_3COOC_6H_5 + HCl$ ⬭

C $CH_3CH=CH_2 + Cl_2 \rightarrow CH_3CHClCH_2Cl$ ⬭

D $CH_3CH_2CH_2Br + NaOH \rightarrow CH_3CH_2CH_2OH + NaBr$ ⬭

(Total 1 mark)