Q1.

This question is about the preparation of an ester.

(a) Ester **F** can be prepared from propan-2-ol and ethanoic acid.

Give an equation for this reaction.

Name ester **F**.

Equation

_____

Name _____

(2)

This method is used to prepare a sample of ester **F**.

Step 1
Mix 10 cm^3 of propan-2-ol with 10 cm^3 of ethanoic acid.
Add 5 drops of concentrated sulfuric acid.
Reflux this reaction mixture for 20 minutes.

Step 2
Transfer the cooled reaction mixture to a separating funnel.
Add 20 cm^3 of aqueous sodium carbonate and shake the mixture.

Step 3
Transfer the organic layer to a beaker and add 5 g of anhydrous magnesium sulfate.
Decant off the organic liquid.

Step 4
Collect the ester using simple distillation.

(b) Describe how **Step 1** should be done.

In your description you should

- give details of suitable equipment used to add each reagent to the reflux apparatus
- draw a labelled diagram of the apparatus used for refluxing the reaction mixture
- explain any safety precautions needed other than eye protection.

_____

_____

_____

_____

(6)

(c) In **Step 2** the reaction mixture from **Step 1** is shaken with aqueous sodium carbonate.

State the purpose of the sodium carbonate.

Suggest a precaution that should be taken while this mixture is shaken in the separating funnel.

Give a reason for your suggested precaution.

Purpose of sodium carbonate _____

_____

Precaution _____

_____

Reason _____

_____

(3)

(d) Give the reason for the use of anhydrous magnesium sulfate in **Step 3**.

_____

_____

(1)

(e) Suggest how the purity of the ester can be confirmed during the distillation in **Step 4**.

_____

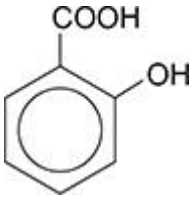
_____

(1)

(Total 13 marks)

Q2.

The structure of 2-hydroxybenzenecarboxylic acid is shown.



(a) Give the equation for the reaction of 2-hydroxybenzenecarboxylic acid with methanol.

In your equation, include the **skeletal** formula of the organic product.

_____

(2)

Aspirin is produced from 2-hydroxybenzenecarboxylic acid by reaction with ethanoic anhydride in the presence of concentrated phosphoric acid.

Method

1. Add 2-hydroxybenzenecarboxylic acid to a conical flask.
2. Add excess ethanoic anhydride.
3. Add a few drops of concentrated phosphoric acid.
4. Heat the flask to 85 °C for 10 minutes.
5. Cool the flask and pour the contents into 150 cm^3 of cold water.
6. Filter and wash the impure solid aspirin.
7. Recrystallise the aspirin using a 50:50 mixture of water and ethanol.
8. Check the purity of the aspirin.

(b) Aspirin can also be produced by reacting 2-hydroxybenzenecarboxylic acid with ethanoyl chloride.

State why ethanoic anhydride is preferred to ethanoyl chloride for this preparation.

_____

_____

(1)

(c) Give the name of the mechanism for the reaction of 2-hydroxybenzenecarboxylic acid with ethanoic anhydride.

_____

(1)

(d) Suggest the role of the concentrated phosphoric acid.

_____

(1)

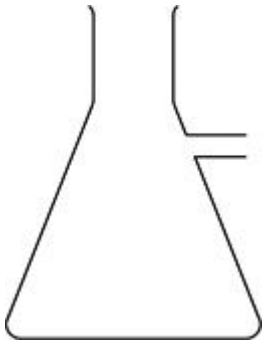
(e) Suggest why reflux is **not** essential when the flask is heated to 85 °C for 10 minutes.

_____

_____

(1)

(f) Complete and label the diagram below to show how the impure solid is filtered.



(2)

(g) Suggest the identity of **two** impurities present in the filtered solid aspirin before it is washed in Step 6 of the method.

Impurity 1 _____

Impurity 2 _____

(2)

(h) Describe the recrystallisation process used to purify the aspirin.

Include the method and apparatus used.

(6)

(i) State the physical property that is measured to check the purity of the aspirin.

Describe **two** ways the result would show that the product is impure.

Physical property _____

1 _____

_____

2 _____

_____

(3)

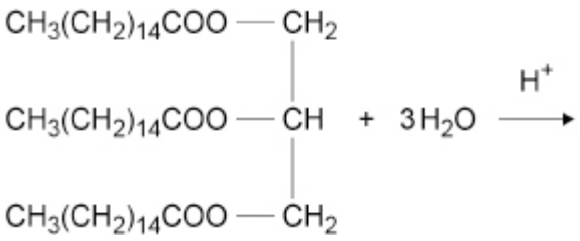
(Total 19 marks)

Q3.

This question is about biofuels.

Palmitic acid, $CH_3(CH_2)_{14}COOH$, can be made by hydrolysis of the triester in palm oil under acidic conditions.
Palmitic acid can be used as a biofuel.

(a) Complete the equation for the hydrolysis of the triester in palm oil under acidic conditions.



(2)

(b) Palmitic acid burns in air.

In a calorimetry experiment, combustion of 387 mg of palmitic acid increases the temperature of 0.150 kg of water from 23.9 °C to 37.5 °C

Calculate a value, in kJ mol^{-1}, for the enthalpy of combustion of palmitic acid in this experiment.
Give your answer to the appropriate number of significant figures.

The specific heat capacity of water is 4.18 J K^{-1} g^{-1}

Enthalpy of combustion _____ kJ mol^{-1}

(5)

(c) State how the value calculated in part (b) is likely to differ from data book values.

Give one reason, other than heat loss, for this difference.

Difference _____

Reason _____

_____

(2)

(d) A sample of a different biofuel, made from sewage sludge, is found to contain 37.08% carbon, 5.15% hydrogen and 24.72% oxygen by mass. The rest of the sample is sulfur.

Calculate the empirical formula of this biofuel.

Empirical formula _____

(3)

(e) Complete combustion of the biofuel made from sewage sludge produces the greenhouse gas carbon dioxide.

Suggest **one** other possible environmental problem with the complete combustion of this biofuel.

State the formula of the pollutant responsible for this problem.

Environmental problem _____

_____

Formula _____

(2)

(f) Ethanol is a biofuel that can be produced by the fermentation of glucose.

$$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$$

Glucose has the structural formula shown.

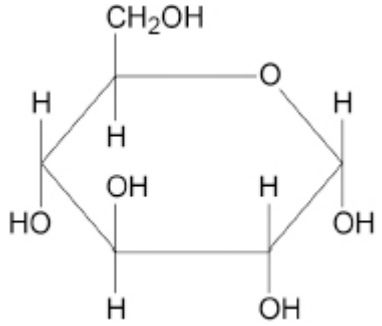


Table 1 shows some mean bond enthalpy values.

Table 1

	C–H	**C–C**	**C–O**	**C=O**	**O–H**
Mean bond enthalpy / kJ mol^{-1}	412	348	360	805	463

Use the equation and the data in **Table 1** to calculate an approximate value of ΔH for the fermentation of glucose. For this calculation you should assume that all the substances are in the gaseous state.

ΔH _____ kJ mol^{-1}

(3)

(g) The carbon dioxide produced from fermentation can be reacted with steam to make more ethanol.

The equation for this reaction is

$$2\ CO_2(g) + 3\ H_2O(g) \rightarrow C_2H_5OH(g) + 3\ O_2(g)$$

Table 2 shows some standard enthalpies of formation.

Table 2

	$CO_2(g)$	**$O_2(g)$**	**$C_2H_5OH(g)$**	**$H_2O(g)$**
$\Delta f H^{\ominus}$ / kJ mol^{-1}	–394	0	–235	–242

Use the data in **Table 2** to calculate a standard enthalpy change value for this reaction.

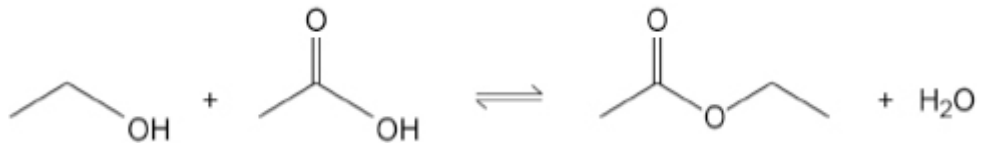
Standard enthalpy change _____ kJ mol^{-1}

(2)

(Total 19 marks)

Q4.

Ethyl ethanoate can be made by reacting ethanol with ethanoic acid in the presence of concentrated sulfuric acid.



Method

1. A mixture of ethanol, ethanoic acid, and concentrated sulfuric acid, with anti-bumping granules, is heated under reflux for 10 minutes.
2. The apparatus is rearranged for distillation.
3. The mixture is heated to collect the liquid that distils between 70 and 85 °C
4. The distillate is placed in a separating funnel. Aqueous sodium carbonate is added, and a stopper is placed in the funnel. The mixture is shaken, releasing pressure as necessary.
5. The lower aqueous layer is removed and the upper organic layer is placed in a small conical flask.
6. Anhydrous calcium chloride is added to the sample in the conical flask. The flask is shaken well and left for a few minutes.
7. The liquid from the flask is redistilled and the distillate is collected between 74 and 79 °C

(a) State the role of concentrated sulfuric acid in this reaction.

_____

_____

(1)

(b) The reaction mixture is flammable.

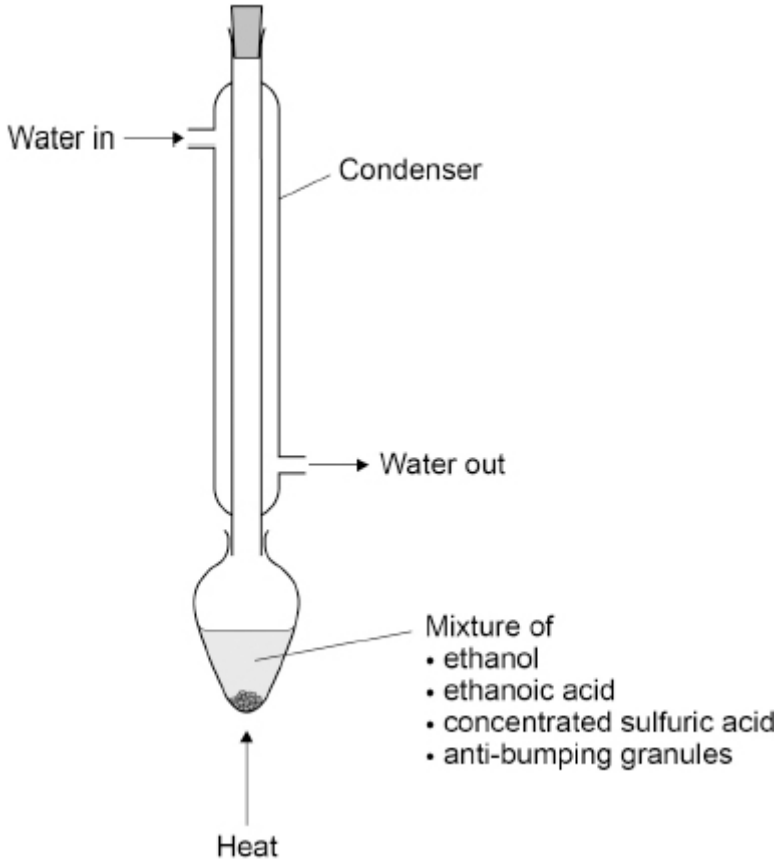
Suggest how the reaction mixture should be heated in step 1.

_____

_____

(1)

(c) The figure below shows how a student set up the apparatus for reflux in step 1.
You should assume that the apparatus is clamped correctly.



Identify **two** mistakes the student made in setting up the apparatus.

State the problem caused by each mistake.

Mistake 1 _____

_____

Problem caused _____

_____

_____

Mistake 2 _____

_____

Problem caused _____

_____

_____

(4)

(d) State why sodium carbonate is added to the distillate in step 4.

Explain why there is a build-up of pressure in the separating funnel.

_____

_____

_____

_____

(2)

(e) Give a reason why two layers form in the separating funnel.

Suggest why ethyl ethanoate forms the upper layer.

Reason _____

_____

Suggestion _____

_____

(2)

(f) State why anhydrous calcium chloride is added in step 6.

_____

_____

(1)

(g) A student uses the method to prepare some ethyl ethanoate.

The student adds 10.0 cm^3 of ethanol (M_r = 46.0) to 5.25 g of ethanoic acid (M_r = 60.0) and obtains 5.47 g of ethyl ethanoate (M_r = 88.0).

For ethanol, density = 0.790 g cm^{-3}

Determine the limiting reagent.

Calculate the percentage yield of ethyl ethanoate.

Limiting reagent _____

Percentage yield _____

(5)

(h) Suggest a reason why the percentage yield is **not** 100%.

_____

_____

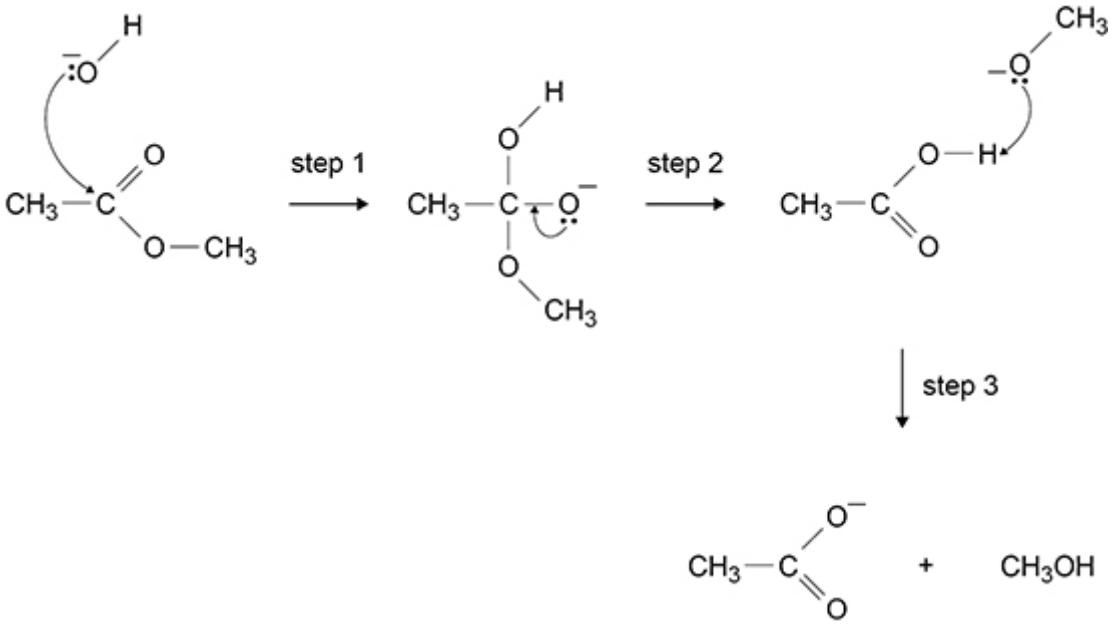
(1)

(Total 17 marks)

Q5.

This question is about esters.

The diagram below shows an incomplete mechanism for the reaction of an ester with aqueous sodium hydroxide.



(a) Add **three** curly arrows to complete the mechanism in above diagram.

_____

(3)

(b) Name the type of reaction shown in the diagram above.

_____

(1)

(c) Deduce the role of the CH_3O^- ion in step **3** shown in the diagram above.

_____

(1)

(d) A triester in vegetable oil reacts with sodium hydroxide in a similar way.

Give a use for a product of this reaction.

_____

(1)

(Total 6 marks)