

Question 40

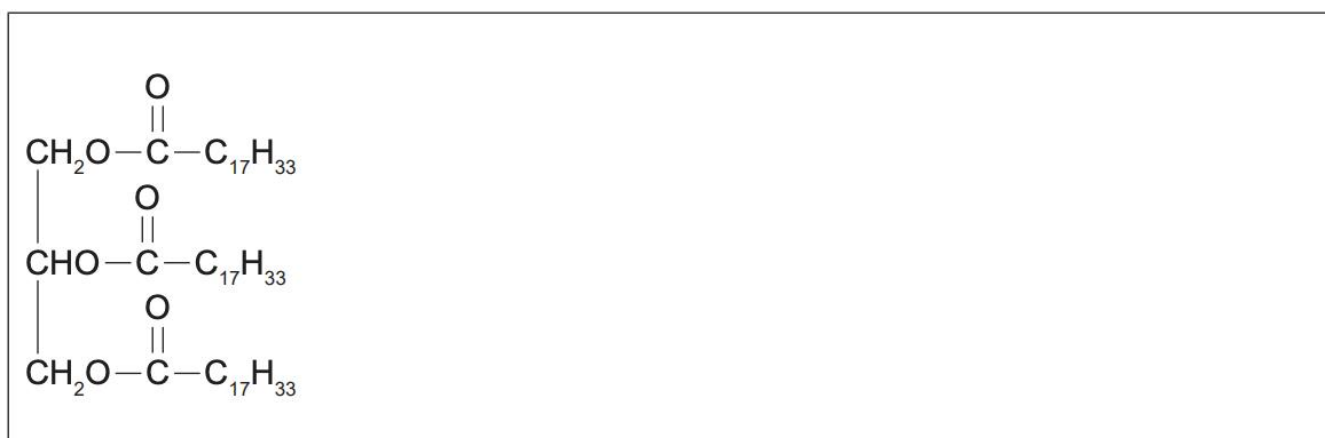
(16 marks)

Thousands of fast-food outlets across Australia use vegetable oil in cooking. Large volumes of vegetable oil waste are thus produced and need to be disposed of. A disposal option is turning the vegetable oil waste into biodiesel.

Vegetable oil waste is a mixture of free fatty acids and triglycerides. Triolein, the triglyceride of the free fatty acid oleic acid, is typically present in large amounts. The condensed structural formulae of oleic acid and triolein are shown below.

$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$ <p>oleic acid (a free fatty acid)</p>	$\begin{array}{c} \text{O} \\ \\ \text{CH}_2\text{O}-\text{C}-\text{C}_{17}\text{H}_{33} \\ \\ \text{O} \\ \\ \text{CHO}-\text{C}-\text{C}_{17}\text{H}_{33} \\ \\ \text{O} \\ \\ \text{CH}_2\text{O}-\text{C}-\text{C}_{17}\text{H}_{33} \end{array}$ <p>triolein (the triglyceride of oleic acid)</p>
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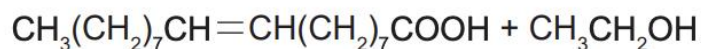
- (a) Write a balanced equation, using condensed structural formulae, to show the formation of biodiesel from triolein and ethanol. Assume that a suitable catalyst is present. (3 marks)



- (b) Lipase is a protein that can be used to catalyse the reaction between triolein and ethanol. To which class of biological chemicals (other than proteins) does lipase belong? (1 mark)
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The free fatty acids found in vegetable oil waste will react with the ethanol that was intended for biodiesel synthesis, establishing an equilibrium.

- (c) Complete the following equation to show the equilibrium that is established between oleic acid and ethanol. Represent all organic substances as condensed structural formulae and assume acidic conditions. (2 marks)



\rightleftharpoons

In an industrial setting, reaction conditions are adjusted to favour the forward direction of the oleic acid/ethanol equilibrium.

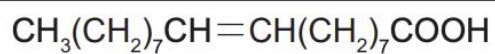
- (d) Identify **two** different actions that can be carried out to favour the forward direction of this equilibrium. (2 marks)

One: _____

Two: _____

The base sodium hydroxide can also catalyse the reaction between triolein and ethanol. The free fatty acids in the vegetable oil waste also react with the base.

- (e) (i) Write a balanced equation showing the reaction of oleic acid with sodium hydroxide. Represent all organic substances as condensed structural formulae. (2 marks)



- (ii) To which class of compounds does the organic product of this reaction belong? (1 mark)
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- (f) Which of the catalysts, lipase or sodium hydroxide, is more likely to be the industrially preferred catalyst when using vegetable oil waste to make biodiesel? Justify your answer. (3 marks)

- (g) Other than the recycling of vegetable oil waste, give **two** different reasons why the production of biodiesel from vegetable oil waste is an example of green chemistry but the production of diesel from fossil fuels is not. Each of your reasons needs to contrast biodiesel and fossil fuel diesel. (2 marks)

One: _____

Two: _____
