



Stage 2 Chemistry

Sample Examination Questions 2

Time 65 minutes

- Questions 1 to 4, 59 marks
- Answer all questions
- Write your answers in this question booklet
- You may write on the space provided on the last page if you need more space

1. Wine is an aqueous solution that contains hundreds of different compounds. Traditionally, wine is made by fermenting the glucose in grape juice.

A team of chemists at Ava Winery in the USA has produced synthetic wine by mixing various compounds that are found in traditional wine.

- (a) Write a balanced equation for the fermentation of glucose to produce ethanol.

(2 marks)

- (b) (i) The chemists used gas chromatography (GC) to determine the composition of traditional wine.

State the function of the gas in GC.

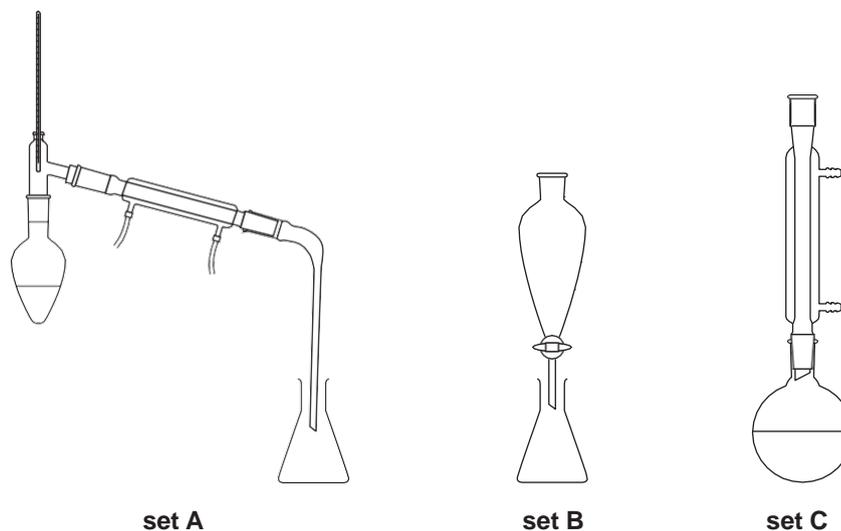
_____ (1 mark)

- (ii) One compound that is included in synthetic wine is ethyl hexanoate. Ethyl hexanoate is produced in a reaction between ethanol and another organic compound, using the process of reflux.

- (1) Name the other organic compound that is used to produce ethyl hexanoate.

_____ (1 mark)

- (2) Three sets of glassware that can be used for the preparation of organic compounds are shown below.



Identify the set of glassware — set A, set B, or set C — that is used for the process of reflux.

_____ (1 mark)

- (3) Explain why the process of reflux is used for the preparation of ethyl hexanoate.

(2 marks)

- (4) The K_c value for the reaction that forms ethyl hexanoate, $C_5H_{11}COOC_2H_5$, was investigated at two different temperatures, **X** and **Y**.

The K_c expression for this reaction is shown below.

$$K_c = \frac{[C_5H_{11}COOC_2H_5][H_2O]}{[C_5H_{11}COOH][C_2H_5OH]}$$

At temperature **X**, the K_c value was determined to be 3.0.

- (A) At temperature **Y**, $C_5H_{11}COOH$ and C_2H_5OH were added to a 1 L flask and left to react.

Initially, $[C_5H_{11}COOH] = 0.70 \text{ mol L}^{-1}$ and $[C_2H_5OH] = 1.0 \text{ mol L}^{-1}$, and no products were present. At equilibrium, $[C_5H_{11}COOC_2H_5] = 0.60 \text{ mol L}^{-1}$ and $[H_2O] = 0.60 \text{ mol L}^{-1}$.

Calculate $[C_5H_{11}COOH]$ and $[C_2H_5OH]$ at equilibrium.

(2 marks)

- (B) Show that at temperature **Y**, the K_c value was 9.0.

(1 mark)

- (C) Temperature **Y** was higher than temperature **X**.

State why the reaction that produces ethyl hexanoate must be endothermic, given that the K_c value was greater at the higher temperature.

(1 mark)

(iii)

The chemists at Ava Winery identified the main compounds that are responsible for flavour in many wines, using various analytical techniques. They trialled different proportions of these compounds and asked an expert wine taster to taste the synthetic wine. Based on the expert's opinion, the chemists believe that they have produced an inexpensive synthetic wine that is comparable in taste to an expensive traditional wine.

A number of winemakers think that synthetic wines will be unable to match the taste of traditional wines, because the roles of all of the hundreds of compounds in wine are not fully understood. However, the chemists are not worried because most of these compounds have no significant effect on the flavour of wine.

Source: based on Baraniuk, C 2016, 'Synthetic wine made without grapes claims to mimic fine vintages', New Scientist, 16 May, viewed 9 June 2018, new.scientist.com

One key concept of science as a human endeavour is 'influence'.

Discuss how people's acceptance of this scientific innovation in winemaking may be influenced by social, economic, or other considerations.

(4 marks)

2. Coconut cream, extracted from coconuts, may be added to curries.

(a) Coconut cream contains both saturated triglycerides and unsaturated triglycerides.

(i) Explain how the proportion of unsaturated triglycerides affects the melting point of coconut cream.

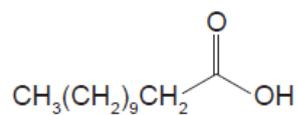
(3 marks)

(ii) Triglycerides in coconut cream are hydrolysed in the human digestive system.

(1) Explain how enzymes increase the rate at which these triglycerides are hydrolysed.

(3 marks)

(2) When these triglycerides are hydrolysed, carboxylic acids are produced. The structural formula of the most abundant of these carboxylic acids, lauric acid, is shown below.

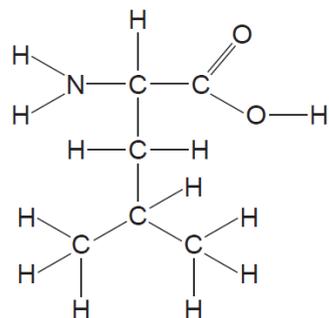


Draw the structural formula of *one* triglyceride that could have been hydrolysed to produce lauric acid.

(2 marks)

(b) Coconut cream contains proteins.

(i) Leucine is an amino acid that is commonly found in these proteins. The structural formula of leucine is shown below.



(1) On the structural formula above, write the δ^+ symbol on one of the H atoms that is able to form hydrogen bonds. (1 mark)

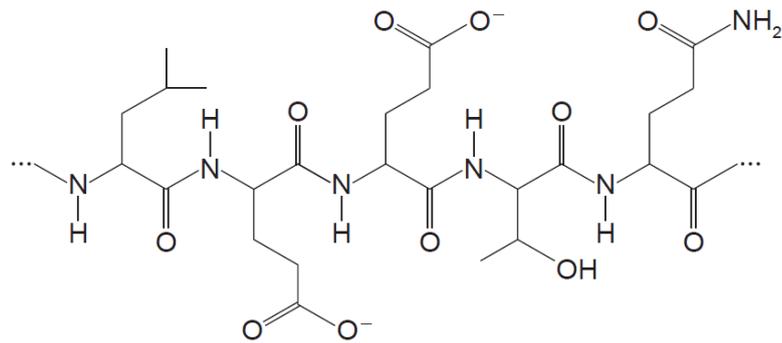
(2) Draw the structural formula of the self-ionised form of leucine.

(2 marks)

(3) Identify the inorganic compound that is produced when two leucine molecules react to form a peptide link.

_____ (1 mark)

- (ii) Cocosin is a protein that is found in coconut cream. The structural formula of a section of one of the protein chains in cocosin is shown below.



- (1) State the number of amino acid molecules that are used to form this section of the protein chain in cocosin.

_____ (1 mark)

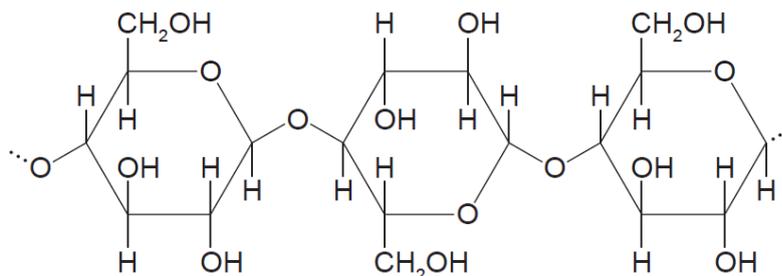
- (2) Explain how the secondary interactions between the protein chains in cocosin could change when very acidic lemon juice is added to coconut cream.

_____ (3 marks)

3. Nail polishes are mixtures of different organic compounds, and are used to decorate fingernails.

(a) Conventional nail polish contains nitrocellulose, which is the basis of the polymer coating that is formed on the nail. Nitrocellulose is dissolved in a solvent that evaporates rapidly once the nail polish is painted on the nail.

(i) Nitrocellulose is produced from the polysaccharide cellulose. The structural formula of cellulose is shown below.



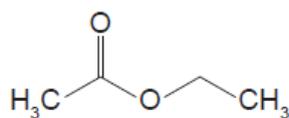
(1) Using the definition of a carbohydrate, explain why cellulose is a carbohydrate.

(2 marks)

(2) Draw the structural formula of the monomer of cellulose.

(2 marks)

- (ii) Nitrocellulose can be dissolved in solvent A. The structural formula of solvent A is shown below.

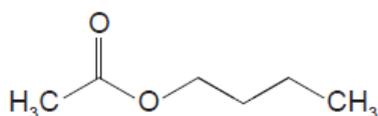


solvent A

Write the systematic name of solvent A.

_____ (2 marks)

- (iii) Nitrocellulose can be dissolved in solvent B. The structural formula of solvent B is shown below.

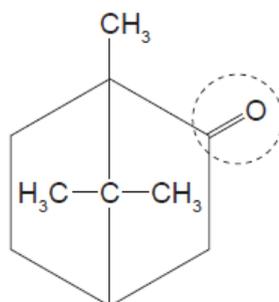


solvent B

Explain why solvent A would evaporate more quickly than solvent B.

_____ (3 marks)

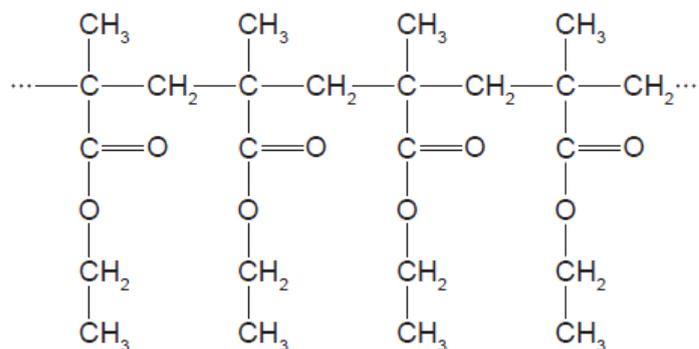
- (iv) Camphor is added to nail polish to strengthen the polymer coating. The structural formula of camphor is shown below.



Name the functional group that is circled on the structural formula of camphor.

_____ (1 mark)

- (b) Acrylic nail polish contains several different polymers. The structural formula of a section of one of these polymers, ethyl methacrylate, is shown in the diagram below.



- (i) *On the diagram above*, use square brackets to mark *one* repeating unit of the ethyl methacrylate polymer. (1 mark)
- (ii) State the type of polymerisation reaction that is used to produce the ethyl methacrylate polymer.

_____ (1 mark)

4. Some soils contain aluminosilicates, which store nutrient cations that promote the growth of crops.

(a) The formula of one clay aluminosilicate that may be present in soil is $\text{KAl}_3[\text{AlSi}_5\text{O}_x](\text{OH})_3$.

(i) Determine the charge on the aluminosilicate anion that is shown in square brackets in the formula above.

_____ (1 mark)

(ii) Hence calculate the value of x , showing your working.

(2 marks)

(b) One aqueous solution of fertiliser has a high concentration of potassium ions ($\text{K}^+_{(\text{aq})}$). When this fertiliser is added to soil, the concentration of potassium ions adsorbed onto the surface of clay aluminosilicates that are present in the soil ($\text{K}^+_{(\text{clay})}$) increases.

Explain how an increased concentration of $\text{K}^+_{(\text{aq})}$ causes more potassium ions to become adsorbed onto the surface of clay aluminosilicates.

_____ (3 marks)

(c) Most soils in the Amazon rainforest do not contain aluminosilicates. Researchers have discovered evidence that people who lived in the Amazon rainforest thousands of years ago added a substance known as 'biochar' to the soil, to improve its ability to grow crops.

Biochar can be formed by heating wood — without burning it — so that the water is removed and carbon is left behind.

(i) Biochar has a carbon lattice structure, which has a large number of carboxylate groups on its surface.

(1) State the type of charge on the carboxylate groups.

_____ (1 mark)

(2) By referring to the charge on the carboxylate groups, explain how biochar can store nutrient cations in soil.

_____ (2 marks)

(ii) Explain *one* advantage to the environment of not burning wood when producing biochar.

_____ (2 marks)

(iii) Biochar remains effective in soil for many years, reducing the need for fertiliser and consequently reducing the amount of fertiliser that enters waterways.

Explain how the presence of excess fertiliser in waterways can lead to harmful consequences for aquatic life.

_____ (3 marks)

- (iv) In many regions around the world, soils are deficient in aluminosilicates and cannot support the growth of crops. Scientific research into the effectiveness of using biochar to increase storage of nutrients in these soils is currently underway at several institutions around the world.

One of the key concepts of science as a human endeavour is 'communication and collaboration'.

With reference to this key concept, discuss how this research is an example of science as a human endeavour.

(2 marks)

