South Australian Certificate of Education

Stage 2 Chemistry

Sample Examination Questions 1

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

Stage 2 Chemistry Examination Questions

1. Most of the metal resources used today occur in a combined form, known as ore, in the Earth's crust.

(a) Copper occurs in both combined and uncombined forms in the Earth's crust.

(i) State why copper can occur in an uncombined form in the Earth's crust.

_____

_____ (1 mark)

(ii) The concentration of copper in an ore can be determined by atomic absorption spectroscopy (AAS), using a copper cathode lamp.

Explain why the radiation emitted by the copper cathode lamp can be absorbed by atoms of copper, but not by atoms of other elements.

_____

_____

_____

_____

_____

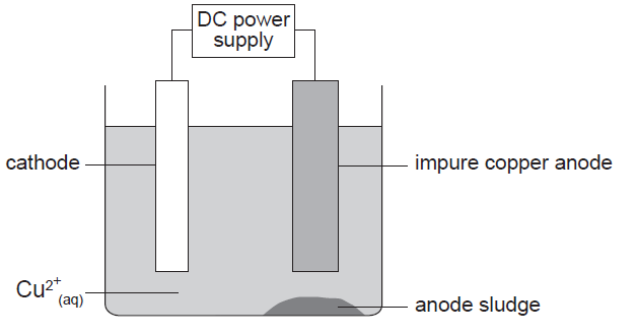
_____ (3 marks)

(iii) Copper ore is treated with chemicals to separate copper minerals from waste rock in the ore.

State *one* reason why the ore is crushed before undergoing this chemical treatment.

_____ (1 mark)

(iv) Copper minerals undergo reduction to produce impure copper metal. The impure copper is purified, using electrolytic refining. A simplified diagram of the apparatus used is shown below.



(1) State the charge on the cathode.

_____ (1 mark)

(2) Explain *one* benefit to a copper manufacturer of using $Cu^{2+}_{(aq)}$, rather than a moltencopper compound, as the electrolyte.

_____

_____

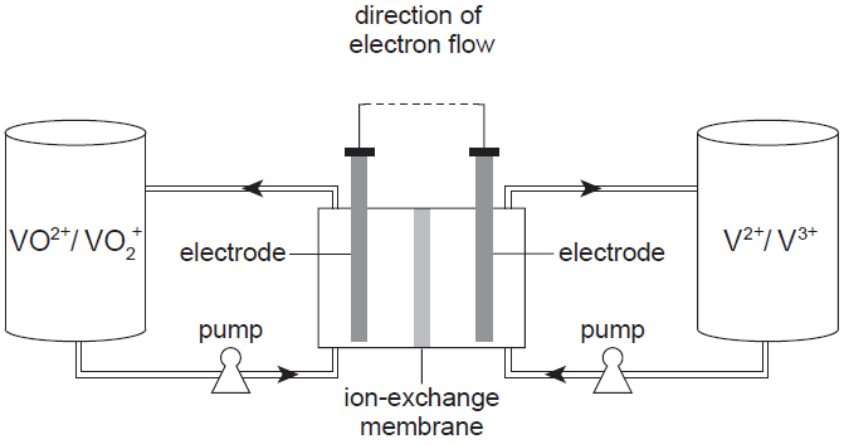
_____

_____ (2 marks)

(3) Using subshell notation, write the electron configuration of the copper atom.

_____ (2 marks)

(b) Vanadium is extracted during the processing of some metal ores, and is used to produce the electrolytes for vanadium flow cells. The diagram below shows a vanadium flow cell during discharge.



(i) During discharge, V^{2+} is oxidised to V^{3+}.

(1) State the electrode — the anode or the cathode — at which this reaction occurs.

_____ (1 mark)

(2) *On the dotted line provided on the diagram above*, draw an arrow to indicate the direction of electron flow during discharge. (1 mark)

(3) Complete the half-equation below for the reduction of VO_2^+ to VO^{2+}.

$$VO_2^+ \longrightarrow VO^{2+}$$

(2 marks)

(ii) State *one* advantage of using a flow cell, rather than another type of fuel cell, to generate electricity.

_____

_____ (1 mark)

(c) Many renewable energy technologies require metal resources that are in limited supply, such as molybdenum.

The process of recycling molybdenum is costly.

State *one* advantage of recycling, rather than discarding, molybdenum.

_____

_____ (1 mark)

2. The atmospheric concentrations of carbon dioxide and nitrogen oxides have been steadily increasing over the past few decades, causing changes in the Earth's oceans. These changes are affecting marine organisms.

(a) The increasing concentrations of carbon dioxide in the atmosphere have resulted in decreasing pH levels in ocean water.

(i) The average pH of ocean water at a particular site is currently 8.06.

Calculate the concentration, in mol L^{-1}, of hydrogen ions in the ocean water at this site.

(1 mark)

(ii) Describe how dissolved carbon dioxide decreases the pH of ocean water, and explain how this decrease in pH affects the shells of some marine organisms.

Include at least one equation in your answer.

(6 marks)

(b) The increasing concentrations of nitrogen oxides in the atmosphere have resulted in increasing concentrations of nitrate ions in oceans.

(i) NO emitted by motor vehicles increases the concentration of nitrogen oxides in the atmosphere.

Write an equation that shows how catalytic converters reduce the quantity of NO emitted by motor vehicles.

(2 marks)

(ii) State *one* natural process that adds nitrate ions to oceans.

_____ (1 mark)

(iii) Increased concentrations of nitrate ions in oceans can increase the growth of marine algae, from which iodine, I_2, can be extracted.

The I_2 extracted from a 0.94 g sample of algae was titrated with thiosulfate solution, $S_2O_3^{2-}{}_{(aq)}$. The equation for the titration reaction is shown below.

$$I_{2(aq)} + 2S_2O_3^{2-}{}_{(aq)} \longrightarrow S_4O_6^{2-}{}_{(aq)} + 2I^-{}_{(aq)}$$

The titre value was 21.30 mL of 0.250 mol L^{-1} thiosulfate solution.

Credit will be given for the correct use of significant figures in answers to part (1). (1 mark)

(1) Calculate the number of moles of thiosulfate used in the titration.

(2 marks)

(2) Calculate the number of moles of I_2 in the algae sample.

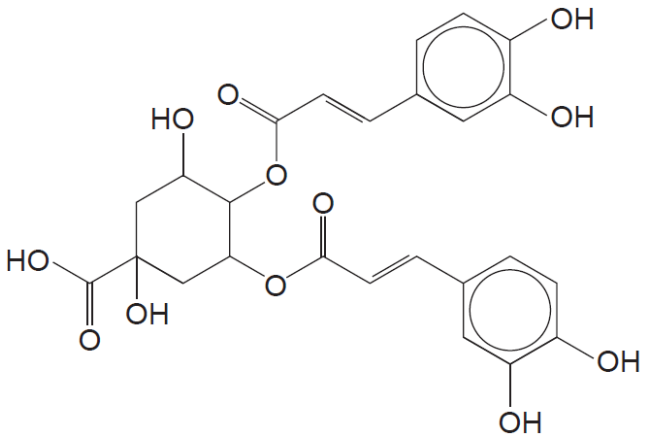
(2 marks)

(3) Calculate the percentage, by mass, of I_2 in the algae sample.

(3 marks)

3. The flavour of coffee is influenced by the type of coffee bean and the length of time for which the beans are roasted.

(a) Several different types of compound contribute to the bitter taste of coffee. The structural formula of one of these compounds is shown below.



(i) *On the structural formula above*, circle *one* ester functional group. (1 mark)

(ii) Explain why this compound forms a weakly acidic solution in water.

_____

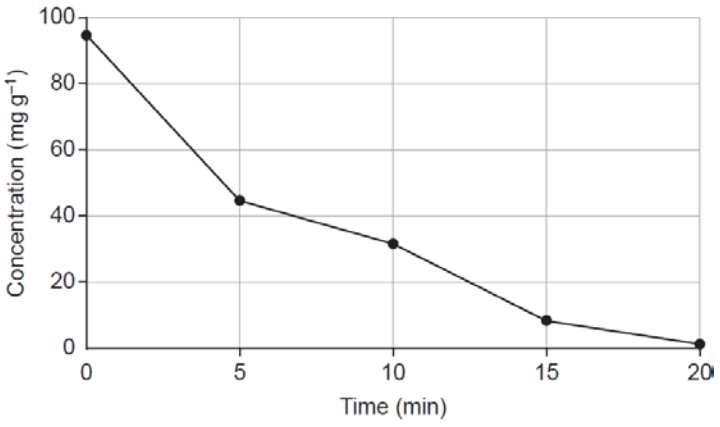
_____

_____

_____ (2 marks)

(b) Chlorogenic acids are compounds that are found in coffee. The graph below represents the concentration of chlorogenic acids in one type of coffee bean during roasting for 20 minutes. The concentration of chlorogenic acids was measured every 5 minutes.

Relationship between roasting time and concentration of chlorogenic acids



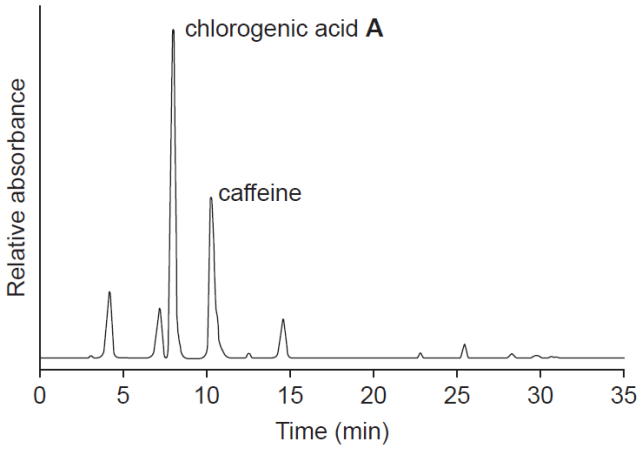
(i) Describe the relationship between roasting time and concentration of chlorogenic acids.

(1 mark)

(ii) State *one* improvement that should be made to the presentation of the data in the graph on page 10.

(1 mark)

(c) High-performance liquid chromatography (HPLC) can be used to separate the compounds present in coffee. The chromatogram produced from coffee made from one type of coffee bean is shown below.



Chlorogenic acid **A** is more hydrophilic than caffeine.

Explain whether, in this separation, the mobile phase was more polar or less polar than the stationary phase.

(3 marks)

4. Globally, there is much interest in using bioethanol as a fuel and as a feedstock for the production of plastic materials.

(a) Bioethanol can be used as a fuel in motor vehicles.

(i) Write a balanced equation for the complete combustion of ethanol.

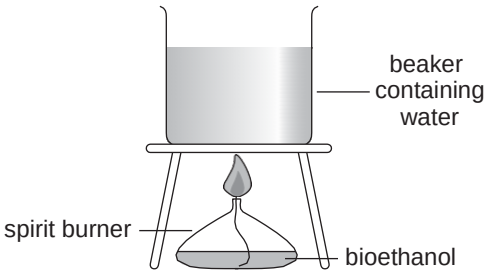
(2 marks)

(ii) The combustion of bioethanol contributes less carbon dioxide to the atmosphere than the combustion of ethanol made from petroleum.

State why this is so.

(1 mark)

(iii) The molar heat of combustion of ethanol was determined experimentally, using bioethanol to heat some water in a beaker. The equipment used is shown in the diagram below.



The following values were recorded:

Increase in temperature of the water = 9.05°C
Decrease in mass of bioethanol = 0.52 g

The calculated molar heat of combustion of ethanol was 832 kJ mol^{-1}.

(1) Explain which *one* of the two recorded values would have been more significantly affected by error.

(2 marks)

(2) Using the experimental values, determine the mass of water that was in the beaker.

The molar mass of ethanol is 46.068 g mol $^{-1}$.

(3 marks)

(iv) State why the combustion of ethanol produces less carbon (soot) than the combustion of longer-chain alcohols such as hexan-1-ol.

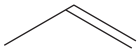
(1 mark)

(v) Explain, with the use of an equation, how NO is formed during the combustion of bioethanol in a motor vehicle engine.

(3 marks)

(b) Bioethanol can be used as a feedstock for the production of biopropene. Biopropene undergoes polymerisation to form biopolypropene, which is a sustainable plastic material that is in high demand.

(i) The structural formula of biopropene is shown below.



Write the molecular formula of biopropene.

_____ (1 mark)

(ii) Explain the disadvantage of using petroleum, rather than bioethanol, as a feedstock for the production of plastic materials.

_____

_____

_____

_____ (2 marks)

(iii) (1) State why biopolypropene is non-biodegradable.

_____

_____ (1 mark)

(2) State *one* disadvantage of biopolypropene being non-biodegradable.

_____

_____ (1 mark)

You may write on this page if you need more space to finish your answers to any of the questions in this question booklet. Make sure to label each answer carefully (e.g. 2(b)(iii)(2) continued).