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January 2010

**Chemistry**  
Assessment Unit A2 1

*assessing*

Periodic Trends and Further Organic,  
Physical and Inorganic Chemistry

[AC211]

WEDNESDAY 27 JANUARY, MORNING



AC211

StudentBounty.com

71	
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Candidate Number

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**TIME**

2 hours.

**INSTRUCTIONS TO CANDIDATES**

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all fifteen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10.

Keep in sequence when answering.

Answer **all five** questions in **Section B**. Write your answers in the spaces provided in this question paper.

**INFORMATION FOR CANDIDATES**

The total mark for this paper is 120.

Quality of written communication will be assessed in Question **11(d)(i)**.

In Section A all questions carry equal marks, i.e. **two** marks for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.

For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
<b>Total Marks</b>	

## Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

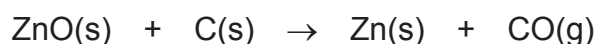
1 Which one of the following substances, when added to water in equimolar amounts, will form the solution with the highest pH?

- A ammonium chloride
- B ammonium ethanoate
- C potassium ethanoate
- D potassium chloride

2 Which one of the following substances has a different molecular formula from its empirical formula?

- A butanoic acid
- B ethanal
- C propanal
- D propanone

3 Zinc is manufactured by the reduction of its oxide using carbon.



$$\Delta H^\ominus = +237 \text{ kJ mol}^{-1}$$

$$\Delta S^\ominus = +190 \text{ JK}^{-1} \text{ mol}^{-1}$$

What is the minimum temperature needed for this reaction to become feasible?

- A 154 K
- B 427 K
- C 975 K
- D 1248 K

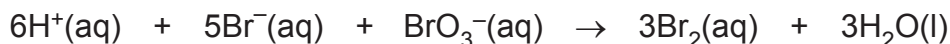
4 How many isomers which have the molecular formula  $\text{C}_3\text{H}_6\text{O}$  can be reduced by lithium to an alcohol?

- A 1
- B 2
- C 3
- D 4

5 Which one of the following compounds contains co-ordinate (dative) bonds?

- A  $\text{Al}_2\text{Cl}_6$
- B  $\text{CCl}_4$
- C  $\text{MgCl}_2$
- D  $\text{NaCl}$

6 The “bromine clock” reaction proceeds according to the equation:



The rate equation is:

$$\text{Rate} = k[\text{H}^+]^2[\text{Br}^-][\text{BrO}_3^-]$$

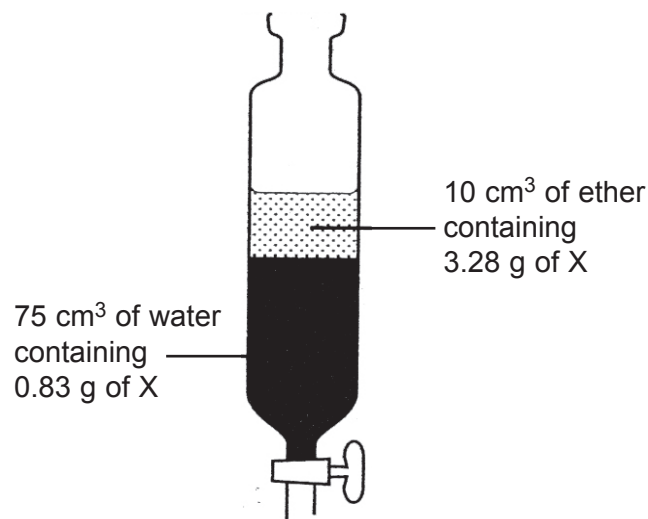
When the rate of disappearance of bromide ions is  $1.2 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1}$ , which one of the following statements is correct?

- A The rate of disappearance of bromate(V) ions,  $\text{BrO}_3^-$ , is  $1.2 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1}$ .
- B The rate of disappearance of bromate(V) ions,  $\text{BrO}_3^-$ , is  $2.4 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$ .
- C The rate of disappearance of hydrogen ions is  $1.4 \times 10^{-8} \text{ mol dm}^{-3} \text{ s}^{-1}$ .
- D The rate of disappearance of hydrogen ions is  $1.0 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1}$ .

7 In which one of the following do all three oxides behave as indicated at room temperature?

	<b>neutralises dilute acid</b>	<b>neutralises dilute alkali</b>	<b>dissolves in water to form an acidic solution</b>
A	$\text{Na}_2\text{O}$	$\text{MgO}$	$\text{SiO}_2$
B	$\text{MgO}$	$\text{Al}_2\text{O}_3$	$\text{Cl}_2\text{O}_7$
C	$\text{P}_4\text{O}_{10}$	$\text{SiO}_2$	$\text{SO}_3$
D	$\text{Al}_2\text{O}_3$	$\text{SO}_2$	$\text{Na}_2\text{O}$

- 8 The diagram shows the distribution of a substance X between ether and water at equilibrium.



What is the value of the partition coefficient  $K_d = \frac{[\text{X in ether}]}{[\text{X in water}]}$ ?

- A 3.95  
B 7.50  
C 29.64  
D 32.80
- 9 Which one of the following would **not** be affected by boiling with aqueous sodium hydroxide?
- A ethyl ethanoate  
B glycerol  
C olive oil  
D propanoic acid
- 10 What is the pH of a solution containing 6.0 g of ethanoic acid,  $\text{CH}_3\text{COOH}$  ( $K_a = 1.74 \times 10^{-5} \text{ mol dm}^{-3}$ ), and 2.0 g of sodium ethanoate,  $\text{CH}_3\text{COONa}$ , dissolved in 100 cm<sup>3</sup> of solution?
- A 2.38  
B 4.15  
C 4.28  
D 4.76

## Section B

Answer **all five** questions in the spaces provided.

**11** Formaldehyde (methanal),  $\text{HCHO}$ , is a colourless gas which is readily soluble in water. The aqueous solution is used for preserving anatomical specimens.

**(a)** Explain why formaldehyde is soluble in water.

\_\_\_\_\_  
\_\_\_\_\_ [2]

**(b)** Formaldehyde is a reducing agent as illustrated by its reaction with Tollen's reagent.

**(i)** Write an equation for the oxidation of formaldehyde using  $[\text{O}]$  to represent the oxidising agent.

\_\_\_\_\_ [1]

**(ii)** Write the half-equation for the reduction of silver ions in Tollen's reagent.

\_\_\_\_\_ [1]

**(iii)** What is observed during this reaction?

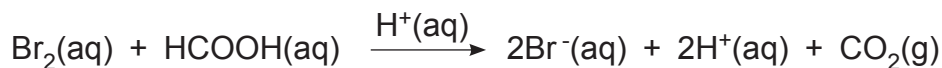
\_\_\_\_\_ [1]

**(c)** Formaldehyde reacts with hydrogen cyanide.

Draw a flow scheme for the mechanism of this reaction.

[3]

(d) Methanoic acid undergoes an acid catalysed reaction with bromine according to the equation:



(i) Suggest an experimental method to investigate the rate of this reaction. How would you find the order of the reaction with respect to bromine?

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[4]

Quality of written communication

[2]

(ii) The rate law was found to be

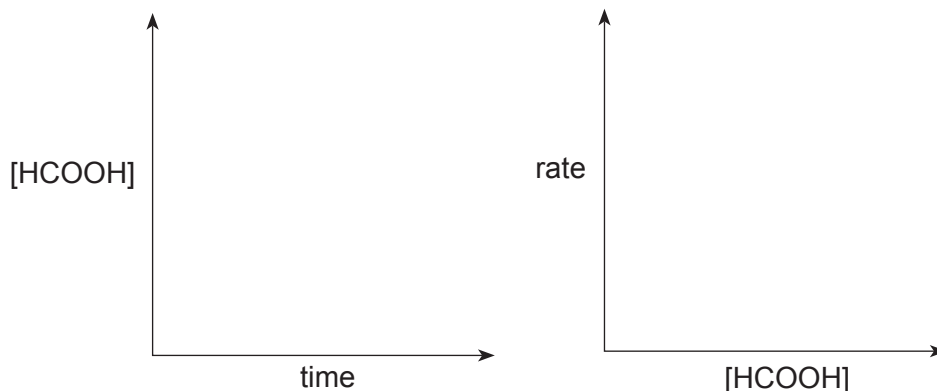
$$\text{Rate} = k[\text{Br}_2][\text{HCOOH}]$$

Deduce the units for the rate constant k.

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[1]

(iii) On the axes below, sketch the expected shape of the graphs in this reaction.



[2]

(e) Methanoic acid reacts with ethanol in the presence of concentrated sulphuric acid to form an ester.

(i) Write the equation for this esterification.

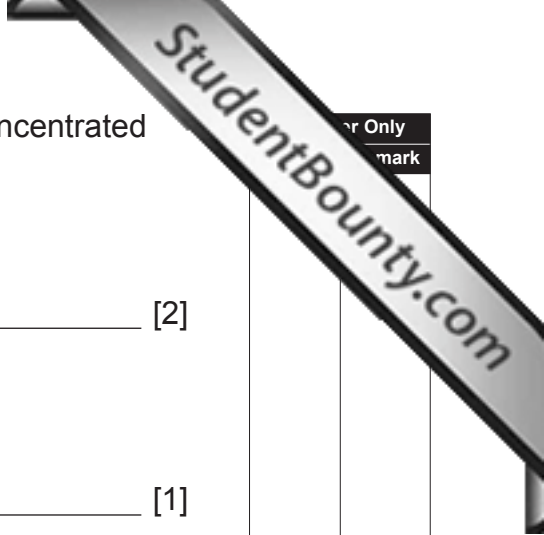
\_\_\_\_\_ [2]

(ii) Name the ester formed.

\_\_\_\_\_ [1]

(iii) State **two** functions of concentrated sulphuric acid in this reaction.

\_\_\_\_\_  
\_\_\_\_\_ [2]



or Only  
mark

12 The combustion of non-renewable hydrocarbon fuels has contributed to the increase in the atmospheric concentration of carbon dioxide. This in turn is believed to be a key factor in global warming.

(a) Carbon dioxide absorbs infra-red radiation. State **two** effects this radiation has on the bonds in a carbon dioxide molecule.

\_\_\_\_\_

\_\_\_\_\_ [2]

(b) Photosynthesis involves conversion of carbon dioxide and water into a carbohydrate and oxygen.

(i) Write an equation for photosynthesis representing the carbohydrate as  $C_6H_{12}O_6$ .

\_\_\_\_\_ [1]

(ii) A mature tree can produce approximately 220 kg of oxygen per year. What volume of carbon dioxide, measured at one atmosphere pressure and 20 °C, does a tree need to produce this mass of oxygen?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ [3]

(iii) Wood is approximately 50% cellulose. Burning wood releases carbon dioxide into the atmosphere. Write an equation for the complete combustion of cellulose. Use the formula  $C_6H_{10}O_5$  to represent cellulose.

\_\_\_\_\_ [2]

(c) The oceans play an important part in determining the percentage of carbon dioxide in the atmosphere. It is estimated that the oceans contain some  $3.9 \times 10^{13}$  tonnes of carbon in total. Calculate the mass of carbon dioxide which the oceans have absorbed to contain this mass of carbon.

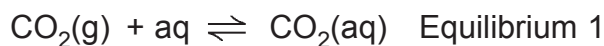
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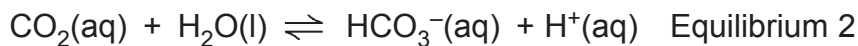
\_\_\_\_\_ [2]



(d) Carbon dioxide dissolves in water according to the equation:



Approximately 4% of the dissolved carbon dioxide reacts with water to form hydrogencarbonate ions and hydrogen ions in a further equilibrium.



(i) Explain the effect a rise in atmospheric carbon dioxide levels would have on the position of Equilibrium 1.

\_\_\_\_\_  
\_\_\_\_\_ [1]

(ii) Write an expression for the equilibrium constant,  $K_c$ , for Equilibrium 2.

\_\_\_\_\_ [1]

(iii) A solution of carbon dioxide is weakly acidic. Explain whether the value of  $K_c$  will be large or small.

\_\_\_\_\_ [1]

13 Ketones and carboxylic acids are produced by the oxidation of alcohols.

(a) The identity of an unknown ketone was determined by preparing the solid derivative from 2,4-dinitrophenylhydrazine and determining the melting point of the purified product.

(i) Write the equation for the reaction of butanone with 2,4-dinitrophenylhydrazine.

[3]

(ii) State the expected colour of the solid derivative.

[1]

(iii) Describe how you would purify the solid derivative.

[3]

(iv) Describe how the melting point of the purified solid would be determined experimentally.

[3]

(v) What **two** effects would impurities have on the recorded melting point?

[2]

(b) Lactic acid,  $\text{CH}_3\text{CHOHCOOH}$ , is a weak acid which builds up in muscles during exercise. The molecule is optically active.

(i) Explain the term **optically active**.

\_\_\_\_\_  
 \_\_\_\_\_ [2]

(ii) Draw the 3D structures of the two chiral isomers.

[2]

(c) In an experiment to determine the percentage by mass of lactic acid in an aqueous solution,  $25.0 \text{ cm}^3$  samples of the acid solution were titrated against  $1 \text{ mol dm}^{-3}$  sodium hydroxide solution. The average titre was found to be  $24.3 \text{ cm}^3$ .

(i) Write the equation for the reaction of lactic acid with sodium hydroxide.

\_\_\_\_\_ [1]

(ii) Calculate the molarity of the lactic acid solution.

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ [3]

(iii) Calculate the concentration of the lactic acid solution in  $\text{g dm}^{-3}$ .

\_\_\_\_\_  
 \_\_\_\_\_ [2]

(iv) Name a suitable indicator for this titration.

\_\_\_\_\_ [1]

- (d) A carboxylic acid was found to contain 58.7% carbon, 9.8% hydrogen and 31.5% oxygen. Deduce the empirical formula of the acid.

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[3]

- (e) Fats and oils are triesters of glycerol and long chain carboxylic acids. The fat contained in mutton is predominantly a triester formed from stearic acid,  $\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$ .

- (i) Draw the structure of this triester.

[2]

- (ii) The saponification value of a fat provides information about the structure. Define the term **saponification value** and explain what a high value would indicate about a fat.

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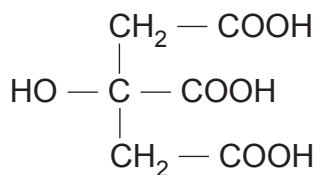
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[4]

- 14 Citric acid is a weak tribasic acid found in citrus fruits. It has the following structure:



- (a) (i) How many asymmetric (chiral) centres are present in the molecule?

\_\_\_\_\_ [1]

- (ii) The partially completed systematic name for citric acid is given below. Complete the name by inserting commas and hyphens in the appropriate spaces.

2 hydroxypropane 1 2 3 tricarboxylic acid [2]

- (b) Citric acid reacts with sodium hydrogencarbonate in an endothermic reaction. The expression  $\Delta G^\ominus = \Delta H^\ominus - T \Delta S^\ominus$  can be used to explain why endothermic processes can proceed spontaneously.

- (i) Write the equation for the reaction of citric acid with **excess** sodium hydrogencarbonate.

[2]

- (ii) State **one** observation which would indicate the reaction was complete.

\_\_\_\_\_ [1]

- (iii) Explain the meaning of the symbol  $\Delta S^\ominus$ .

\_\_\_\_\_ [2]

(iv) Explain, in terms of the expression  $\Delta G^\ominus = \Delta H^\ominus - T \Delta S^\ominus$ , why the reaction of citric acid with sodium hydrogencarbonate proceeds spontaneously despite being endothermic.

\_\_\_\_\_  
 \_\_\_\_\_ [2]

(c) The first acid dissociation constant,  $K_a$ , for citric acid is  $8.4 \times 10^{-4} \text{ mol dm}^{-3}$ .

(i) Write an equation for the first ionisation of citric acid in aqueous solution.

\_\_\_\_\_ [1]

(ii) Write an expression for the first acid dissociation constant,  $K_a$ , for citric acid using RCOOH to represent citric acid.

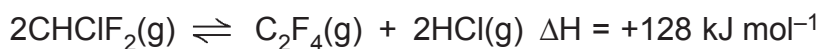
\_\_\_\_\_ [1]

(iii) Calculate the pH of a  $0.1 \text{ mol dm}^{-3}$  solution of citric acid assuming only the first ionisation takes place.

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ [3]

15 Compounds containing fluorine find diverse uses including polymer manufacture and additives for toothpaste.

- (a) The polymer Teflon, polytetrafluoroethene, is made by polymerising tetrafluoroethene which itself is produced from chlorodifluoromethane according to the equation:



- (i) State and explain the effect of increasing the overall pressure on the yield of tetrafluoroethene.

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[2]

- (ii) State and explain the effect of increasing the temperature on the yield of tetrafluoroethene.

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[2]

- (iii) 0.2 mole of chlorodifluoromethane was placed in a 5 dm<sup>3</sup> sealed flask and heated. At equilibrium the mixture obtained contained only 0.04 mole of the gas. Calculate the value of  $K_c$  for this reaction and state its units.

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[4]

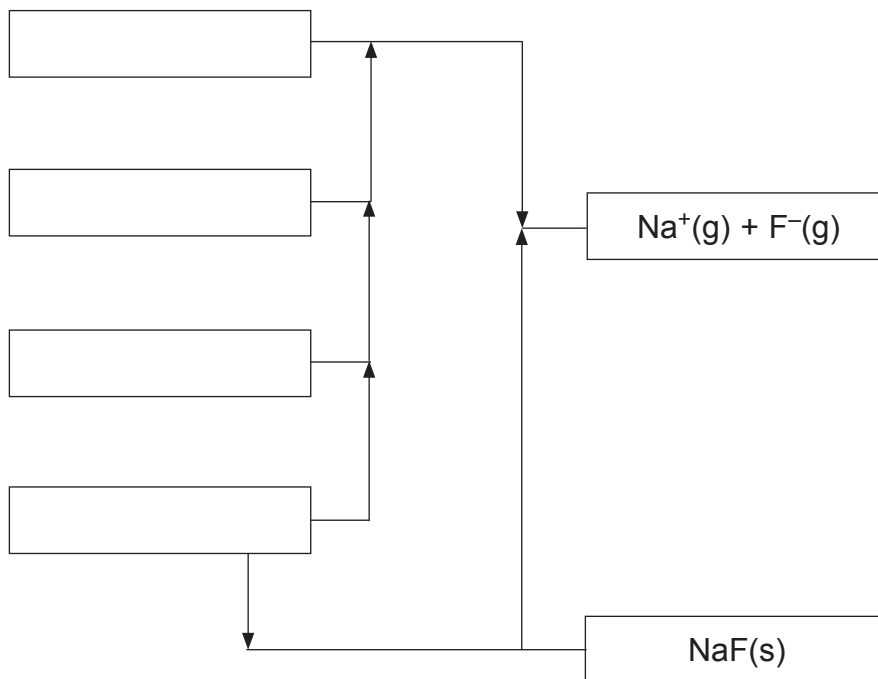
- (iv) State **two** advantages of polymer disposal by incineration compared to landfill.

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[2]

(b) Sodium fluoride is added to toothpaste to reduce tooth decay. The partially completed Born-Haber cycle for sodium fluoride is shown below.



(i) Complete the empty boxes above by inserting the appropriate chemical symbols. [4]

(ii) Using the data below, calculate the lattice enthalpy for sodium fluoride.

	kJ mol <sup>-1</sup>
First ionisation energy of sodium	+496
Enthalpy of atomisation of sodium	+107
Bond enthalpy of fluorine	+158
Electron affinity of fluorine	-333
Enthalpy of formation of sodium fluoride	-574

\_\_\_\_\_ [2]  
 \_\_\_\_\_

(iii) Write the electronic configuration in s, p and d notation for a sodium ion,  $\text{Na}^+$ , and a fluoride ion,  $\text{F}^-$ .

sodium ion \_\_\_\_\_

fluoride ion \_\_\_\_\_ [2]



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**THIS IS THE END OF THE QUESTION PAPER**

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