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General Certificate of Education  
2010

**Chemistry**  
Assessment Unit A2 1

*assessing*

Periodic Trends and Further Organic,  
Physical and Inorganic Chemistry

[AC212]

FRIDAY 21 MAY, AFTERNOON



AC212

StudentBounty.com

71	
Candidate Number	
<input type="text"/>	

**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 sixteen** 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 six** 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 **14(c)(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.

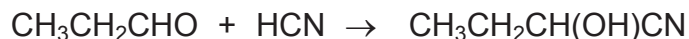
For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
<b>Total Marks</b>	

## 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 The mechanism of the reaction



is described as

- A electrophilic addition.
  - B electrophilic substitution.
  - C nucleophilic addition.
  - D nucleophilic substitution.
- 2 Which one of the following indicators would be suitable for a titration between molar solutions of sulphuric acid and ammonia?

pH range

- A malachite green      0.2–1.8
- B methyl yellow        2.9–4.0
- C thymolphthalein    8.3–10.6
- D alizarin yellow      10.1–13.0

- 3 Methanol is manufactured by the reaction of carbon monoxide with hydrogen:



The reaction is carried out at 250 °C and 50 atmospheres pressure. Which one of the following changes to the conditions would maximise the equilibrium yield of methanol?

	temperature	pressure
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

- 4 The partition coefficient,  $K_d$ , of an organic compound X between ether and water is 0.0. An aqueous solution of X containing 3.0 g in 250 cm<sup>3</sup> of solution was subjected to a single extraction with 50 cm<sup>3</sup> of ether. What mass of X was extracted on shaking with 50 cm<sup>3</sup> of ether?
- A 0.14 g  
B 0.60 g  
C 2.40 g  
D 2.86 g

- 5 What is the conjugate base of the acid HCO<sub>3</sub><sup>-</sup>?

- A CO<sub>3</sub><sup>2-</sup>  
B H<sub>2</sub>CO<sub>3</sub>  
C H<sub>3</sub>O<sup>+</sup>  
D OH<sup>-</sup>

- 6 The decomposition of calcium carbonate is represented by the following equation:



$$\Delta H^\ominus = +178 \text{ kJ mol}^{-1}$$

$$\Delta S^\ominus = +161 \text{ JK}^{-1} \text{ mol}^{-1}$$

What is the standard free energy change,  $\Delta G^\ominus$ , for this reaction at 25 °C?

- A -48 kJ mol<sup>-1</sup>  
B +130 kJ mol<sup>-1</sup>  
C +174 kJ mol<sup>-1</sup>  
D +339 kJ mol<sup>-1</sup>
- 7 The compound CH<sub>3</sub>CH(OH)CH<sub>2</sub>COOCH<sub>3</sub> is found in marshmallows. Which one of the following statements is **incorrect**?
- A Hydrolysis of the compound produces methanol as one of the products.  
B The compound has only one chiral centre.  
C The compound turns acidified potassium dichromate(VI) green on warming.  
D The compound produces a silver mirror when heated with Tollen's reagent.

- 8 Ethanedioic acid has the structure:



What volume of 0.5 M sodium hydroxide solution is required to completely neutralise 25.0 cm<sup>3</sup> of 0.25M aqueous ethanedioic acid?

- A 6.25 cm<sup>3</sup>  
B 12.50 cm<sup>3</sup>  
C 25.00 cm<sup>3</sup>  
D 50.00 cm<sup>3</sup>
- 9 Propanone reacts with 2,4-dinitrophenylhydrazine to form a solid derivative. What is the relative molecular mass of this derivative?
- A 235  
B 237  
C 238  
D 241
- 10 X and Y react according to the equation



The rate law was found by experiment to be

$$\text{Rate} = k[Y]^2$$

Which one of the following would be a possible mechanism for the reaction?

- A  $X + Y \rightarrow XY$  (fast);  $XY + Y \rightarrow XY_2$  (slow)  
B  $Y + Y \rightarrow Y_2$  (slow);  $Y_2 + X \rightarrow XY_2$  (fast)  
C  $X + Y + Y \rightarrow XY_2$  (slow)  
D  $X + Y \rightarrow XY$  (slow);  $XY + Y \rightarrow XY_2$  (fast)

## Section B

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

**11** Ammonium nitrate is an important fertiliser which also finds use in explosives.

**(a)** Ammonium nitrate is produced by the reaction of ammonia with nitric acid.

**(i)** Write the equation for this reaction.

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

**(ii)** State and explain whether an aqueous solution of ammonium nitrate is acidic, neutral or alkaline.

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

**(iii)** The nitrate(V) ion,  $\text{NO}_3^-$ , is trigonal planar and contains a single covalent bond, a double covalent bond and a dative (co-ordinate) bond. Draw a dot and cross diagram to show the bonding in the nitrate(V) ion.

[2]

**(b)** Ammonium nitrate decomposes on heating to form nitrogen(I) oxide and water.

**(i)** Write the equation for this decomposition.

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

**(ii)** This reaction is exothermic and has a positive entropy change. Explain why this process is spontaneous at all temperatures.

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

(c) Ammonium nitrate is an artificial fertiliser.

(i) State **one** advantage of artificial fertilisers compared to natural ones.

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

(ii) Calculate the percentage of nitrogen in ammonium nitrate.

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

(d) Moderately high nitrate(V) concentrations in drinking water can result in methaemoglobinaemia in babies, the so-called “Blue-Baby” Syndrome.

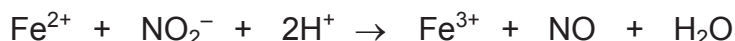
(i) Explain how nitrate(V) ions enter public water supplies.

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

(ii) Concentrations of nitrate(V) ions in drinking water above  $0.05 \text{ mg cm}^{-3}$  can result in “Blue-Baby” Syndrome. Calculate the molarity of this solution.

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

(iii) Nitrate(V) ions are reduced to nitrate(III) ions by bacteria. The nitrate(III) ions subsequently react with iron(II) ions in haemoglobin.



With reference to oxidation numbers, explain why this equation is an example of a redox reaction.

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

12 Propanoic acid is a weak acid which finds use in buffer solutions and in the preparation of esters.

(a) Propanoic acid has a  $pK_a$  value of 4.87. Calculate the pH of a 0.05 M solution of the acid.

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[4]

(b) A buffer solution may be made up by mixing propanoic acid and sodium propanoate in aqueous solution. With the aid of relevant equations, explain how this buffer resists a change in pH on addition of a small amount of acid.

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[4]

(c) Methyl propanoate may be prepared in the laboratory by the reaction of propanoic acid and methanol.

(i) Write the equation for the preparation of methyl propanoate.

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[1]

(ii) Concentrated sulphuric acid is added to the reaction mixture. State **one** function of this acid in the preparation.

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[1]

- (iii) Propanoic acid has a boiling point of 141 °C, while that of methyl propanoate is only 79 °C despite its higher relative formula mass. Explain the difference in the two boiling points.

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[2]

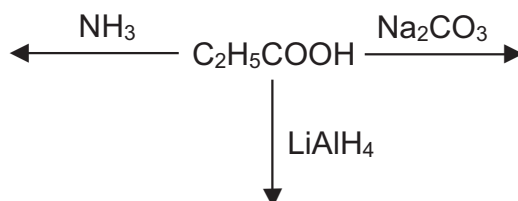
- (iv) Propanoyl chloride may be used in place of propanoic acid for this preparation. State **two** advantages of using the acyl chloride.

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[2]

- (d) Complete the diagram below by inserting the organic product formed in each case.



[3]



13 On crossing the third period of the Periodic Table, from sodium to chlorine, the change in character from metallic to non-metallic is clearly evident in the elements and their compounds.

(a) Using **only** third period elements answer the following questions.

(i) Name the element which forms an oxide in which it has an oxidation state of +6.

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

(ii) Name the oxide which has the highest melting point.

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

(iii) State the formula of the chloride which in its solid form contains both ionic and covalent bonds.

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

(iv) Classify the following oxides as acidic, amphoteric or basic.

oxide	classification
magnesium	
silicon	
phosphorus	

[3]

(b) Gallium is a Group III element which Mendeleev predicted would be similar to aluminium despite not having been discovered when he constructed his original Periodic Table.

(i) Gallium oxide is neutralised by hydrochloric acid. Write the equation for this reaction.

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

(ii) Gallium chloride dimerises in a similar way to aluminium chloride thus resulting in the formula  $\text{Ga}_2\text{Cl}_6$ . Draw a dot and cross diagram, using outer shells only, to show the bonding in  $\text{Ga}_2\text{Cl}_6$ .

[2]

14 Iodine is an essential element for healthy growth and fertility in animals.

- (a) The element may be prepared in the laboratory by heating potassium iodide with concentrated sulphuric acid and manganese(IV) oxide. Iodine, potassium hydrogensulphate, manganese(II) sulphate and water are formed. Write the equation for this preparation.

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

- (b) Iodine reacts with propanone in an acid catalysed reaction.



The rate law was determined to be:

$$\text{Rate} = k[\text{CH}_3\text{COCH}_3][\text{H}^+]$$

- (i) Name the instrument which could be used to measure the concentration of iodine in conjunction with a calibration curve.

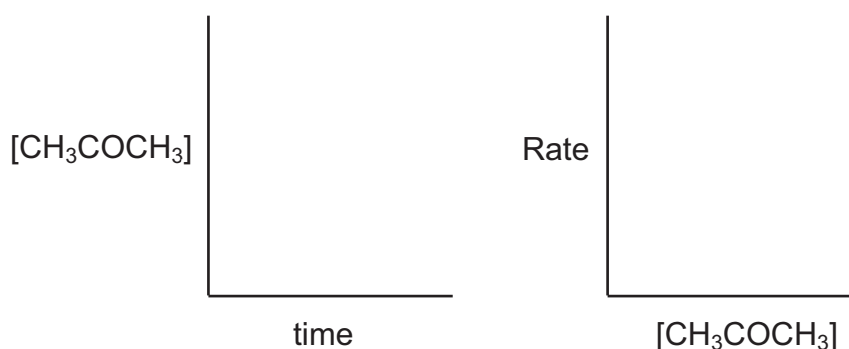
\_\_\_\_\_ [1]

- (ii) State what the symbol  $k$  represents and deduce its units.

$k$  \_\_\_\_\_

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

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

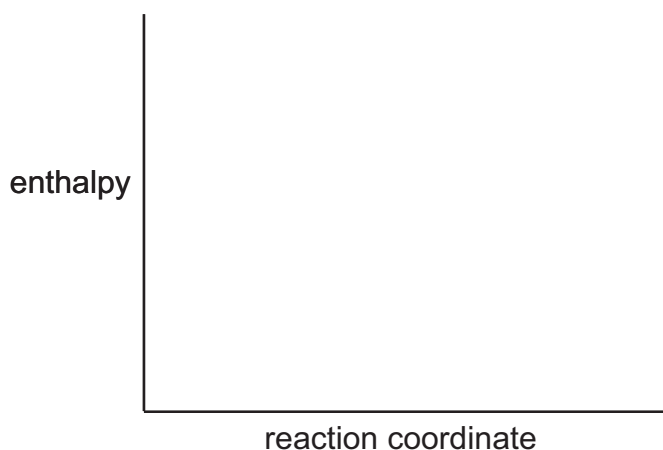


[2]

- (iv) Deduce the overall effect of doubling the initial concentrations of propanone, iodine and acid on the initial rate of reaction.

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

(v) On the axes below, draw an enthalpy level diagram for the reaction labelling both the catalysed and uncatalysed pathways, assuming the reaction is exothermic.



[2]

(vi) Suggest what effect, if any, the use of a catalyst will have on the value of  $k$  for this reaction at a given temperature.

[1]

(c) The iodine value of a fat or oil provides information about its structure.

(i) Describe, with experimental detail, how you would determine the iodine value of a sample of linseed oil. Details on calculations should not be given.

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[5]

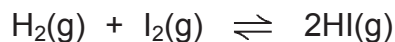
Quality of written communication

[2]

(ii) Linseed oil has a relatively low iodine value. What does this tell you about its structure?

[1]

- (d) Hydrogen and iodine react to form hydrogen iodide according to the equation:



Equimolar amounts of hydrogen and iodine were allowed to reach equilibrium at a given temperature. At equilibrium 75% of the hydrogen, by mass, had been converted to hydrogen iodide.

- (i) Calculate  $K_c$  for this reaction and state its units.

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[3]

- (ii) Explain why the volume of the container was not needed to calculate  $K_c$  for this reaction.

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[1]

- (iii) Calculate the value of  $K_c$  for the reverse reaction at the same temperature.

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[1]

- (e) Lead(II) iodide is a bright yellow solid produced by mixing solutions of lead(II) nitrate and potassium iodide. 50.0 cm<sup>3</sup> of 0.4 M potassium iodide were mixed with excess lead(II) nitrate solution. The precipitate was filtered, washed, dried and found to weigh 3.8 g. Calculate the percentage yield.



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[3]

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**(Questions continue overleaf)**

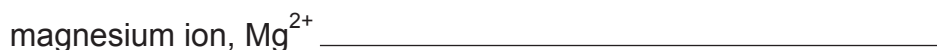
15 Sea water contains over 3% by mass of dissolved chlorides such as sodium and magnesium.

(a) Chlorine exhibits a wide range of oxidation states in its compounds. Deduce the oxidation state of chlorine in each of the compounds below.

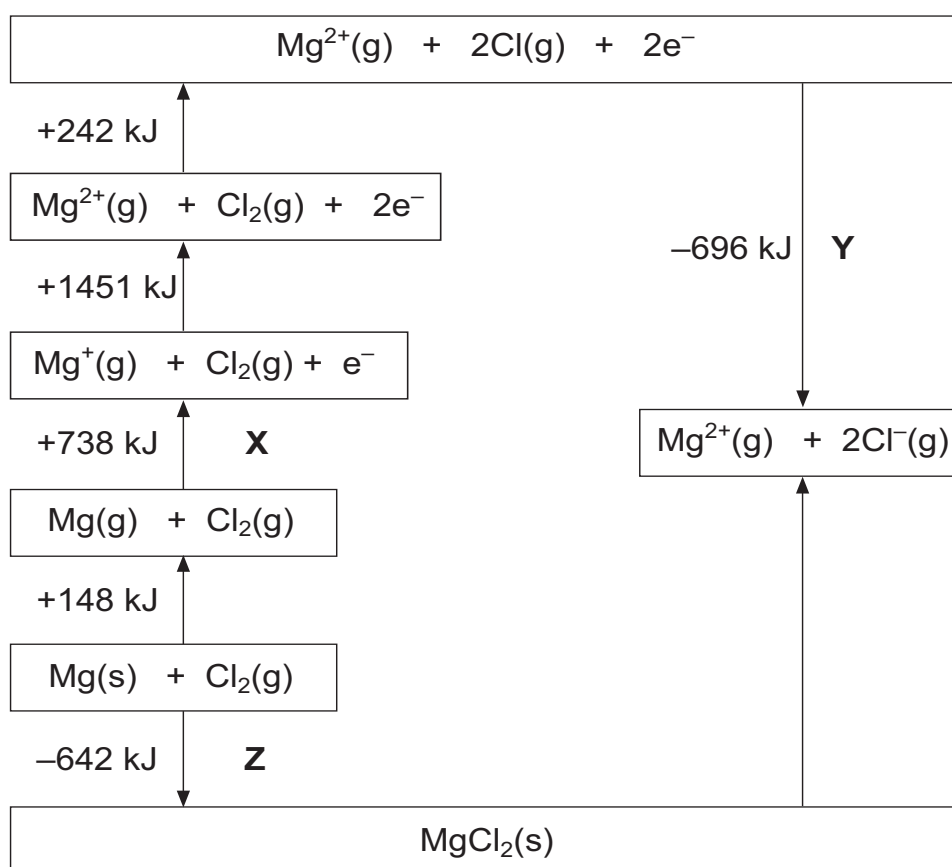


(b) Magnesium chloride is an ionic compound.

(i) State the electronic configuration of a magnesium ion and a chloride ion in the ground state using the s, p and d notation.



(ii) The Born-Haber cycle for the formation of magnesium chloride is shown below.



Name the energy changes X, Y and Z.

X \_\_\_\_\_

Y \_\_\_\_\_

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

(iii) Calculate the lattice enthalpy for magnesium chloride.

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

(c) Both thionyl chloride,  $\text{SOCl}_2$ , and phosphorus pentachloride react with carboxylic acids to yield the same organic product.

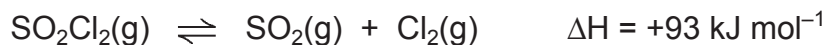
(i) Write equations to show the reaction of both thionyl chloride and phosphorus pentachloride with butanoic acid.

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

(ii) Explain the advantage of using thionyl chloride instead of phosphorus pentachloride in the preparation of an acyl chloride.

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

(d) Sulphuryl chloride,  $\text{SO}_2\text{Cl}_2$ , dissociates at high temperatures according to the equation:



(i) State and explain the effect of increasing the temperature on the extent of dissociation.

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

(ii) State and explain the effect of increasing the total pressure on the extent of dissociation.

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[2]

(iii) When 2.0 moles of sulphuryl chloride were allowed to dissociate at a given temperature, the equilibrium mixture was found to contain 1.5 moles of chlorine at a total pressure of 150 kPa. Calculate the value of the equilibrium constant  $K_p$  for this reaction and state its units.

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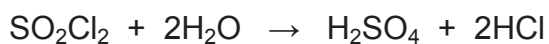
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[4]

(e) Sulphuryl chloride is rapidly hydrolysed by water.



Calculate the pH of the solution made by dissolving 135 g of sulphuryl chloride in water to make 1 dm<sup>3</sup> of solution.

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[3]



16 Aldehydes are so named because they can be obtained from alcohols ("al") by dehydrogenation ("dehyd") using a finely divided copper catalyst at 300 °C.

(a) Write the equation for the dehydrogenation of ethanol to ethanal.

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

(b) Ethanal reacts with cold dilute potassium carbonate solution to yield 3-hydroxybutanal,  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CHO}$  which is optically active.

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

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

(ii) Draw the three-dimensional structures for the two optical isomers of 3-hydroxybutanal.

[2]

(ii) 3-hydroxybutanal may be dehydrated to form but-2-enal. Suggest a structure for but-2-enal.

[1]

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

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