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General Certificate of Education
2012

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Centre Number
71
Candidate Number

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic,
Physical and Inorganic Chemistry

[AC212]



TUESDAY 15 MAY, AFTERNOON

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 seventeen** 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 seven** 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)**.

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 | |
| 17 | |
| Total Marks | |

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 compounds has coordinate bonds in its structure?
- A Aluminium chloride, Al_2Cl_6
 - B Magnesium chloride, MgCl_2
 - C Phosphorus pentachloride, PCl_5
 - D Sodium chloride, NaCl
- 2 Which one of the following equations represents the lattice enthalpy of sodium chloride?
- A $\text{NaCl}(\text{aq}) \rightarrow \text{Na}(\text{g}) + \text{Cl}(\text{g})$
 - B $\text{NaCl}(\text{aq}) \rightarrow \text{Na}^+(\text{g}) + \text{Cl}^-(\text{g})$
 - C $\text{NaCl}(\text{s}) \rightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
 - D $\text{NaCl}(\text{s}) \rightarrow \text{Na}^+(\text{g}) + \text{Cl}^-(\text{g})$
- 3 Which one of the following reactions would give an increase in entropy?
- A $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
 - B $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$
 - C $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightarrow 2\text{HI}(\text{g})$
 - D $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g})$
- 4 Which one of the following statements about the formation of an ester from ethanoyl chloride and propan-1-ol is correct?
- A Concentrated sulfuric acid is required.
 - B Heat is required.
 - C The ester produced is called ethyl propanoate.
 - D The reaction goes to completion.

- 5 Which one of the following is the conjugate base of butanoic acid?
- A $C_3H_7COO^-$
 - B $C_3H_7COOH_2^+$
 - C $C_4H_9COO^-$
 - D $C_4H_9COOH_2^+$
- 6 The partition coefficient of an organic compound, X, between ether and water is 6.0. Which one of the following is the mass of X extracted when an aqueous solution of X containing 2.50 g in 150 cm^3 of solution is shaken with 50 cm^3 of ether?
- A 0.10 g
 - B 0.83 g
 - C 1.67 g
 - D 2.37 g
- 7 Which one of the following is the general formula of a simple carboxylic acid?
- A $C_nH_nO_2$
 - B $C_nH_{2n}O$
 - C $C_nH_{2n}O_2$
 - D $C_nH_{2n+2}O$
- 8 Which one of the following statements about K_w is **not** correct?
- A K_w has a value of 1×10^{-14} at 25°C
 - B $\text{p}K_w = -\log K_w$
 - C The units of K_w are mol dm^{-3}
 - D The value of K_w changes with temperature

- 9 Which one of the following is the correct classification of silicon dioxide?
- A Acidic
 - B Amphoteric
 - C Basic
 - D Neutral
- 10 A 1.1 g sample of an oil was treated with Wjij's solution and excess potassium iodide solution. The liberated iodine reacted with 7.3 cm³ of 0.1 mol dm⁻³ sodium thiosulfate solution. The blank titration required 43.5 cm³ of sodium thiosulfate. Which one of the following is the iodine value of the oil?
- A 41.76
 - B 45.94
 - C 50.53
 - D 58.60

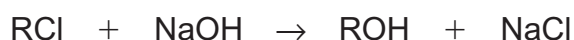
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(Questions continue overleaf)

Section B

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

- 11 A chloroalkane is reacted with an aqueous solution of sodium hydroxide according to the following equation.



- (a) (i) The rate of reaction can be investigated by monitoring the concentration of sodium hydroxide. Describe a titration method for carrying this out.

[3]

- (ii) How would you use the results to determine the rate of reaction?

[2]

- (b) The following results were obtained for the reaction.

| Experiment | [RCl] (mol dm ⁻³) | [NaOH] (mol dm ⁻³) | Rate (mol dm ⁻³ s ⁻¹) |
|------------|-------------------------------|--------------------------------|--|
| 1 | 1.3×10^{-3} | 9.0×10^{-4} | 0.2 |
| 2 | 2.6×10^{-3} | 9.0×10^{-4} | 0.4 |
| 3 | 1.3×10^{-3} | 1.8×10^{-3} | 0.4 |

- (i) Use these results to deduce:

the order of the reaction with respect to RCl _____ [1]

the order of the reaction with respect to NaOH _____ [1]

the rate equation _____ [1]

(ii) Calculate the value of the rate constant stating its units.

_____ [2]

(iii) Name the mechanism of this reaction.

_____ [1]

(iv) Classify RCl as a primary or tertiary chloroalkane giving a reason for your answer.

_____ [1]

12 Lauric acid, $C_{11}H_{23}COOH$, the main acid found in coconut oil, is also found in macadamia nuts. It is a white solid at room temperature with a melting point of $45^{\circ}C$, and is insoluble in water.

(a) Write the empirical formula for lauric acid.

_____ [1]

(b) Explain why ethanoic acid is soluble in water whereas lauric acid is insoluble.

_____ [3]

(c) Describe a chemical test to prove that lauric acid is an acid.

_____ [2]

(d) Write an equation for the reaction of lauric acid with thionyl chloride.

_____ [2]

(e) Lauric acid can be reduced to the corresponding alcohol.

(i) Write an equation for the reduction using $[H]$ to represent the reducing agent.

_____ [2]

(ii) Name a suitable reducing agent.

_____ [1]

(f) The main constituent of coconut oil is the triester formed from lauric acid and glycerol. It is called lauric acid triglyceride and has a saponification value of 260.

(i) What is meant by the term **saponification**?

_____ [2]

(ii) Write an equation for the saponification of lauric acid triglyceride.

[2]

(iii) Calculate the volume of 0.1 mol dm^{-3} hydrochloric acid required to neutralise the unreacted potassium hydroxide when 100 cm^3 of 0.1 mol dm^{-3} potassium hydroxide hydrolyses 1.72 g of lauric acid triglyceride.

_____ [4]

13 Dichlorine heptoxide is formed when perchloric acid (HClO_4) is treated with the dehydrating agent phosphorus pentoxide.

(a) (i) Write an equation for the removal of water from perchloric acid.

_____ [1]

(ii) Write the equation for the reaction of phosphorus pentoxide with water.

_____ [2]

(b) Deduce the oxidation numbers of the following elements:

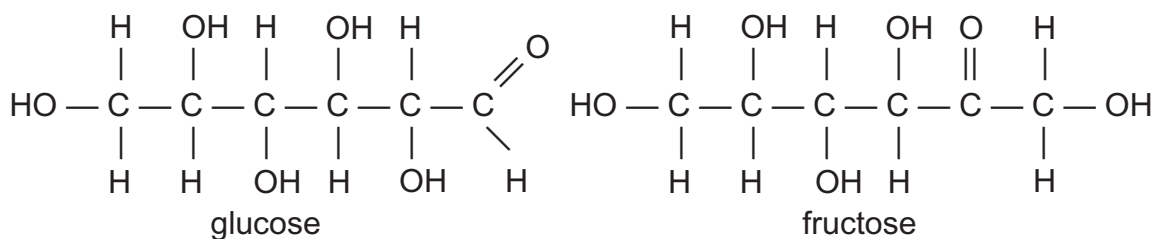
phosphorus in phosphorus pentoxide _____

chlorine in perchloric acid _____ [2]

(c) Calculate the percentage of chlorine in dichlorine heptoxide to one decimal place.

_____ [2]

14 The structures of glucose and fructose are shown below.



(a) Glucose and fructose are **structural isomers**. What is meant by this term?

_____ [2]

(b) Name **two** functional groups that are present in **both** glucose and fructose.

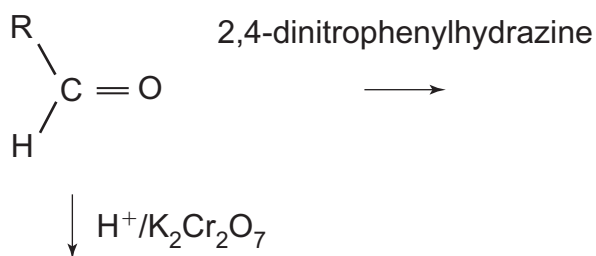
_____ [2]

(c) Despite the difference in structures between glucose and fructose, suggest why they are **both** reducing agents and state what would be observed with Fehling's and Tollen's solutions.

_____ [4]

Quality of written communication [2]

- (d) (i) In the scheme below glucose is represented by RCHO. Write the structure of the organic products formed when glucose reacts with the stated reagents.



[2]

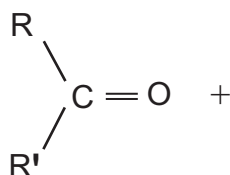
- (ii) Describe the appearance of the product formed from glucose and 2,4-dinitrophenylhydrazine.

_____ [2]

- (iii) Giving practical details, describe how this product can be used to provide information to identify glucose.

 _____ [4]

- (e) Complete the flow scheme below to show the mechanism for the reaction between fructose (RCOR') and hydrogen cyanide.



[3]

15 Ozone (O₃) is found as a gas in the Earth's atmosphere. It is beneficial in the upper atmosphere as it shields the Earth from ultraviolet radiation. However, in the lower atmosphere it can act as a greenhouse gas.

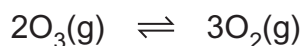
(a) (i) Describe how a gas contributes to the greenhouse effect.

 _____ [2]

(ii) State one long-term result of an increase in greenhouse gases.

_____ [1]

(b) Ozone is 30% dissociated at equilibrium according to the following equation:



(i) Calculate the value of K_p for this dissociation reaction, stating its units, if the total pressure is 10 atmospheres.

 _____ [4]

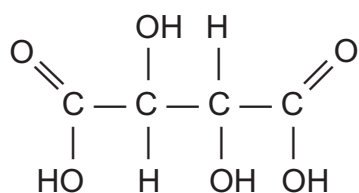
(ii) Explain the effect of increasing the pressure on the above equilibrium.

 _____ [2]

(iii) What effect would this increase in pressure have on the value of K_p?

_____ [1]

- 16 Tartaric acid is one of several organic acids that have an important role in winemaking. These acids affect the colour and taste, assist in the fermentation process, and act as preservatives.



- (a) Tartaric acid is a dicarboxylic acid. Suggest the meaning of **dicarboxylic**.

_____ [1]

- (b) Tartaric acid exhibits optical activity.

- (i) What do you understand by the term **optical activity**?

_____ [2]

- (ii) On the structure above mark the asymmetric centre(s) in tartaric acid. [1]

- (iii) Explain why some samples of tartaric acid extracted from wine do not display optical activity.

_____ [1]

- (c) The first pK_a value for the ionisation of tartaric acid is 2.9. Calculate the pH of a 0.1 mol dm^{-3} solution of tartaric acid. Assume only one H^+ dissociation.

_____ [3]

(d) A titration is carried out to determine the amount of tartaric acid in wine. A 25.0 cm^3 portion of white wine from a 750 cm^3 bottle is titrated against 0.2 mol dm^{-3} NaOH. 9.8 cm^3 of NaOH are required to *completely* neutralise the acid.

(i) Suggest a suitable indicator for the titration and explain your choice.

 _____ [2]

(ii) Calculate the mass of tartaric acid in the bottle of wine.

 _____ [4]

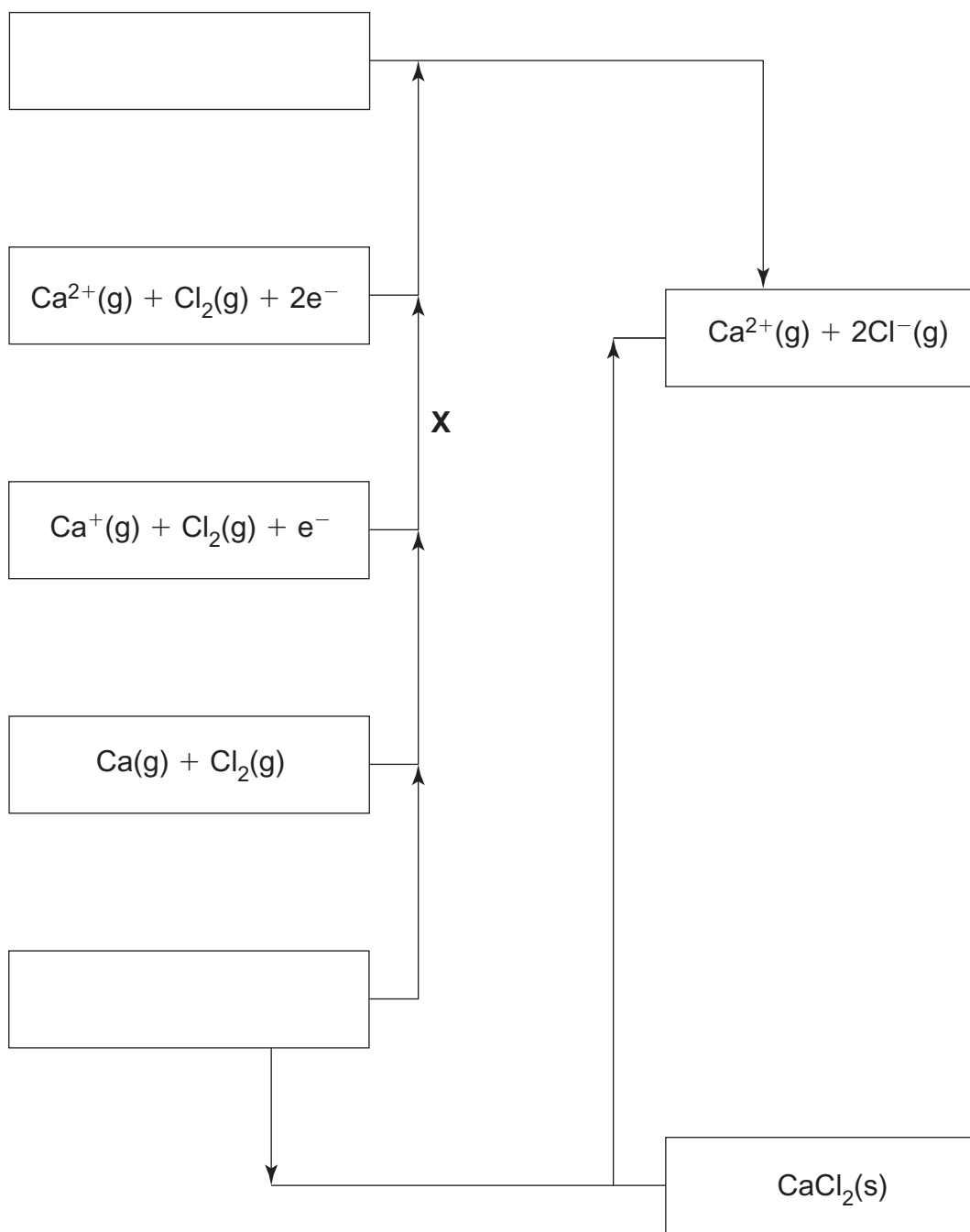
(e) Two molecules of tartaric acid can combine to form an ester. Draw the structure of an ester produced.

[2]

(f) A mixture of tartaric acid and tartrate ions acts as a buffer solution. Using $\text{C}_4\text{H}_6\text{O}_6$ to represent tartaric acid and $\text{C}_4\text{H}_5\text{O}_6^-$ to represent a tartrate ion, write equations to show how this buffer solution responds to the addition of acid and base.

 _____ [2]

17 The incomplete Born-Haber cycle for calcium chloride is shown below.



(a) Complete the **two** empty boxes in the cycle. [2]

(b) Name the enthalpy change that is labelled X.

_____ [2]

(c) Using the values below calculate the lattice enthalpy of calcium chloride.

| | kJ mol⁻¹ |
|---|----------------------------|
| First ionisation energy of calcium | +590 |
| Second ionisation energy of calcium | +1146 |
| Enthalpy of atomisation of calcium | +190 |
| Bond enthalpy of chlorine | +242 |
| Electron affinity of chlorine | -348 |
| Enthalpy of formation of calcium chloride | -795 |

[2]

(d) Use the lattice enthalpy which you calculated in part (c) and the enthalpies of hydration given below to determine the enthalpy of solution of calcium chloride.

$$\Delta H_{\text{hyd}}(\text{Ca}^{2+}) = -1651 \text{ kJ mol}^{-1}$$

$$\Delta H_{\text{hyd}}(\text{Cl}^{-}) = -364 \text{ kJ mol}^{-1}$$

[2]

(e) Suggest a value for the pH of the solution formed when calcium chloride is dissolved in water and explain your answer.

[2]

(f) The entropy change, ΔS , for the formation of calcium chloride is $-152 \text{ J mol}^{-1} \text{ K}^{-1}$. Using a suitable calculation, state and explain whether or not the formation of calcium chloride is a spontaneous process at 298 K.

[3]

THIS IS THE END OF THE QUESTION PAPER

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