Rewarding Learning

Centre Number

71

Candidate Number

ADVANCED
General Certificate of Education
2011

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

AC212

MONDAY 23 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 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 number 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 **13(a)(iv)**.
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	
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 oxides has a giant covalent structure?

A Al_2O_3
B Na_2O
C P_4O_{10}
D SiO_2

2 Heat is produced when magnesium reacts with sulfuric acid:

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

Which one of the following is true for the reaction?

A ΔS is negative
B ΔH is positive
C ΔG is positive
D the reaction is feasible at any temperature

3 Magnesium chloride has a lattice enthalpy of $2493\,kJ\,mol^{-1}$ and an enthalpy of solution of $-155\,kJ\,mol^{-1}$. If the enthalpy of hydration for Mg^{2+} ions is $-1920\,kJ\,mol^{-1}$ then the enthalpy of hydration for Cl^- ions is:

A $-728\,kJ\,mol^{-1}$
B $-364\,kJ\,mol^{-1}$
C $+364\,kJ\,mol^{-1}$
D $+728\,kJ\,mol^{-1}$

4 One mole of propanoic acid, one mole of methanol and two moles of water were mixed and allowed to reach equilibrium. At equilibrium 0.5 mole of methyl propanoate was present. The value of K_c for this reaction is

A 1.00
B 1.25
C 5.00
D 10.00

5 Propanone reacts with iodine in the presence of an acid according to the equation:

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

The most appropriate method for investigating the rate of this reaction is

A colorimetry.
B weighing the reaction vessel.
C titrating samples with an acid.
D use a graduated syringe.

6 Which one of the following represents the units of K_c for the following equilibrium?

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$$

A $mol^{-1}\ dm^{-3}$
B $mol\ dm^{-3}$
C $mol^{-1}\ dm^3$
D $mol\ dm^3$

7 Which one of the following compounds reacts with both $LiAlH_4$ and PCl_5?

A CH_3CH_2OH
B CH_3CH_2CHO
C CH_3COCH_3
D CH_3CH_2COOH

8 The standard entropy change for the following reaction is $139\,J\,K^{-1}\,mol^{-1}$.

$$Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(g)$$

The standard entropies of $Fe_2O_3(s)$, $H_2(g)$ and $Fe(s)$ are 90, 131 and $27\,J\,K^{-1}\,mol^{-1}$ respectively. Which one of the following is the standard entropy of steam?

A $332\,J\,K^{-1}\,mol^{-1}$
B $189\,J\,K^{-1}\,mol^{-1}$
C $145\,J\,K^{-1}\,mol^{-1}$
D $85\,J\,K^{-1}\,mol^{-1}$

9 Butan–1–ol was reacted with an excess of propanoic acid in the presence of a small amount of concentrated sulfuric acid. 6.0 g of the alcohol produced 7.4 g of the ester. Which one of the following is the percentage yield of the ester?

A 57%
B 70%
C 75%
D 81%

10 Which one of the following chlorides has atoms joined together by coordinate bonding?

A Al_2Cl_6
B $MgCl_2$
C NaCl
D PCl_5

Section B

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

11 Ethane–1,2–diol ($HOCH_2CH_2OH$) is used in the production of polyesters.

(a) (i) Write an equation for the reaction of ethane–1,2–diol with excess ethanoic acid, in the presence of concentrated sulfuric acid, to form a diester.

_____ [2]

(ii) Write an expression for the equilibrium constant, K_c, for the above reaction and state its units.

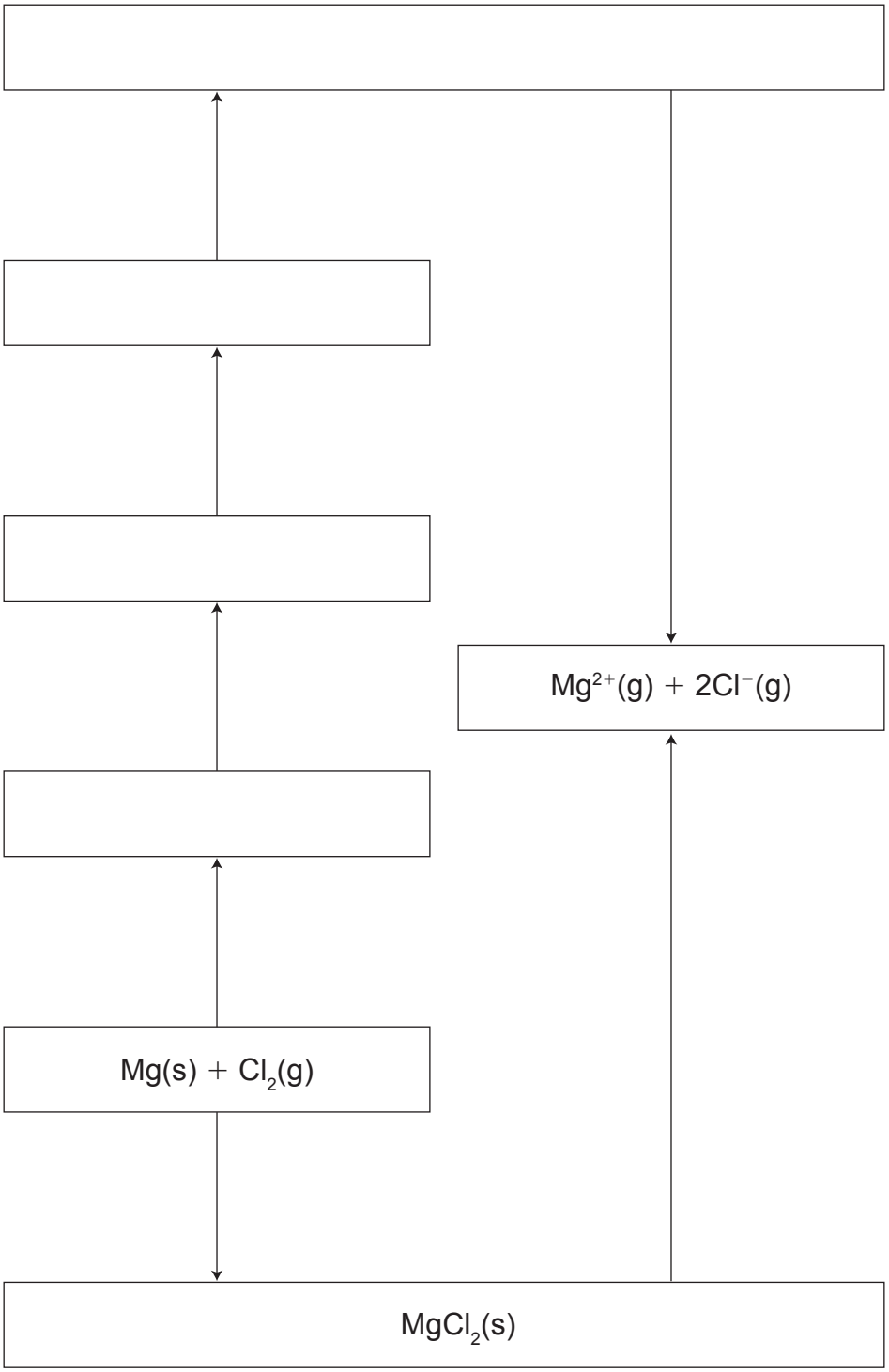
_____ [2]

(b) Using [O] to represent an oxidising agent, write an equation for the oxidation of ethane–1,2–diol with excess oxidising agent.

_____ [2]

12 Magnesium chloride is a water-soluble ionic compound formed from magnesium and chlorine.

(a) (i) Complete the Born–Haber cycle for the formation of magnesium chloride.



[4]

(ii) Using the data given below, calculate the electron affinity of chlorine.

	kJ mol^{-1}
Standard enthalpy of formation for magnesium chloride	−642
Lattice enthalpy for magnesium chloride	2493
Atomisation enthalpy of chlorine	121
First ionisation enthalpy of magnesium	736
Second ionisation enthalpy of magnesium	1450
Atomisation enthalpy of magnesium	150

_____

_____

_____

_____ [2]

(b) Give the electron structure of:

magnesium ions _____ [1]

chloride ions _____ [1]

(c) Magnesium chloride dissolves in water and has an enthalpy of solution of −155 kJ mol^{-1}. Define the term **enthalpy of solution**.

_____

_____

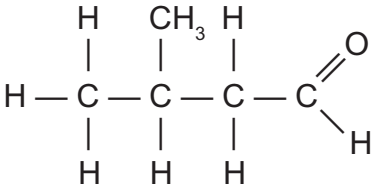
_____ [2]

13 Simple aldehydes and ketones have the same general formula.

(a) (i) What is the general formula of an aldehyde or ketone?

_____ [1]

(ii) Name the following aldehyde.



_____ [1]

(iii) Draw and name **two** structural isomers of the above compound which are ketones.

Isomer 1

Name _____ [2]

Isomer 2

Name _____ [2]

(iv) Describe, with experimental details, how an aldehyde can be distinguished from a ketone.

_____

_____

_____

_____

_____

_____

_____ [4]

Quality of written communication [2]

(v) Draw a structural isomer of the aldehyde in **(ii)** which exhibits *cis-trans* (E–Z) stereoisomerism.

[1]

(vi) Draw and label the stereoisomers of the above compound.

[3]

(b) Unknown ketones can be identified by reacting with 2,4–dinitrophenylhydrazine.

(i) Describe the appearance of the organic product formed when an unknown ketone reacts with 2,4–dinitrophenylhydrazine.

_____

_____ [2]

(ii) Draw the structure of the product obtained when butanone reacts with 2,4–dinitrophenylhydrazine.

[3]

(iii) How can this product be used to confirm the identity of butanone?

_____

_____

_____

_____ [2]

(iv) Using [H] to represent the reducing agent, write an equation for the reduction of butanone and name the product.

_____ [3]

14 Sulfuric acid is described as a strong Brønsted–Lowry acid and sodium hydroxide as a strong Brønsted–Lowry base. Carboxylic acids contain the −COOH functional group and are described as weak Brønsted–Lowry acids. The most familiar carboxylic acid is ethanoic acid, which is present in vinegar.

(a) (i) What is meant by the term **strong acid**?

_____

_____ [1]

(ii) What is meant by the term **Brønsted–Lowry acid**?

_____

_____ [1]

(iii) Write an equation to define pH.

_____ [1]

(iv) Calculate the pH of a 0.20 mol dm^{-3} solution of completely ionised sulfuric acid.

_____

_____

_____ [2]

(v) Write an equation to define K_w.

_____ [1]

(vi) Calculate the pH of a 0.20 mol dm^{-3} solution of sodium hydroxide ($K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6}).

_____

_____

_____ [2]

(vii) Write an equation for the neutralisation of sulfuric acid using sodium hydroxide.

_____ [2]

(b) The acid dissociation constant, K_a, for ethanoic acid is 1.74×10^{-5} mol dm^{-3}.

(i) Write the expression for the acid dissociation constant of ethanoic acid.

[1]

(ii) Calculate the pH of a 0.20 mol dm^{-3} solution of ethanoic acid.

[3]

(c) When a solution of ethanoic acid is partially neutralised using sodium hydroxide a buffer solution is formed.

(i) Write an equation for the reaction which occurs when sodium hydroxide is added to ethanoic acid.

_____ [1]

(ii) Calculate the pH of the buffer solution formed when 15.0 cm^3 of a 0.20 mol dm^{-3} solution of sodium hydroxide is added to 25.0 cm^3 of a 0.20 mol dm^{-3} solution of ethanoic acid.

_____

_____

_____

_____

_____

_____

_____ [4]

(iii) Explain how aqueous sodium ethanoate responds to the addition of a small amount of acid.

_____

_____

_____

_____ [2]

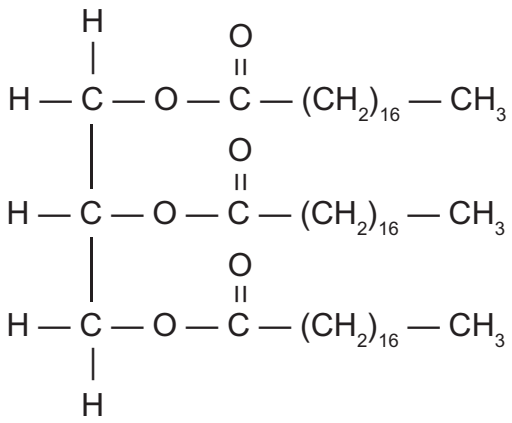
(iv) Would a solution of sodium ethanoate be acidic, alkaline or neutral? Explain your answer.

_____

_____

_____ [2]

15 Fats are triesters of fatty acids. The saponification value of a fat provides a measure of how long the carbon chains are in the fatty acid molecules. The following fat, stearin, is present in lard:



stearin

(a) When refluxed with potassium hydroxide stearin produces the potassium salt of stearic acid (potassium stearate) and only one other product.

(i) Using R− to represent $CH_3(CH_2)_{16}-$, write an equation for the reaction of stearin with excess potassium hydroxide.

[2]

(ii) State the systematic name of the other product.

_____ [1]

(iii) Define the term **saponification value** as applied to a fat.

_____

_____

_____ [3]

(iv) Use the definition and the structure of stearin to calculate its saponification value.

_____

_____

_____

_____

_____

_____

_____ [4]

(b) The methyl ester of stearic acid is present in biodiesel.

(i) Give the molecular formula of the ester.

_____ [1]

(ii) Give the equation for the complete combustion of this ester.

_____ [2]

(iii) State **two** natural processes which influence the concentration of carbon dioxide in the atmosphere.

_____

_____ [2]

16 The ionic equation for the alkaline hydrolysis of C_4H_9Br is shown below.

$$C_4H_9Br + OH^- \rightarrow C_4H_9OH + Br^-$$

(a) Data for this reaction is given in the table below.

Experiment	Initial $[C_4H_9Br]$ (mol dm^{-3})	Initial $[OH^-]$ (mol dm^{-3})	Initial Rate (mol $dm^{-3}s^{-1}$)
1	0.02	0.02	40.0
2	0.01	0.02	20.0
3	0.03	0.04	60.0

(i) What is the order of the reaction with respect to C_4H_9Br? Explain your reasoning.

_____

_____

_____ [2]

(ii) What is the order with respect to OH^-? Explain your reasoning.

_____

_____

_____ [2]

(iii) Write the rate equation for the reaction.

_____ [1]

(iv) Calculate a value for the rate constant and give its units.

_____

_____

_____ [2]

(v) Draw a reaction mechanism for the hydrolysis of C_4H_9Br which is consistent with your rate equation. Show the structure of C_4H_9Br clearly in your mechanism and identify the rate determining step.

[4]

(b) There are a number of structural isomers with molecular formula C_4H_9OH. Only one of these structural isomers contains an asymmetric centre and can exist as optical isomers.

(i) What is meant by the term **asymmetric centre**?

_____

_____

_____ [1]

(ii) Explain, in terms of structure, the meaning of the expression **optical isomers**.

_____

_____

_____ [2]

(iii) Give the structural formula and name of the structural isomer, of C_4H_9OH, which contains an asymmetric centre.

_____ [2]

(iv) Draw the 3D representations of the **two** optical isomers of the molecule identified in part **(iii)**.

[2]

(v) How can one optical isomer be distinguished from the other?

_____

_____

_____ [2]

THIS IS THE END OF THE QUESTION PAPER

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