Rewarding Learning

Centre Number	
71	

Candidate Number

ADVANCED
General Certificate of Education
January 2014

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

AC212

MONDAY 13 JANUARY, 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(b)(ii)**.
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, containing some data, is included in this question paper.

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 describes the mechanism for the reaction of hydrogen cyanide with propanone?

A Electrophilic addition

B Electrophilic substitution

C Nucleophilic addition

D Nucleophilic substitution

2 A reaction is always spontaneous when

A ΔH and ΔS are both positive.

B ΔH and ΔS are both negative.

C ΔH is positive and ΔS is negative.

D ΔH is negative and ΔS is positive.

3 The compound $CH_2(OH)CH(CH_3)CH = CH_2$ has

A a trans isomer.

B an E isomer.

C no optical isomers.

D two optical isomers.

4 Which one of the following is the correct systematic name for the compound below?

$$CH_2ICOCH_2CH_3$$

A 1-iodobutan-2-one

B 1-iodobutan-3-one

C 4-iodobutan-2-one

D 4-iodobutan-3-one

5 Which one of the following is correct when the pressure on the equilibrium below is increased at constant temperature?

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

	value of K_p	**mole fraction of N_2O_4**
A	decreases	increases
B	increases	no change
C	no change	decreases
D	no change	increases

6 Which one of the following salts dissolves in water to form a solution with the highest pH?

A Ammonium chloride

B Ammonium ethanoate

C Sodium chloride

D Sodium ethanoate

7 Which one of the following describes how infrared radiation interacts with a greenhouse gas?

A Absorption

B Emission

C Reflection

D Transmission

8 Which one of the following is a product formed between benzaldehyde, C_6H_5CHO, and 2,4-dinitrophenylhydrazine?

A $C_6H_5CHNNHC_6H_3(NO_2)_2$

B $C_6H_5CH_2NNC_6H_3(NO_2)_2$

C $C_6H_5CHNHNC_6H_3(NO_2)_2$

D $C_6H_5CHNHNHC_6H_3(NO_2)_2$

9 The partition coefficient of X between cyclohexane and water is 7.5. What mass of X is removed from a solution containing 10.0 g of X in 100 cm^3 of water by using 10 cm^3 of cyclohexane?

A 4.3 g

B 7.0 g

C 8.8 g

D 9.9 g

10 Which one of the following statements is correct for the hydrolysis of a primary alkyl halide?

A A carbocation is formed

B A positively charged transition state is formed

C A negatively charged transition state is formed

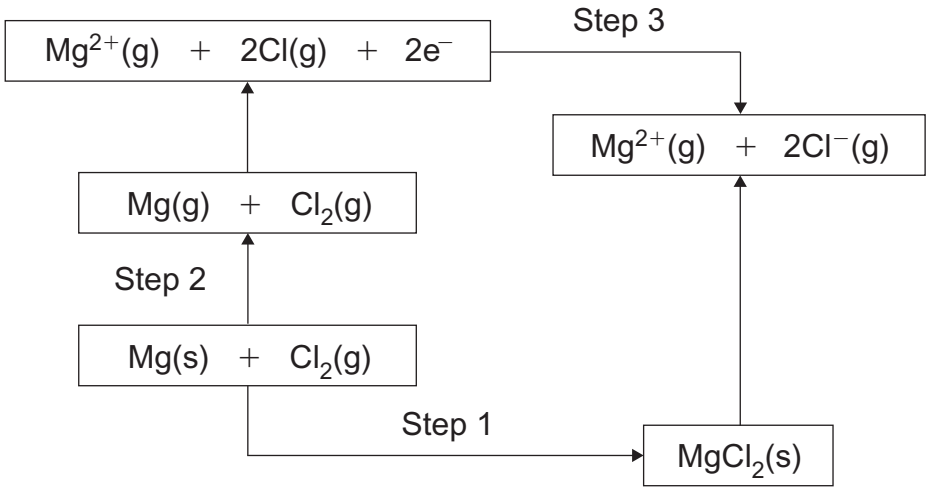
D The reaction is first order

Section B

Answer **all seven** questions in this section

Examiner Only	
Marks	Remark

11 The lattice enthalpy of magnesium chloride can be calculated using the diagram set out below.



(a) What is the name given to this type of diagram?

_____ [1]

(b) What name is given to each step in the diagram?

Step 1 _____

Step 2 _____

Step 3 _____ [3]

(c) Use the information below to calculate the lattice enthalpy of magnesium chloride.

$Mg(s) \rightarrow Mg(g)$	$\Delta H = +149$ kJ mol^{-1}
$Mg(g) \rightarrow Mg^{2+}(g) + 2e^-$	$\Delta H = +2240$ kJ mol^{-1}
$\frac{1}{2} Cl_2(g) \rightarrow Cl(g)$	$\Delta H = +121$ kJ mol^{-1}
$Cl(g) + e^- \rightarrow Cl^-(g)$	$\Delta H = -364$ kJ mol^{-1}
$Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$	$\Delta H = -642$ kJ mol^{-1}

_____

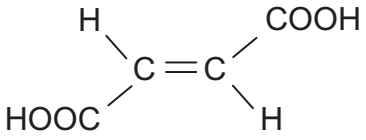
_____

_____

_____ [3]

Examiner Only	
Marks	Remark

12 The E isomer of butenedioic acid is called fumaric acid and is produced naturally in the body.



fumaric acid

(a) Explain why E/Z isomerism exists.

_____

_____ [2]

(b) The ester diethyl fumarate is used in the treatment of psoriasis.

(i) Write the equation for the formation of diethyl fumarate from fumaric acid and ethanol.

_____ [2]

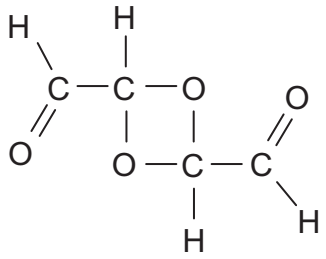
(ii) State **one** condition which is necessary to carry out this reaction.

_____ [1]

(iii) Name the catalyst for the reaction.

_____ [1]

(c) The structure below is an isomer of fumaric acid.



Describe, giving experimental details and observations, how you would use Fehling's solution to distinguish between fumaric acid and this structure.

_____

_____

_____

_____ [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

13 The oxides and chlorides of the third Period of the Periodic Table show a variation in properties across the Period.

(a) Give the formulae of the oxides of phosphorus and chlorine in their highest oxidation states of +5 and +7 respectively.

_____ [2]

(b) Aluminium oxide is amphoteric.

(i) Explain what is meant by the term **amphoteric**.

_____

_____ [1]

(ii) Write an equation for the reaction of aluminium oxide with aqueous sodium hydroxide.

_____ [2]

(iii) Write an equation for the reaction of aluminium oxide with hydrochloric acid to form aluminium chloride.

_____ [1]

(c) Solid aluminium chloride exists as the dimer, Al_2Cl_6.

(i) Suggest what is meant by the term **dimer**.

_____

_____ [1]

(ii) Using outer electrons only, draw a dot and cross diagram to show the bonding in the dimer of aluminium chloride.

[2]

(d) The chlorides of the third period form aqueous solutions with different pH values.

Examiner Only	
Marks	Remark

(i) Give the pH of the solutions formed when excess sodium chloride and phosphorus(V) chloride are added to water.

Sodium chloride: _____

Phosphorus(V) chloride: _____ [2]

(ii) Explain, with the help of equations, why the pH values of these solutions are different.

_____

_____

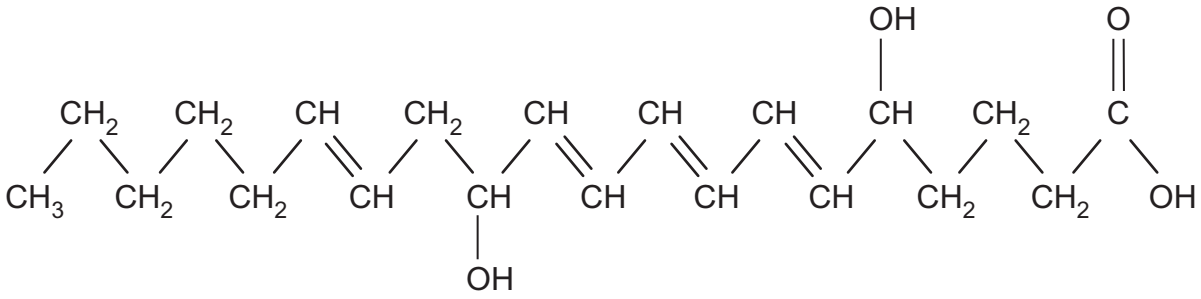
_____

_____

_____

_____ [4]

14 Leukotriene B4 (LTB4) is a fatty acid released by leukocytes in response to inflammation. It may be represented as shown below.



leukotriene B4

Examiner Only	
Marks	Remark

(a) What is the empirical formula of LTB4?

_____ [1]

(b) The iodine value of LTB4 can be measured using Wij's reagent.

(i) What is meant by the **iodine value** of a fatty acid?

_____

_____ [2]

(ii) Describe how you would use Wij's reagent to measure the experimental iodine value of LTB4.

_____

_____

_____

_____

_____

_____

_____

_____

_____ [6]

Quality of written communication [2]

(iii) Calculate the theoretical iodine value of LTB4 using the definition given in **(b)(i)**.

Examiner Only

Marks	Remark

_____

_____

_____ [3]

(c) Explain what is meant by the **saponification value** of a fat.

_____

_____ [2]

(d) **(i)** On hydrolysis a fat, X, forms two molecules of palmitic acid, $C_{15}H_{31}COOH$, and one molecule of myristic acid, $C_{13}H_{27}COOH$. Draw a structure for the unhydrolysed fat.

[2]

(ii) Calculate the saponification value of the fat, X.

_____

_____

_____ [3]

Examiner Only	
Marks	Remark

15 (a) The Water Gas reaction is used to produce hydrogen according to the equation below.

$$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$$

The standard enthalpy of formation and standard molar entropy of formation of the reactants and products are given in the table below.

	standard enthalpy of formation (kJ mol^{-1})	**standard molar entropy (J K^{-1} mol^{-1})**
CO(g)	−110.5	197.9
$H_2O(g)$	−241.8	188.7
$CO_2(g)$	−393.5	213.6
$H_2(g)$	0	114.6

(i) Why is the standard enthalpy of formation of hydrogen zero?

_____ [1]

(ii) Calculate the standard enthalpy change of the reaction.

_____

_____

_____ [2]

(iii) Calculate the standard entropy change of the reaction.

_____

_____

_____ [2]

(iv) Using your answers to parts **(ii)** and **(iii)** calculate the temperature at which the reaction becomes feasible.

_____

_____

_____ [2]

(b) Hydrogen, produced by the Water Gas reaction, is used in the manufacture of ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) Write the expression for K_p for the forward reaction.

_____ [1]

(ii) A mixture of 1 mole of nitrogen and 3 moles of hydrogen was allowed to reach equilibrium at 1×10^7 Pa and 500 °C. At equilibrium the mixture contained 0.6 moles of hydrogen. Calculate the value of K_p, stating the units, if any, for the reaction.

_____

_____

_____

_____

_____ [4]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

16 Acidified hydrogen peroxide oxidises iodide ions according to the equation below:

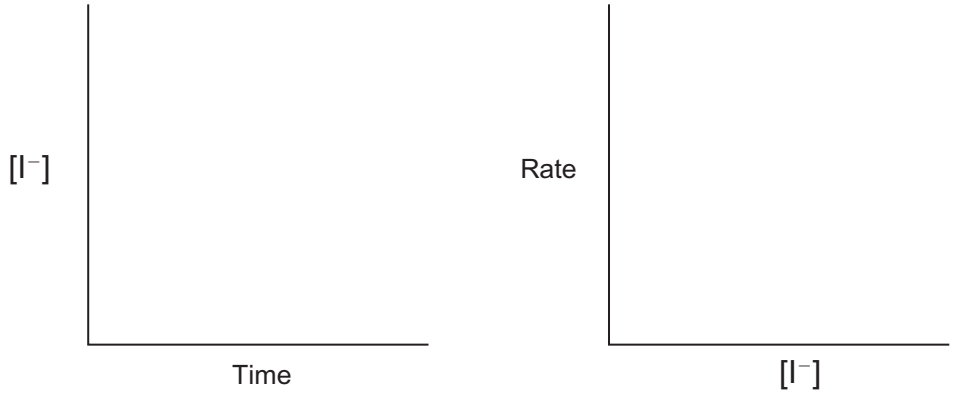
$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

(a) Name the reagent and the expected result to show that iodine is produced in the reaction.

_____

_____ [2]

(b) (i) The reaction is first order with respect to iodide ions. Using the axes below draw the shapes of the graphs expected.



[2]

(ii) The table below shows initial rates for the reaction for different concentrations of hydrogen peroxide and hydrogen ions at constant temperature.

experiment	**$[H_2O_2(aq)]$ (mol dm^{-3})**	**$[H^+(aq)]$ (mol dm^{-3})**	**initial rate $\times 10^{-6}$ (mol dm^{-3} s^{-1})**
1	0.00075	0.10	2.1
2	0.00150	0.10	4.2
3	0.00150	0.20	4.2

State the order of the reaction with respect to

hydrogen peroxide _____

hydrogen ions _____ [2]

(iii) State the rate equation for the reaction between H_2O_2 and acidified I^- ions.

_____ [1]

(iv) For experiment 1 the concentration of the iodide ions was $0.1\,mol\,dm^{-3}$. Calculate the value of the rate constant, stating its units if any.

_____

_____ [3]

(c) The reaction takes place in two steps. The first step is rate determining and is:

$$H_2O_2(aq) + I^-(aq) \rightarrow H_2O(l) + IO^-(aq)$$

(i) What is meant by the **rate determining step**?

_____ [1]

(ii) Suggest the equation for the second step in the reaction.

_____ [2]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

17 Methanoic acid, HCOOH, is present in nettle stings and ant bites. It has some typical features of a carboxylic acid as well as some unique properties particular to itself.

(a) (i) Describe what you would observe when methanoic acid is added to aqueous sodium carbonate, giving an equation for the reaction.

_____

_____ [2]

(ii) Methanoic acid can decompose forming carbon monoxide. Write the equation for this reaction.

_____ [1]

(b) Methanoic acid is a strong reducing agent as it can behave as an aldehyde.

(i) Giving experimental details and observations describe the reaction between methanoic acid and Tollen's reagent.

_____

_____

_____ [2]

(ii) Write the ionic equation for the reduction of the metal ion present in Tollen's reagent.

_____ [1]

(c) Methanoic acid is a weak acid.

(i) Give the formula of the conjugate base of methanoic acid.

_____ [1]

(ii) The K_a of methanoic acid is $1.6 \times 10^{-4}\,mol\,dm^{-3}$. Calculate the pH of $0.1\,mol\,dm^{-3}$ methanoic acid solution.

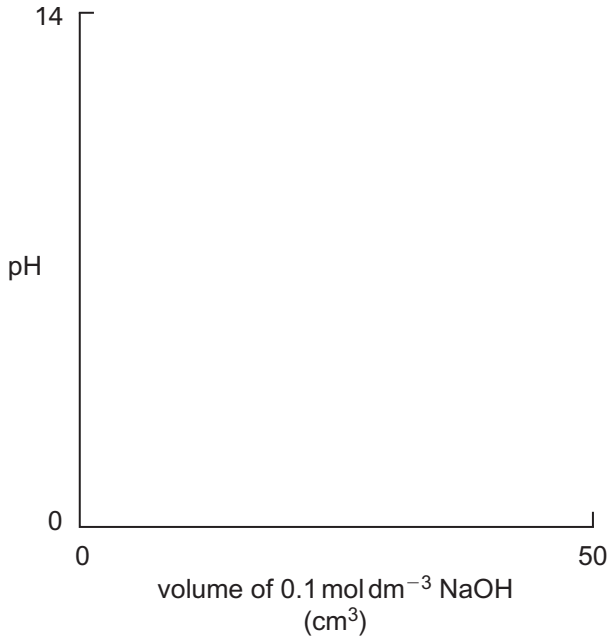
_____

_____

_____ [2]

Examiner Only	
Marks	Remark

(d) Sketch the titration curve for the addition of 50 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution to 25 cm^3 of 0.1 mol dm^{-3} methanoic acid solution.



[3]

(e) A buffer solution is formed when sodium hydroxide solution is added to excess methanoic acid.

(i) What is meant by a **buffer solution**?

_____

_____ [2]

(ii) Using **two** equations involving methanoate ions, describe how the solution containing sodium methanoate and methanoic acid acts as a buffer.

_____

_____

_____

_____

_____

_____ [4]

(iii) 2 g of sodium hydroxide were added to 500 cm^3 of 0.3 mol dm^{-3} methanoic acid. Calculate the pH of the buffer.

[5]

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER