cea

Rewarding Learning

Centre Number

71

Candidate Number

ADVANCED
General Certificate of Education
January 2011

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic,
Physical and Inorganic Chemistry

[AC212]

AC212

WEDNESDAY 26 JANUARY, MORNING

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 **15(b)(iii)**.
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	

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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 When the contents of a gas cylinder containing 19 kg of propane have been completely burned the increase in atmospheric carbon dioxide is

A   19 kg
B   38 kg
C   57 kg
D   76 kg

2 For the reaction of hydrogen with nitrogen monoxide the rate equation is:
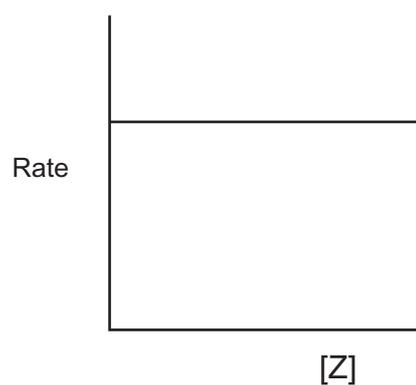
$$\text{Rate} = k[H_2][NO]^2$$

What are the units of the rate constant?

A $mol^{-1}\ dm^3\ s^{-1}$
B $mol\ dm^{-3}\ s^{-1}$
C $mol^{-2}\ dm^{-6}\ s^{-1}$
D $mol^{-2}\ dm^6\ s^{-1}$

3 Which one of the following oxides has ionic bonding and reacts with water to form a strongly alkaline solution?

A Al_2O_3
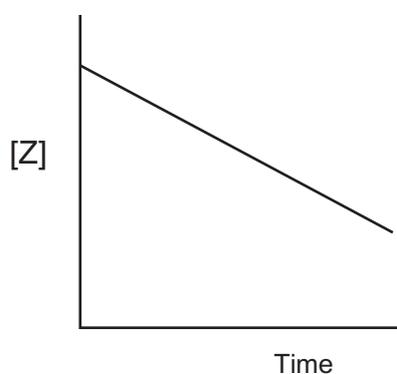B Na_2O
C P_4O_{10}
D SO_3

4   Which one of the following graphs shows a reaction that is first order with respect to reactant Z?
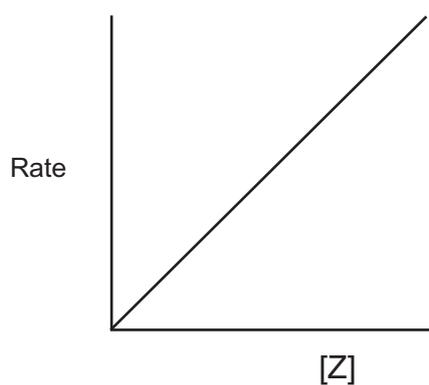
A

B

C
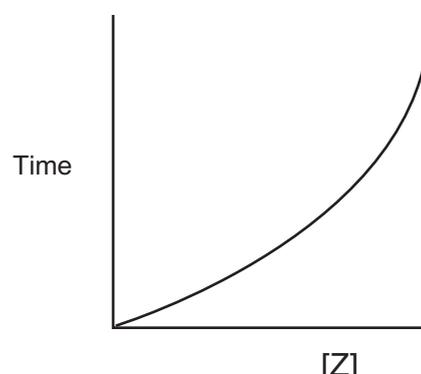
D

5   Which one of the following represents the units of K_c for the equilibrium shown below?

$$N_2(g) \ + \ 3H_2(g) \ \rightleftharpoons \ 2NH_3(g)$$
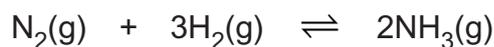
A $mol^{-2} \, dm^{-6}$
B $mol^{-2} \, dm^{6}$
C $mol^{2} \, dm^{-6}$
D $mol^{2} \, dm^{6}$

6   The partition coefficient of an organic acid between ether and water is 5. When $100 \, cm^3$ of a solution containing $10 \, g$ of the acid is shaken with two successive $20.0 \, cm^3$ portions of ether, what mass of the acid would be extracted?

A   2.5 g
B   5.0 g
C   6.0 g
D   7.5 g

7 Which one of the following organic compounds does **not** exist?

A An aldehyde with formula C_2H_4O
B An alkene with formula C_6H_{12}
C An ester with formula $C_3H_6O_2$
D A ketone with formula C_2H_4O

8 Consider the equilibrium:

$$2SO_2(g) \ + \ O_2(g) \ \rightleftharpoons \ 2SO_3(g)$$
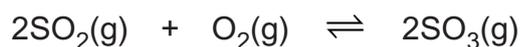
Which one of the following is true when the total pressure of the system is increased at a constant temperature?

	Mole fraction of SO_3	Value of K_p
A	Increases	Decreases
B	Increases	Increases
C	Decreases	Unchanged
D	Increases	Unchanged

9 An equilibrium mixture contains 56 g of nitrogen gas, 14 g of hydrogen gas and 34 g of ammonia gas. Which one of the following is the mole fraction of hydrogen gas?
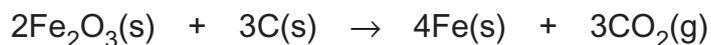
A 0.135
B 0.250
C 0.636
D 0.700

10 Which one of the following salts will dissolve to produce a solution with the highest pH?

A ammonium chloride
B ammonium ethanoate
C sodium chloride
D sodium ethanoate

Section B

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

11 Data for the reduction of iron(III) oxide by carbon, are shown in the table below.

$$2Fe_2O_3(s) \quad + \quad 3C(s) \quad \rightarrow \quad 4Fe(s) \quad + \quad 3CO_2(g)$$

Substance	$\Delta H_f^{\ominus}$/kJ mol^{-1}	$S^{\ominus}$/J K^{-1} mol^{-1}
Fe_2O_3	−824.2	87.4
C	0.0	5.7
Fe	0.0	27.3
CO_2	−393.5	213.6

(a) (i) Calculate the values of $\Delta H^{\ominus}$, $\Delta S^{\ominus}$ and $\Delta G^{\ominus}$ for the reaction at 298 K.

$\Delta H^{\ominus}$ _____

_____

_____ [2]

$\Delta S^{\ominus}$ _____

_____

_____ [2]

$\Delta G^{\ominus}$ _____

_____

_____ [1]

(ii) Using your results from part **(i)** explain why this reaction is not feasible at 298 K.

_____ [1]

(b) Calculate the temperature above which this reaction is feasible.

_____

_____

_____ [2]

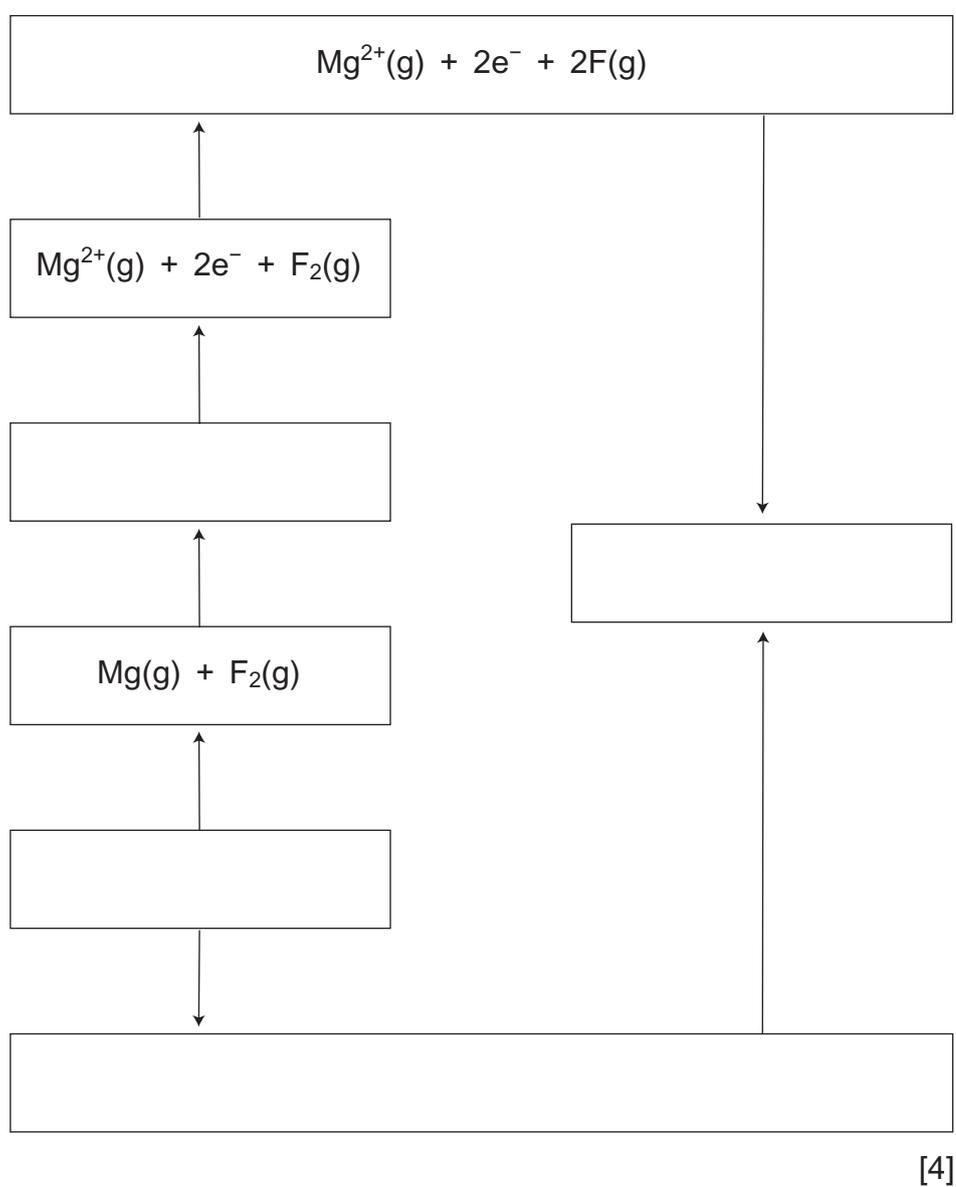**12** The strength of the ionic bonding in compounds, such as magnesium fluoride and magnesium chloride, is related to the lattice enthalpy of the compound.

(a) Define the term **lattice enthalpy**.

_____

_____

_____ [2]

(b) (i) Complete the Born-Haber cycle for magnesium fluoride:

$$Mg^{2+}(g) + 2e^- + 2F(g)$$

$$Mg^{2+}(g) + 2e^- + F_2(g)$$

$$Mg(g) + F_2(g)$$

[4]

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

	kJmol⁻¹

Standard enthalpy of formation for magnesium fluoride -1123
First electron affinity of fluorine -348
Atomisation enthalpy of fluorine 79
First ionisation enthalpy of magnesium 736
Second ionisation enthalpy of magnesium 1450
Atomisation enthalpy of magnesium 150

[2]

(c) Magnesium fluoride and magnesium chloride are both soluble in water. Magnesium chloride has an enthalpy of solution of -155 kJ mol⁻¹.

(i) Using diagrams, show how magnesium and fluoride ions interact with water molecules in an aqueous solution of magnesium fluoride.

[2]

(ii) Given that the enthalpies of hydration of magnesium ions and chloride ions are -1920 kJ mol⁻¹ and -364 kJ mol⁻¹ respectively, calculate the lattice enthalpy of magnesium chloride.

[2]

13 Butanone reacts with hydrogen cyanide to form a product that contains an asymmetric centre.

$$\text{CH}_3\text{CH}_2 - \underset{\underset{\text{CH}_3}{|}}{\overset{\overset{\text{OH}}{|}}{\text{C}}} - \text{CN}$$
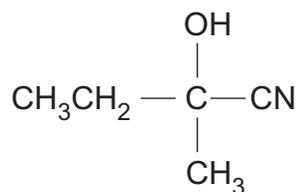
The reaction mechanism is similar to that for the reaction between hydrogen cyanide and propanone.

(a) (i) Give the systematic name of the product.

_____ [2]

(ii) What type of stereoisomerism is shown by the product?

_____ [1]

(iii) Draw the 3D representations of the stereoisomers.

[2]

(iv) Name the mechanism for the reaction.

_____ [1]

(v) Draw the mechanism for this reaction.

[3]

(b) Butanone can be reduced using lithal. The product is optically inactive and dehydrates to give a mixture of but-1-ene and but-2-ene.

(i) Using [H] to represent lithal, write the balanced equation for the reduction.

_____ [2]

(ii) Name the product.

_____ [1]

(iii) Give the meaning of the term **optically inactive**.

_____

_____ [1]

(iv) Suggest why the product is optically inactive.

_____

_____ [2]

(v) Draw and label the E and Z isomers of but-2-ene.

[2]

Examiner Only	
Marks	Remark

(c) Butanal is a structural isomer of butanone. Describe, giving practical details, how you would carry out a chemical test to distinguish between samples of butanal and butanone.

_____

_____

_____

_____

_____

_____ [3]

(d) 2,4-dinitrophenylhydrazine reacts with both butanone and butanal to form 2,4-dinitrophenylhydrazones.

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

[3]

  (ii) What would be observed in the reaction?

_____

_____ [2]

(iii) Explain, experimentally, how the 2,4-dinitrophenylhydrazones can be used to confirm the identity of the reactants.

_____

_____

_____

_____

_____ [4]

14 At 25 °C, the acid dissociation constant, K_a, for propanoic acid is 1.35×10^{-5} mol dm^{-3}. A buffer solution can be prepared by mixing a solution of propanoic acid with a solution of sodium propanoate.

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

[1]

(ii) Calculate the pH of a 0.25 mol dm^{-3} solution of propanoic acid.

[3]

**(iii)** What is meant by the term **buffer solution**?

[2]

(iv) Calculate the pH of the buffer solution formed when $300\,cm^3$ of a $0.25\,mol\,dm^{-3}$ solution of propanoic acid is mixed with $200\,cm^3$ of a $0.15\,mol\,dm^{-3}$ solution of sodium propanoate.

_____

_____

_____

_____

_____

_____ [4]

(b) The titration curve below shows the change in pH when a $0.20\,mol\,dm^{-3}$ solution of sodium hydroxide is added, from a burette, to $25.0\,cm^3$ of a solution of propanoic acid of unknown concentration.

pH

18.5   Volume of NaOH added (cm^3)
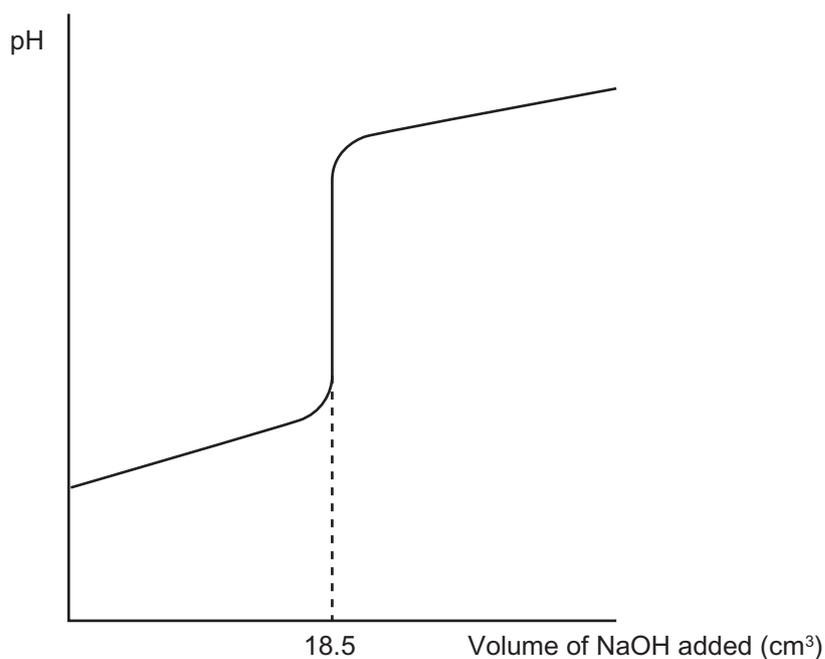
(i) Write the equation for the neutralisation reaction which occurs.

_____ [1]

[Turn over

(ii) Suggest a suitable indicator for this titration. Give the colour change and explain why the indicator is suitable.

_____

_____

_____

_____ [4]

(iii) Calculate the concentration of the propanoic acid.

_____

_____

_____

_____ [3]

(iv) At $25\,^{\circ}C$, K_w has the value 1.00×10^{-14} $mol^2\,dm^{-6}$. Calculate the pH of the 0.20 $mol\,dm^{-3}$ solution of sodium hydroxide.

_____

_____

_____ [2]

15 Fats and vegetable oils are triesters of long-chain carboxylic acids. Base catalysed hydrolysis of an oil produces glycerol and the sodium salt of octadeca-9,12-dienoic acid as the only products.

$$CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7COOH$$

octadeca-9,12-dienoic acid
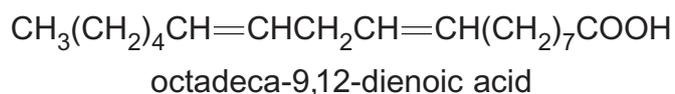
(a) (i) Draw the structure of glycerol.

[1]

(ii) State the systematic name for glycerol.

_____ [2]

(iii) Draw the structure of the oil.

[1]

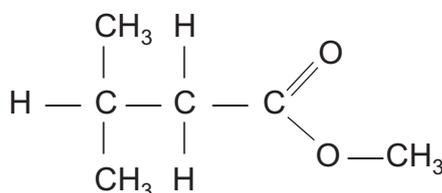**(iv)** Define the term **iodine value** as applied to an oil.

_____

_____

_____ [2]

(v) Use the definition given in part **(iv)** and the structure given in part **(iii)** to calculate the iodine value of the oil.

_____

_____

_____

_____

_____

_____ [4]

(b) Simple monoesters, such as the one shown below, can be prepared by reacting carboxylic acids with alcohols:

$$H - \underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}} - \underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}} - C\overset{\diagup O}{\diagdown O-CH_3}$$

(i) Give the systematic names of the carboxylic acid and alcohol required to prepare this ester.

Acid _____ [1]

Alcohol _____ [1]

(ii) Write the equation for the formation of the ester.

_____ [2]

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16

(iii) Describe, giving experimental details, the preparation of a pure, dry sample of the ester.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ [6]

Quality of written communication   [2]

16 The concentration of CO_2 in the atmosphere depends on natural and man-made processes.

(a) State **two** natural processes by which CO_2 concentration in the atmosphere is decreased.

_____ [2]

(b) Carbon dioxide can be produced during the production of electricity.

(i) Explain why the carbon dioxide forms.

_____

_____

_____ [2]

(ii) Industry attempts to reduce the emission of CO_2 by reacting emitted gases with alkaline slurries containing hydroxide ions. Write an equation for the reaction of aqueous carbon dioxide with OH^- ions.

_____ [2]

(c) Carbon dioxide molecules in the atmosphere absorb IR radiation which leads to carbon dioxide being called a "Greenhouse" gas.

(i) Explain how CO_2 absorbs IR radiation.

_____

_____ [1]

(ii) Explain what a Greenhouse gas does in terms of Global Warming.

_____

_____

_____ [2]

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER

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