Rewarding Learning

Centre Number

71

Candidate Number

ADVANCED
General Certificate of Education
2013

Chemistry

Assessment Unit A2 1

assessing

Periodic Trends and Further Organic, Physical and Inorganic Chemistry

[AC212]

THURSDAY 23 MAY, MORNING

MV18

TIME

2 hours, plus your additional time allowance.

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(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 at the end of each question indicate the marks awarded to each question or part question.
A Periodic Table of the Elements, containing some data, is included in this question paper.

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 is the conjugate acid of the hydrogenphosphate(V) ion, HPO_4^{2-}?

A H_3PO_4

B $H_3PO_4^-$

C $H_2PO_4^-$

D PO_4^{3-}

2 Which one of the following terms does **not** describe the reaction below?

$$C_2H_5OH + CH_3COOH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

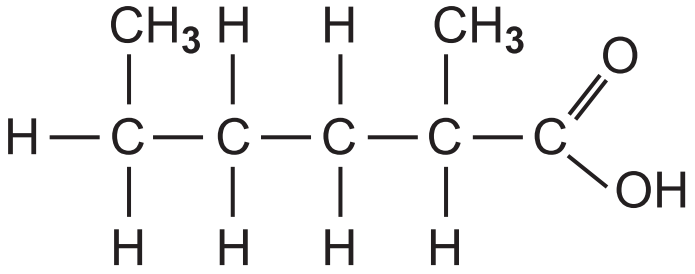
A Condensation

B Esterification

C Hydration

D Reversible

3 Which one of the following is the systematic name for the carboxylic acid shown below?



A 1,4-dimethylpentanoic acid

B 2,5-dimethylpentanoic acid

C 2-methylhexanoic acid

D 5-methylhexanoic acid

4 Which one of the following solid compounds exhibits covalent bonding?

A Aluminium oxide

B Magnesium chloride

C Sodium chloride

D Sulfur trioxide

5 Which one of the following solutions has a pH of 1?

A 0.1 M HCl

B 0.1 M H_2SO_4

C 0.2 M HCl

D 0.2 M H_2SO_4

6 A gaseous mixture contains 0.10 g hydrogen and 6.35 g iodine, at a pressure of 30 kPa. Which one of the following is the partial pressure of hydrogen?

A 10 kPa

B 20 kPa

C 30 kPa

D 47 kPa

7 Which one of the following molecules can exist as E–Z isomers?

A $CH_3CH_2CHCH_2$

B $CH_3CH(OH)COOH$

C $CH_3CH_2CHCHCH_3$

D $CH_3CH_2CH(OH)CH_2CH_3$

8 Which one of the following salts would produce a neutral solution when dissolved in water?

A Ammonium chloride

B Potassium chloride

C Potassium ethanoate

D Sodium carbonate

9 10.0 g of benzoic acid were dissolved in 50.0 cm^3 of ether. The partition coefficient, K_d, for benzoic acid between ether and water is 18.0. Which one of the following is the volume of water required to extract 1.0 g of benzoic acid?

A 3.2 cm^3

B 50.0 cm^3

C 100.0 cm^3

D 162.0 cm^3

10 Which one of the following gases present in the atmosphere does **not** act as a greenhouse gas?

A Argon

B Carbon dioxide

C Methane

D Water vapour

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(Questions continue overleaf)

Section B

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

11 The oxides of the Period 3 elements exhibit different properties in terms of their reactions with acids, bases and water.

(a) Name a basic oxide from Period 3. [1]

_____

(b) Write the formula for an amphoteric oxide from Period 3. [1]

_____

(c) Sulfur dioxide is an acidic oxide. Write an equation for the reaction of sulfur dioxide with excess sodium hydroxide solution. [2]

_____

(d) State the type of bonding and structure found in silicon dioxide. [2]

_____

_____

(e) Name one Period 3 oxide which does not react with water. [1]

_____

(f) Chlorine(VII) oxide reacts with water. Write an equation for this reaction. [2]

(g) Phosphorus(V) oxide also reacts with water according to the equation:

$$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$$

Name the product. [1]

---

12 Pentyl ethanoate is the ester formed from pentan-1-ol and ethanoic acid.

$$CH_3COOH + C_5H_{11}OH \rightleftharpoons CH_3COOC_5H_{11} + H_2O$$

(a) Draw the structure of pentyl ethanoate showing all the bonds present. [1]

(b) 1.1 g of pentan-1-ol and 1.2 g of ethanoic acid were mixed. Equilibrium was established at 298 K.

(i) Write an expression for the equilibrium constant, K_c, for this reaction. [1]

(ii) At equilibrium 0.6 g of ethanoic acid remained. Calculate the value of K_c. [4]

(iii) K_c for the reaction at 330 K is 6.47 and at 350 K the value is 8.31. State whether the reaction is exothermic or endothermic and explain your answer. [2]

13 Gunpowder is a mixture of potassium nitrate, carbon and sulfur. The explosive effect of gunpowder is caused by the rapid production of a large volume of gas from a small mass of solid.

(a) $2KNO_3$**(s) +** S**(s) +** 3C**(s)** $\rightarrow$ K_2S**(s) +** N_2**(g) +** $3CO_2$**(g)**

(i) State the oxidation numbers of each element in the equation before and after reaction. [2]

(ii) Explain, in terms of oxidation numbers, why this reaction is a redox reaction. [2]

(b) A sample of gunpowder was prepared using the following quantities.

6 g of potassium nitrate
1 g of carbon
1 g of sulfur

Calculate the total volume of gas produced from the explosion of this mixture at 20 °C and one atmosphere pressure. [4]

(c) The table below gives the standard enthalpy of formation, $\Delta H_f^{\ominus}$, values for potassium nitrate, potassium sulfide and carbon dioxide.

	$\Delta H_f^{\ominus}$ /kJ mol^{-1}
KNO_3	–493
K_2S	–418
CO_2	–394

Using Hess's Law, calculate the enthalpy change for the explosion of gunpowder in kJ. [3]

(d) The standard entropy values, $S^{\ominus}$, for the reactants and products in the explosion of gunpowder are given below.

	$S^{\ominus}$/J K^{-1} mol^{-1}
KNO_3	172
S	32
C	5.7
K_2S	115
N_2	191
CO_2	214

(i) Calculate the standard entropy change for the explosion of gunpowder. [2]

(ii) Explain why this reaction is feasible at all temperatures. [2]

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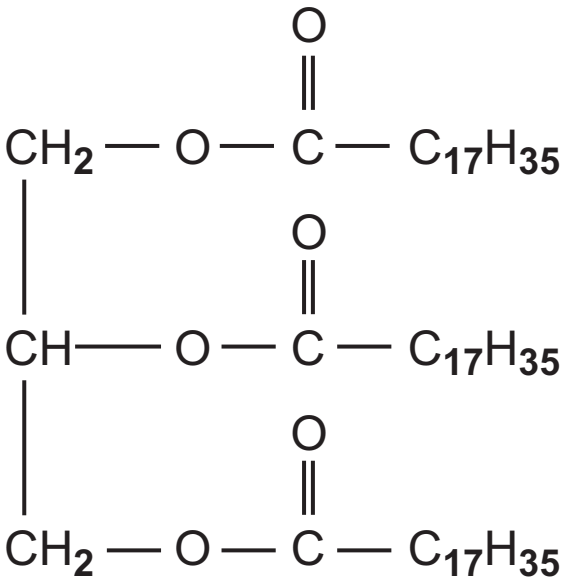
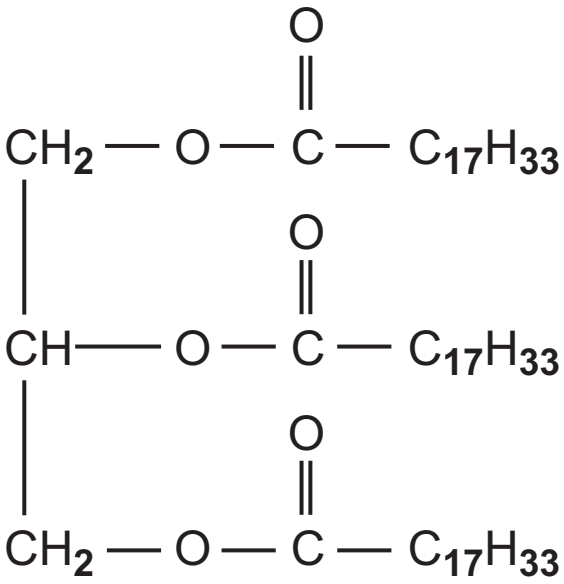
(Questions continue overleaf)

14 The structures of glyceryl tristearate and glyceryl trioleate are shown below.



glyceryl tristearate



glyceryl trioleate

(a) Saponification of glyceryl tristearate can be carried out using sodium hydroxide or potassium hydroxide.

(i) Write an equation for the saponification of glyceryl tristearate using sodium hydroxide. [3]

(ii) Write the molecular formula for glyceryl tristearate and calculate its relative molecular mass. [2]

Molecular formula: _____

Relative Molecular Mass: _____

(iii) Define the term **saponification value**. [2]

_____

_____

(iv) Calculate the saponification value of glyceryl tristearate. [4]

_____

_____

_____

_____

(b) The iodine value of a fat or oil may be determined experimentally. The iodine value of glyceryl trioleate is 86.2 whereas the value for glyceryl tristearate is 0.

(i) What is meant by the term **iodine value**? [2]

_____

_____

(ii) Explain why the iodine value of glyceryl tristearate is 0. [1 mark]

_____

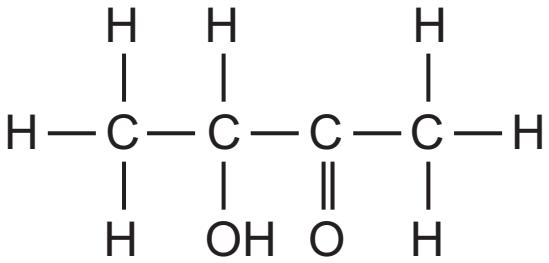
_____

(iii) Describe, giving practical details, how you would determine the iodine value of a fat or oil. Details of the calculation are not required. [6]

Quality of written communication [2]

(iv) Suggest why glyceryl tristearate is a solid at room temperature and pressure whereas glyceryl trioleate is a liquid. [2]

15 Acetoin is found naturally in butter and is added to foods to give a buttery taste. It is also added to some cigarettes to improve flavour. The structure of acetoin is shown below.



(a) (i) State the systematic name for acetoin. [2]

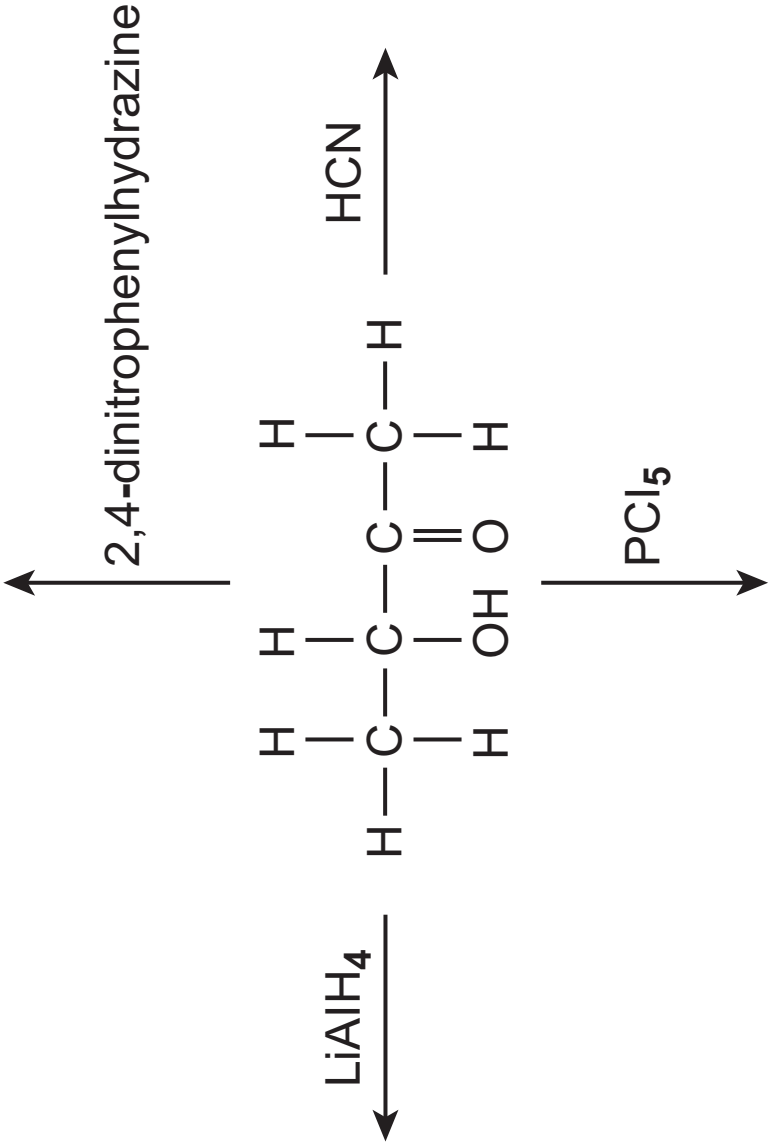
_____

(ii) Explain why acetoin is soluble in water. [2]

_____

_____

(iii) The scheme below shows some of the reactions of acetoin. Complete the scheme to show the structure of the organic product for each reaction. [4]



(iv) Suggest the name of the mechanism for the reaction of acetoin with hydrogen cyanide. [2]

(b) Acetoin undergoes mild oxidation when warmed with acidified potassium dichromate. The table below gives kinetics data for an experiment involving the oxidation of acetoin.

[acetoin] mol dm^{-3}	**[H^+] mol dm^{-3}**	**[$Cr_2O_7^{2-}$] mol dm^{-3}**	**rate of reaction mol dm^{-3} s^{-1}**
0.1	1.0	0.1	4.36×10^{-3}
0.2	1.0	0.1	1.74×10^{-2}
0.2	2.0	0.2	6.98×10^{-2}
0.2	2.0	0.4	1.40×10^{-1}

(i) Using [O] to represent the oxidising agent write an equation for the oxidation of acetoin. [2]

(ii) What colour change would be observed when acetoin is oxidised using acidified potassium dichromate? [2]

(iii) Using the information in the table above determine the order of reaction with respect to each of the reactants below: [2]

acetoin _____

H^+ _____

$Cr_2O_7^{2-}$ _____

(iv) Write a rate equation for the reaction. [1]

_____

(v) Determine the value of the rate constant and state its units. [2]

_____

_____

_____

(c) Acetoin is optically active.

(i) Explain what is meant by the term **optically active**. [2]

_____

_____

(ii) Explain, in terms of structure, why acetoin is optically active. [2]

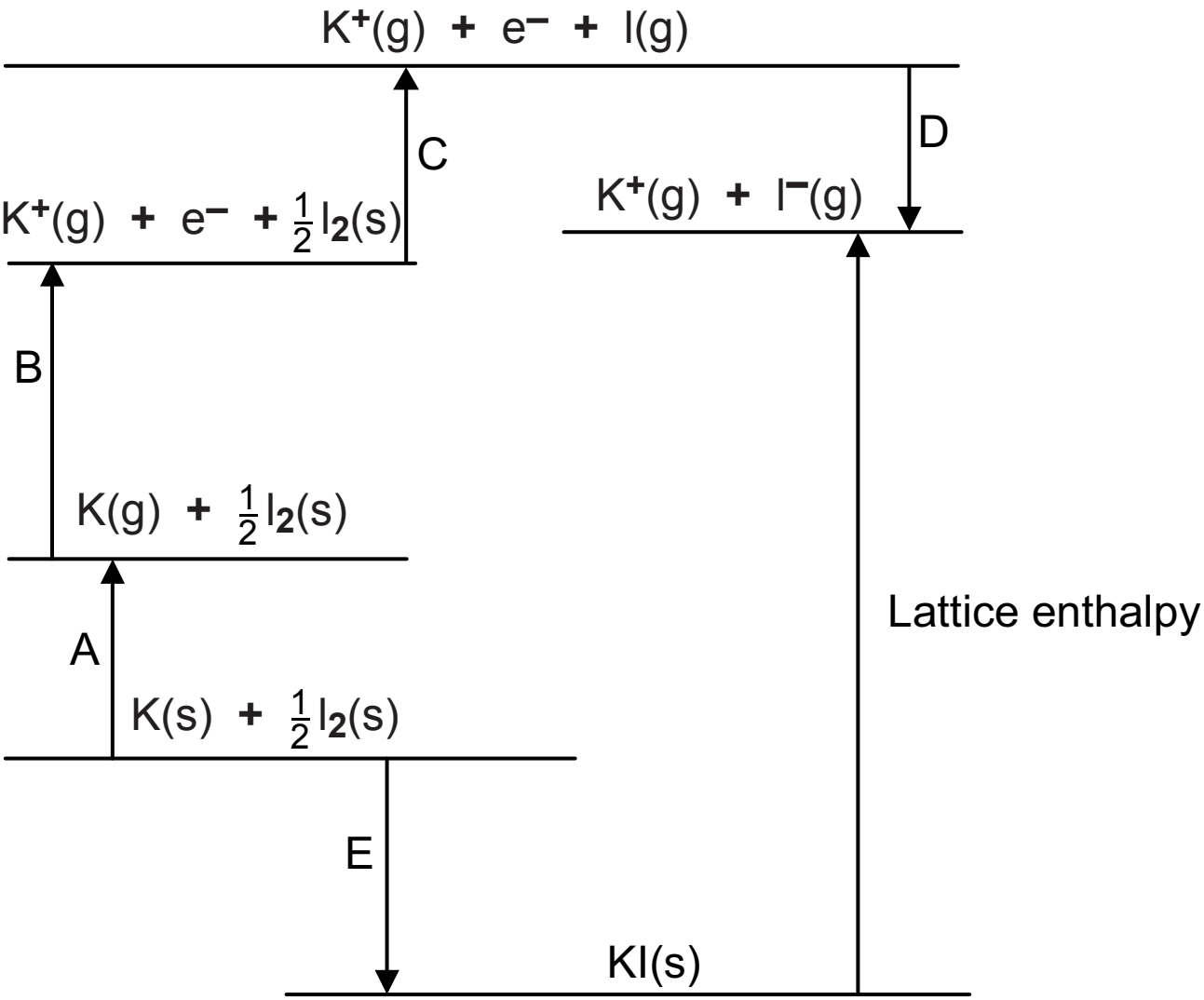
_____

_____

(iii) Draw the two optical isomers of acetoin below. [2]

(iv) Explain why a mixture of the two isomers of acetoin may **not** exhibit any optical activity. [2]

16 A Born-Haber cycle for potassium iodide is shown below. The lattice enthalpy is labelled. Other enthalpy changes are shown by the letters A to E.



(a) For the following questions state which letter (A to E) represents the enthalpy changes:

Standard enthalpy of formation of potassium iodide [1]

_____

First electron affinity of iodine [1]

_____

First ionisation energy of potassium [1]

Enthalpy of atomisation of potassium [1]

(b) Calculate the lattice enthalpy of potassium iodide using the following data. [2]

	kJ mol^{-1}
A	**+**89.5
B	**+**420.0
C	**+**106.6
D	**–**295.4
E	**–**327.6

kJ mol^{-1}

(c) (i) Potassium chloride has a lattice enthalpy of **+**710 kJ mol^{-1} and that for potassium bromide is **+**679 kJ mol^{-1}. State **three** other enthalpy changes in a Born-Haber cycle for these compounds which would be different. [3]

(ii) Explain why the enthalpy changes given in **(c)(i)** are different for each compound. [3]

(d) Potassium chloride is very soluble in water.

(i) Write an equation, including state symbols, to represent potassium chloride dissolving in water. [2]

(ii) The enthalpy change of hydration for the potassium ion is **–**305 kJ mol^{-1} and the value for the chloride ion is **–**384 kJ mol^{-1}. Using the lattice enthalpy value stated in **(c)(i)** for potassium chloride, calculate the enthalpy change when one mole of potassium chloride is dissolved in water. [2]

THIS IS THE END OF THE QUESTION PAPER

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