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Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry
and Further Organic Chemistry

[AC222]



TUESDAY 3 JUNE, 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 fifteen** 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 five** 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(d)(i)**.

In Section A all questions carry equal marks, i.e. **two** marks for each question.

In Section B the figures printed down the right-hand side of pages 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.

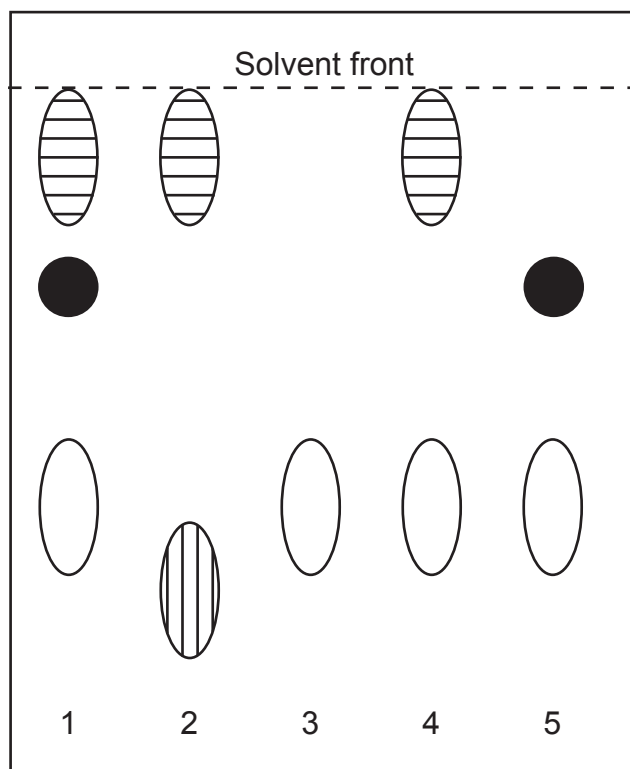
For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
Total Marks	

Section A

For each of the following questions only **one** of the lettered responses is correct.

Select the correct response in each case and mark its code letter in the appropriate box as illustrated on the answer sheet.

- 1 Paper chromatography was used to identify the amino acids in a hydrolysed polypeptide. The starting point for each amino acid is shown at points 2–5 in the chromatogram below.



Which one of the following mixtures makes up the polypeptide?

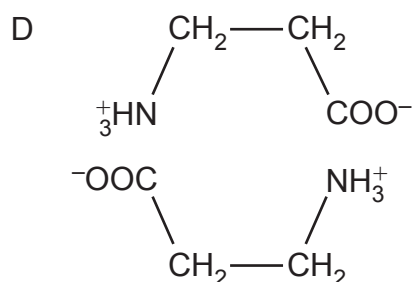
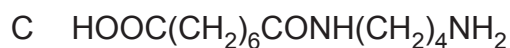
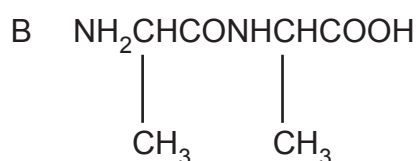
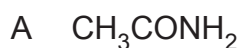
- A 2 + 5
- B 3 + 4
- C 3 + 5
- D 4 + 5

- 2 Oxygen has three isotopes ^{16}O , ^{17}O and ^{18}O . A sample of oxygen was analysed using a mass spectrometer and three groups of peaks were obtained:

group P corresponding to the ion C^{16}O^+
 group Q corresponding to the ion C^{17}O^+
 group R corresponding to the ion C^{18}O^+

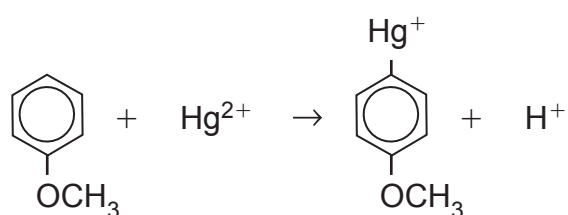
Which one of the following is the order on the mass/charge axis of the three groups?

- A P Q R
 B P R Q
 C Q P R
 D Q R P
- 3 Which one of the following compounds is a peptide?



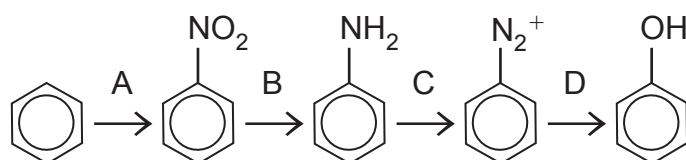
- 4 When 2.6 g of a metal X are added to copper(II) sulfate solution, a precipitate is obtained. The relative atomic mass of X is 52. Which one of the following ions is produced?
- A X^+
- B X^{2+}
- C X^{3+}
- D X^{4+}

- 5 The reaction below shows the mercury(II) ion reacting with anisole.

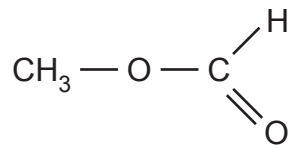


Which one of the following is the role of the mercury ion?

- A Catalyst
- B Electrophile
- C Nucleophile
- D Oxidising agent
- 6 Which one of the steps in the following synthesis requires the reagent $\text{NaNO}_2(\text{s})/\text{HCl}(\text{aq})$?



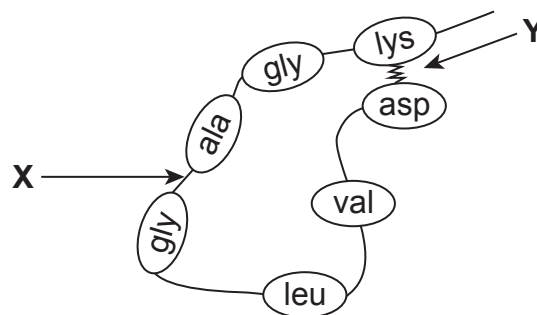
7 The structure below represents an organic compound.



This compound is an example of

- A an acid.
- B an aldehyde.
- C an ester
- D a ketone

8 The following diagram shows a section of a protein chain. The three-letter words represent the names of amino acids.



Different types of bonds are formed at X and Y.

Which one of the following represents the bonds X and Y?

- | X | Y |
|-----------------|---------------|
| A hydrogen bond | hydrogen bond |
| B hydrogen bond | ionic bond |
| C peptide bond | hydrogen bond |
| D peptide bond | ionic bond |

9 A sample of DDT, $C_{14}H_9Cl_5$ was found to contain 0.120 g of carbon. The following was the mass of chlorine in the sample?

- A 0.127 g
- B 0.335 g
- C 0.994 g
- D 1.01 g

10 Which one of the following industrial processes is catalysed by a metal compound?

- A hydrogenation of alkenes
- B manufacture of sulfuric acid
- C oxidation of ammonia
- D reaction of nitrogen with hydrogen

Section B

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

- 11 Complete the table below to give the colours of the metal ions

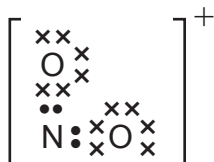
metal ion	colour of aqueous solution
$\text{Cu}^{2+}(\text{aq})$	
$\text{Cr}^{3+}(\text{aq})$	
$\text{Co}^{2+}(\text{aq})$	
$\text{Fe}^{3+}(\text{aq})$	

[3]

- 12 Benzene and its derivatives are nitrated by the nitronium ion which is formed when nitric acid reacts with sulfuric acid.



The nitronium ion has the following electron structure:



- (a) (i) How does this structure explain the positive charge on the nitronium ion?

_____ [1]

- (ii) Explain whether the nitronium ion is an electrophile or a nucleophile.

_____ [2]

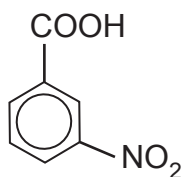
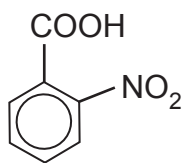
- (iii) Draw a flow scheme to show the mechanism for the reaction of benzene with the nitronium ion to form nitrobenzene.

[3]

- (iv) Explain whether this mechanism is addition or substitution.

_____ [2]

- (b) Benzoic acid is nitrated to produce three products which are shown below together with their melting points and their former names.



ortho-nitrobenzoic acid

145 °C

meta-nitrobenzoic acid

174 °C

para-nitrobenzoic acid

186 °C

- (i) Suggest the systematic names for *ortho*, *meta* and *para* nitrobenzoic acids.

ortho nitrobenzoic acid _____

meta nitrobenzoic acid _____

para nitrobenzoic acid _____ [2]

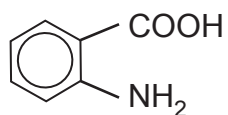
- (ii) Suggest, using hydrogen bonding, why the melting points of these nitrobenzoic acids increase as the nitro group is further away from the carboxylic acid group.

_____ [2]

- (iii) Each of these nitrobenzoic acids can be reduced to amino compounds. Name the reagent used and explain how the amines can be liberated from the reaction mixture.

_____ [2]

(c) The best known aminobenzoic acid is anthranilic acid.



(i) When distilled it is decarboxylated to form phenylamine. What is meant by the term **decarboxylated** and write the equation for the reaction.

_____ [3]

(ii) Anthranilic acid could be described as an amino acid but it is not part of any protein. Suggest an explanation for this contradictory statement.

_____ [2]

(iii) Anthranilic acid is diazotised to form a diazonium ion. State the condition necessary for this reaction.

_____ [1]

(iv) Suggest the structure of the product when the diazotised anthranilic acid is coupled with phenol.

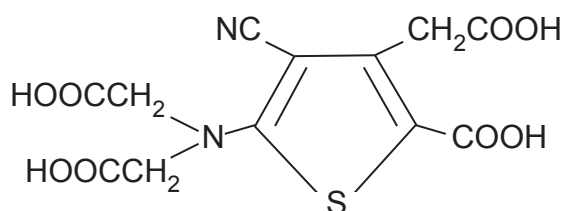
[2]

(v) Explain why it is not possible to couple diazotised butylamine with phenol.



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- 13 The monostrontium salt of ranelic acid has recently been hailed as a wonder drug which can slow the progress of osteoarthritis, the tear disease that destroys joints, and thus save on costly hip and knee replacements. Strontium ions increase bone density and are commonly used to treat osteoporosis. Ranelic acid is similar in some respects to ethylenediaminetetraacetate (edta).



ranelic acid

- (a) Both ranelic acid and edta are polydentate ligands.

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

_____ [2]

- (ii) Explain what is meant by the term **polydentate**.

_____ [2]

- (iii) Draw a diagram to show the outer electron structure of the nitrile group and use it to suggest why it can or cannot act as a ligand.

_____ [3]

(b) Write the formula of the monostrontium salt of ranelic acid ions present.

(c) Both edta and ranelic acid form complexes with the ions of Group II metals such as calcium and strontium. Suggest whether edta might be expected to displace ranelic acid from its complex with strontium ions.

_____ [2]

(d) (i) Describe the titration of a standard solution of edta with a solution of magnesium ions, giving experimental details and explaining the colour change.

_____ [5]

Quality of written communication [2]

- (ii) A saturated solution of magnesium hydroxide was prepared by dissolving the solid in 1 dm³ of water and then filtering the solution. A 25.0 cm³ sample was titrated with 0.01 mol dm⁻³ solution and a titre of 15.6 cm³ was required. Calculate the concentration of the magnesium hydroxide solution in mol dm⁻³.

[4]

- (e) Edta is used in treating blood and water. Explain, in each case, what the role of edta is.

- (i) The role of edta in treating blood.

[2]

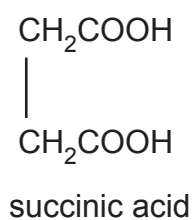
- (ii) The role of edta in treating water.

[2]

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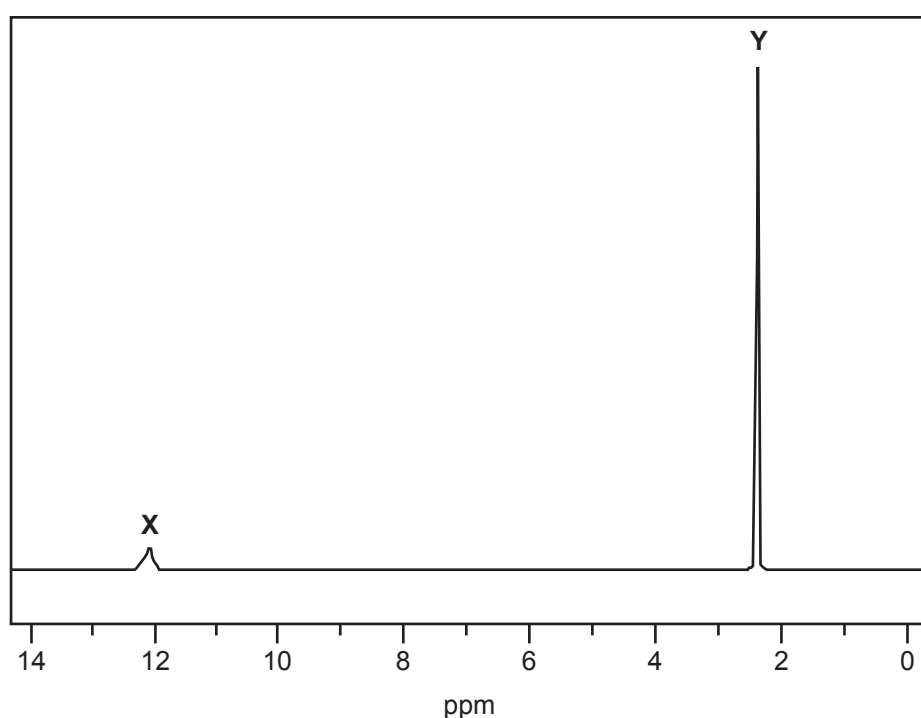
(Questions continue overleaf)

- 14 Succinic acid is a dicarboxylic acid and was named after the Latin word for amber from which it was first obtained by distillation (Lat: succin)



It is a crystalline solid with a melting point of 185°C and is moderately soluble in water and ethanol.

- (a) The high resolution nmr spectrum of succinic acid is shown below.



- (i) Explain why the CH₂ groups do not interact with each other.

_____ [1]

- (ii) Identify which hydrogen atoms give rise to the peaks at X and Y.

X _____ [1]

Y _____ [1]

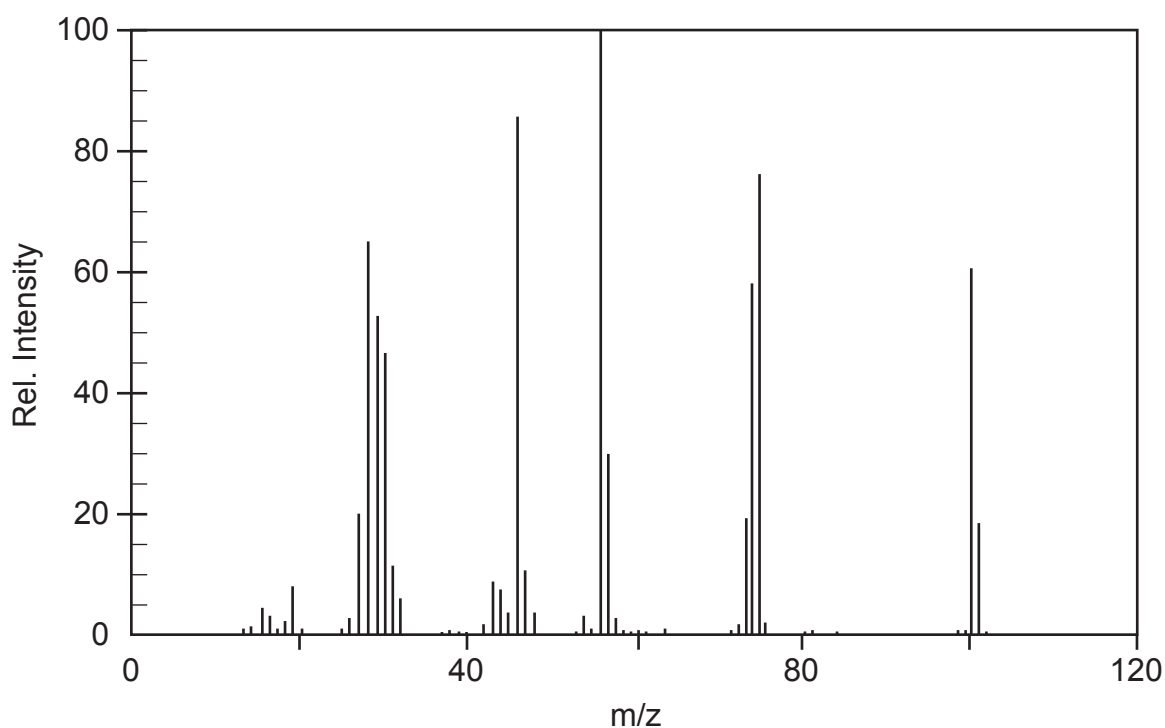
(iii) Explain why peak X is at a greater chemical shift than

(iv) Draw the integration curve on the spectrum.

(v) The TMS signal is missing from the spectrum. Draw the signal on the spectrum.

[1]

(b) The mass spectrum of succinic acid is shown below.



(i) Explain the meaning of the term **base peak**.

[1]

(ii) Identify the base peak.

[1]

(iii) Suggest formulae for the following m/z values of the fragment ions

45 _____ [1]

100 _____ [1]

(c) When heated with excess ethane-1,2-diol succinic acid forms polymers known as alkyd resins.

(i) Draw the structure of the polymer showing the repeat

[3]

(ii) What is the name given to this type of polymerisation?

[1]

(iii) Suggest why the polymer is acidic.

[1]

(iv) Explain why this polymer is biodegradable.

[2]

(d) Succinic acid reacts with excess ammonia to form the diammonium salt which, when heated, is dehydrated to form the diamide.

(i) Draw the flow scheme for the reactions above.

[2]

(ii) Name the reagent used to convert an amide into a nitro compound.

(iii) Draw the structure of the product formed when the diethyl ester of succinic acid reacted with excess lithium.

[2]

(e) Succinic acid can be analysed by converting it to the diethyl ester and submitting the ester to GLC analysis.

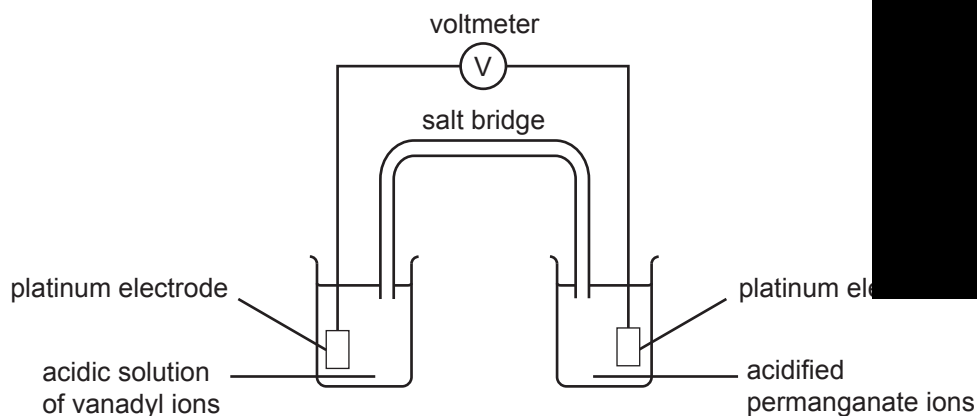
(i) Why is it better to use the ester rather than the acid in GLC analysis?

_____ [2]

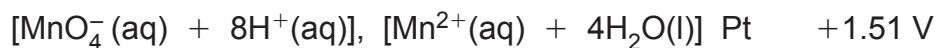
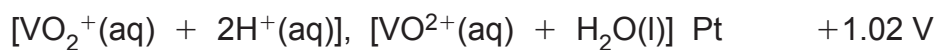
(ii) Explain the results expected if the sample of the ester was 90% pure.

_____ [2]

15 The cell shown below was set up to investigate the reaction between an acidic solution of vanadyl ions, VO_2^+ , with acidified permanganate ions.



The standard electrode potentials for the two systems are shown below:



(a) Explain in which direction the electrons flow in the external circuit.

_____ [2]

(b) The reaction taking place is a redox reaction. Explain, by referring to oxidation numbers in the cell, what is meant by the term **redox**.

_____ [2]

(c) Write the equations for the reactions taking place in the two half-cells and combine them to obtain the overall equation.

_____ [3]

(d) (i) Describe the colour change in the vanadyl half-cell.

(ii) Describe the colour change in the permanganate half-cell.

(e) Calculate the reading that will be observed on the voltmeter.

[2]

(f) Explain the purpose of the salt bridge and how it works.

[2]

(g) The electrode potentials of the half-cells are measured using a hydrogen electrode. Describe a hydrogen electrode and state the conditions under which it operates.

[4]

THIS IS THE END OF THE QUESTION PAPER

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