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Candidate Number

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Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry
and Further Organic Chemistry

[AC222]

TUESDAY 1 JUNE, AFTERNOON



AC222

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 **16(b)**.

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	
17	

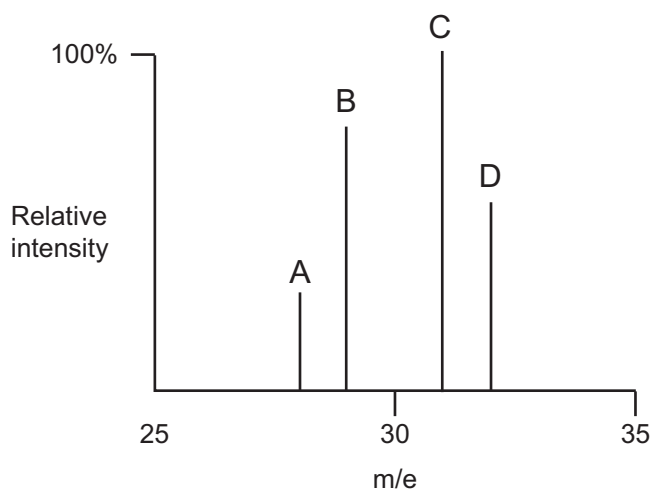
Total Marks	
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Section A

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 The mass spectrum of methanol is shown below.
Which one of the following is the base peak?



- 2 Which one of the following represents the electronic configuration for the Fe^{3+} ion?

- A $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
- B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$
- C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^1$
- D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

- 3 Which one of the following formulae **cannot** be determined by colorimetry?

- A $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$
- B $[\text{Fe}(\text{SCN})(\text{H}_2\text{O})_5]^{2+}$
- C $[\text{Ni}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$
- D $[\text{Zn}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$

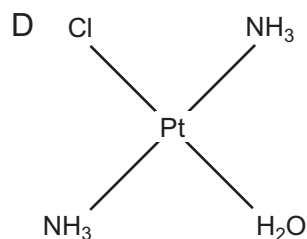
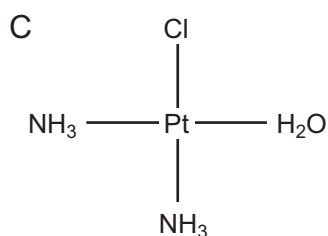
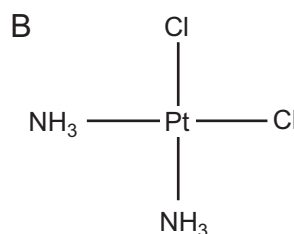
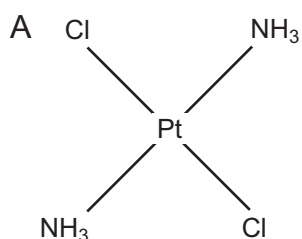
4 The standard electrode potentials for a series of redox equations are listed.

	E^\ominus/V
$\text{Mn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Mn}(\text{s})$	-1.19
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Fe}(\text{s})$	-0.44
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Ni}(\text{s})$	-0.25
$\text{I}_2(\text{s}) + 2\text{e}^- \rightleftharpoons 2\text{I}^-(\text{aq})$	+0.54
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Ag}(\text{s})$	+0.80

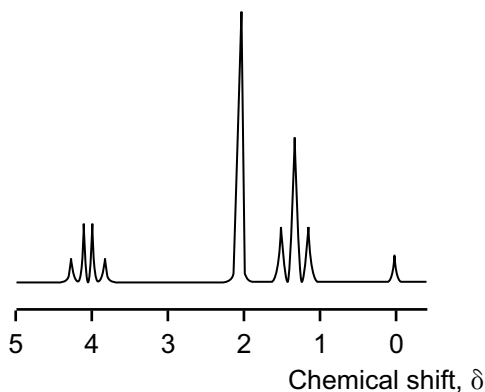
Which one of the elements listed will reduce $\text{Fe}^{3+}(\text{aq})$ to $\text{Fe}^{2+}(\text{aq})$, but not to $\text{Fe}(\text{s})$?

- A Iodine
- B Manganese
- C Nickel
- D Silver

5 Which one of the following represents the structure of cisplatin?



- 6 The nmr spectrum of a compound **X** is shown below.



Which one of the following is **X**?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
 B $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$
 C $\text{CH}_3\text{COOCH}_2\text{CH}_3$
 D $\text{CH}_3\text{CH}_2\text{COOH}$
- 7 A green solid was dissolved in water and the resulting solution divided into two portions. Sodium hydroxide solution was added to one of the portions and ammonia solution to the other. The results are summarised in the table below.

Solution added	Few drops of solution	Excess solution
Sodium hydroxide solution	Green precipitate	No effect
Ammonia solution	Green precipitate	Dissolves to form a blue solution

Which one of the following ions was present in the green solid?

- A Cr^{3+}
 B Cu^{2+}
 C Fe^{2+}
 D Ni^{2+}
- 8 Which one of the following is the colour of chrome alum crystals?

- A Black
 B Green
 C Orange
 D Violet

- 9 25.0 cm³ of hydrogen peroxide solution were added to excess acidified potassium iodide solution and the resulting solution made up to 500 cm³.
25.0 cm³ of the diluted solution reacted with 36.4 cm³ of sodium thiosulphate solution of concentration 0.10 mol dm⁻³.
Which one of the following is the concentration of the undiluted hydrogen peroxide?

- A 0.07 mol dm⁻³
- B 0.15 mol dm⁻³
- C 1.46 mol dm⁻³
- D 2.91 mol dm⁻³

- 10 Which one of the following pairs of monomers will **not** combine to form a polymer?

- A HOOC(CH₂)₄COOH and H₂N(CH₂)₆NH₂
- B H₂N(CH₂)₆NH₂ and H₂N(CH₂)₆NH₂
- C CH₂CH₂ and CH₂CH₂
- D HOOC(CH₂)₄COOH and HO(CH₂)₂OH

Section B

Answer **all seven** questions in this section

- 11 (a) Complete the table below by giving the name of the indicator and the colour change at the end point.

Titration	Indicator	Colour change	
		from	to
Edta added to magnesium ions			
Thiosulphate ions added to iodine			

[6]

- (b) Some iron tablets, used to treat anaemia, contain iron(II) fumarate ($\text{FeC}_4\text{H}_2\text{O}_4$).

Five of these iron tablets were dissolved in dilute sulphuric acid and the solution made up to 250 cm^3 with distilled water. On titration 25.0 cm^3 of this solution reacted with 18.7 cm^3 of 0.01 mol dm^{-3} acidified potassium manganate(VII) solution.

- (i) Write the equation for the reaction of iron(II) ions with acidified manganate(VII) ions.

_____ [2]

- (ii) What is the colour change at the end point of the titration?

From _____ to _____ [2]

- (iii) Calculate the mass of iron(II) fumarate in each tablet.

_____ [4]

12 (a) Polythene is a typical addition polymer.

(i) State the conditions necessary for the formation of HD polythene.

Temperature: _____

Pressure: _____

Catalyst: _____ [3]

(ii) Making reference to their structures, explain the difference in flexibility between HD and LD polythene.

_____ [2]

(b) Polyethylene terephthalate is a polyester.

(i) Draw the repeating unit for polyethylene terephthalate.

[2]

(ii) Give **one** use for polyethylene terephthalate.

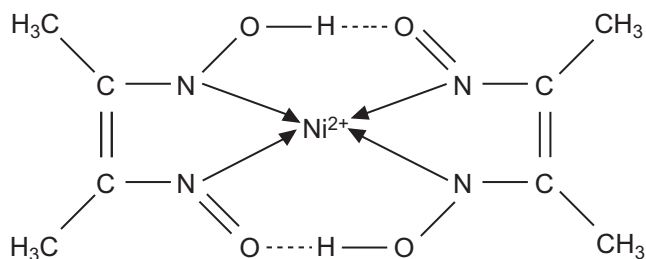
_____ [1]

13 Transition metals form complex ions with ligands.

(a) Explain what is meant by the term **polydentate ligand**.

_____ [2]

(b) The complex below is formed when dimethylglyoxime is added to a solution of hydrated nickel(II) ions.



(i) What is the co-ordination number of the nickel(II) ion?

_____ [1]

(ii) Suggest the shape around the central nickel(II) ion.

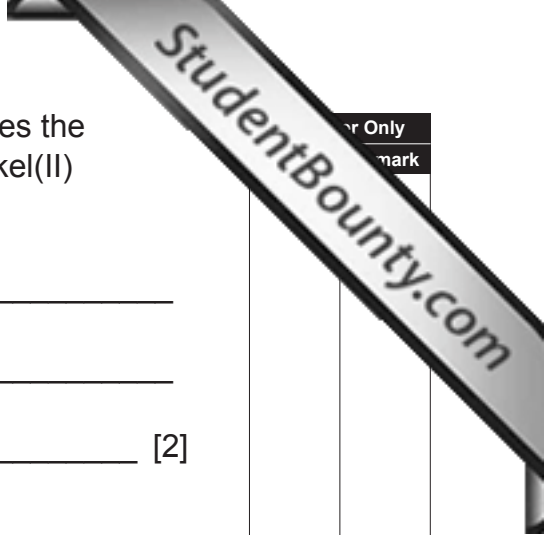
_____ [1]

(iii) What type of bonds in the complex are represented by each of the following?

— _____
----- _____
→ _____ [3]

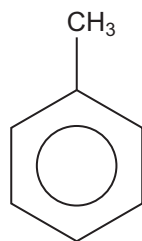
(c) Explain in terms of entropy why dimethylglyoxime displaces the water ligands in the hydrated nickel(II) ion to form the nickel(II) dimethylglyoxime complex.

[2]

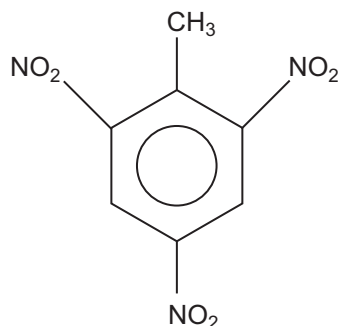


For Only
mark

- 14 The explosive trinitrotoluene (TNT) is prepared by the nitration of methylbenzene (toluene).



Toluene



TNT

- (a) Suggest a systematic name for TNT.

_____ [1]

- (b) TNT burns to form a mixture of carbon dioxide, nitrogen and water.

Write an equation for the complete combustion of TNT.

_____ [2]

- (c) TNT is prepared from toluene by using the same nitrating mixture as is used to nitrate benzene.

- (i) Name the acids present in the nitrating mixture.

_____ [2]

- (ii) Write an equation for the formation of the nitrating species.

_____ [2]

- (iii) What name is given to the nitrating species?

_____ [1]

(d) The mechanism for nitrating toluene is similar to that for nitrating benzene.

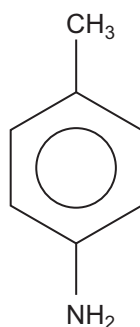
(i) What name is given to this mechanism?

_____ [2]

(ii) Draw the mechanism for the mononitration of toluene.

[2]

(e) 4-nitrotoluene can be converted to toluidine.



Toluidine

(i) Name the reagents which could be used to convert 4-nitrotoluene to toluidine.

_____ [2]

(ii) A salt of toluidine is formed during the reduction. How can toluidine be liberated from this salt?

_____ [1]

(f) Toluidine is used in the manufacture of dyes.
The first step in the process is to convert the toluidine to its diazonium ion using nitrous acid.

(i) Write an equation for the formation of nitrous acid from sodium nitrite.

_____ [1]

(ii) What conditions are necessary for the reaction between toluidine and nitrous acid to form the diazonium ion?

_____ [1]

(iii) Write an equation for the conversion of toluidine to its diazonium ion.

_____ [2]

(g) One dye is made by reacting the toluidine diazonium ion with phenol.

(i) What name is given to this type of reaction?

_____ [1]

(ii) Draw the structure of the dye formed.

[2]

(iii) Explain why this dye is coloured.

_____ [3]

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(Questions continue overleaf)

15 Vanadium and chromium are typical transition metals.

(a) Explain, in terms of electronic structure, what is meant by a **transition metal**.

_____ [1]

(b) Vanadium(V) oxide acts as a heterogeneous catalyst in the conversion of sulphur dioxide to sulphur trioxide in the manufacture of sulphuric acid.

(i) Write the equation for the conversion of sulphur dioxide to sulphur trioxide.

_____ [1]

(ii) What is meant by a **heterogeneous** catalyst?

_____ [1]

(iii) Explain, in terms of chemisorption, how vanadium(V) oxide acts as a catalyst in this reaction.

_____ [3]

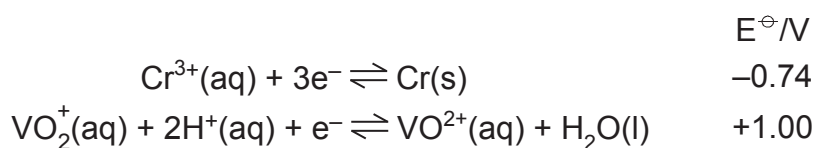
(c) An acidified solution of ammonium vanadate(V) undergoes a series of reductions when it is stirred with zinc.

(i) Complete the table below, giving the colour of $\text{VO}^{2+}(\text{aq})$ and $\text{V}^{3+}(\text{aq})$ formed at the different stages of the reduction.

Ion	Colour
$\text{VO}_2^+(\text{aq})$	Yellow
$\text{VO}^{2+}(\text{aq})$	
$\text{V}^{3+}(\text{aq})$	
$\text{V}^{2+}(\text{aq})$	Violet

[2]

(ii) Chromium will also reduce ammonium vanadate(V).



Write an equation for the reaction between chromium and $\text{VO}_2^+(\text{aq})$ ions and calculate the e.m.f. of the reaction.

e.m.f. _____ [3]

(d) Potassium chromate(VI), K_2CrO_4 can be prepared by oxidising a solution of chromium(III) ions.

(i) Name a suitable oxidising agent.

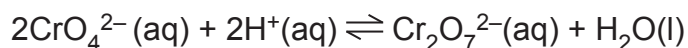
_____ [1]

(ii) Give the colour change on oxidising the chromium(III) ions to chromate(VI) ions.

from: _____

to: _____ [2]

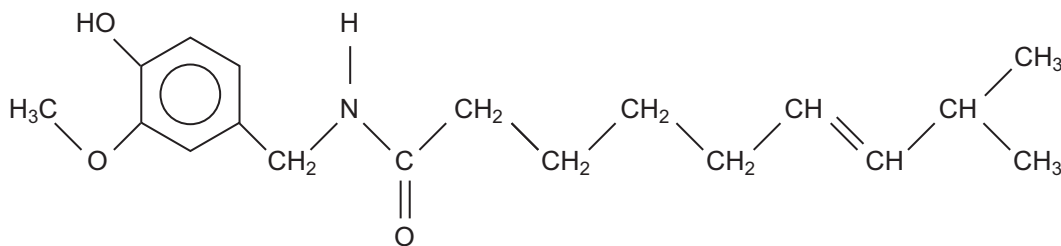
(iii) Chromate(VI) and dichromate ions are involved in the following equilibrium:



State and explain the colour change when sodium hydroxide solution is added to this equilibrium.

_____ [3]

- 16 The burning sensation felt when eating chilli peppers is caused by capsaicin.



Capsaicin

- (a) Capsaicin is used in pepper sprays at a concentration of 5% by mass per volume (5 g in 100 cm³).

- (i) What is the molecular formula of capsaicin?

_____ [1]

- (ii) Calculate the concentration of capsaicin in mol dm⁻³ of the pepper spray.

 _____ [3]

- (b) A sample of capsaicin extracted from chilli peppers will contain a large number of organic impurities.

Describe how you would use two-way paper chromatography to show that the sample contained capsaicin.

 _____ [4]

Quality of written communication [2]

17 Proteins are formed from amino acids.

(a) (i) Describe the primary, secondary and tertiary structure of proteins.

Primary: _____
_____ [1]

Secondary: _____
_____ [2]

Tertiary: _____
_____ [2]

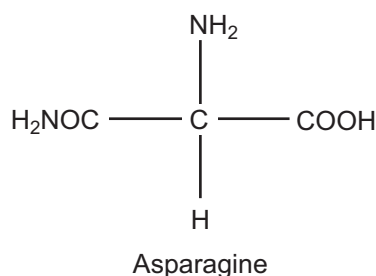
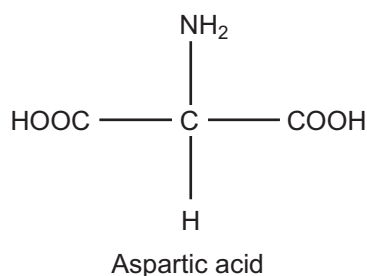
(ii) Explain why some proteins can act as enzymes.

_____ [2]

(iii) Explain why the efficiency of most enzymes is lowered at 60°C.

_____ [2]

(b) Aspartic acid and asparagine are amino acids.



(i) Suggest how aspartic acid could be converted to asparagine.

_____ [1]

- (ii) Write an equation for the reaction between aspartic acid and asparagine to form a dipeptide.

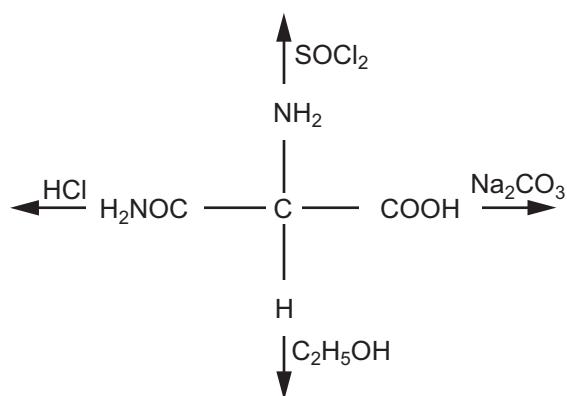
_____ [2]

- (iii) Amino acids dissolve in water to form a dipolar ion (zwitterion).

Draw the structure of the dipolar ion formed by asparagine.

[1]

- (iv) Complete the following flow diagram to show the structure of the organic product formed.



[4]

