Rewarding Learning

Centre Number

| 71 | |
|---|---|

Candidate Number

| |
|---|
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**ADVANCED**
**General Certificate of Education**
**2012**

# Chemistry

## Assessment Unit A2 2

*assessing*

## Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

**[AC222]**

AC222

**WEDNESDAY 23 MAY, 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 **16(c)(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 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 | |

## 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 applies to the ligand substitution reaction shown?

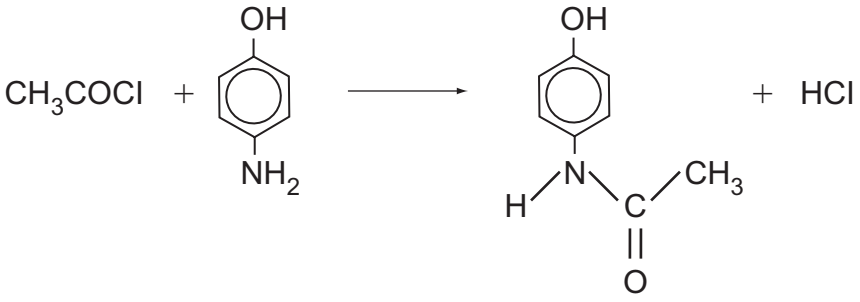
$$[Ni(H_2O)_6]^{2+} + 3en \rightarrow [Ni(en)_3]^{2+} + 6H_2O$$

| | Change in Coordination Number | $\Delta S^{\ominus}$ |
|---|---|---|
| A | 6 to 3 | negative |
| B | 6 to 3 | positive |
| C | none | negative |
| D | none | positive |

**2** Which one of the following lists the compounds in order of increasing base strength?

A ethanamide, methylamine, phenylamine
B ethanamide, phenylamine, methylamine
C methylamine, ethanamide, phenylamine
D phenylamine, ethanamide, methylamine

**3** The reaction of 4-hydroxyphenylamine to produce paracetamol is shown below.




If the reaction has an 80% yield, 10.9 g of 4-hydroxyphenylamine produces

A 12.1 g of paracetamol.
B 13.6 g of paracetamol.
C 15.1 g of paracetamol.
D 18.9 g of paracetamol.

**4** Which one of the following methods may be used to separate a mixture of amino acids obtained from protein hydrolysis?

A distillation
B recrystallisation
C solvent extraction
D thin-layer chromatography

**5** Which one of the following is a correct statement about the stereochemistry of the complex $[Pt(NH_3)_2Cl_2]$?

A It is square planar and has cis/trans isomers.
B It is square planar and has two optical isomers.
C It is tetrahedral and has cis/trans isomers.
D It is tetrahedral and has two optical isomers.

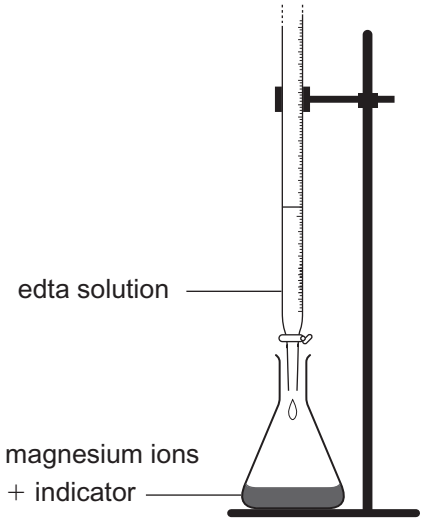
**6** 25.0 $cm^3$ of potassium iodate(V) solution were added to excess potassium iodide solution dissolved in sulfuric acid. The iodine liberated required 30.0 $cm^3$ of 0.05 mol $dm^{-3}$ $Na_2S_2O_3$ solution. Which one of the following is the concentration of the potassium iodate(V) solution?

A 0.01 mol $dm^{-3}$
B 0.02 mol $dm^{-3}$
C 0.04 mol $dm^{-3}$
D 0.05 mol $dm^{-3}$

**7** Which one of the following gives the ground state electronic configuration for the copper atom and the copper(II) ion?

| | copper atom | copper(II) ion |
|---|---|---|
| A | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9\ \ 4s^2$ | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$ |
| B | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9\ \ 4s^2$ | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$ |
| C | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$ | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^1$ |
| D | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$ | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$ |

**8** The diagram below shows the titration of a solution of magnesium ions with edta using Eriochrome Black T as indicator.




What is the colour change at the end point?

A blue to red
B green to blue
C red to green
D red to blue

**9** Which one of the following statements about glycine is **not** correct?

A It has a relatively high melting point.
B It contains 32% carbon by mass.
C It exists as optical isomers.
D It is soluble in water.

**10** Which one of the following statements about propanamide is **not** correct?

A It produces an M+1 peak at 73 in its mass spectrum.
B It can be dehydrated to form propanenitrile.
C It has the molecular formula $C_3H_7NO$.
D It is a weaker base than ammonia.

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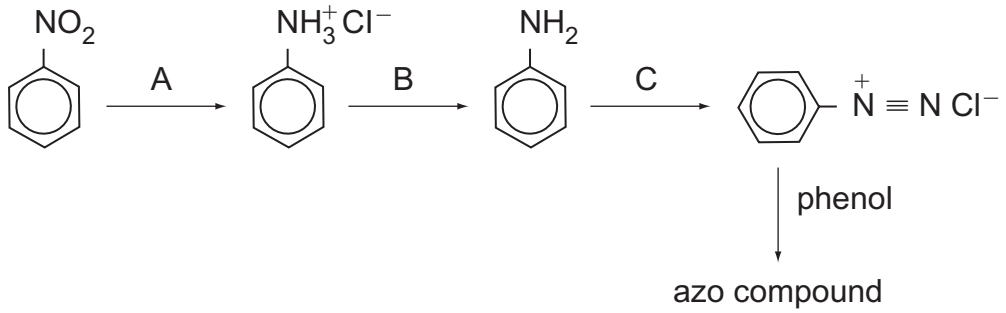
**(Questions continue overleaf)**

## Section B

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

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**11** The amino group is found in amines. Phenylamine is used in the synthesis of azo compounds. Consider the following sequence of steps:




**(a) (i)** Give the names of the reagents used in the following steps.

A _____ [2]

B _____ [1]

C _____ [2]

**(ii)** Give the conditions used in step C and name the product.

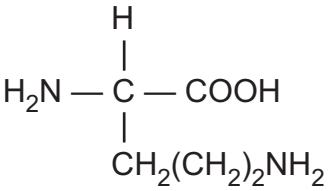
_____

_____ [2]

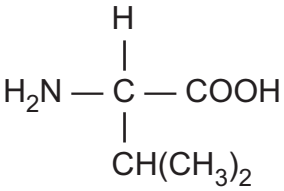
**(iii)** Draw the structure of the azo compound. Describe its appearance and name the compound.

_____ [3]

**(b)** Amino acids, such as lysine and valine, also contain the amino group.



lysine



valine

**(i)** Draw the zwitterion of valine.

[1]

**(ii)** Draw the structure of lysine when it is dissolved in an *excess* of a strong acid.

[2]

**(iii)** Draw the structures of the **two** dipeptides which can be formed from one molecule of glycine and one molecule of alanine. Circle the peptide link in each structure.

[3]

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**12** Standard electrode potentials can be used to predict the feasibility of reactions.

| | $E^{\ominus}$/V |
|---|---|
| $Na^+(aq) + e^- \rightleftharpoons Na(s)$ | −2.71 |
| $Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$ | −2.37 |
| $Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$ | −1.66 |
| $Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$ | −0.76 |
| $Cr^{3+}(aq) + e^- \rightleftharpoons Cr^{2+}(aq)$ | −0.41 |
| $2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$ | 0.00 |
| $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ | +0.77 |

**(a)** Define the term **standard electrode potential**.

_____

_____

_____ [3]

**(b)** From the table, select the species which is the most powerful reducing agent.

_____ [1]

**(c)** Write the equation for the reaction of aluminium with aqueous zinc ions and calculate the e.m.f.

_____

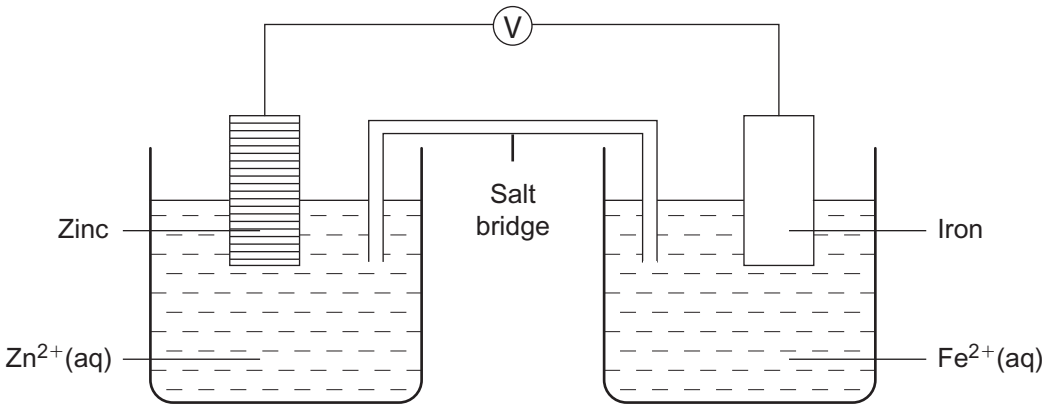
_____

_____ [3]

Examiner Only

| Marks | Remark |
|---|---|
| | |

**(d)** Under standard conditions, the e.m.f. of the cell shown below is +0.32 V.




Calculate the standard electrode potential for the iron half-cell.

_____

_____ [1]

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**13** Nuclear magnetic resonance spectroscopy (nmr) is an important analytical technique.

**(a)** In the question below, draw one possible structure for each of the compounds A, B, C and D.

**(i)** Compounds A and B are isomers with the molecular formula $C_4H_8O_2$. Both have a triplet, a singlet and a quartet in their nmr spectrum.

A B

[2]

**(ii)** Compound C has the molecular formula $C_6H_{12}$ and has only one peak in its nmr spectrum.

[1]

**(iii)** Compound D has the molecular formula $C_5H_{13}N$. It is a tertiary amine with three types of chemically equivalent hydrogen atom which exist in the ratio of 6:6:1 and produce a doublet in the nmr spectrum.

[1]

Examiner Only

| Marks | Remark |
|---|---|
| | |

**(b)** Mass spectrometry is another important analytical technique.

2-chloropropanoic acid produces molecular ion peaks at 108 and 110. It also produces a significant fragment peak at 91.

**(i)** Suggest why there are **two** molecular ion peaks.

_____

_____ [2]

**(ii)** Identify the fragment ion.

_____ [2]

**(iii)** Complete the table giving the integration values and the splitting of each peak in the nmr spectrum of 2-chloropropanoic acid:

| | **Peak 1** | **Peak 2** | **Peak 3** |
|---|---|---|---|
| Integration | 3 | | |
| Splitting | | | singlet |

[4]

| Examiner Only | |
|---|---|
| Marks | Remark |

**14** Iron(II) ions are part of the structure of haemoglobin. Many people supplement their diet by taking "iron tablets" which contain hydrated iron(II) sulfate, $FeSO_4.7H_2O$.

**(a)** "Iron tablets" with a total mass of 8.00 g were dissolved in dilute sulfuric acid and the solution was made up to 250 $cm^3$ in a volumetric flask. 25.0 $cm^3$ portions of this solution were titrated with 0.02 mol $dm^{-3}$ acidified potassium manganate(VII). The average titre was found to be 24.0 $cm^3$.

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

_____ [2]

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

_____ [2]

**(iii)** Calculate the percentage of hydrated iron(II) sulfate in the tablets.

_____

_____

_____

_____

_____

_____

_____ [5]

Examiner Only

| Marks | Remark |
|---|---|

**(b)** The $[Fe(H_2O)_6]^{3+}$ ion behaves as a Brønsted acid by the loss of one hydrogen ion.

**(i)** Write an equation to show $[Fe(H_2O)_6]^{3+}$ behaving as a Brønsted acid.

_____ [2]

**(ii)** Write the expression for the acid dissociation constant of the $[Fe(H_2O)_6]^{3+}$ ion.

_____ [1]

**(iii)** What is observed when sodium hydroxide solution is added to a solution containing $[Fe(H_2O)_6]^{3+}$ ions?

_____

_____ [2]

**(iv)** Describe a different chemical test, including observations, which can be used to detect the presence of low concentrations of $[Fe(H_2O)_6]^{3+}$ ions. Give the formula of any new complex formed.

_____

_____

_____

_____ [4]

**(c)** With reference to the iron(II) ions in haemoglobin, explain why breathing carbon monoxide can result in death.

_____

_____

_____ [2]

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**15** Benzene is toxic and carcinogenic, however, the reactions of aromatic compounds can be studied in the laboratory using other substances such as methyl benzoate.

**(a)** The electrons in the π bonds in benzene are delocalised. Draw two structures for benzene to show the p-orbitals before and after delocalisation.

before after

[2]

**(b)** Nitration of methyl benzoate can be achieved using a "nitrating mixture" of concentrated nitric and sulfuric acids.

**(i)** Write an equation to show how these two acids react when mixed.

_____ [2]

**(ii)** Name the ion, produced in this reaction, which attacks the methyl benzoate molecule.

_____ [1]

**(iii)** Draw a flow scheme to show the mechanism of the mononitration of methyl benzoate and name the mechanism.

Name of mechanism _____ [4]

**(iv)** Name the organic product of this reaction.

_____ [1]

**(v)** Describe the appearance of this organic product.

_____

_____ [2]

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

| Examiner Only | |
|---|---|
| Marks | Remark |

**16** Transition metals form coloured complex ions and exist in a range of oxidation states.

**(a)** In terms of electron structures, explain why zinc is not a transition metal.

_____

_____

_____ [2]

**(b)** The $VO_2^+$ ion can be reduced to $V^{2+}$ using zinc in the presence of an acid. Zinc is oxidised to form $Zn^{2+}$ ions.

**(i)** Write a half-equation for the reduction of $VO_2^+$ to $V^{2+}$.

_____ [2]

**(ii)** Combine the above half-equation with the following oxidation half-equation:

$$Zn \longrightarrow Zn^{2+} + 2e^-$$

to give the ionic equation for the reaction.

_____ [2]

**(iii)** When this reduction is carried out in the laboratory a series of colour changes are observed. Complete the following table:

| Ion | Colour |
|---|---|
| $VO_2^+$ | |
| | Blue |
| | Green |
| $V^{2+}$ | |

[4]

| Examiner Only | |
|---|---|
| Marks | Remark |

**(c)** Potassium dichromate ($K_2Cr_2O_7$) can be prepared by the oxidation of a chromium(III) salt such as hydrated chromium(III) chloride, $CrCl_3.6H_2O$.

**(i)** Describe the preparation of potassium dichromate from hydrated chromium(III) chloride. Include all observations.

[6]

Quality of written communication [2]

**(ii)** When 13.33 g of hydrated chromium(III) chloride were used, 2.93 g of potassium dichromate were obtained. Calculate the percentage yield.

[4]

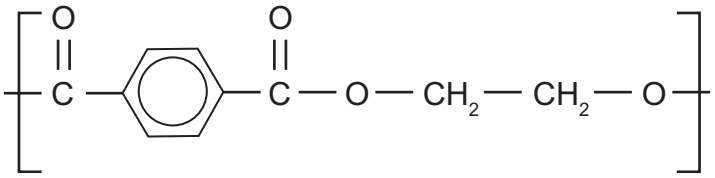
| Examiner Only | |
|---|---|
| Marks | Remark |

**17** Polymers are long chain molecules produced by addition or condensation reactions. Polyesters and polyamides are the two main types of condensation polymer.

**(a)** The polyamide nylon-6,6 is made by a condensation reaction between 1,6-diaminohexane and hexanedioic acid. Draw a section of the polymer showing **two** repeating units.

[3]

**(b)** The repeating unit of the polymer PET is shown below:




**(i)** Draw the structure of the smaller of the two monomers.

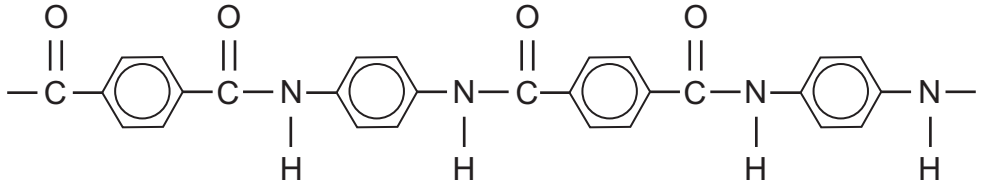
[1]

**(ii)** Name this monomer.

_____ [1]

| Examiner Only | |
|---|---|
| Marks | Remark |

**(c)** Kevlar is a polyamide used in bulletproof jackets. A section of the polymer chain is shown below:



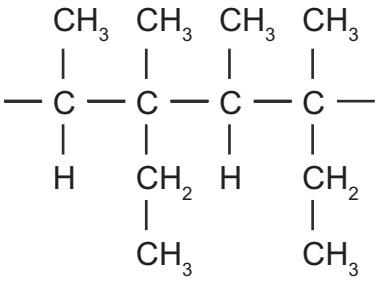
**(i)** How many repeating units are shown?

_____ [1]

**(ii)** Give the structures of the two monomers which can be used to produce Kevlar.

[2]

**(d)** A section of an addition polymer is shown below:



Name the monomer used to produce this polymer.

_____ [2]

**THIS IS THE END OF THE QUESTION PAPER**