Rewarding Learning

Centre Number	
71	

Candidate Number

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 corre

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

1 Which one of the following applies to the ligand substitution reaction shown?

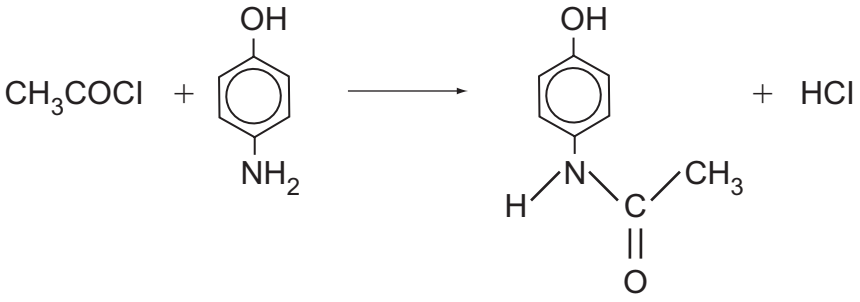
$$[Ni(H_2O)_6]^{2+} + 3en \rightarrow [Ni(en)_3]^{2+} + 6H_2O$$

	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 [illegible]ds 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.

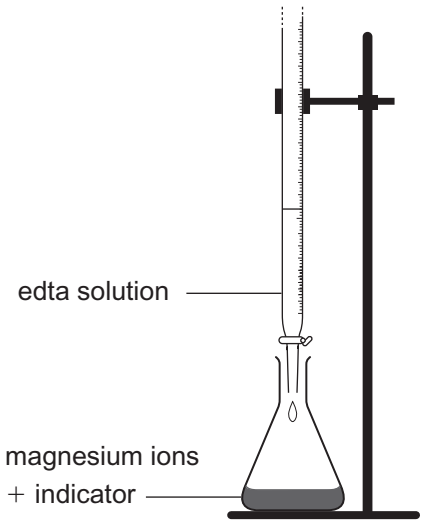
6 $25.0\,cm^3$ of potassium iodate(V) solution were added to excess potassium iodide solution dissolved in sulfuric acid. The iodine liberated required $30.0\,cm^3$ of $0.05\,mol\,dm^{-3}$ $Na_2S_2O_3$ solution. Which one of the following is the concentration of the potassium iodate(V) solution?

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 wit[illegible]g 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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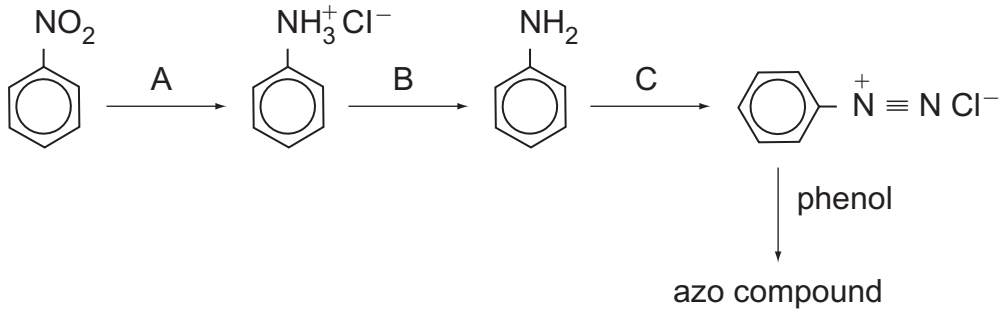
(Questions continue overleaf)

Section B

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

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.

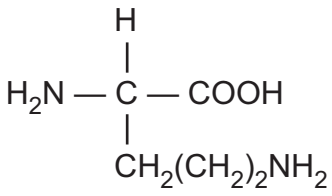
_____

_____ [2]

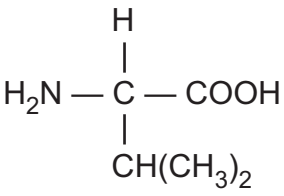
(iii) Draw the structure of the azo compound. Describe its appearance and name the compound.

_____ [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]

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]

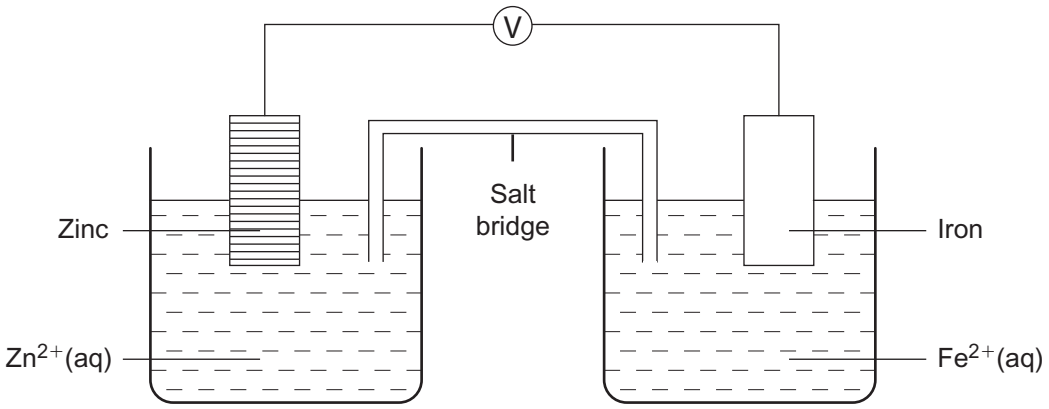
(c) Write the equation for the reaction of aluminium with aqueous zinc ions and calculate the e.m.f.

_____

_____

_____ [3]

(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]

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]

(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]

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]

(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]

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]

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:

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

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]

(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.

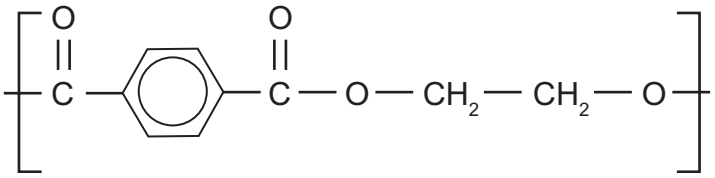
[4]

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:



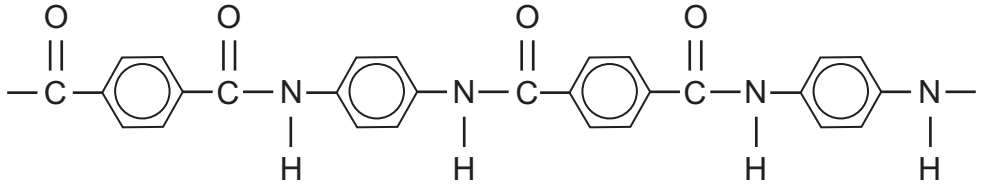
(i) Draw the structure of the smaller of the two monomers.

[1]

(ii) Name this monomer.

_____ [1]

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



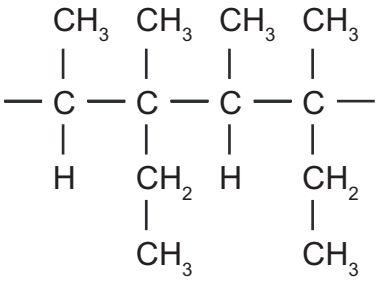
(i) How many repeating units are shown?

_____ [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

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