Rewarding Learning

71	

Candidate Number

ADVANCED
General Certificate of Education
January 2010

Chemistry

Assessment Unit A2 2

assessing

Module 5: Analytical, Transition Metals and Further Organic Chemistry

[A2C21]

A2C21

WEDNESDAY 27 JANUARY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fourteen** 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 four** 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 90.
Quality of written communication will be assessed in question **14(d)**.
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	
Total Marks	

BLANK PAGE

Section A

For each of the 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 illustrated on the answer sheet.

1 How many electrons are there in the delocalised π electron system in a benzene ring?

A 3
B 6
C 9
D 12

2 Which one of the following molecules is **not** planar?

A 

B CCl_4

C BF_3

D $Pt(NH_3)_2Cl_2$

3 Which one of the following spectroscopic techniques involves the breaking of bonds?

A infra-red spectroscopy
B mass spectroscopy
C n.m.r. spectroscopy
D ultra-violet spectroscopy

4 Which one of the following statements describes the secondary structure of a protein?

A The formation of the α-helix.
B The folding of the α-helix.
C The sequence of the amino acids.
D The sequence of the peptide links.

5 The mechanism for the formation of nitrobenzene from benzene is described as

A electrophilic addition.
B electrophilic substitution.
C nucleophilic addition.
D nucleophilic substitution.

6 Which one of the following describes the charge and coordination number of the $[Ni(edta)]^{2-}$ complex?

	Charge	Coordination number
A	2+	1
B	2–	1
C	2+	6
D	2–	6

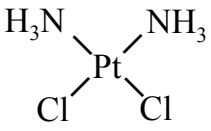
7 A 50 cm^3 sample of a gaseous hydrocarbon required exactly 250 cm^3 of oxygen for complete combustion and produced 150 cm^3 of carbon dioxide. All measurements of volumes were made under the same conditions. Which one of the following is the correct formula of the hydrocarbon?

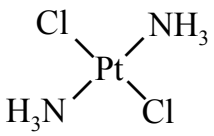
A C_3H_4
B C_3H_8
C C_5H_{10}
D C_5H_{12}

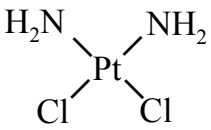
8 What is the total number of isomers of dibromobenzene, $C_6H_4Br_2$?

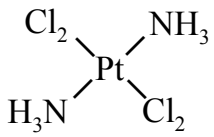
A 2
B 3
C 4
D 5

9 Which one of the following complexes is used as an anti-cancer drug?

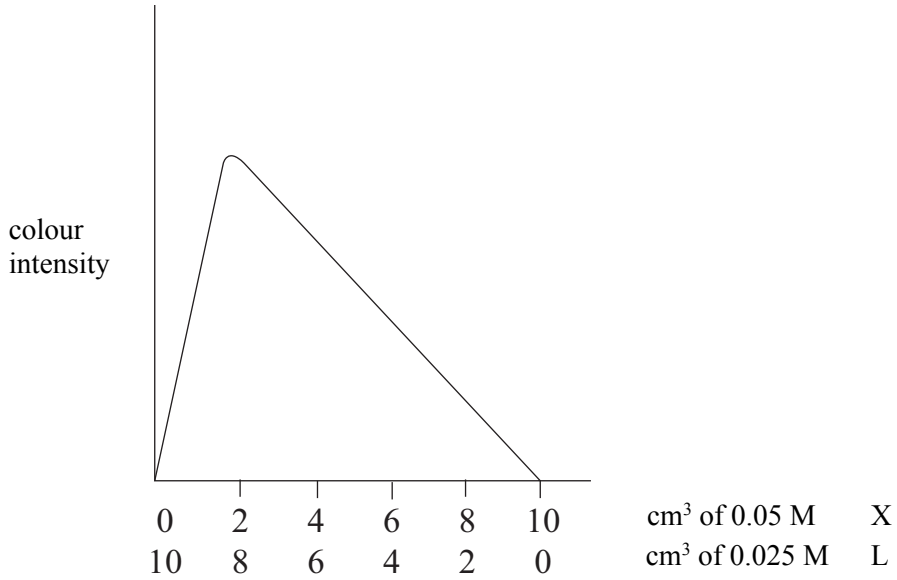
A 

B 

C 

D 

10 The graph below shows the change in colour intensity when a 0.05 M solution of metal ion X and a 0.025 M solution of a complexing ligand L are mixed in varying proportions.



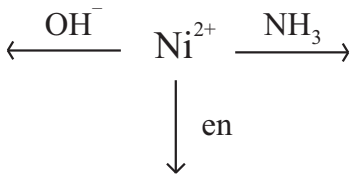
The formula of the complex formed is

A XL_2
B XL_4
C XL_8
D X_2L

Section B

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

11 Complete the flow scheme below by writing the formulae of the three nickel compounds formed.



[3]

12 Potassium manganate(VII) forms purple-red crystals which are soluble in water giving a deep purple solution. It is a powerful oxidising agent either as a solid or in solution.

(a) When heated, potassium manganate(VII) decomposes to form oxygen.

$$2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$$

The manganese compound MnO_2 is a black insoluble solid whilst K_2MnO_4 is a soluble green solid.

(i) Explain, with experimental details, how you would obtain a pure dry sample of MnO_2 from the reaction mixture.

_____

_____

_____[3]

(ii) Using oxidation numbers explain the redox changes when $KMnO_4$ decomposes.

_____

_____

_____[3]

(iii) Calculate the volume of oxygen obtained at 20 °C and one atmosphere pressure when 2.0 g of potassium manganate(VII) are completely decomposed.

_____

_____

_____[3]

(b) A solution of potassium manganate(VII) oxidises nitrites to nitrates.

$$6H_2SO_4 + 4KMnO_4 + 5Ca(NO_2)_2 \rightarrow 2K_2SO_4 + 4MnSO_4 + 5Ca(NO_3)_2 + 6H_2O$$

(i) Rewrite this equation as an ionic equation.

_____[2]

(ii) State the colour change observed.

_____[1]

(c) Potassium manganate(VII) may be used to determine the concentration of iron(II) ions in solution.
The equation for the reaction is:

$$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$$

(i) A sample of steel (2.0 g) was dissolved in an excess of dilute sulphuric acid and the solution was made up to 250 cm^3 with water. 25.0 cm^3 samples of this solution were titrated with 0.02 M potassium manganate(VII) solution. The average titre was 34.9 cm^3. Calculate the percentage of iron in the sample of steel.

_____

_____

_____

_____

_____ [3]

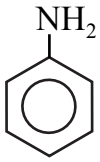
(ii) An excess of sodium hydroxide solution was added to the titration flask after the titration was complete. Write **three** equations for the reactions taking place.

_____

_____

_____ [3]

13 Phenylamine (aniline) was discovered in 1826 by distilling the dye indigo. The name aniline is derived from anil, the Portuguese word for indigo.



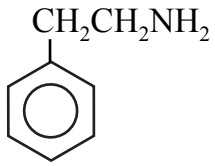
aniline

(a) Reduction of nitrobenzene produces aniline. Write the equation for the reduction of nitrobenzene using [H] to represent the reducing agent.

_____ [2]

(b) Aniline is basic and reacts with strong acids to form crystalline salts.

(i) State the basicity of aniline compared to ammonia and phenylethylamine.



phenylethylamine

_____ [1]

(ii) Write the equation for the reaction of aniline with hydrochloric acid.

_____ [1]

(iii) Explain why phenylethylamine is a primary amine.

_____

_____ [1]

(c) The boiling point of aniline is 110 °C, that of phenylethylamine is 195 °C and propylbenzene is 159 °C. Explain these relative boiling points in terms of intermolecular forces.

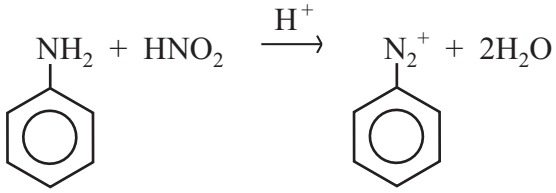
_____

_____

_____

_____ [3]

(d) When aniline is treated with nitrous acid at a low temperature the benzene diazonium ion is formed.



(i) Draw the structure of the benzene diazonium ion, $C_6H_5N_2^+$, showing all the bonds between the nitrogen atoms and the location of the charge. (Do **not** show the detailed structure of the benzene ring.)

[2]

(ii) Name the reagents used to generate the nitrous acid.

_____ [2]

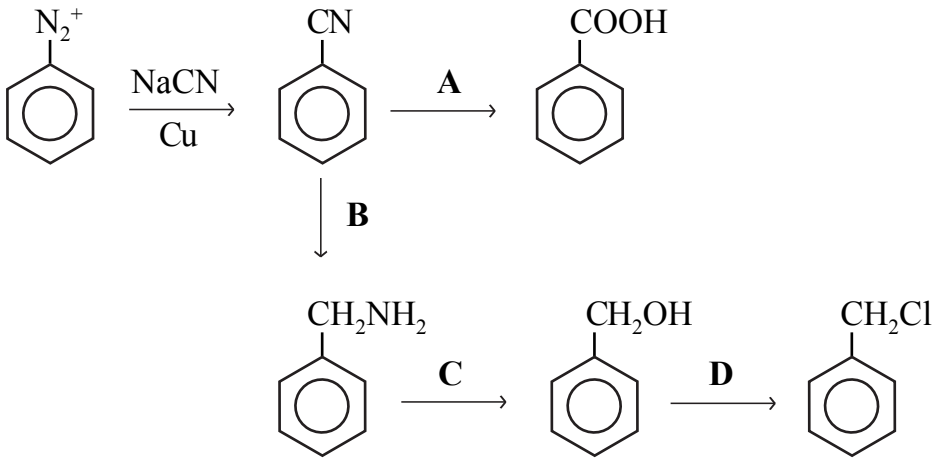
(iii) If phenylethylamine is treated with nitrous acid under the same conditions the diazonium ion is not formed. Explain why.

_____

_____

_____ [2]

(iv) If a solution of benzene diazonium ion is treated with aqueous sodium cyanide in the presence of a copper catalyst cyanobenzene is produced. Name the reagents A–D in the flow scheme below.



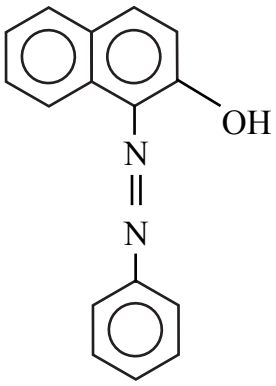
A _____

B _____

C _____

D _____ [4]

(e) The benzene diazonium ion reacts with a compound X to form compound Y, a red precipitate.



compound Y

(i) Suggest the structure of X.

[1]

(ii) Y is a conjugated molecule. Explain the meaning of the term **conjugated**.

_____

_____[2]

(iii) Using the concept of conjugation and energy levels explain why Y is coloured.

_____

_____

_____

_____[3]

14 Propanoic acid and ethyl methanoate are isomers which can be identified using spectroscopic techniques.

(a) (i) Explain why propanoic acid and ethyl methanoate are regarded as isomers.

_____

_____ [2]

(ii) Write the equation for the formation of ethyl methanoate by an esterification reaction.

_____ [2]

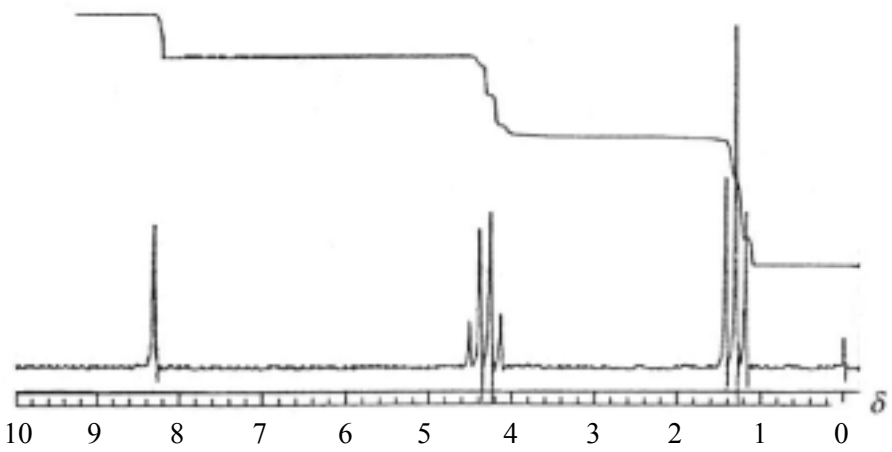
(iii) This esterification is an equilibrium reaction. Explain how you would increase the yield of ethyl methanoate.

_____

_____

_____ [2]

(b) The n.m.r. spectrum of ethyl methanoate is shown below.



(i) Name the substance responsible for the signal at $\delta = 0$ and state its formula.

_____[2]

(ii) Explain the n.m.r. spectrum of ethyl methanoate with reference to spin–spin splitting, peak integration and chemical shift.

Spin–spin splitting

_____

_____

_____[2]

Peak integration

_____

_____

_____[2]

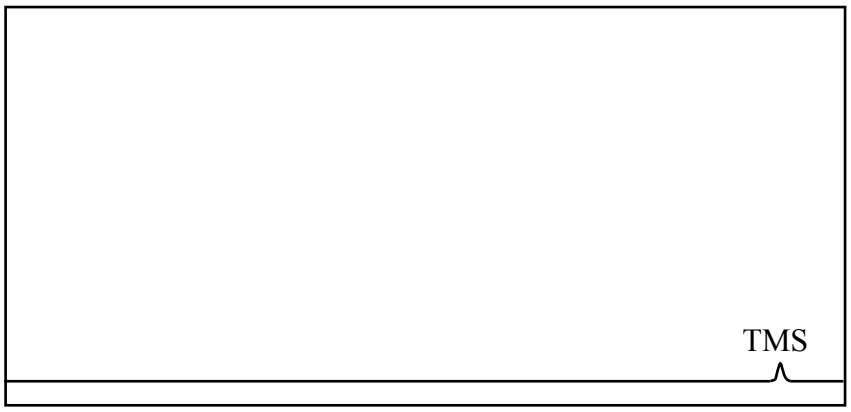
Chemical shift

_____

_____

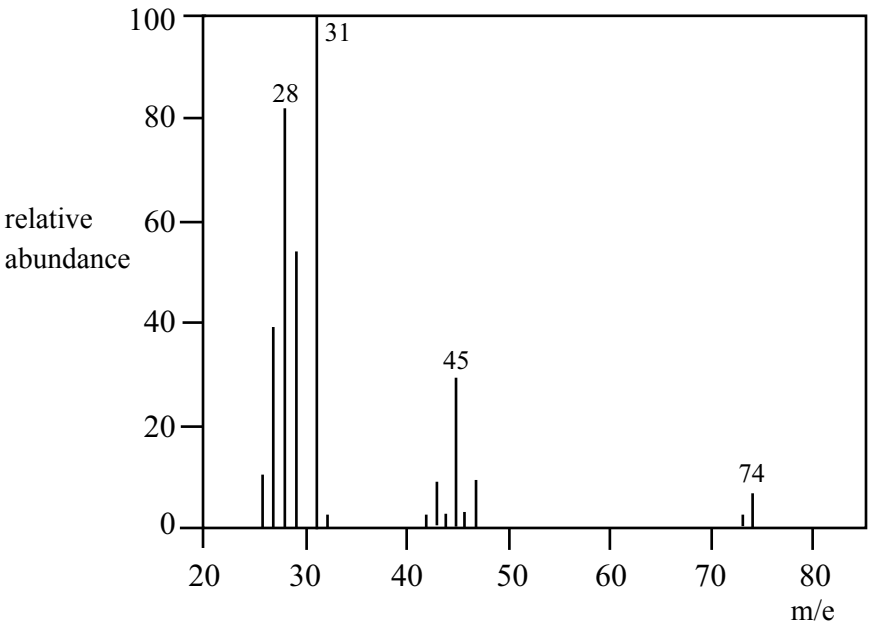
_____[2]

(iii) Sketch the n.m.r. spectrum of propanoic acid on the chart below, labelling the peaks appropriately and showing the spin–spin splitting together with peak integration.



[3]

(c) The mass spectrum of ethyl methanoate is shown below.



Identify the ions responsible for the peaks.

m/e	**ion**
28	_____
45	_____

[2]

(d) Explain how the absorption of radiation by molecules gives rise to infra-red spectra and how you would use infra-red spectroscopy to distinguish between propanoic acid and ethyl methanoate. Refer to specific bonds and their absorptions.

_____

_____

_____

_____

_____ [4]

Quality of written communication [2]

THIS IS THE END OF THE QUESTION PAPER