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71
Candidate Number

Chemistry

Assessment Unit A2 2

assessing

Module 5: Analytical, Transition Metals and Further
Organic Chemistry

[A2C21]



WEDNESDAY 27 MAY, AFTERNOON

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 sixteen** 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 six** 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 **15(f)(vi)**.

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	

Total Marks	
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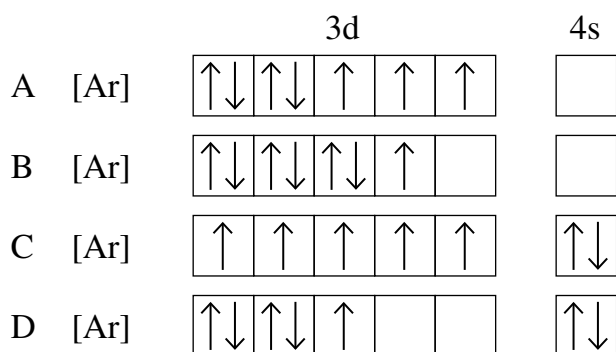
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Section A

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 as illustrated on the answer sheet.

1 Which one of the following is the electronic structure of the Co^{2+} ion in the ground state?



2 Which one of the following gives the order of **increasing** basic strength for ammonia, ethylamine and phenylamine?

- A ammonia, phenylamine, ethylamine
- B ethylamine, ammonia, phenylamine
- C phenylamine, ammonia, ethylamine
- D phenylamine, ethylamine, ammonia

3 Which one of the following statements describes the primary structure of a protein?

- A The folding of the α -helix.
- B The formation of a β -pleated sheet.
- C The sequence of amino acids.
- D The coiling of the chains.

4 The mechanism for the bromination of benzene is described as

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

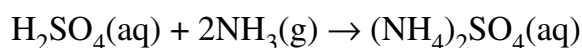
5 20 cm³ of a hydrocarbon C_xH_y were exploded in excess oxygen. The total volume of gases after reaction was found to be 50 cm³ lower than at the start. On bubbling through lime water and hydroxide solution a further contraction of 80 cm³ occurred, all measurements were made at room temperature and one atmosphere pressure. The formula of the hydrocarbon was

- A C₂H₄
- B C₂H₆
- C C₄H₆
- D C₄H₈

6 Iodoethane may be converted to propylamine by reaction with

- A ammonia.
- B ammonia followed by lithal, LiAlH₄.
- C potassium cyanide followed by ammonia.
- D potassium cyanide followed by lithal, LiAlH₄.

7 The fertiliser ammonium sulphate is manufactured according to the equation:



Which one of the following mixtures will produce the greatest mass of ammonium sulphate? (1 tonne = 1000 kg)

	mass of sulphuric acid/tonne	mass of ammonia/tonne
A	4	6
B	5	5
C	8	2
D	9	1

8 Which one of the following nickel complexes is the most stable?

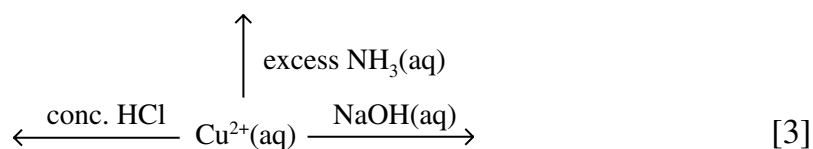
- A [Ni(H₂O)₆]²⁺
- B [Ni(NH₃)₆]²⁺
- C [Ni(en)₃]²⁺
- D [Ni(edta)]²⁻

- 9 Which one of the following reagents will **not** produce a precipitate when a few drops are added to separate samples of iron(III) sulphate solution?
- A ammonia solution
 - B barium chloride solution
 - C potassium thiocyanate solution
 - D sodium hydroxide solution
- 10 Which one of the following processes does **not** involve any redox reactions?
- A Decomposition of OCl^- ions using Co^{2+} ions.
 - B Determination of magnesium ions in solution using edta.
 - C Determination of the percentage of iron in aluminium foil.
 - D Preparation of potassium dichromate from chromium(III) ions.

Section B

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

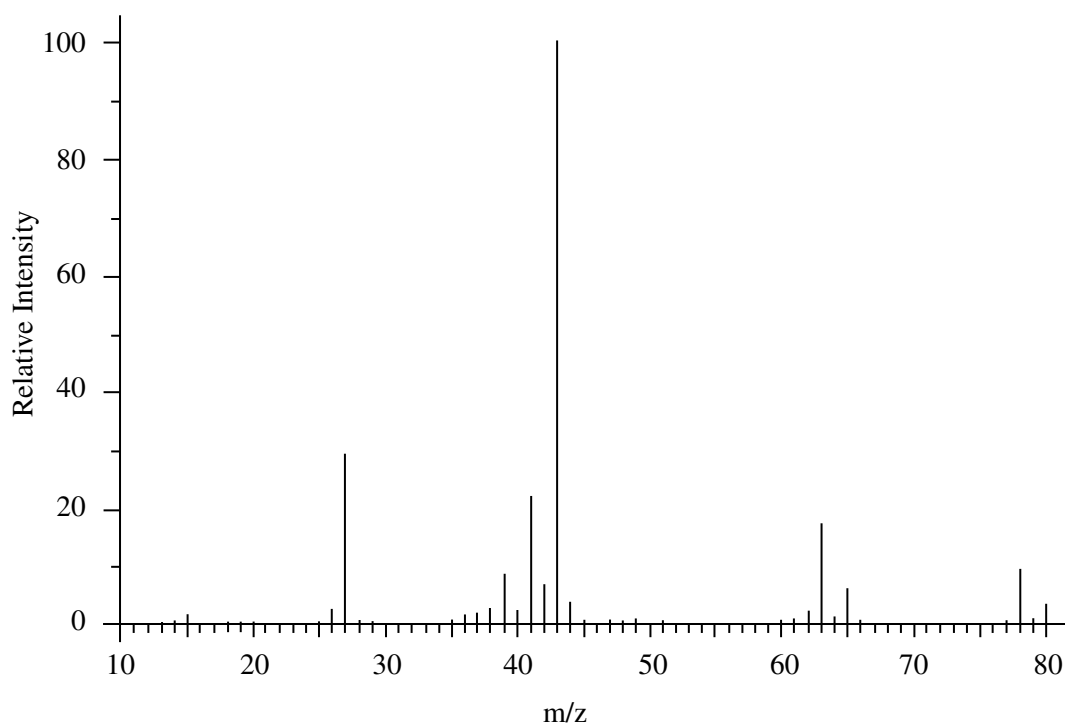
- 11 (a) Complete the flow scheme below by writing the formulae of the three compounds formed.



- (b) Copper(II) sulphate solution reacts with aqueous barium nitrate to form a white precipitate. Write the equation for this reaction.

_____ [1]

- 12 The mass spectrum of 2-chloropropane, $\text{CH}_3\text{CHClCH}_3$, is shown below.



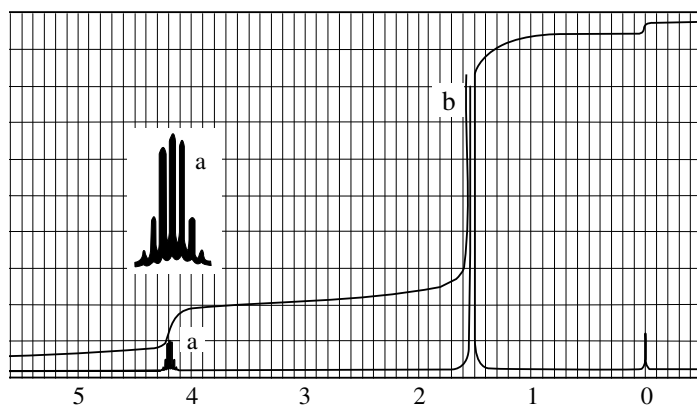
- (a) (i) Suggest why **two** molecular ion peaks are present in the spectrum.

_____ [1]

(ii) State the formula for the species giving rise to the peak at $m/e = 63$.

_____ [1]

(b) The n.m.r. spectrum of 2-chloropropane contains two sets of peaks as shown below.



(i) Explain the peak integration.

_____ [2]

(ii) Explain the chemical shifts.

_____ [1]

(iii) Explain the splitting pattern a.

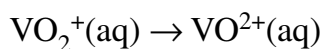
_____ [1]

(iv) Explain why b is a doublet.

_____ [1]

13 Vanadium is a characteristic transition metal showing variable oxidation states and catalytic action.

- (a) The following change occurs when a solution containing VO_2^+ ions is shaken with zinc amalgam.



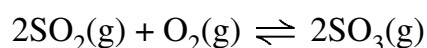
Deduce the oxidation state of vanadium in each of the two species and hence state the role of the zinc amalgam in the reaction.

VO_2^+ _____

VO^{2+} _____

_____ [3]

- (b) Vanadium pentoxide is used as a solid heterogeneous catalyst in the Contact process, catalysing the conversion of sulphur dioxide to sulphur trioxide.



- (i) Explain the term **heterogeneous**.

_____ [1]

- (ii) Explain in terms of surface chemistry how the vanadium pentoxide catalyses the above reaction.

 _____ [2]

(c) Vanadium(III) sulphate dissolves in water to form a green solution.

(i) State the formula of vanadium(III) sulphate.

_____ [1]

(ii) Suggest the formula of hydrated vanadium(III) ions in aqueous solution and state the shape of this complex ion.

_____ [2]

14 In the 19th century, used tea leaves were often recycled by boiling with iron(II) sulphate and sheep dung before being coloured with compounds such as Prussian Blue.

(a) Prussian Blue, $\text{KFe}[\text{Fe}(\text{CN})_6]$, may be prepared by adding potassium ferrocyanide solution, $\text{K}_4[\text{Fe}(\text{CN})_6]$, to a suitable aqueous iron salt.

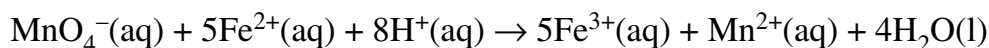
(i) Identify the ions present in potassium ferrocyanide solution.

_____ [2]

(ii) Suggest a suitable iron salt to react with potassium ferrocyanide in the preparation of Prussian Blue.

_____ [1]

(b) Drinks made with this “recycled” tea contained aqueous iron(II) ions. The concentration of iron(II) ions in solution can be determined by titration with standard potassium manganate(VII) solution.



(i) State the colour change noted at the end point of the titration.

_____ [2]

(ii) Calculate the volume of 0.1 M potassium manganate(VII) solution required to react with 25.0 cm^3 of a solution which contains 7.84 g of iron(II) ions per litre.

_____ [3]

(c) Iron(II) sulphate and ammonium sulphate combine to form the double salt iron(II) ammonium sulphate, $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$.

(i) Describe how a back titration may be used to determine the percentage of ammonia in a sample of ammonium sulphate (details of calculations are not required). You may assume all apparatus used is clean and dry.

[4]

(ii) Suggest why this method would be unsuitable for determining the percentage of ammonia in the double salt.

[2]

(iii) Calculate the mass of iron(II) sulphate required to make 20.0 g of the double salt.

[3]

15 Aromatic chemistry is a branch of organic chemistry which includes those compounds with 6-membered ring structures such as benzene and methylbenzene (toluene), $C_6H_5CH_3$.

(a) Name the industrial source of benzene.

_____ [1]

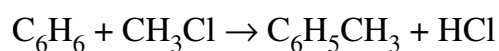
(b) State the empirical formula of benzene.

_____ [1]

(c) Describe the bonding present in benzene.

_____ [3]

(d) Benzene may be converted to methylbenzene (toluene) by reaction with chloromethane in the presence of aluminium chloride.



The mechanism is similar to that for the nitration of benzene.

(i) Suggest the function of the aluminium chloride.

_____ [1]

(ii) Suggest the formula of the species which attacks the benzene ring.

_____ [1]

(e) Nitration of benzene forms nitrobenzene, $C_6H_5NO_2$.

(i) Name the reagents used for the nitration of benzene.

_____ [2]

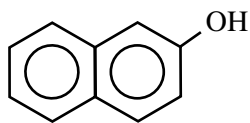
(ii) Further nitration results in the formation of dinitrobenzene. Draw and name the structure of one of the three possible isomers of dinitrobenzene.

[2]

(iii) State the reagents and conditions for the reduction of nitrobenzene to phenylamine.

_____ [3]

- (f) Phenylamine reacts with a mixture of sodium nitrite and hydrochloric acid to form benzene diazonium chloride. The benzene diazonium ion forms a scarlet precipitate of azo-2-naphthol when added to an alkaline solution of 2-naphthol.



2-naphthol

- (i) Sodium nitrite and hydrochloric acid react to form nitrous acid *in situ*. Write the equation for this reaction.

_____ [1]

- (ii) Draw the structure of the benzene diazonium ion.

[2]

- (iii) Explain why ethylamine does not form such a diazonium ion.

_____ [1]

- (iv) Name the type of reaction between benzene diazonium chloride and 2-naphthol to form the azo-2-naphthol.

_____ [1]

- (v) Deduce the molecular formula of azo-2-naphthol.

_____ [1]

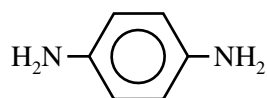
(vi) Explain, in terms of electron transitions, why azo dyes are coloured.

[3]

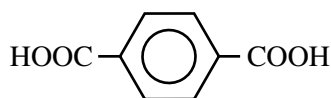
Quality of written communication

[2]

- 16 Kevlar is used to make bullet-proof vests. The first step in its production is the polymerisation of the two monomers shown below:



benzene -1,4-diamine



benzene -1,4-dicarboxylic acid

- (a) State how infra-red spectroscopy could be used to distinguish between the two monomers.

_____ [2]

- (b) Write an equation for the reaction between benzene-1,4-dicarboxylic acid and excess sodium carbonate solution.

_____ [2]

- (c) (i) Draw the structure of the dimer formed between the two monomers.

[1]

- (ii) Name the link formed between the two monomers.

_____ [1]

- (iii) Kevlar is a very strong and rigid material. Suggest why this polymer exhibits such properties.

_____ [2]

THIS IS THE END OF THE QUESTION PAPER
