Rewarding Learning

Centre Number

Candidate Number

ADVANCED
General Certificate of Education
2017

Chemistry

Assessment Unit A2 2

assessing

Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

[AC222]

AC222

MONDAY 19 JUNE, MORNING

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 fifteen** 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 five** questions in **Section B**. **You must answer the questions in the spaces provided**.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 120.
Quality of written communication will be assessed in Question **13(b)**.
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 the Elements, containing some data, is included in this question paper.

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 states a condition at which a standard hydrogen electrode operates?

A A platinum/palladium electrode

B A temperature of 20 °C

C Hydrogen gas at a pressure of 1 atmosphere

D Sulfuric acid at a concentration of 1.0 M

2 Which one of the following compounds is the most soluble in water?

A $CH_3CH_2OCOCH_3$

B $CH_3CO_2CH_3$

C $C_2H_5NH_2$

D $C_6H_{13}COOH$

3 Phosphorus burns in oxygen to form phosphorus pentoxide which dissolves in water to form phosphoric acid. Sodium hydroxide neutralises phosphoric acid.

$$P_4 + 5O_2 \rightarrow P_4O_{10}$$
$$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$$
$$3NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3H_2O$$

Which one of the following is the volume of 0.30 M sodium hydroxide required to neutralise the phosphoric acid formed from 0.31 g of phosphorus?

A $7\,cm^3$

B $100\,cm^3$

C $200\,cm^3$

D $500\,cm^3$

4 Which one of the following industrial processes is catalysed by a mixture of metals?

A Hardening of unsaturated oils

B Manufacture of sulfuric acid

C Oxidation of ammonia

D Synthesis of ammonia

5 Addition of an excess of a concentrated solution of ammonia to chloroethanoic acid gives

A $CH_2ClCONH_2$.

B $CH_2ClCO_2NH_4$.

C $NH_2CH_2CO_2NH_4$.

D $NH_2CH_2CONH_2$.

[Turn over

6 Which one of the following amino acids can **not** be found in proteins?

A NH_2CH_2COOH

B $NH_2CH_2CH(CH_3)COOH$

C $NH_2CH(COOH)CH_2OH$

D $NH_2CO(CH_2)_2CH(NH_2)COOH$

7 Which species can act as an oxidising agent but not as a reducing agent?

A Cl_2^-

B Cl^-

C ClO_2^-

D ClO_4^-

8 Two standard electrode potentials are shown below.

$$Sn^{2+} + 2e^- \rightleftharpoons Sn \qquad -0.14\,V$$
$$Mn^{2+} + 2e^- \rightleftharpoons Mn \qquad -1.19\,V$$

Which one of the following is the strongest oxidising agent?

A Mn

B Mn^{2+}

C Sn

D Sn^{2+}

9 [Ar] is the electronic configuration of argon. Which one of the following is the electronic configuration of an iron(III) ion in the ground state?

A $[Ar]\ 3d^5$

B $[Ar]\ 3d^6$

C $[Ar]\ 4s^2 3d^3$

D $[Ar]\ 4s^1 3d^4$

10 The volatile product formed when ammonium ethanoate is heated with phosphorus pentoxide for an extended period is

A ethanamide.

B ethanenitrile.

C phosphoric acid.

D water.

Section B

Answer **all five** questions in the spaces provided

11 The following table shows the reaction of some transition metal ion solutions with a few drops of aqueous ammonia solution and then with excess aqueous ammonia solution. Results for the first ion have been completed. Fill in the remaining spaces.

transition metal ion solutions	**addition of aqueous ammonia solution**	**addition of excess aqueous ammonia solution**
Mn^{2+}	white precipitate	no further reaction
Fe^{2+}		
Fe^{3+}		
Co^{2+}		
Ni^{2+}		
Cu^{2+}		

[8]

12 Naphthalene is the largest single constituent of coal tar (6%).

naphthalene

It is insoluble in water but very soluble in benzene. Naphthalene resembles benzene in many of its reactions but forms addition and substitution products more readily and is more easily oxidised and reduced.

(a) The structure of naphthalene showing double bonds, which is drawn above, is known as a Kekulé structure. There are two possible Kekulé structures for naphthalene. Draw the other one.

[1]

(b) The structures of benzene and naphthalene are based on delocalised π electrons. This results in the shape of the benzene molecule being flat.

(i) Explain what is meant by the term **delocalised**.

_____

_____ [2]

(ii) Explain what is meant by the term **π electrons**.

_____

_____ [2]

(iii) How many π electrons does one molecule of naphthalene have?

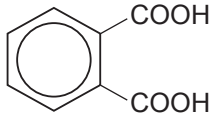
_____ [1]

[Turn over

(c) Benzene is a liquid at room temperature with a boiling point of 80 °C. Naphthalene is a solid at room temperature with a melting point of 80 °C. Explain why benzene is a liquid and naphthalene is a solid.

[2]

(d) Benzene is very slowly oxidised by acidified potassium manganate(VII) but naphthalene is readily oxidised forming phthalic acid.



phthalic acid

(i) Draw the structures of the other **two** isomers of phthalic acid, labelling them A and B.

[2]

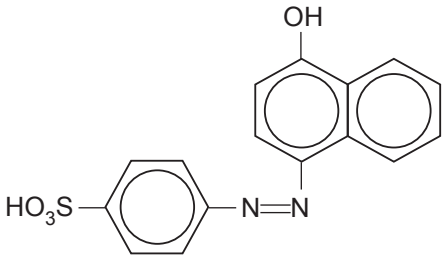
(ii) Which one of these phthalic acids (A or B) is used to make polyethylene terephthalate?

[1]

(iii) Draw the structure of one repeating unit of polyethylene terephthalate.

[2]

(e) One of the most important uses of naphthalene compounds is the formation of azo dyes. Orange 1 was the first acidic azo dye on the market. It is formed by the coupling of diazotised sulfanilic acid with 1-naphthol.



Orange 1

(i) Draw the structures of the **two** reactants which couple to form Orange 1.

[2]

(ii) Describe how a diazotisation reaction is carried out.

[3]

(iii) Explain, in terms of electronic structure, why this azo dye is coloured.

[3]

[Turn over

(iv) Orange 1 contains the sulfonic acid group, $-SO_3H$. Write the equation for the reaction of a sulfonic acid group with sodium hydroxide.

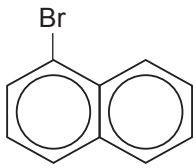
_____ [1]

(v) Explain why the solubility of Orange 1 is greatly increased as a sodium salt.

_____

_____ [1]

(f) Naphthalene is brominated by boiling it in a solvent with bromine and a suitable catalyst to give 1-bromonaphthalene.



1-bromonaphthalene

(i) Suggest the name of a catalyst used in the bromination of benzene and naphthalene.

_____ [1]

(ii) Draw a flow scheme to show the mechanism for the catalysed bromination of naphthalene.

[3]

(iii) Explain why benzene is not easily brominated but ethene is.

_____

_____ [2]

13 The amount of chlorine in water is readily determined by liberating iodine from potassium iodide.

$$2KI + Cl_2 \rightarrow 2KCl + I_2$$

The iodine produced can then be titrated with sodium thiosulfate.

$$I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI$$

(a) A spatula measure of potassium iodide, an excess, was added to 75 cm^3 of water through which chlorine had been bubbled. A 25.0 cm^3 sample of the water was titrated against 0.01 M sodium thiosulfate solution. The titre value was 22.5 cm^3.

(i) Name the indicator used in the titration.

_____ [1]

(ii) When is the indicator added?

_____ [1]

(iii) State the colour change at the end point.

_____ [2]

(iv) Calculate the volume of chlorine gas bubbled into the water. Assume the gas is bubbled through at 20 °C and one atmosphere pressure and that all of the gas dissolves.

_____

_____

_____

_____

_____ [4]

(b) Titration methods are not accurate with chlorine concentrations lower than 0.03 parts per million. Orthotoluidine reacts with chlorine to produce a yellow colour which can be used in colorimetry to determine the concentration of chlorine.

Explain, giving full experimental detail, how you would use colorimetry to determine the concentration of chlorine in a sample of water.

[4]

Quality of written communication [2]

14 There are four amino compounds that have the formula C_3H_9N. They are shown below with their trivial names and their boiling points.

$CH_3CH_2CH_2NH_2$ propylamine, 48 °C	$CH_3CH_2NHCH_3$ ethylmethylamine, 37 °C
$(CH_3)_2CHNH_2$ isopropylamine, 32 °C	$(CH_3)_3N$ trimethylamine, 4 °C

(a) Explain why these amines are isomers.

_____

_____

_____ [2]

(b) (i) Explain why trimethylamine has a lower boiling point than propylamine.

_____

_____

_____

_____ [2]

(ii) Describe how a mixture of milligrams of these isomers could be separated.

_____

_____

_____

_____ [2]

(c) Propylamine is made by the reaction of 1-chloropropane with ammonia to form a salt.

(i) Write an equation for this reaction.

_____ [2]

(ii) How would you liberate the amine from the salt?

_____

_____ [1]

(d) Explain which of the amines are primary, secondary or tertiary amines.

_____

_____

_____

_____

_____ [3]

(e) Give the systematic name for isopropylamine.

_____ [2]

(f) The amines, when placed in a mass spectrometer, produce fragment ions. A major fragment ion in one mass spectrum had an m/e ratio of 43. Identify this fragment ion and use it to explain which amine(s) might produce it.

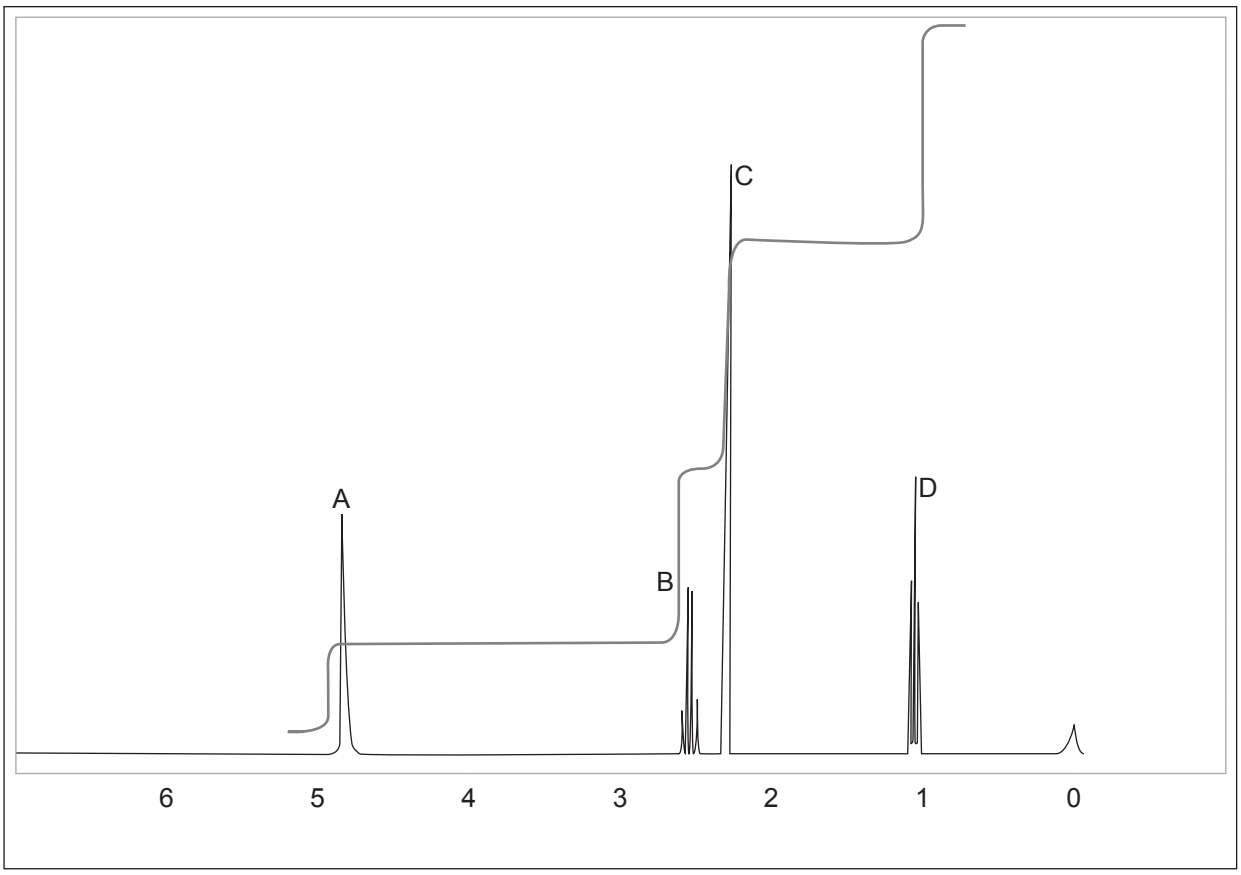
_____

_____

_____ [2]

[Turn over

(g) The nmr spectrum shown below is for one of the amines.



(i) Identify the chemical which causes the signal at 0.0.

_____ [1]

(ii) Explain why the signal at 0.0 is a singlet.

_____

_____ [2]

(iii) Explain how the integration curve can be used to identify the hydrogen attached to the nitrogen.

_____

_____ [2]

(iv) Explain the splitting pattern for peaks B and D.

_____

_____ [2]

(v) Identify the amine.

_____ [1]

(vi) Explain how infrared spectrometry could be used to confirm the identity of the amine.

_____

_____ [2]

[Turn over

15 Cyanide ions react with thiosulfate ions to produce thiocyanate ions and sulfite ions.

$$CN^- + S_2O_3^{2-} \rightarrow SCN^- + SO_3^{2-}$$

(a) What is the oxidation number of sulfur in thiosulfate and sulfite ions?

_____

_____ [2]

(b) **(i)** Name the ion which is used to show the presence of thiocyanate ions.

_____ [1]

(ii) What is the colour produced when using this ion?

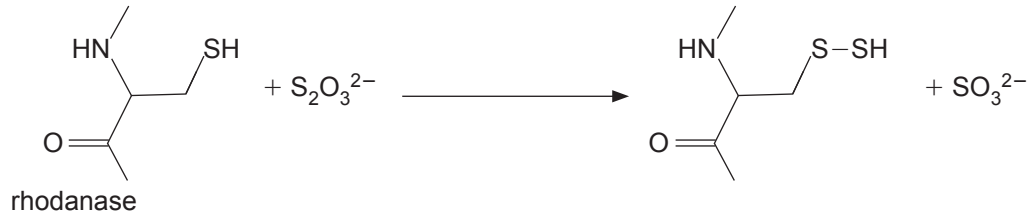
_____ [1]

(iii) Write the equation for the reaction.

_____ [2]

(c) The reaction of cyanide ions with thiosulfate ions is catalysed by rhodanase.

STEP 1



STEP 2

(i) Explain how the flow scheme confirms that rhodanase acts as a catalyst.

_____

_____ [2]

(ii) Rhodanase is an enzyme. Explain what is meant by the term **enzyme**.

_____

_____ [1]

(iii) Explain why the ability of rhodanase to act as a catalyst decreases with increasing temperature.

_____

_____ [2]

(iv) In the rhodanase structure the –SH group is attached to a cysteine group which is an amino acid.

$CH_2SHCH(NH_2)COOH$

cysteine

Write equations for the reactions of cysteine with sodium carbonate and with nitrous acid.

sodium carbonate

_____ [2]

nitrous acid

_____ [2]

(v) The structure –S–S– occurs in proteins. State its name and explain the role it plays in protein structure.

_____

_____ [2]

[Turn over

(d) Cyanide ions, thiosulfate ions and thiocyanate ions can all form complexes.

(i) What name is given to these ions which can form complexes?

_____ [1]

(ii) Cyanide ions form the complex ion $[Fe(CN)_6]^{3-}$. Draw the shape of this complex ion, and state, in terms of the cyanide ion, why this shape is formed.

_____ [2]

(iii) Thiosulfate ions form the complex $[Ag(S_2O_3)_2]^{3-}$ when they remove silver bromide from photographic emulsions. What is the charge on the silver ion in the complex?

_____ [1]

(iv) Thiocyanate ions have two structures i.e. $^{-}S—C{\equiv}N$ or $S{=}C{=}N^{-}$. What are the implications for the structure of thiocyanate complexes?

_____

_____

_____ [2]

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For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
Total Marks	