Rewarding Learning

71

Candidate Number

ADVANCED
General Certificate of Education
January 2010

Chemistry

Assessment Unit A2 3A

assessing

Module 6A: Synoptic Paper

[A2C31]

A2C31

MONDAY 1 FEBRUARY, 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 six** questions.
Section A contains a Planning Exercise.
Section B contains **five** questions assessing different aspects of the specification.

INFORMATION FOR CANDIDATES

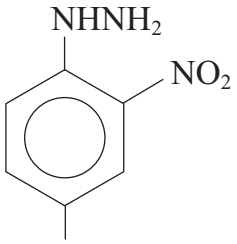
The total mark for this paper is 80.
Quality of written communication will be assessed in Question 1.
Figures in brackets printed down the right-hand side of pages indicate the mark awarded to each question or part question.
A Periodic Table of Elements (including some data) is provided.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
Total Marks	

Section A

1 Planning Exercise

Plan an experiment to prepare the 2,4-dinitrophenylhydrazone derivative of propanal and then determine its melting point.



2,4-dinitrophenylhydrazine

CH_3CH_2CHO

propanal

A solution of 2,4-dinitrophenylhydrazine is the reagent used to prepare 2,4-dinitrophenylhydrazones by reaction with aldehydes or ketones.

The solution is prepared as follows:

"Suspend 1g of powdered 2,4-dinitrophenylhydrazine in 30 cm^3 of stirred methanol and cautiously add 2 cm^3 of concentrated sulphuric acid; this gives 32 cm^3 of solution."

Your plan should include:

(a) the equation for the reaction of 2,4-dinitrophenylhydrazine with propanal;

_____ [3]

(b) a calculation to show the volume of reagent required to prepare 0.2 g of the 2,4-dinitrophenylhydrazone of propanal assuming a 75% yield;

_____

_____

_____

_____

_____ [5]

(c) full experimental details of the recrystallisation of the 2,4-dinitrophenylhydrazone from ethanol to produce pure dry crystals and an explanation of the most important safety point to be observed;

[5]

(d) full experimental details of the determination of the melting point of the 2,4-dinitrophenylhydrazone;

[3]

(e) an explanation of the use of the melting point to confirm the purity and identity of the carbonyl compound as propanal.

_____

_____

_____

_____ [2]

Quality of written communication [2]

Section B

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

2 Phosphorus pentoxide is formed by the combustion of phosphorus, P_4, in air or oxygen.
It is a white powder which dissolves exothermically in water, eventually forming phosphoric(V) acid.

(a) Calculate the volume of air, at 20 °C and a pressure of one atmosphere, which is needed to convert 12.4 g of phosphorus into phosphorus pentoxide. (Assume air contains 20% oxygen by volume.)

_____

_____

_____

_____ [4]

(b) Phosphoric(V) acid, H_3PO_4, is tribasic. Write the formulae of the three sodium salts that can be formed from phosphoric acid.

_____ [2]

(c) Phosphorus pentoxide "removes the elements of water" from nitric acid to form nitrogen(V) oxide. Write the equation for the reaction. Do not include phosphorus pentoxide in the equation.

_____ [1]

3 Cobalt(II) ions react with nitrite ions in the presence of acid to form cobalt(III) ions together with nitrogen(II) oxide. This reaction is similar to that of iron(II) ions with nitrous acid.
The cobalt(III) ion reacts with an excess of nitrite ions to form the hexanitrocobalt(III) complex ion.

$$Co^{3+}(aq) + 6NO_2^-(aq) \rightarrow [Co(NO_2)_6]^{3-}(aq)$$

(a) (i) Write an equation for the reaction of cobalt(II) ions with nitrite ions in the presence of hydrogen ions.

_____ [1]

(ii) Draw the 3D shape of the hexanitrocobalt(III) complex ion.

[1]

(b) Cobalt(III) ions are stabilised in ammonium cobalt alum, $NH_4Co(SO_4)_2.12H_2O$, which is bright blue.

(i) Calculate the percentage of cobalt in ammonium cobalt alum.

_____

_____

_____ [3]

(ii) Write the formulae of the ions which are produced when ammonium cobalt alum is dissolved in water.

_____ [2]

(iii) Describe what is observed when acidified barium ions are added to the solution.

_____

_____ [2]

4 Lithium hydride reacts with aluminium chloride to form lithal ($LiAlH_4$) and lithium chloride.

(a) (i) Write the equation for the reaction of lithium hydride with aluminium chloride.

_____ [2]

(ii) Draw the dot and cross electron structure for the tetrahydridoaluminate ion (AlH_4^-).

[2]

(iii) Draw and name the shape of the tetrahydridoaluminate ion.

[2]

(b) Lithal is used as a reducing agent in organic chemistry. Maleic acid, the *cis* form of HOOC—CH═CH—COOH, is reduced by lithal.

(i) Draw the structure of maleic acid.

[1]

(ii) Draw the structure of fumaric acid which is the *trans* isomer of maleic acid.

[1]

(iii) When heated, maleic acid loses water to form maleic anhydride. The two —COOH groups react with each other and water is eliminated. Suggest the structure of maleic anhydride.

[1]

(iv) Suggest why fumaric acid cannot form an anhydride.

_____

_____ [1]

(v) Draw the structure of the product from the reaction of maleic acid with an excess of lithal.

[2]

5 Magnesium chloride occurs in sea water and is also found as carnallite, $KCl.MgCl_2.6H_2O$. It can be prepared in the laboratory using dilute hydrochloric acid and magnesium carbonate with the product crystallising from solution as $MgCl_2.6H_2O$. Alternatively the anhydrous chloride may be prepared by combining chlorine directly with magnesium.

(a) Using a diagram describe how you could prepare a sample of anhydrous magnesium chloride from magnesium and chlorine from a gas cylinder. State and explain the safety precautions to be taken.

_____

_____

_____ [4]

(b) Explain why a solution of magnesium chloride is slightly acidic.

_____

_____

_____ [2]

(c) Magnesium chloride can form a series of hydrates apart from the hexahydrate. The formula of an unknown hydrate can be determined by titrating the magnesium ions present using edta.
13.4 g of a magnesium chloride hydrate were dissolved in 1 litre of water and 25.0 cm^3 samples were titrated with a 0.10 M solution of edta. The average titre was 20.0 cm^3. Calculate the value of x in $MgCl_2.xH_2O$.

_____

_____

_____ [4]

(d) Predict the reaction of hydrated magnesium chloride with concentrated sulphuric acid and explain the observations expected.

_____

_____

_____ [3]

(e) Describe how you could demonstrate experimentally using a silver salt that chloride ions are present in carnallite. Write an ionic equation for the reaction taking place.

_____

_____

_____ [4]

6 Propanone reacts with iodine in the presence of acid according to the equation:

$$CH_3COCH_3 + I_2 \xrightarrow{H^+} CH_3COCH_2I + HI$$

The rate equation for the reaction is:

$$\text{rate} = k[H^+]\,[CH_3COCH_3]$$

(a) (i) What is the overall order of the reaction?

_____ [1]

(ii) Deduce the units of k.

_____ [2]

(b) The concentration of iodine can be measured as the reaction proceeds by two different methods. One is colorimetry and the other is by titrating with sodium thiosulphate.

(i) Explain how you would determine the concentration of iodine by colorimetry.

_____

_____

_____

_____ [4]

(ii) Write the equation for the reaction of thiosulphate ions, $S_2O_3^{2-}$, with iodine and explain how you would carry out a titration to determine the concentration of iodine. Details of calculations are not required.

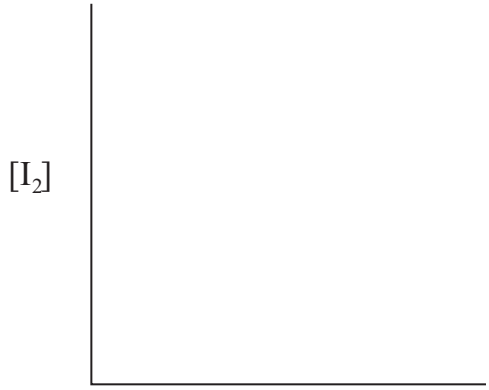
_____

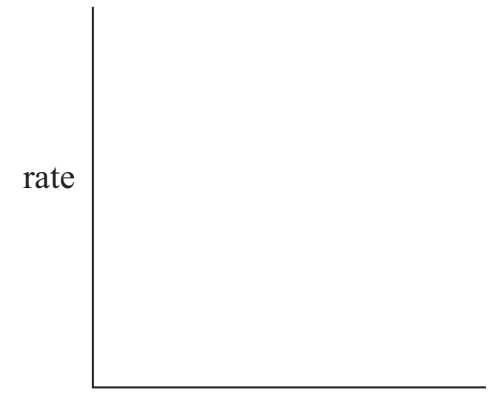
_____

_____

_____ [4]

(c) On the axes below sketch the graphs obtained by experiment.





[2]

(d) Explain what the rate equation suggests about the mechanism of this reaction.

_____

_____

_____ [2]

THIS IS THE END OF THE QUESTION PAPER