Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

3099313969

CHEMISTRY **9701/21**

Paper 2 AS Level Structured Questions **October/November 2018**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **12** printed pages.

CAMBRIDGE International Examinations

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

1 Iron pyrite, FeS_2, has a yellow colour that makes it look like gold metal. The compound contains the ions Fe^{2+} and S_2^{2-}.

(a) (i) Give the full electronic configuration of Fe^{2+}.

$1s^2$ ..... [1]

(ii) Calculate the oxidation number of sulfur in the S_2^{2-} ion.
Assume that each sulfur atom in the ion has the same oxidation number.

oxidation number of sulfur in the S_2^{2-} ion = ... [1]

(b) Describe the metallic bonding in gold.

.....

.....

..... [2]

(c) Iron pyrite is often called *fool's gold* because of its appearance. Impure samples of iron pyrite often contain a small amount of gold.

The gold can be obtained from impure iron pyrite. The impure iron pyrite is roasted in oxygen, to produce iron(III) oxide and sulfur dioxide. Gold does not react with oxygen.

(i) The sulfur dioxide produced during roasting would cause environmental consequences if released into the atmosphere.

State and explain **one** of these environmental consequences.

.....

.....

..... [2]

(ii) Complete the equation to show the roasting of iron pyrite in oxygen.

$4FeS_2$ + ... $\rightarrow$ $2Fe_2O_3$ + ...

[2]

(iii) A sample of impure iron pyrite was roasted in oxygen. The composition of the mixture of solid products is shown.

solid product	mass / g
Fe_2O_3	33.18
Au	0.37

Calculate the mass of FeS_2 present in the sample of impure iron pyrite.
Assume that all the FeS_2 was converted to Fe_2O_3 during the roasting process.

(M_r: FeS_2, 120.0; Fe_2O_3, 159.6)

mass of FeS_2 = ... g [2]

(iv) Use your answer to **(iii)** to calculate the percentage by mass of gold in this sample of impure iron pyrite. Assume that gold is the only impurity in this sample of impure iron pyrite.

Give your answer to **two** significant figures.

(If you were unable to calculate an answer to **(iii)**, use 55.00 g as the mass of FeS_2 in this calculation. This is **not** the correct answer.)

percentage by mass of gold = ... % [1]

[Total: 11]

[Turn over

2 **(a)** Nitrogen, N_2, is an inert gas that makes up 78% of the Earth's atmosphere.

(i) Explain why nitrogen is inert.

.....

.....

..... [2]

(ii) Draw a 'dot-and-cross' diagram of a nitrogen molecule. Show outer electrons only.

[1]

(b) Nitrogen, N_2, and oxygen, O_2, react together in the air during lightning strikes to form nitrogen monoxide, NO.

(i) Explain why the reaction of N_2 and O_2 occurs during lightning strikes.

.....

..... [1]

(ii) Write two equations to suggest how the NO formed reacts further to create nitric acid, HNO_3.

1 .....

2 .....

[2]

(c) Nitrate fertilisers are used to provide nitrogen for plant growth. Uncontrolled use of these can cause a reduction in animal and plant life in natural water supplies.

Explain how uncontrolled use of nitrate fertilisers can cause this problem.

.....

.....

.....

..... [3]

(d) Some soils have compounds such as ammonium nitrate, calcium carbonate and calcium hydroxide added to them.

(i) Suggest why calcium hydroxide is added to some soils.

..... [1]

(ii) When calcium hydroxide reacts with compounds containing the ammonium ion, NH_4^+, a gas is produced.

State the identity of this gas and explain why the reaction occurs.

gas .....

explanation .....

.....

.....
[2]

(iii) Another fertiliser, calcium ammonium nitrate, is formed when solid calcium carbonate is added to a mixture of aqueous ammonium nitrate and dilute nitric acid.

Suggest what would be **observed** in this reaction.

.....

.....

..... [2]

(iv) Calcium nitrate decomposes at a higher temperature than calcium ammonium nitrate.

Write an equation for the thermal decomposition of calcium nitrate.

..... [1]

[Total: 15]

3 Trihalomethanes are organic molecules in which three of the hydrogen atoms of methane are replaced by halogen atoms, for example $CHCl_3$.

(a) $CHCl_3$ is a colourless liquid with a high vapour pressure.

(i) Explain what is meant by *high vapour pressure*.

.....

.....

.....

..... [2]

(ii) An important reaction of $CHCl_3(g)$ is the manufacture of $CHClF_2(g)$, using the following reversible reaction.

$$CHCl_3(g) + 2HF(g) \rightleftharpoons CHClF_2(g) + 2HCl(g)$$

Use the data to calculate the enthalpy change of reaction, ΔH_r, for the formation of $CHClF_2(g)$ as shown in the equation.

compound	enthalpy change of formation, ΔH_f / kJ mol^{-1}
$CHCl_3(g)$	–103.2
$CHClF_2(g)$	–482.2
HF(g)	–273.3
$HCl(g)$	–92.3

enthalpy change of reaction, ΔH_r = ... kJ mol^{-1} [3]

(iii) The reaction in **(ii)** is carried out using a heterogeneous catalyst.

Explain fully the meaning of the terms *heterogeneous* and *catalyst*.

heterogeneous .....

.....

.....

catalyst .....

.....

.....

.....

[3]

(b) $CHCl F_2$ was used as an alternative to chlorofluorocarbons (CFCs). $CHCl F_2$ should no longer be used because it was found to contribute to the *enhanced greenhouse effect*.

(i) Give the meaning of the term *enhanced greenhouse effect*.

.....

..... [1]

(ii) Explain how $CHCl F_2(g)$ may contribute to this effect.

.....

.....

..... [2]

(iii) Suggest another environmental problem associated with the use of $CHCl F_2$.

..... [1]

(c) $CHCl F_2$ is also used to produce the monomer tetrafluoroethene, C_2F_4.

This monomer can be used to produce poly(tetrafluoroethene), PTFE.

(i) State the type of polymerisation that occurs during the production of PTFE.

..... [1]

(ii) Draw the repeat unit of PTFE.

[1]

(iii) Suggest why PTFE is used as a coating for cooking pans.

.....

.....

.....

..... [1]

(iv) Waste disposal can cause litter problems.

State two **other** difficulties associated with the disposal of PTFE.

1 .....

.....

2 .....

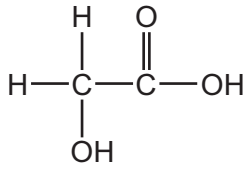
.....

[2]

[Total: 17]

Question 4 starts on the next page.

4 The structure of glycolic acid is shown.



glycolic acid

(a) Complete the table to show what you would **observe** when an aqueous solution of glycolic acid is added separately to each of the reagents. If a reaction occurs, state the functional group of glycolic acid that is responsible for the reaction.

reagent	observation with glycolic acid	does a reaction occur? ✓ /✗	functional group
$Na_2CO_3(aq)$			
2,4-DNPH			
acidified $Cr_2O_7^{2-}$			

[4]

(b) Two reaction sequences to make glycolic acid are shown.

sequence A $HCHO \xrightarrow[\text{reaction } \mathbf{1}]{\text{HCN and NaCN}} \mathbf{X} \xrightarrow[\text{reaction } \mathbf{2}]{} CH_2(OH)CO_2H$

sequence B $CH_3CO_2H \xrightarrow[\text{reaction } \mathbf{3}]{Br_2} CH_2BrCO_2H \xrightarrow[\text{reaction } \mathbf{4}]{} CH_2(OH)CO_2H$

(i) Draw the structure of **X**.

[1]

(ii) Name the reagent for reaction **2**.

..... [1]

(iii) Name the mechanism of reaction **3**.

..... [1]

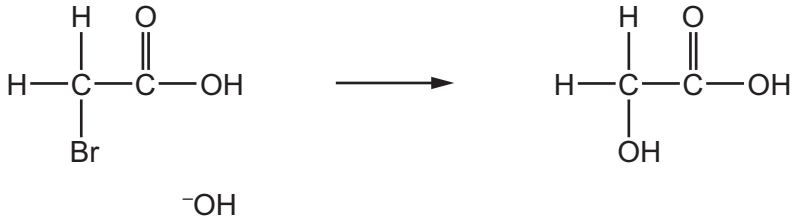
(iv) Suggest the essential condition for reaction **3**.

..... [1]

(v) Reaction **4** occurs via an S_N2 mechanism.

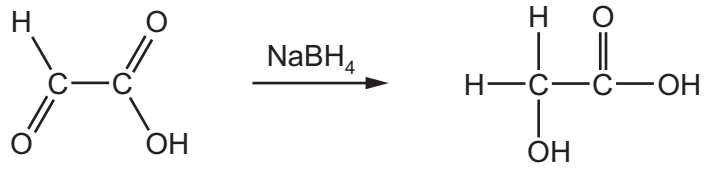
Complete the diagram for the mechanism for reaction **4**.

Include all relevant charges, partial charges, curly arrows and lone pairs.



[2]

(c) Glycolic acid can also be made by reacting glyoxylic acid with $NaBH_4$.



glyoxylic acid glycolic acid

(i) State the role of $NaBH_4$ in this reaction.

..... [1]

(ii) Write an equation for this reaction using molecular formulae.
Use [H] to represent $NaBH_4$.

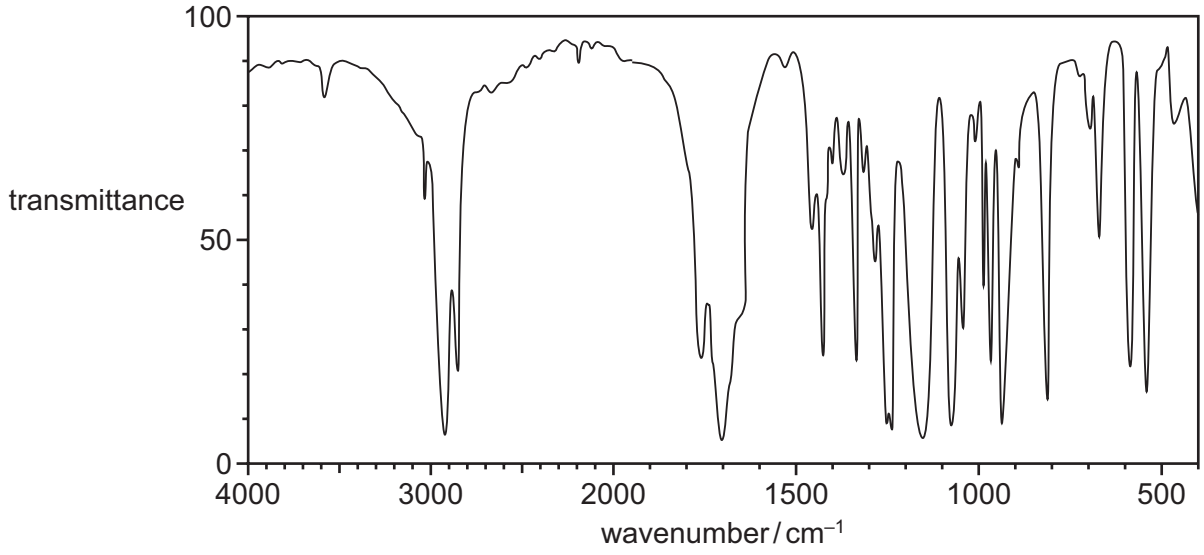
..... [2]

(d) When glycolic acid is heated in the presence of a sulfuric acid catalyst, a new compound, **Y**, $C_4H_4O_4$, is formed.
The equation for the reaction is given.

$$2CH_2(OH)CO_2H \rightarrow C_4H_4O_4 + 2H_2O$$

glycolic acid **Y**

(i) The infra-red spectrum of **Y** is shown.



State how this spectrum differs from an infra-red spectrum of glycolic acid. Explain your answer with particular reference to the peaks within the range 1500 – 4000 cm^{-1}.

.....

.....

..... [2]

(ii) Suggest a structure for **Y**.

[2]

[Total: 17]