Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0644123117

CHEMISTRY **9701/22**

Paper 2 AS Level Structured Questions **February/March 2020**

1 hour 15 minutes

You must answer on the question paper.

You will need: Data booklet

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Blank pages are indicated.

[Turn over

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

1 Group 2 metals form alkaline solutions in water.

(a) (i) Write the equation for the reaction of calcium oxide with water.

..... [1]

(ii) Identify the ion that causes an aqueous solution to be alkaline.

..... [1]

(b) The table shows the melting points of some Group 2 metal oxides.

compound	melting point / °C
MgO	2825
CaO	2613
SrO	2531
BaO	1923

Explain the trend in the melting points of the oxides down Group 2.

.....

.....

..... [2]

(c) Oxygen reacts readily with some metals, but each Group 2 metal requires strong heating to start the reaction with oxygen.

Suggest why strong heating is required to start these reactions.

.....

..... [1]

(d) Beryllium oxide reacts with hydrochloric acid to form molecules of $BeCl_2$.

Deduce the bond angle in $BeCl_2$.

..... [1]

(e) Unlike the other oxides of Group 2 metals, beryllium oxide is amphoteric.

(i) Give the meaning of the term *amphoteric*.

.....

..... [1]

(ii) Beryllium oxide and aluminium oxide have similar chemical properties.

The $Be(OH)_4^{2-}$ anion is a product of the reaction between beryllium oxide and excess concentrated $OH^-(aq)$.

Construct an equation for this reaction.

..... [1]

(f) Magnesium oxide reacts reversibly with chlorine according to the following equation.

$$2MgO(s) + 2Cl_2(g) \rightleftharpoons 2MgCl_2(s) + O_2(g)$$

Under certain conditions, a dynamic equilibrium is established.

(i) State **two** features of a reaction that is in dynamic equilibrium.

1 .....

2 .....
[2]

(ii) The equilibrium constant, K_p, is given by the following expression.

$$K_p = \frac{p_{O_2}}{p_{Cl_2}^2}$$

At 1.00×10^5 Pa and 500 K, 70% of the initial amount of $Cl_2(g)$ has reacted.

Calculate K_p and state its units.

K_p = ...

units = ...
[3]

[Turn over

(g) Magnesium peroxide, MgO_2, is made in the following reaction.

$$MgO(s) + H_2O_2(l) \rightarrow MgO_2(s) + H_2O(l) \qquad \Delta H = -96\,kJ\,mol^{-1}$$

compound	enthalpy change of formation, ΔH_f / kJ mol^{-1}
MgO(s)	–602
$H_2O_2(l)$	–188
$H_2O(l)$	–286

(i) The peroxide ion is O_2^{2-}.

Deduce the average oxidation number of oxygen in the peroxide ion.

..... [1]

(ii) Define the term *enthalpy change of formation*.

.....

.....

..... [2]

(iii) Use the data given to calculate the enthalpy change of formation of $MgO_2(s)$.

ΔH_f $MgO_2(s)$ = ... kJ mol^{-1} [2]

(iv) Magnesium peroxide decomposes slowly to form magnesium oxide and oxygen.

$$MgO_2(s) \rightarrow MgO(s) + \tfrac{1}{2}O_2(g)$$

Use your answer to **(g)(iii)** and the data in the table to calculate the enthalpy change of this reaction.

If you were unable to obtain an answer to **(g)(iii)**, *use the value* $\Delta H_f = -550\,kJ\,mol^{-1}$. *This is* ***not*** *the correct answer.*

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

[Total: 19]

2 The Group 17 elements, chlorine, bromine and iodine, are non-metals that show trends in their physical and chemical properties.

(a) Describe the trend in the colour of the Group 17 elements down the group.

.....

..... [1]

(b) The Group 17 elements can oxidise many metals to form halides.

(i) Describe the relative reactivity of the elements in Group 17 as oxidising agents.

.....

..... [1]

(ii) Chlorine reacts with hot tin metal to form tin(IV) chloride, $SnCl_4$.

$SnCl_4$ is a colourless liquid at room temperature that reacts vigorously with water to form an acidic solution.

Suggest the type of structure and bonding shown by $SnCl_4$. Explain your answer.

.....

.....

.....

.....

..... [2]

(c) The Group 17 elements form soluble halides with sodium.

(i) Describe what is seen when dilute $AgNO_3(aq)$ is added to NaBr(aq) followed by aqueous ammonia.

.....

.....

..... [2]

(ii) NaC*l* reacts with concentrated H_2SO_4 to form HC*l* and $NaHSO_4$.

Explain the difference between the reactions of concentrated H_2SO_4 with NaC*l* and with NaI. Your answer should refer to the role of the sulfuric acid in each reaction.

.....

.....

.....

.....

.....

..... [3]

(d) The hydrogen halides are useful reagents in organic and inorganic reactions.

(i) Describe and explain the trend in the boiling points of the hydrogen halides, HC*l*, HBr and HI.

.....

.....

.....

..... [2]

(ii) Describe and explain the trend in the thermal stabilities of the hydrogen halides, HC*l*, HBr and HI.

.....

.....

.....

..... [2]

[Turn over

(e) Lucas's reagent is a mixture of HCl and ZnCl_2. Primary, secondary and tertiary alcohols can be distinguished by their reaction with Lucas's reagent.

Alcohols react with the HCl in Lucas's reagent to form halogenoalkanes.

ZnCl_2 acts as a homogeneous catalyst for these reactions.

(i) Explain the meaning of the term *homogeneous*.

.....

..... [1]

(ii) Pentan-3-ol, $C_2H_5CH(OH)C_2H_5$, reacts slowly with HCl to form a secondary halogenoalkane.

Complete the equation for this reaction using structural formulae.

$C_2H_5CH(OH)C_2H_5$ + ... [1]

(iii) The fastest reaction shown by Lucas's reagent is with a tertiary alcohol.

Draw the structure of the tertiary alcohol that is an isomer of pentan-3-ol.

[1]

(iv) Tertiary alcohols tend to react with Lucas's reagent using the same mechanism as in their reaction with HCl.

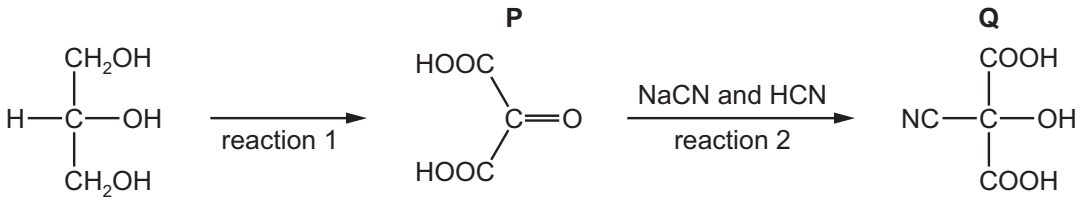
Suggest the type of reaction shown by tertiary alcohols with Lucas's reagent.

..... [1]

[Total: 17]

3 Glycerol, $CH_2(OH)CH(OH)CH_2OH$, is widely used in the food industry and in pharmaceuticals.

(a) A series of reactions starting from glycerol is shown.



(i) Suggest the reagent(s) and conditions for reaction 1.

.....

..... [2]

(ii) Name the reaction mechanism for reaction 2.

..... [1]

(iii) Give the observation you would make when 2,4-dinitrophenylhydrazine is added to **P**.

..... [1]

(iv) **Q** does **not** show optical isomerism.

Explain why.

.....

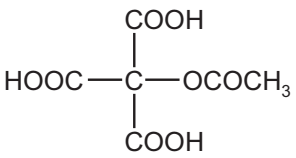
.....

.....

..... [1]

(v) When **Q** is heated with excess aqueous ethanoic acid in the presence of a catalytic amount of sulfuric acid, two reactions take place to form compound **R**.

R



Identify the two types of reaction that occur.

1 .....

2 .....
[2]

(b) Glycerol can be used as a starting material in the manufacture of nitroglycerine, $C_3H_5N_3O_9$.

Nitroglycerine decomposes rapidly on heating to form a mixture of gases.

$$4C_3H_5N_3O_9(l) \rightarrow 12CO_2(g) + 10H_2O(g) + 6N_2(g) + O_2(g)$$

A sample of nitroglycerine decomposes, releasing 1.06 dm^3 of $O_2(g)$ at 850 K and 1.00×10^5 Pa.

(i) Calculate the mass of nitroglycerine that decomposes.

mass of nitroglycerine = ... g [3]

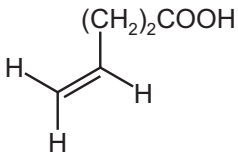
(ii) Calculate the total volume of gas released by this decomposition at 850 K and 1.00×10^5 Pa.

total volume of gas = ... dm^3 [1]

(c) Fats are compounds made from glycerol and unsaturated carboxylic acids.

4-pentenoic acid is an example of an unsaturated carboxylic acid.

4-pentenoic acid



(i) Give the molecular formula of 4-pentenoic acid.

..... [1]

(ii) Draw the repeat unit of the addition polymer that can be formed from 4-pentenoic acid.

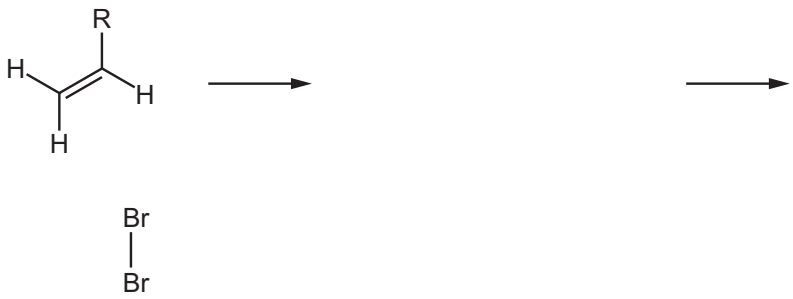
[1]

(iii) Unsaturated acids are often brominated before being added to soft drinks.

Complete the mechanism for the addition of Br_2 to 4-pentenoic acid.

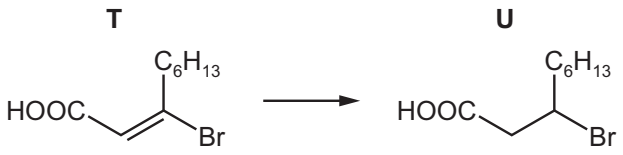
- Include the structures of the intermediate and the product of the reaction.
- Include all charges, partial charges, lone pairs and curly arrows.

In the mechanism, R has been used to represent $(CH_2)_2COOH$.



[4]

(d) A reaction of another unsaturated carboxylic acid, **T**, is shown.



(i) **T** is one of a pair of geometrical (*cis-trans*) isomers.

Draw the other geometrical isomer of **T** and explain why the molecules exhibit this form of isomerism.

.....

.....

.....

[3]

(ii) Identify the reagent used to convert **T** to **U**.

..... [1]

(iii) The C–Br bond has an absorption between 500 cm^{-1} and 600 cm^{-1} in an infrared spectrum.

The infrared spectra for both **T** and **U** have absorptions between 2850 cm^{-1} and 2950 cm^{-1}. These correspond to C–H bonds.

Identify:

- two other absorptions that would be seen in the infrared spectra of both **T** and **U**
- one other absorption that would **only** be seen in the infrared spectrum of **T**.

For each absorption, give the range of the absorption and the bonds that correspond to these absorptions.

absorption 1 present in both spectra .....

.....

.....

absorption 2 present in both spectra .....

.....

.....

absorption **only** present in spectrum of **T** .....

.....

.....

[3]

[Total: 24]

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