Cambridge Assessment International Education

# Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*1309098231*

**CHEMISTRY** **9701/22**

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

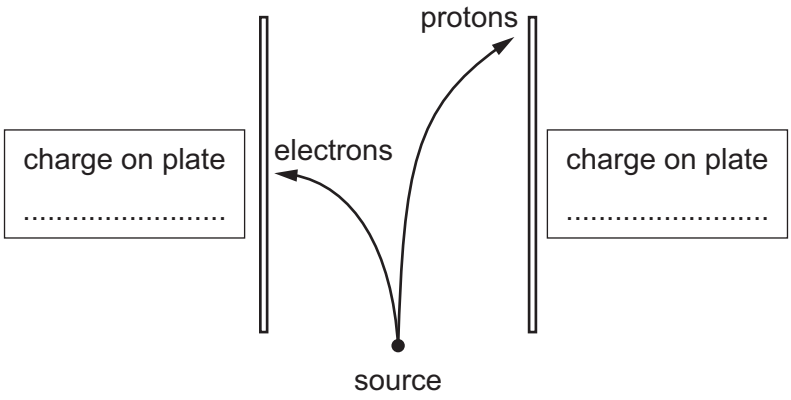
- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

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

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

**1** Atoms contain the subatomic particles electrons, protons and neutrons. Protons and electrons were discovered by observations of their behaviours in electric fields.

**(a)** The diagram shows the behaviour of separate beams of electrons and protons in an electric field.




**(i)** Complete the diagram with the relative charge of each of the electrically charged plates. [1]

**(ii)** On the diagram, draw a line to show how a separate beam of neutrons from the same source behaves in the same electric field. [1]

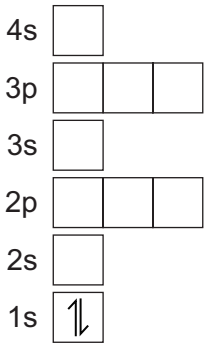
**(b)** Electrons in atoms up to $_{36}Kr$ are distributed in s, p and d orbitals.

**(i)** State the number of occupied orbitals in an isolated atom of $_{36}Kr$.

| type of orbital | s | p | d |
|---|---|---|---|
| number of orbitals | | | |

[3]

**(ii)** Complete the diagram to show the number and relative energies of the electrons in an isolated atom of $_{14}Si$.




[2]

**(iii)** The diagram shows a type of orbital.

State the total number of electrons that exist in all orbitals of this type in an atom of $_{9}F$.

..... [1]

**(iv)** The first ionisation energies of elements in the first row of the d block ($_{21}Sc$ to $_{29}Cu$) are very similar. For all these elements, it is a 4s electron that is lost during the first ionisation.

Suggest why the first ionisation energies of these elements are very similar.

.....

.....

.....

..... [3]

**(c)** *Hydron* is a general term used to represent the ions $^{1}_{1}H^{+}$, $^{2}_{1}H^{+}$ and $^{3}_{1}H^{+}$.

State, in terms of subatomic particles in the nucleus, what is the same about each of these ions and what is different.

same .....

different .....
[1]

[Total: 12]

**2** The Period 3 elements, Na to S, all react with oxygen to form oxides.

**(a)** State the trend in acid/base behaviour of the oxides of the Period 3 elements, from Na to S.

.....

..... [1]

**(b)** State and explain the trend, from Na to S, in the maximum oxidation number of the Period 3 elements in their oxides.

.....

.....

..... [2]

**(c)** Sodium oxide and phosphorus(V) oxide both react with water.

**Name** the product of each reaction.

| reaction | product |
|---|---|
| sodium oxide with water | |
| phosphorus(V) oxide with water | |

[2]

**(d)** Explain why phosphorus(V) oxide has a low melting point of approximately 300 °C but magnesium oxide has a high melting point of approximately 2850 °C.

.....

.....

.....

.....

.....

..... [3]

**(e)** Aluminium oxide, $Al_2O_3$, reacts separately with both acids and alkalis.

**(i)** Write an equation for the reaction of aluminium oxide with excess aqueous hydrochloric acid.

..... [1]

**(ii)** Write an equation for the reaction of aluminium oxide with excess aqueous sodium hydroxide.

..... [1]

**(f)** Describe the lattice structure of silicon(IV) oxide.

Your answer should include reference to the arrangement of the silicon and oxygen atoms and the bonds between them.

.....

.....

.....

..... [2]

**(g)** Sodium oxide and silicon(IV) oxide react to form sodium silicate(IV), $Na_2SiO_3$.

Sodium oxide is obtained from the thermal decomposition of sodium carbonate.

Write equations for the following reactions:

**(i)** sodium oxide with silicon(IV) oxide

..... [1]

**(ii)** the thermal decomposition of sodium carbonate, forming sodium oxide and carbon dioxide.

..... [1]

[Total: 14]



**[Turn over**

**3** $PCl_5$, $PCl_3$ and $NCl_3$ are halides of Group 15 elements.

**(a)** $PCl_5$ can be formed from the reaction of phosphorus with chlorine. $PCl_5$ has a melting point of 161 °C.

**(i)** Write an equation for the formation of $PCl_5$ from the reaction of phosphorus and chlorine.

..... [1]

**(ii)** State the type of structure and bonding shown by liquid $PCl_5$.

..... [1]

**(b)** A small amount of $PCl_5$ is added to excess water. The $PCl_5$ reacts vigorously to form a colourless solution.

**(i)** Give **one** other observation you would make when $PCl_5$ reacts with excess water.

..... [1]

**(ii)** Write the equation for the reaction of $PCl_5$ with excess water.

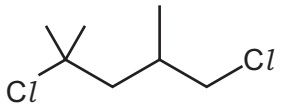
..... [1]

**(iii)** Estimate the pH of the resulting solution.

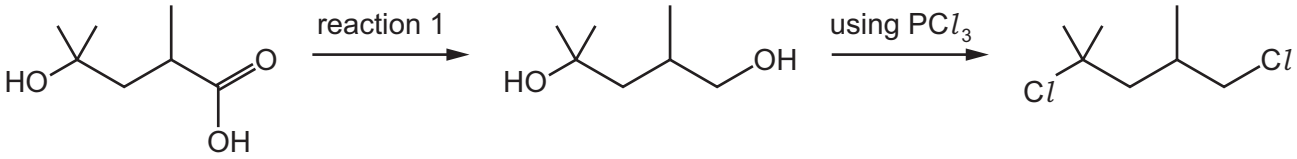
..... [1]

**(c)** $PCl_3$ is used to convert alcohols to chloroalkanes, such as compound **T**.

**T**




A possible synthesis of **T** is shown.



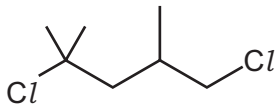

**(i)** Identify a reagent that could be used in reaction 1.

..... [1]

**(ii)** **T** exhibits optical isomerism.

Explain what is meant by the term *optical isomer* and circle any atom(s) in **T** that give rise to optical isomerism.

**T**




.....

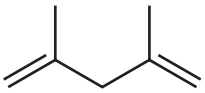
.....

.....

[2]

**(iii)** **T** is a **minor** product in the reaction of compound **S** with excess HC*l*.

**S**



Draw the structure of the **major** product of the reaction of **S** with excess HC*l*.

[1]

**(d)** $NCl_3$ is a yellow liquid that can be used to bleach flour.

**(i)** Predict the shape of the $NCl_3$ molecule and the C*l*–N–C*l* bond angle.

shape .....

bond angle .....
[2]

**(ii)** $NCl_3$ reacts with water to form HOC*l*, a weak Brønsted-Lowry acid.

Explain fully what is meant by the term *weak Brønsted-Lowry acid*.

.....

.....

..... [2]

**(iii)** $NCl_3$(l) decomposes according to the equation shown.

$$2NCl_3(l) \rightarrow N_2(g) + 3Cl_2(g)$$

A sealed container of volume 250 $cm^3$ contains an unreactive gas at a pressure of $1.00 \times 10^5$ Pa.

0.241 g of $NCl_3$(l) was injected into the sealed container.

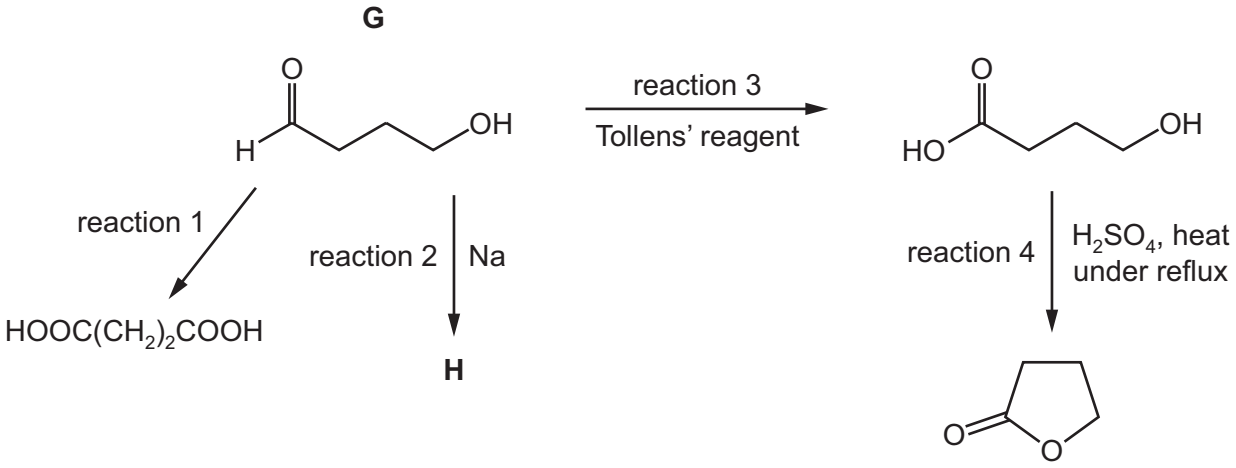
The sealed container was heated to make the $NCl_3$(l) decompose fully and then cooled to 20 °C.

Calculate the final **total** pressure inside the sealed container at 20 °C after the $NCl_3$(l) has fully decomposed.

final **total** pressure = ..... Pa
[4]

[Total: 17]

**4** Some reactions of compound **G** are shown.




**(a) (i)** State the type of reaction that occurs in reaction 1.

..... [1]

**(ii)** Suggest the reagent(s) and conditions required for reaction 1.

.....

..... [2]

**(iii)** Draw the structure of the organic product, **H**, from reaction 2.

[1]

**(iv)** State what you would observe in reaction 3.

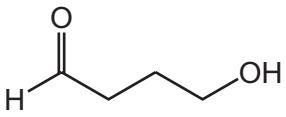
..... [1]

**(v)** Give the type of reaction shown by reaction 4.

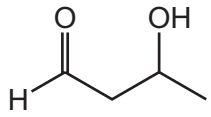
..... [1]

**(b)** **G** and **J** are structural isomers of each other.

**G**




**J**




**(i)** Name the type of structural isomerism shown by **G** and **J**.

..... [1]

**(ii)** Suggest **one** chemical test that can distinguish **G** from **J**. Give the result of the test with each compound.

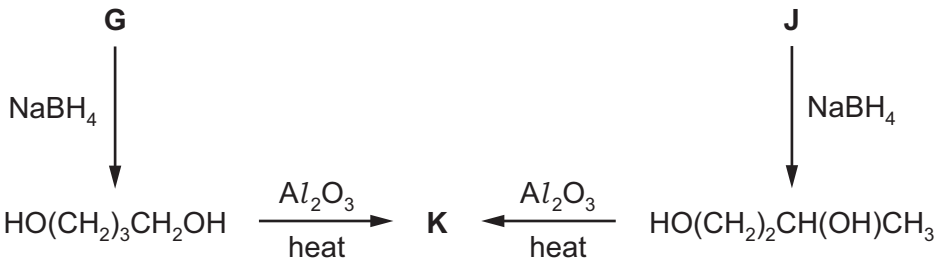
test .....

result with **G** .....

result with **J** .....

[2]

In the reaction schemes below, **G** and **J** are converted into organic compound **K**.




**(iii)** State the role of $NaBH_4$ in the reactions with **G** and **J**.

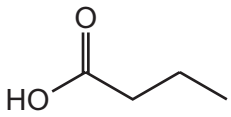
..... [1]

**(iv)** Identify the organic product **K**.

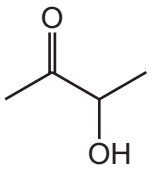
..... [1]

**(c)** **P** and **Q** have the same molecular formula as **G**.

**P**




**Q**



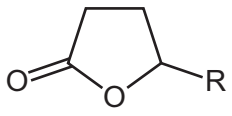

Complete the table with the expected observations for the reactions of **P** and **Q** with the named reagents.

| reagent | result with **P** | result with **Q** |
|---|---|---|
| $Br_2(aq)$ | | |
| 2,4-dinitrophenylhydrazine | | |
| aqueous sodium carbonate | | |

[3]

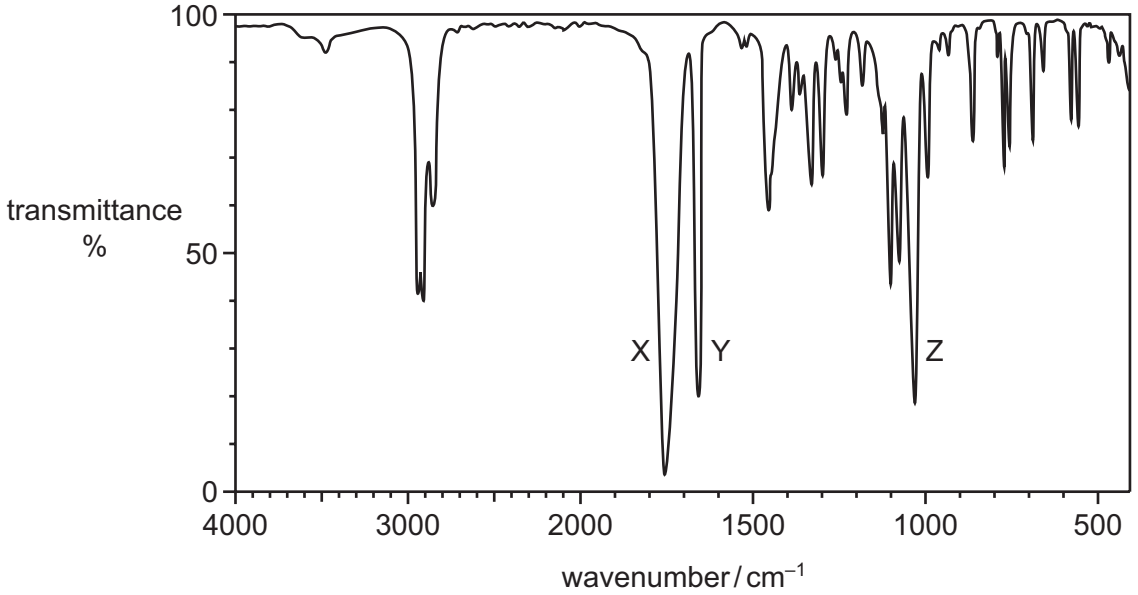
**(d)** The structure of compound **L** is shown. R represents a hydrocarbon chain.

**L**




A student was asked to deduce the full structure of **L**.

The student analysed **L** using infrared spectroscopy. The following spectrum was obtained.




**(i)** Identify the bonds responsible for the absorptions marked X and Z.

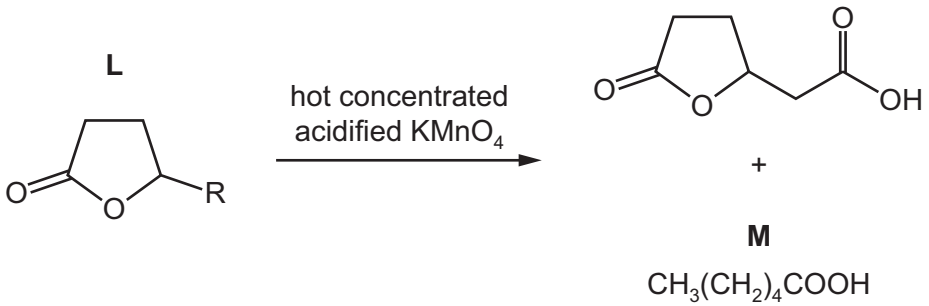
X .....

Z .....

[1]

Absorption Y shows that **L** has a C=C bond present in the R group.

The student decided to treat **L** with hot concentrated acidified potassium manganate(VII). The products of the reaction are shown.




**(ii)** Name **M**.

..... [1]

**(iii)** Use the information in **(d)** to deduce the molecular formula of **L**.

molecular formula of **L** = ..... [1]

[Total: 17]

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