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.

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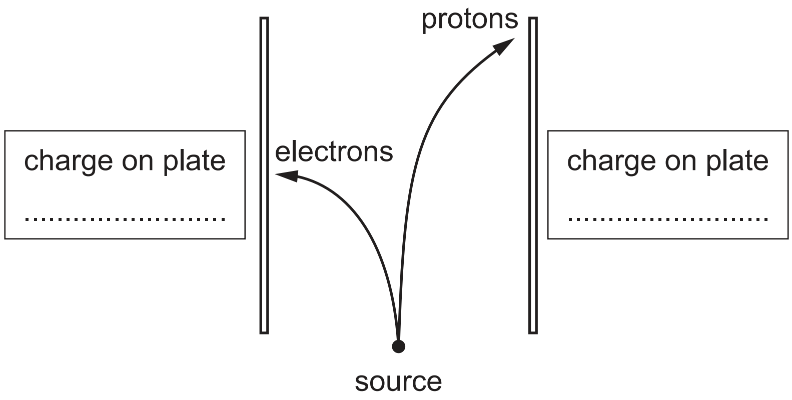
[Turn over

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]

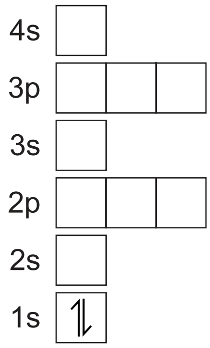
(b) Electrons in atoms up to $_{36}Kr$ are distributed in s, p and d orbitals.

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

type of orbital	s	p	d
number of orbitals			

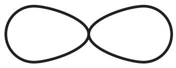
[3]

(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]

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.

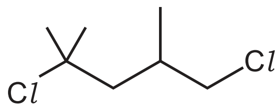
.... [1]

(iii) Estimate the pH of the resulting solution.

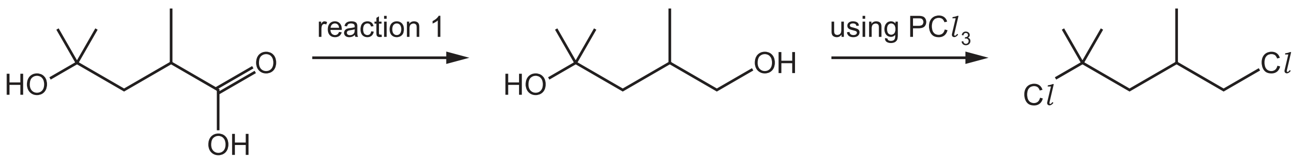
.... [1]

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

T



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



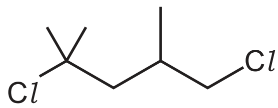
(i) Identify a reagent that could be used in reaction 1.

.... [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



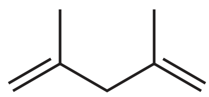
....

....

.... [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 Cl–N–Cl bond angle.

shape ....

bond angle ....
[2]

(ii) NCl_3 reacts with water to form $HOCl$, 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 1.00×10^5 Pa.

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

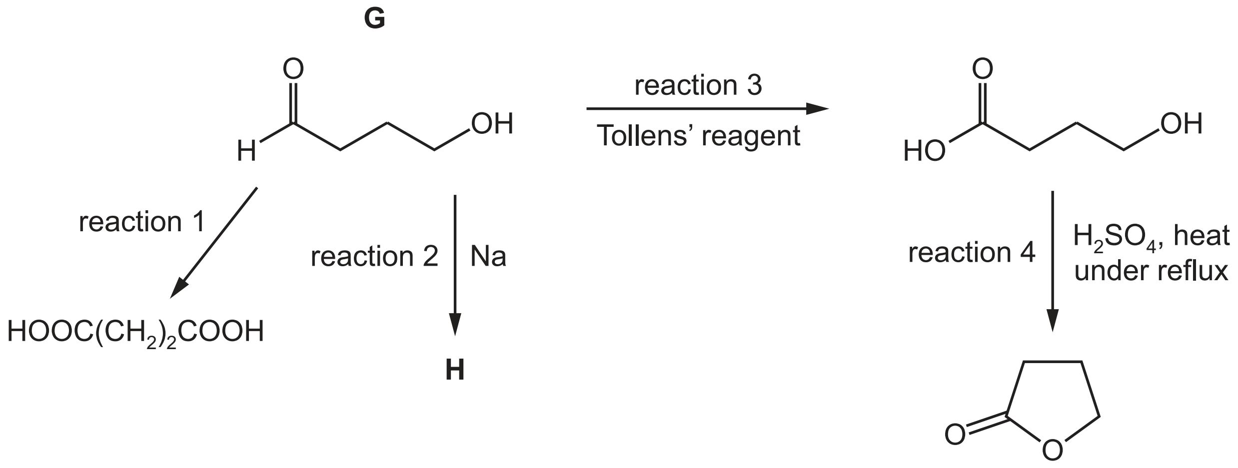
The sealed container was heated to make the $NCl_3(l)$ decompose fully and then cooled to 20 °C.

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.

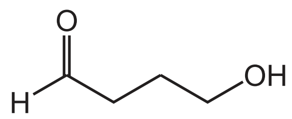
.... [1]

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

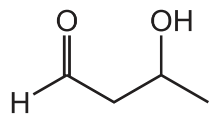
.... [1]

(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**.

$$\mathbf{G} \xrightarrow{NaBH_4} HO(CH_2)_3CH_2OH \xrightarrow[\text{heat}]{Al_2O_3} \mathbf{K} \xleftarrow[\text{heat}]{Al_2O_3} HO(CH_2)_2CH(OH)CH_3 \xleftarrow{NaBH_4} \mathbf{J}$$

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

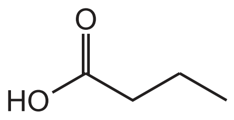
.... [1]

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

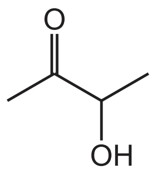
.... [1]

(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.

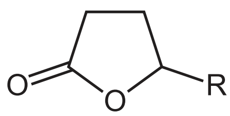
reagent	result with **P**	result with **Q**
Br_2(aq)		
2,4-dinitrophenylhydrazine		
aqueous sodium carbonate		

[3]

[Turn over

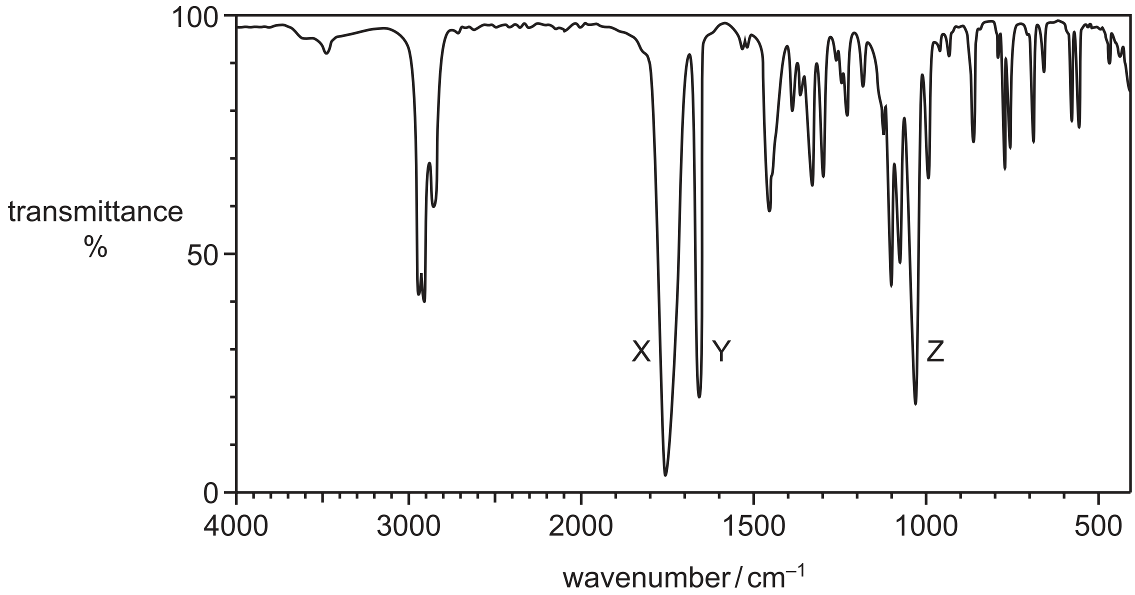
(d) The structure of compound **L** is shown. R represents a hydrocarbon chain.

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.

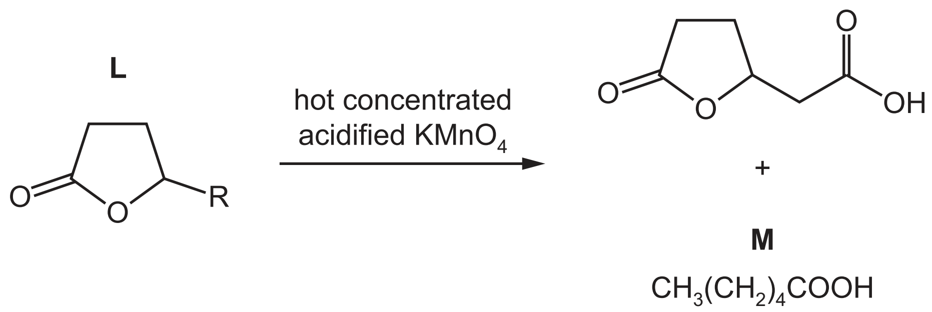
X ....

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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