



CANDIDATE
NAME

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CT GROUP

21S

CHEMISTRY

9729/03

Paper 3 Free Response

30 September 2021

55 min

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class 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.

Answer **all** questions in the spaces provided on the Question Paper. If additional space is required, you should use the pages at the end of this booklet. The question number and part must be clearly shown.

Section A

Question 1 is a compulsory question.

Section B

Answer only **one** question from this section.

The use of an approved scientific calculator is expected, where appropriate.

A Data Booklet is provided.

You are reminded of the need for good English and clear presentation in your answers.

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.

For Examiner's Use	
Question No.	Marks obtained
1	/ 20
^Circle the question attempted below	
^ 2 / 3	/ 15
Deductions (s.f.)	
Deductions (units)	
Deductions (margins)	
Deductions (others)	
Total Marks	35

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pressure, p /kPa	volume, V /dm ³	pressure $\times$ volume, pV /kPa dm ³
500	4.62	2310
1000	2.25	
1500	1.46	
2000	1.07	2140

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(b) Alkenes may be converted to alkanes by using hydrogen gas in the presence of platinum.

State the role of platinum and describe its mode of action for the reaction. [4]

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- [2]



[3]

- [2]

[illegible]

Concepts in Q1d
not tested in
2023 Promo

When heated with acidified potassium manganate(VII), both **P** and **Q** give butanone and ethanoic acid, while **R** gives effervescence and butanedioic acid.



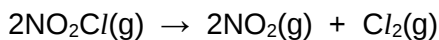
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Section B

Answer **one** question from this section.

- 2 (a) At 700 K, nitryl chloride, NO_2Cl , decomposes to nitrogen dioxide and chlorine gas according to the following equation:



NO_2Cl is placed in a 10 dm^3 sealed vessel at 10.44 atm. Decomposition occurs and the rate of reaction is followed by measuring the partial pressure of Cl_2 at various times, as shown in Fig. 2.1 below.

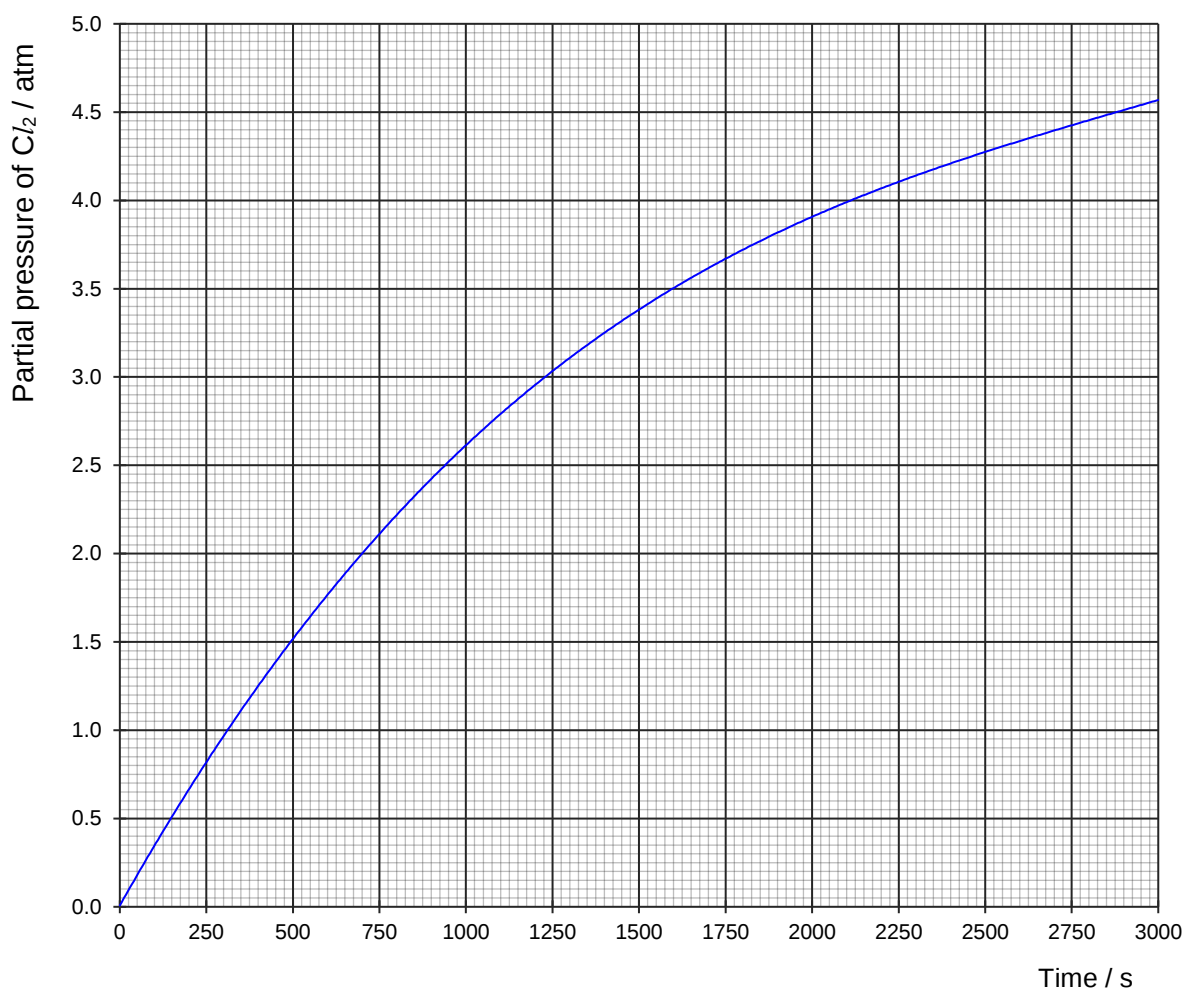


Fig. 2.1

- (i) The partial pressure of Cl_2 is 5.22 atm when the reaction is complete.

Using Fig. 2.1, determine the order of reaction with respect to NO_2Cl . [2]

- (ii) Write the rate equation for the reaction in terms of partial pressures. [1]

- (iii) Using Fig. 2.1, determine the initial rate, in atm s^{-1} . Hence, determine the rate constant for the reaction. [2]

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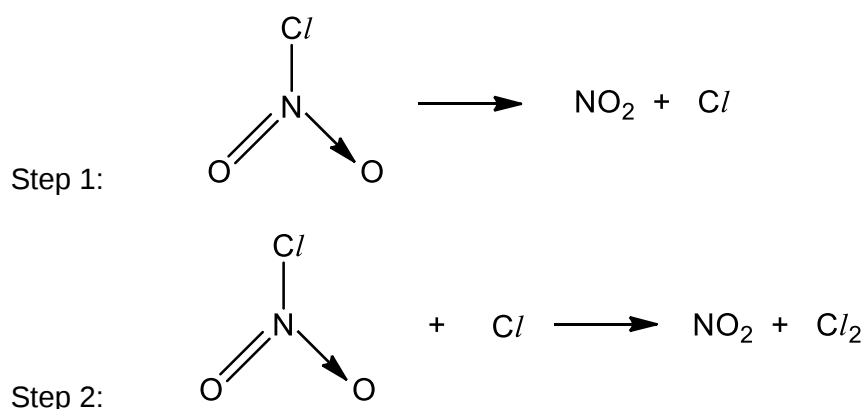


Fig. 2.2

- (i)** Draw the Lewis structure of NO_2 . [1]
- (ii)** The bond angle in NO_2 was found to be 134° . Explain why the bond angle is greater than 120° . [1]
- (iii)** The bond length of $\text{N}-\text{O}$ and of $\text{N}=\text{O}$ are about 122.6 pm and 117.7 pm respectively. Given that the bond lengths of both nitrogen-oxygen bonds in NO_2 are 120.1 pm, suggest an explanation for this observation. [2]
- (iv)** In Fig. 2.2 above, complete the mechanism by showing all the unpaired electrons, and the movement of electrons using curly arrows. [2]

[illegible]

$$2\text{NO(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{NO}_2\text{(g)}$$

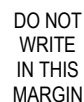
(i) Write an expression for the equilibrium constant, K_p , for the reaction. [1]

(ii) Given that K_p for the above equilibrium is 0.0198 MPa^{-1} , calculate the total equilibrium pressure, in MPa. [3]

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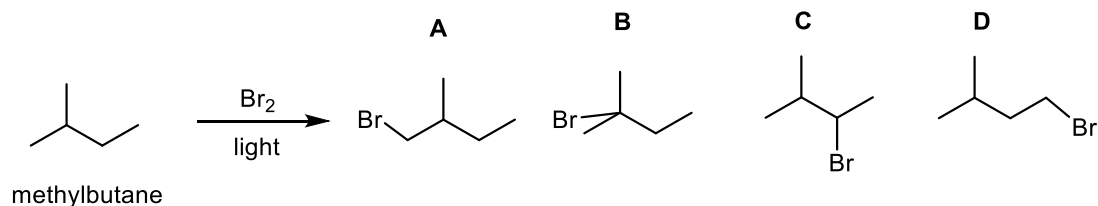
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(b) Ethane undergoes free radical substitution with bromine in the presence of ultraviolet light.

(i) Describe the mechanism of the bromination of ethane. [3]

(ii) In the bromination of methylbutane, four different bromoalkanes, **A** to **D**, can be formed.



Assuming all the hydrogen atoms present in methylbutane are equally likely to be replaced during this reaction, calculate the percentage of the four products **A** to **D** that you would expect to find in the mixture. [2]

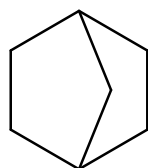
(iii) When this reaction was performed in the laboratory, the actual ratio of the products obtained was as follows:

A: 0.2% **B**: 93.5% **C**: 6.2% **D**: 0.1%

By comparing the ratio of the percentage of each product actually produced with that predicted in (b)(ii), calculate the relative reactivity of replacing a hydrogen to form **B** compared with replacing a hydrogen to form **C**. [1]

(iv) Suggest an explanation for the relative reactivity obtained in (b)(iii). [1]

(v) Norbornane is the prototype of a class of bicyclic hydrocarbons and has a history of use in many fields of chemistry.



norbornane

Draw the structures of all the different bromoalkane constitutional isomers that could be formed by the replacement of one hydrogen atom in norbornane with a bromine. [1]

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