

CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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Secondary 6

8/08/24

CHEMISTRY

August 2024

Paper 4

1 hour

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use the black or dark blue pen.
- 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.
- You should show all your working in the booklet.
- You are **not** allowed to use a calculator.

INFORMATION

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [].

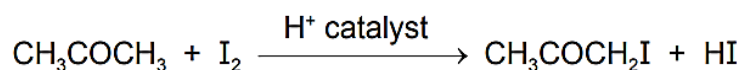
For Teacher's Use	
Question No	Marks
1	
2	
3	
4	
5	
6	
Total	

Invigilator's Name:

Invigilator's Sign:

Answer all the questions in the spaces provided

- 1 The initial rate of reaction for propanone and iodine in acid solution is measured in a series of experiments at a constant temperature.



The rate equation was determined experimentally to be as shown.

$$\text{rate} = k[\text{CH}_3\text{COCH}_3][\text{H}^+]$$

- (a) State the order of reaction with respect to

- CH_3COCH_3
- I_2
- H^+

and state the overall order of this reaction.

..... [2]

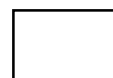
- (b) The rate of this reaction is $5.40 \times 10^{-3} \text{ mol dm}^{-3} \text{ s}^{-1}$ when

- the concentration of CH_3COCH_3 is $1.50 \times 10^{-2} \text{ mol dm}^{-3}$
- the concentration of I_2 is $1.25 \times 10^{-2} \text{ mol dm}^{-3}$
- the concentration of H^+ is $7.75 \times 10^{-1} \text{ mol dm}^{-3}$.

- (i) Calculate the rate constant, k , for this reaction. State the units of k .

$k =$

Units = [2]

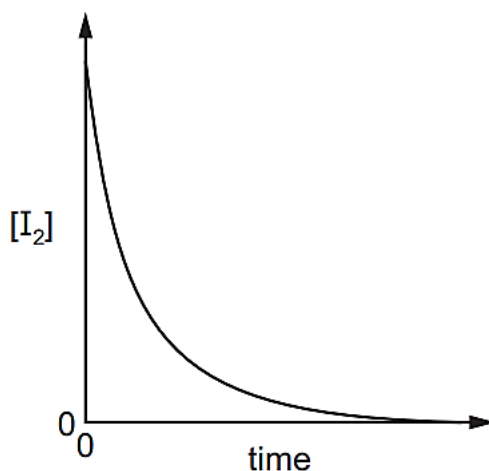


- (ii) Complete the table by placing one tick (✓) in each row to describe the effect of decreasing the temperature on the rate constant and on the rate of reaction. [1]

	decreases	no change	increases
rate constant			
rate of reaction			

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- (c) From the results, a graph is produced which shows how the concentration of I_2 change during the reaction.



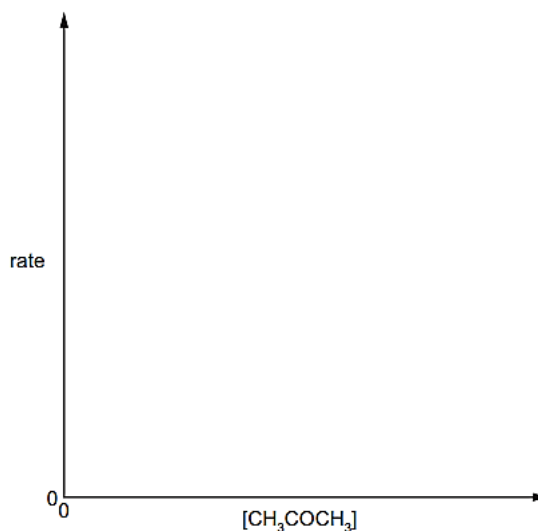
Describe how this graph could be used to determine the initial rate of the reaction.

.....

[1]



- (d) On the axes below, sketch a graph to show how the initial rate changes with different initial concentrations of CH_3COCH_3 in this reaction.

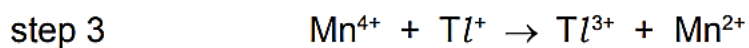
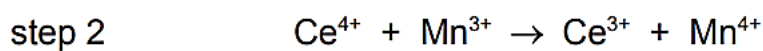
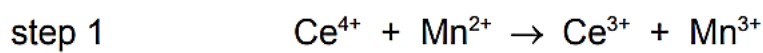


[1]

- (e) The rate of a reaction between metal ions was studied.

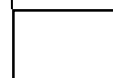
The following three-step mechanism has been suggested for this reaction.

Step 1 is the rate-determining step.



- (i) Explain the meaning of the term rate-determining step.

.....
[1]



(ii) Use this mechanism to

- determine the overall equation for this reaction

.....

- suggest the role of Mn^{2+} ions in this mechanism.

Explain your answer.

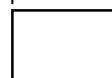
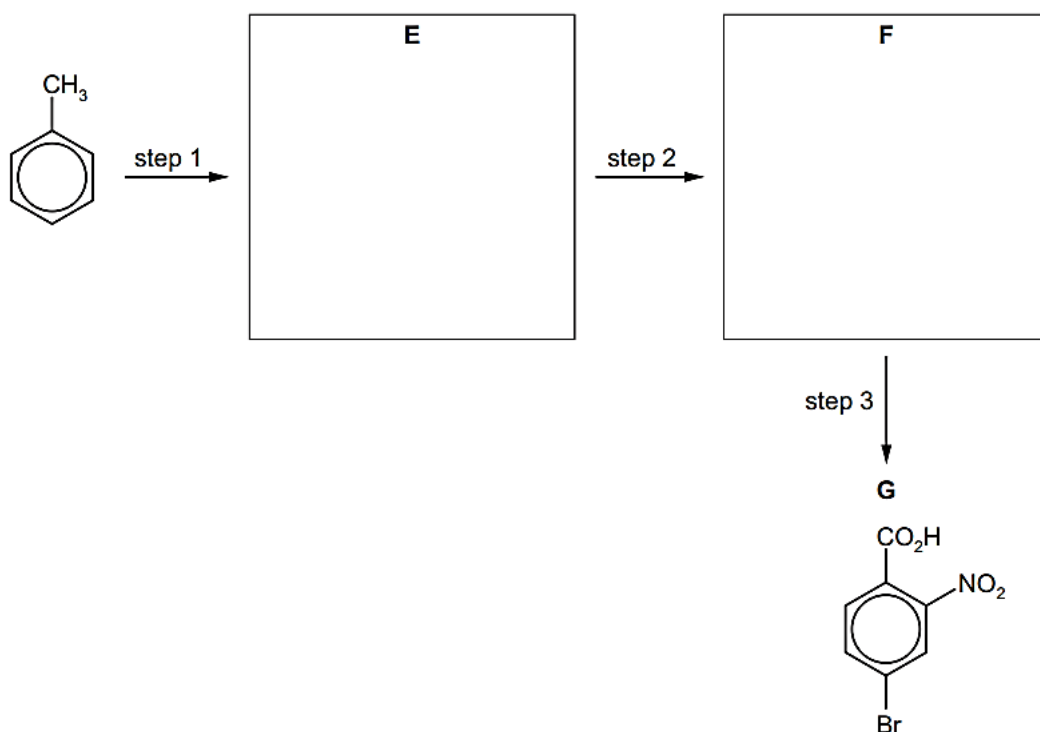
.....

.....

.....[1]

[Total:9]

2 Compound G can be synthesised from methylbenzene in three steps.



(i) Give the systematic name of compound G.

..... [1]

(ii) Deduce the identities of E and F and draw their structures in the boxes. [2]

(iii) Suggest reagents and conditions for each of steps 1 to 3 in

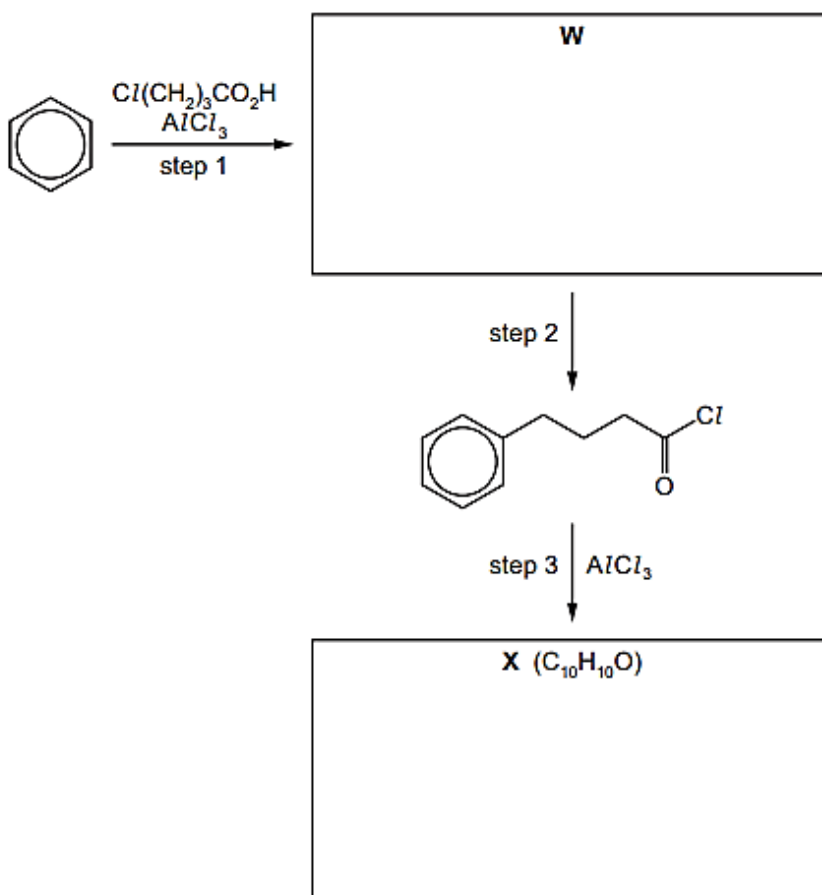
step 1

step 2

step 3 [3]

[Total:6]

3 A three-step synthesis of X ($C_{10}H_{10}O$) from benzene is suggested as shown



(i) Step 1 is the alkylation of benzene by electrophilic substitution.

Use R-Cl to represent $\text{Cl}(\text{CH}_2)_3\text{CO}_2\text{H}$.

Write an equation for the formation of an electrophile from R-Cl and AlCl_3 .

..... [1]

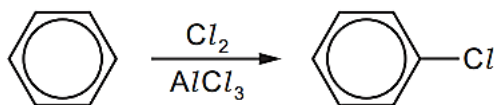
(ii) Deduce and draw the structures of W and X in the boxes. [2]

(iii) Suggest the reagents and conditions for step 2.

..... [1]

[Total:4]

4 Chlorobenzene can be prepared from benzene as shown.



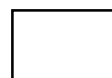
Aluminium chloride, AlCl_3 , catalyses this reaction.

(i) Write an equation to show how AlCl_3 generates the electrophile needed in this reaction.

..... [1]

(ii) Draw the mechanism of the reaction between this electrophile and benzene to form chlorobenzene. Include all relevant curly arrows and charges.

[4]



(iii) Write an equation to show how the catalyst is regenerated.

.....[1]

(c) (i) Catalysts can be heterogeneous or homogeneous. Explain what is meant by a homogeneous catalyst.

.....

..... [1]

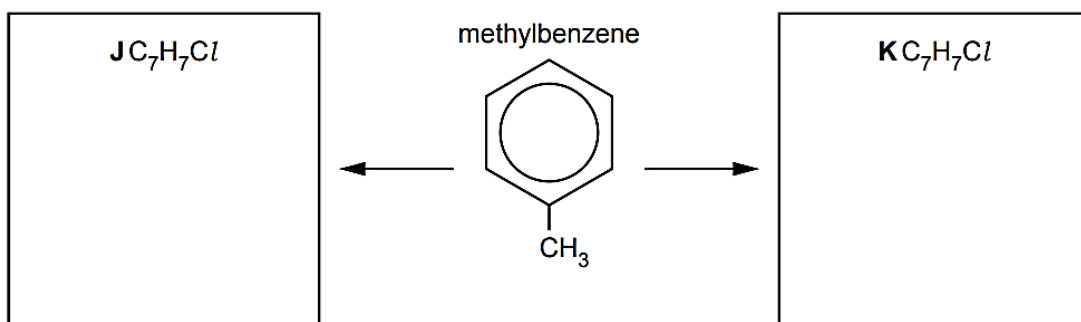
(ii) Complete the table by placing one tick (✓) in each row to indicate the mode of action of the catalyst in each reaction.

	heterogeneous	homogeneous
Rh in the removal of NO ₂ from exhaust gases of cars		
Fe ³⁺ in the I ⁻ /S ₂ O ₈ ²⁻ reaction		

[1]

[Total:8]

- 5 When treated with Cl₂ under suitable conditions, methylbenzene forms compound J. When treated with Cl₂ under different conditions with different reagents, methylbenzene forms compound K. Suggest and draw structures of compounds J and K in the boxes. The molecular formula of each compound is given.



State the reagents and conditions required to form each product.

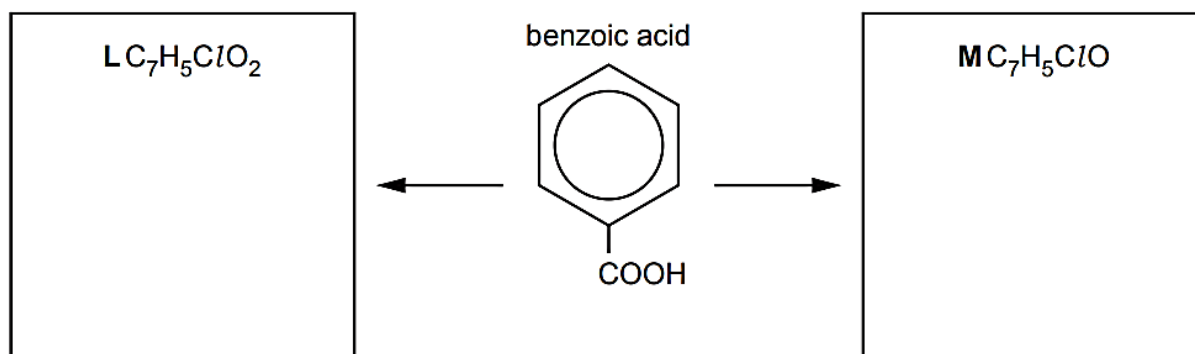
to form compound J

to form compound K [4]

- (ii) When treated with a chlorine-containing reagent under suitable conditions, benzoic acid forms compound L. When treated with a different chlorine-containing reagent under different conditions, benzoic acid forms compound M.

Suggest and draw structures of compounds L and M in the boxes.

The molecular formula of each product is given.



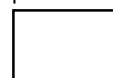
State the reagents and conditions to form compound M from benzoic acid.

..... [3]

[Total:7]

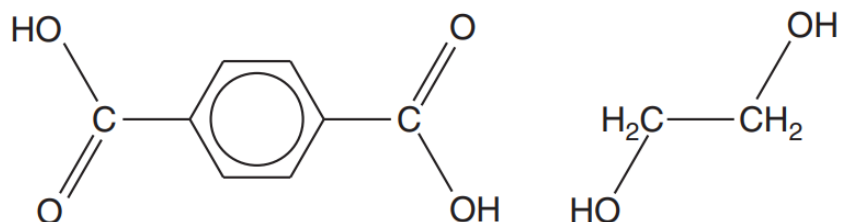
- 6(a) State one difference between addition and condensation polymerisation.

.....



[1]

- (b) The polymer formed from the co-polymerisation of the two monomers shown is known as Terylene.

**benzene-1, 4-dicarboxylic acid****ethane-1-2-diol**

- (i) The two monomers react by condensation polymerisation.

What other molecule is formed in this reaction?

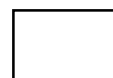
[1]

- (ii) Draw the structure of one repeat unit of Terylene.

- (iii) What is the name given to polymers containing the same functional group as Terylene?

[4]

[Total: 6]



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Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ (4.18 J g ⁻¹ K ⁻¹)

