Halogenoalkanes

Question Paper 3

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Halogen Derivatives
Sub-Topic	Halogenoalkanes
Paper Type	Theory
Booklet	Question Paper 3

Time Allowed: **65 minutes**

Score: **/54**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 Calcium chloride, $CaCl_2$, is an important industrial chemical used in refrigeration plants, for de-icing roads and for giving greater strength to concrete.

(a) Show by means of an equation what is meant by the lattice energy of calcium chloride.

..... [1]

(b) Suggest, with an explanation, how the lattice energies of the following salts might compare in magnitude with that of calcium chloride.

(i) calcium fluoride, CaF_2

.....

.....

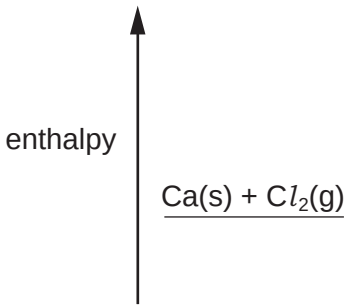
(ii) calcium sulfide, CaS

.....

..... [3]

(c) Use the following data, together with additional data from the *Data Booklet*, to calculate the lattice energy of $CaCl_2$.

standard enthalpy change of formation of $CaCl_2$	–796 kJ mol^{-1}
standard enthalpy change of atomisation of Ca(s)	+178 kJ mol^{-1}
electron affinity per mole of chlorine atoms	–349 kJ mol^{-1}



lattice energy = ... kJ mol^{-1} [3]

(d) When a solution of $CaCl_2$ is added to a solution of the dicarboxylic acid, malonic acid, the salt calcium malonate is precipitated as a white solid. The solid has the following composition by mass: Ca, 28.2%; C, 25.2%; H, 1.4%; O, 45.2%.

(i) Calculate the empirical formula of calcium malonate from these data.

(ii) Suggest the structural formula of malonic acid.

[3]

[Total: 10]

2 Ethane reacts with chlorine to form chloroethane.

$$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(g) + HCl(g)$$

(a) Use bond energies from the *Data Booklet* to calculate the enthalpy change for this reaction. Include a sign in your answer.

enthalpy change = ... $kJ\,mol^{-1}$ [3]

(ii) State the conditions needed for this reaction to occur.

..... [1]

(iii) Use a series of equations to describe the mechanism of this reaction including the names of each stage and an indication of how butane can be produced as a minor by-product.

.....

.....

.....

.....

.....

..... [5]

(b) Chloroethane can be converted back into ethane by a two-stage process via an intermediate compound, **X**.

$$C_2H_5Cl \xrightarrow{\text{reaction 1}} \mathbf{X} \xrightarrow{\text{reaction 2}} C_2H_6$$

(i) Give the name of **X**.

..... [1]

(ii) Suggest the reagent and conditions needed for reaction 1.

..... [2]

(iii) Suggest the reagent and conditions needed for reaction 2.

..... [1]

[Total: 13]

3 **(a)** Both chloroalkanes and acyl chlorides react with water, but only acyl chlorides fume in moist air.

(i) State which product causes the fumes in this reaction.

..... [1]

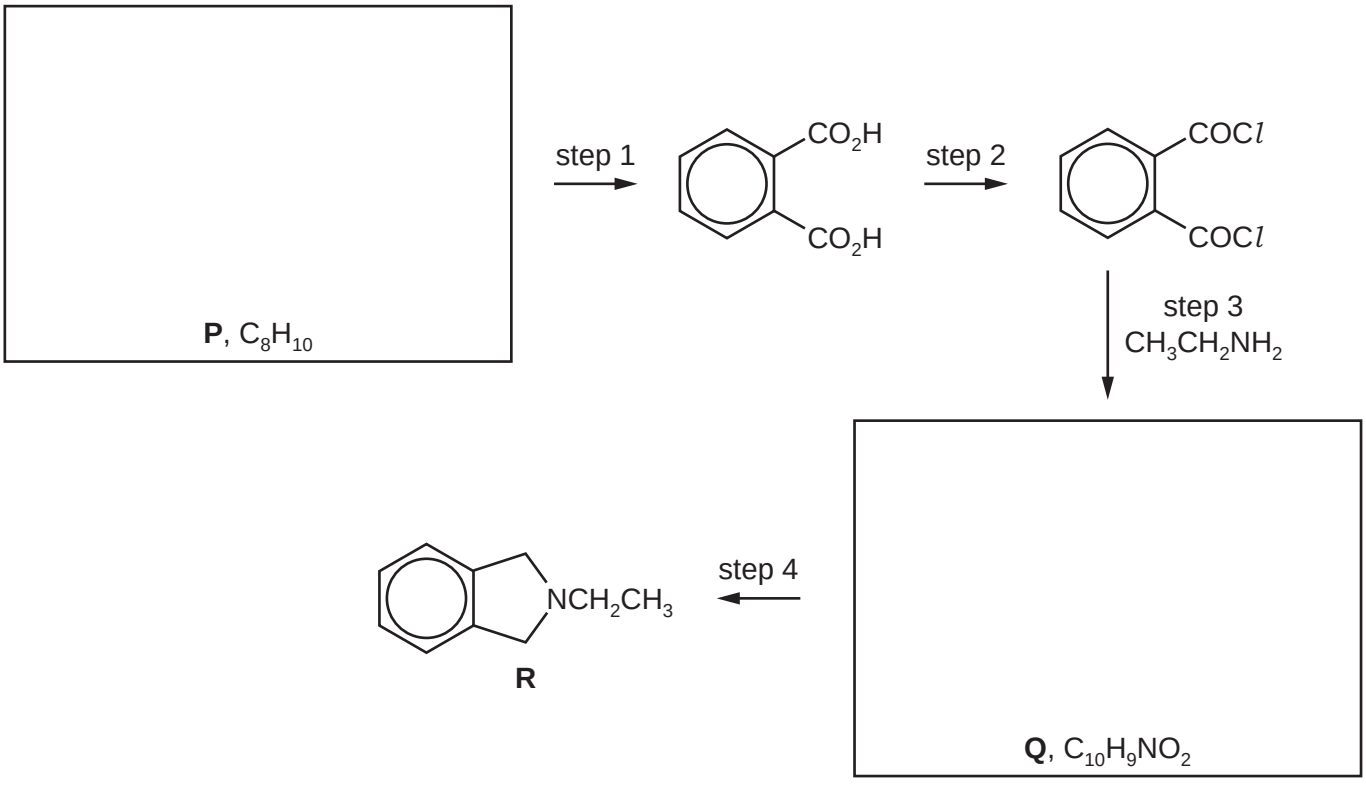
(ii) Explain why the reactivities of chloroalkanes and acyl chlorides differ.

.....

.....

..... [1]

(b) Compound **R** is a useful intermediate in the synthesis of pharmaceutical compounds. It can be made from compound **P** by the following route.



(i) Suggest structures for the starting material **P** and the intermediate **Q**. [2

(ii) Suggest reagents and conditions for the following steps in the above scheme.

step 1 .....

step 2 .....

step 4 .....

[3]

[Total: 7]

4 The halogens and their compounds have a wide variety of uses and the chemical and physical properties of the elements show regular patterns related to their positions in Group VII.

(a) Chlorine, bromine and iodine all react with hydrogen.

(i) State the trend in the reactivities of the halogens with hydrogen.

.....

..... [1]

(ii) Explain this trend in terms of bond energies.

.....

.....

..... [2]

(b) In the laboratory it is not very convenient to prepare hydrogen halides from their elements.

Hydrogen halides can be prepared from their salts.

(i) Write an equation for the reaction of calcium chloride, $CaCl_2$, with concentrated sulfuric acid.

..... [1]

(ii) Explain why hydrogen iodide is not prepared in this way.

.....

..... [1]

(iii) When potassium bromide, KBr, reacts with concentrated sulfuric acid, sulfur dioxide, SO_2, is produced. State what you would **see** and write an equation for this reaction.

.....

..... [3]

(c) **(i)** Give the structures of the four structural isomers of C_4H_9Br **and** identify each as primary, secondary or tertiary.

....

....

[4]

(ii) Name the isomer of C_4H_9Br that contains a chiral centre and draw the three-dimensional structures of the two optical isomers.

name .....

structures

[3]

(d) Aqueous silver nitrate solution was added to separate tubes containing chloroethane, bromoethane and iodoethane. The tubes were heated in a water bath.

A yellow precipitate appeared first in the tube containing iodoethane, followed by a cream precipitate in the tube containing bromoethane and finally a white precipitate appeared in the tube containing chloroethane.

Explain these observations.

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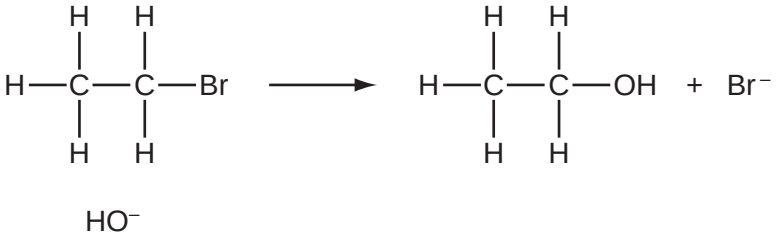
..... [2]

(e) Give the full name of the mechanism for the reaction between aqueous sodium hydroxide and bromoethane.

..... [2]

(ii) Complete the diagram below to represent this mechanism. Include all necessary curly arrows, partial charges and lone pairs.



[2]

(f) In the past, CFCs such as CF_3Cl were widely used as refrigerants.

(i) State a property of CFCs which makes them suitable for use as refrigerants.

..... [1]

(ii) State the damaging effect of CFCs in the upper atmosphere.

.....

Explain your answer.

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.....

.....
[2]

[Total: 24]