Organic Synthesis

Question Paper 3

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Transition Metals & Organic Nitrogen Chemistry
Sub Topic	Organic Synthesis
Booklet	Question Paper 3

Time Allowed: **57 minutes**

Score: **/47**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 This question is about an unknown organic compound, **Q**.

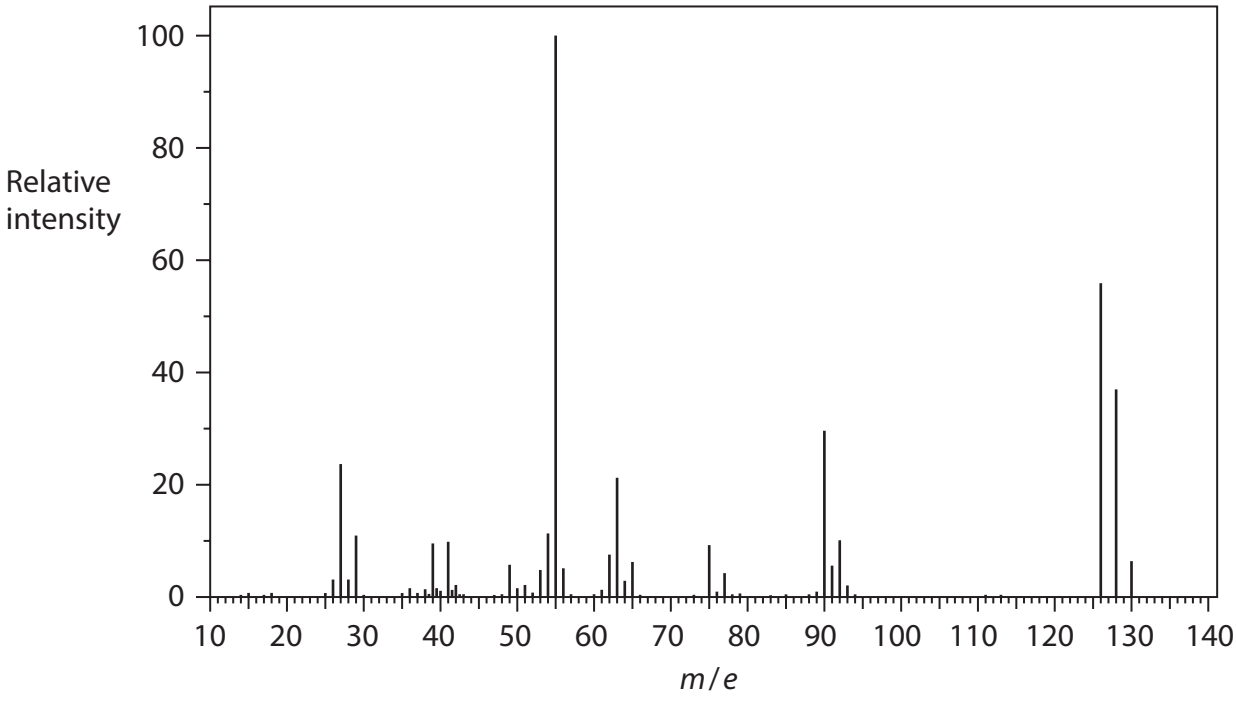
The percentage composition by mass of **Q** is

carbon = 37.8%; hydrogen = 6.30%; chlorine = 55.9%.

(a) Calculate the empirical formula of **Q**.

(2)

(b) The mass spectrum of **Q** is shown below.



(i) Use your answer to part (a) and the mass spectrum to deduce the molecular formula of **Q**.

(1)

(ii) Explain why there are three peaks in the molecular ion region (m/e from 126 to 130) of the mass spectrum of **Q**.

(2)

(iii) State why the peak at $m/e = 126$ is the highest of the three peaks in the molecular ion region.

(1)

*(iv) **Q** reacts with aqueous sodium hydroxide to form an organic compound, **R**.

The functional groups of compound **R** are on different carbon atoms.

Compound **R** reacted slowly with sodium, producing a total of one mole of hydrogen gas per mole of **R**.

When compound **R** was heated under reflux with excess acidified sodium dichromate(VI), an organic compound, **S**, was formed.
Compound **S** reacted rapidly with sodium, producing a total of 0.5 mol of hydrogen gas per mole of **S**.

Draw the **displayed** formulae of the two possible structures for compound **S**.
Explain how your structures are consistent with these data.

(5)

Structure I	Structure II

Explanation .....

(v) Compound **S** reacted with iodine dissolved in aqueous sodium hydroxide, producing a pale yellow precipitate with an antiseptic smell.

Identify the pale yellow precipitate and hence identify which of the structures that you have given in (b)(iv) is compound **S**. Explain your reasoning.

(2)

.....

.....

.....

.....

.....

(vi) **Name** compound **R** and give the equation for its reaction with sodium.

(3)

R = ...

Equation

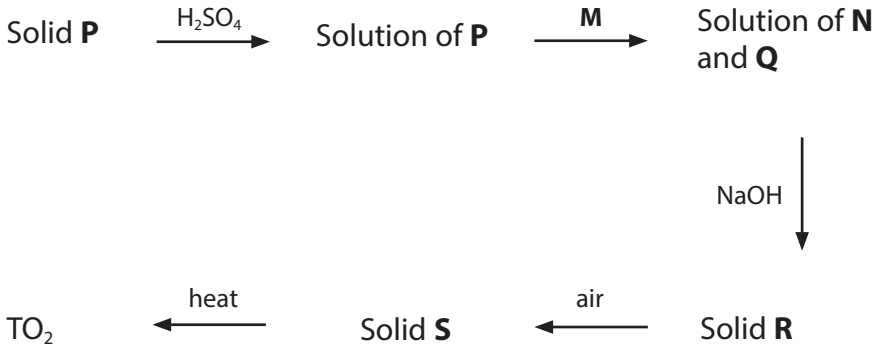
(Total for Question 1 = 16 marks)

2 Compound **P** is a very dark purple solid which gives a lilac flame in a flame test.

A sample of **P** was dissolved in dilute sulfuric acid to form a purple solution. A gaseous hydrocarbon, **M**, was bubbled into this solution which rapidly formed a colourless solution, containing an organic compound, **N**, and an inorganic compound, **Q**.

When aqueous sodium hydroxide was added to **Q**, a very pale brown precipitate, **R**, formed. **R** darkened on standing in air to form a dark brown solid, **S**, which was filtered off and heated to form a dark brown metal oxide, TO_2.

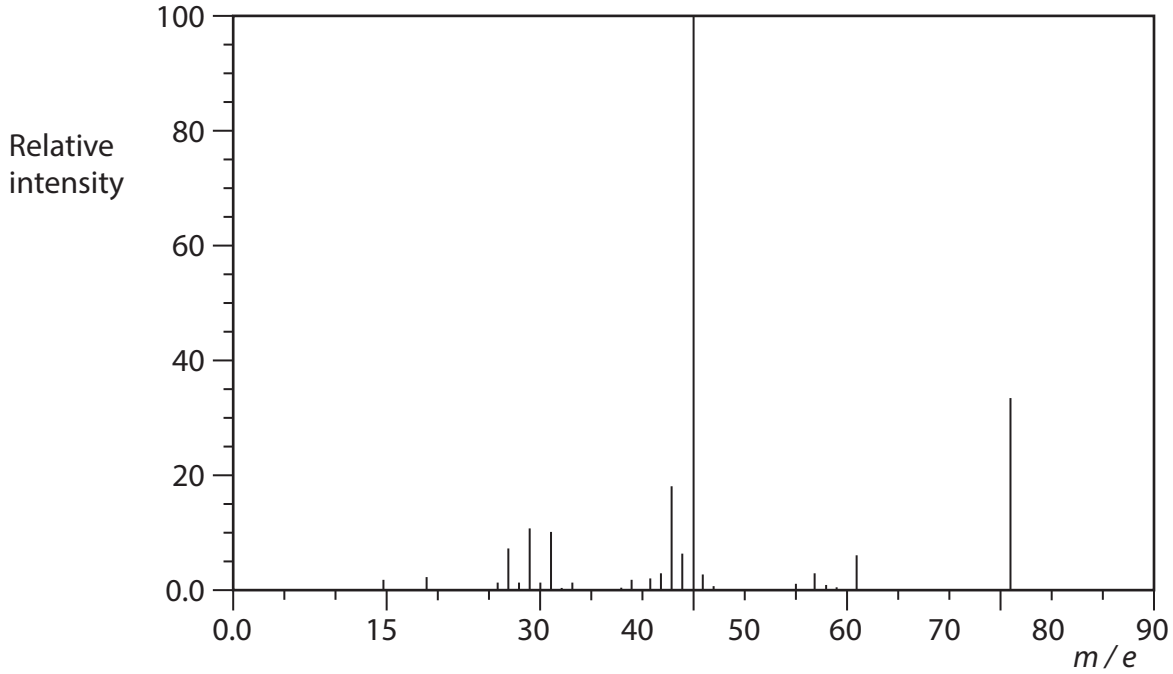
The reaction sequence is summarised below.



(a) Analysis of TO_2 showed that it contained 36.82% by mass of oxygen. Calculate the molar mass of the metal, T, and hence identify T. You **must** show your working.

(3)

(b) The mass spectrum of the organic product **N**, formed when **M** is reacted with the solution of **P**, is shown below.



(i) Label the molecular ion on the mass spectrum and deduce the molar mass of **N**.

(1)

.....

(ii) Identify, by name or formula, **M** and **N**.

(2)

M	
N	

(c) (i) Write an **ionic** equation for the formation of the very pale brown precipitate, **R**. Include state symbols in your answer.

(2)

(ii) Suggest an equation for the conversion of the dark brown solid, **S**, to TO_2. State symbols are not required.

(2)

(d) Write the formula of the cation in **P** and hence give the formula of compound **P**.

(2)

.....

.....

.....

(Total for Question 2 = 12 marks)

3 Crystals of copper(II) sulfate dissolve in water to form a blue solution, **A**. When dilute aqueous ammonia is added to this solution, a pale blue precipitate, **B**, forms which dissolves in excess aqueous ammonia to form a dark blue solution, **C**.

(a) (i) Give the **formula** of the copper species in **A**, **B** and **C**. You should include all of the ligands present in each species.

(3)

A .....

B .....

C .....

(ii) Explain why solution **A** is coloured.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(iii) Explain why solution **A** is a different colour to solution **C**.

(2)

.....

.....

.....

.....

(b) A more concentrated solution of **C** may be prepared by using concentrated aqueous ammonia in place of dilute aqueous ammonia. The crystalline sulfate of **C** may be obtained by cooling the mixture in an ice bath and adding ethanol. The filtered crystals may be recrystallized using ethanol as the solvent.

The steps of the recrystallization are summarised below. In the spaces provided, explain the purpose of each step, referring particularly to any words in **bold** type.

(5)

Step 1 The solid was dissolved in the **minimum** amount of hot ethanol.

.....

.....

.....

Step 2 The **hot** solution was **filtered**.

.....

.....

.....

Step 3 The filtrate was cooled in an **ice bath**.

.....

.....

.....

Step 4 The mixture was **filtered** using **suction filtration**.

.....

.....

.....

.....

(Total for Question 3 = 14 marks)

4 10 cm^3 of a gaseous hydrocarbon, C_xH_y, was mixed with excess oxygen and ignited. The total gas volume was measured at room temperature and pressure before and after combustion, and it was found that it had contracted by 20 cm^3. On shaking the remaining gases with excess potassium hydroxide solution, the total gas volume contracted by a further 40 cm^3.

The equation for the complete combustion of C_xH_y is

$$C_xH_y + (x + (y/4))O_2 \rightarrow xCO_2 + (y/2)H_2O$$

(a) Explain why the volume of gas contracts after combustion.

(1)

.....

.....

(b) Explain why the volume of gas contracts after shaking with excess potassium hydroxide.

(1)

.....

.....

(c) Calculate the molecular formula of C_xH_y.

(3)

(Total for Question 4 = 5 marks)