Gold Paper
A Level only

Question Paper 3

Level	A Level
Subject	Chemistry
Exam Board	OCR
Paper	A Level only
Booklet	Question Paper 3

Time allowed: **90 minutes**

Score: **/67**

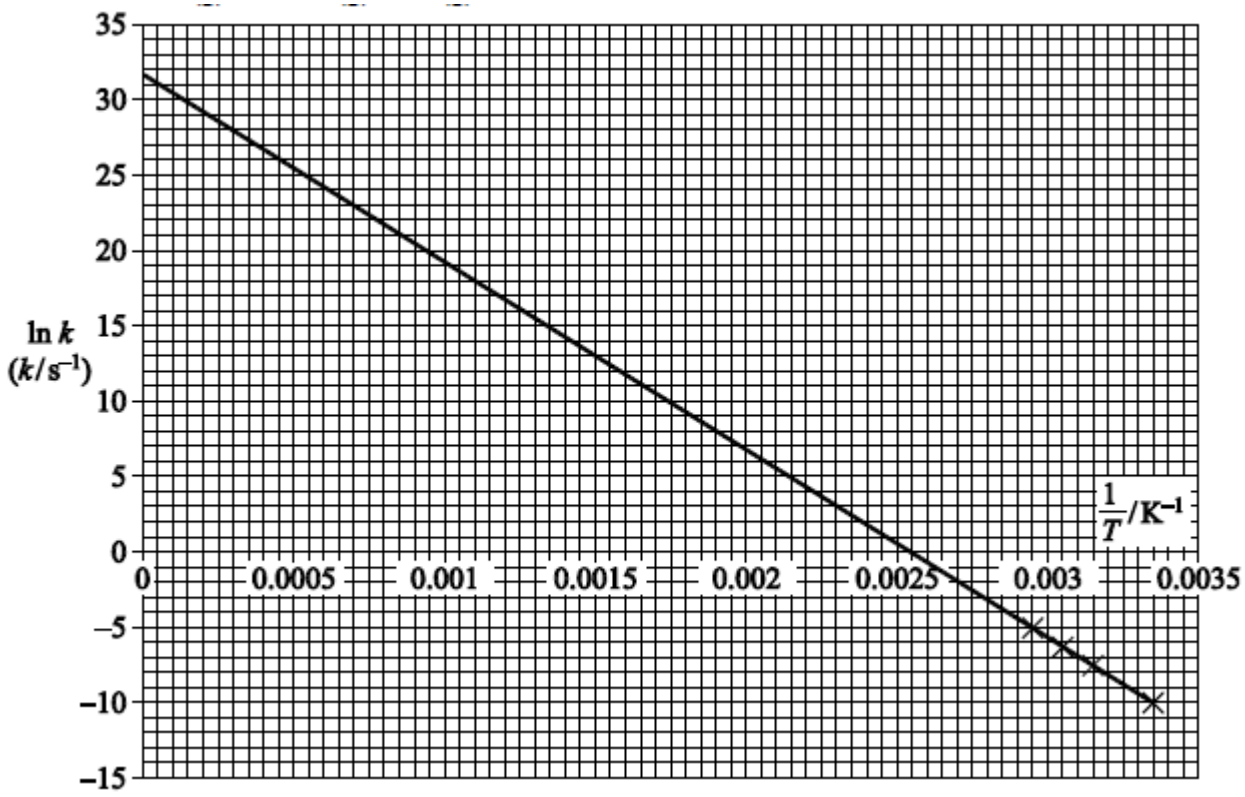
Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

Using the graph, what is the value of the pre-exponential factor, A, for the decomposition of N_2O_5?

$2N_2O_5(g) \rightarrow 4NO(g) + O_2(g)$



A $3.45\ s^{-1}$

B $31.5\ s^{-1}$

C $1.04 \times 10^{5}\ s^{-1}$

D $4.79 \times 10^{13}\ s^{-1}$

[1]

A chemist prepares and analyses some esters.

(a) The chemist prepares an ester of propan-2-ol, $CH_3CH(OH)CH_3$, by reacting $CH_3CH(OH)CH_3$ with ethanoic anhydride, $(CH_3CO)_2O$.

Using structural formulae, write an equation for the reaction of propan-2-ol and ethanoic anhydride. [2]

(b) A sample contains a mixture of two esters contaminated with an alkane and an alcohol.

The chemist attempts to separate the four organic compounds in the mixture using gas chromatography, GC.

The column in the gas chromatograph contains a liquid alkane which acts as the stationary phase.

(i) How does a liquid stationary phase separate the organic compounds in a mixture? [1]

(ii) Suggest how well these four compounds would be separated using the alkane stationary phase. In your answer, include some indication of the length of the retention times.

Explain your answer. [2]

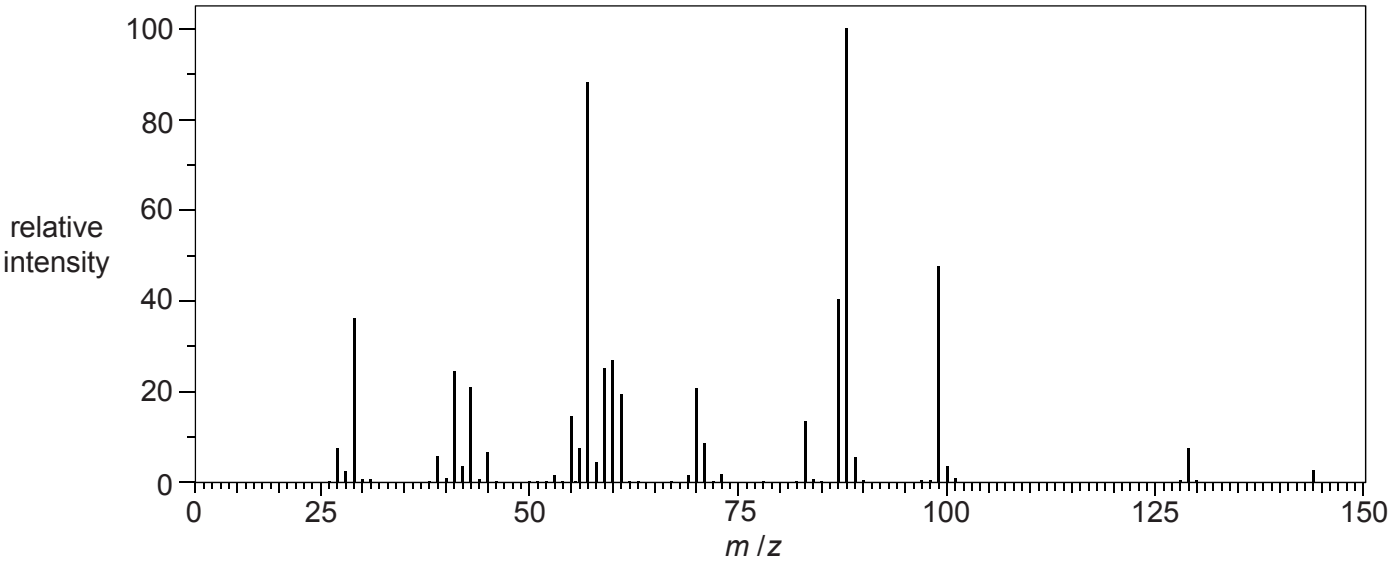
(c) GC is often used together with other techniques, such as mass spectrometry, MS, and NMR spectroscopy, to provide a far more powerful analytical tool than GC alone.

One of the esters in a perfume is separated by GC and then analysed.

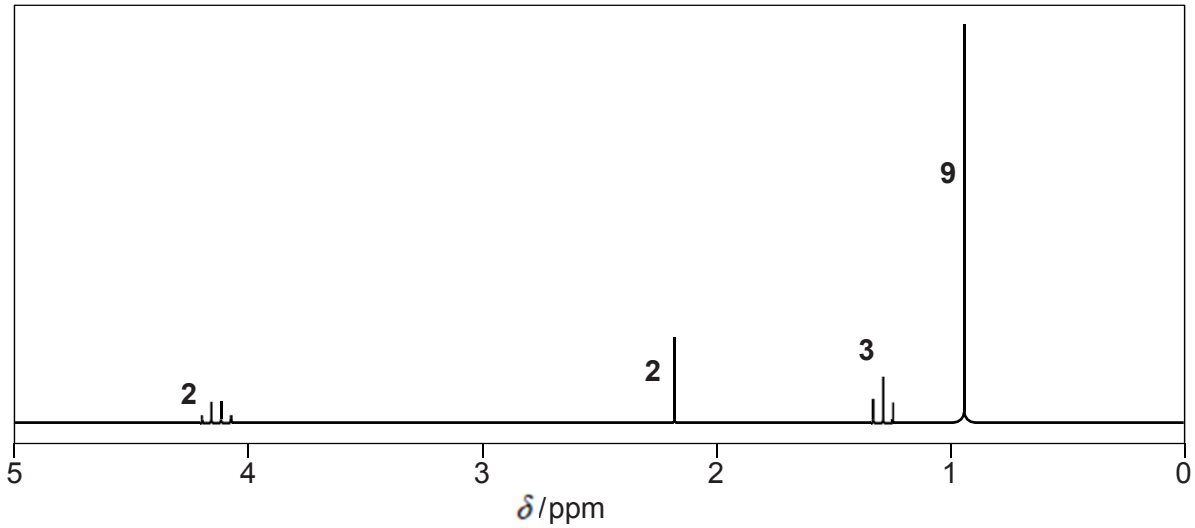
The results are shown below.

Elemental analysis by mass
C, 66.63%; H, 11.18%; O, 22.19%

Mass spectrum



Proton NMR spectrum
The numbers by each peak are the relative peak areas.



Use the results to identify the ester. Show **all** your reasoning.

In your answer, you should use appropriate technical terms, spelled correctly.

[10]

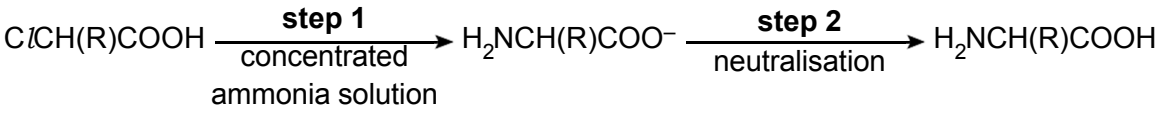
[Total 15 Marks]

Read the passage below and answer the questions that follow.

α-Amino acids can be synthesised in the laboratory by the two synthetic routes below.

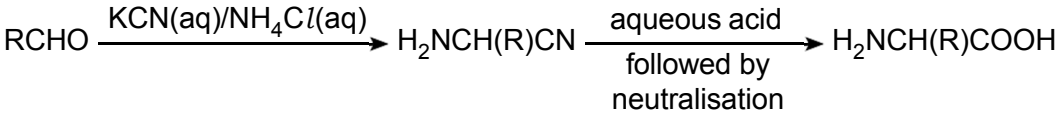
Synthesis 1

An α-chlorocarboxylic acid is reacted with an excess of concentrated ammonia solution. The resulting solution is neutralised to produce an α-amino acid.



Synthesis 2

An aldehyde is reacted with an aqueous solution of potassium cyanide and ammonium chloride. The resulting product is hydrolysed with aqueous acid and then neutralised to produce an α-amino acid.



(a) A chemist attempted the synthesis of the α-amino acid alanine (where R is CH_3) using **synthesis 1**.

(i) Write the equation for the reaction of $ClCH(CH_3)COOH$ with excess concentrated ammonia solution, $NH_3(aq)$, in **step 1** of **synthesis 1**. [1]

(ii) A disadvantage of **synthesis 1** is that the α-amino acid can react further. For example, in the synthesis of alanine, an impurity with molecular formula $C_6H_{11}NO_4$ is also formed.

Draw the structure of this impurity. [1]

(b) A chemist attempted the synthesis of the α-amino acid aspartic acid (where R is CH_2COOH) using **synthesis 2**.

(i) Draw the **skeletal** formula of the organic compound that could be used to synthesise aspartic acid using **synthesis 2**. [1]

(ii) Draw **3D** diagrams of the optical isomers of aspartic acid. [2]

(c) Many pharmaceuticals also have a chiral centre.

Discuss two possible **disadvantages** of producing a chiral drug as a mixture of stereoisomers.

State **two** ways in which a single optical isomer might be synthesised. [4]

[Total 9 Marks]

Iron and platinum are transition elements. They both form ions that combine with ligands to form complex ions. Some of these complexes are important in biological systems.

(a) Complete the electron structures of:

an atom of Fe: $1s^2 2s^2 2p^6$

an ion of Fe^{2+}: $1s^2 2s^2 2p^6$ [2]

(b) State **one** property of Fe^{2+}, other than the ability to form complex ions, which is typical of an ion of a transition element. [1]

(c) Aqueous iron(II) sulfate takes part in redox reactions.

Using oxidation numbers, show that both reduction and oxidation have taken place in the redox reaction of aqueous iron(II) sulfate shown below.

$$6FeSO_4 + 7H_2SO_4 + Na_2Cr_2O_7 \rightarrow 3Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + Na_2SO_4 + 7H_2O$$

[2]

(d) Hexaaquairon(II) ions, $[Fe(H_2O)_6]^{2+}$, take part in a ligand substitution reaction with ammonia.

$$[Fe(H_2O)_6]^{2+}(aq) + 6NH_3(aq) \rightleftharpoons [Fe(NH_3)_6]^{2+}(aq) + 6H_2O(l)$$

Write an expression for the stability constant, K_{stab}, for this equilibrium. [2]

(e) Haemoglobin is a complex of iron(II).

(i) Explain how ligand substitutions allow haemoglobin to transport oxygen in the blood. [2]

(ii) In the presence of carbon monoxide, less oxygen is transported in the blood.
In terms of stability constants, suggest why. [2]

(f) Platin, $Pt(NH_3)_2Cl_2$, is a complex of platinum(II) that has two stereoisomers. One of these stereoisomers is used in medicine.

(i) Platin is a neutral complex.
Explain why platin is neutral [1]

(ii) Draw diagrams of the two stereoisomers of platin and describe its bonding. [3]

(iii) Describe the action of platin in the treatment of cancer patients. [1]

(g) The use of platin in medicine can cause unpleasant side effects for patients.

In the search for alternatives, chemists often start with the current drug and modify its properties by chemically changing some of the groups.

A recent discovery is a drug called carboplatin. The structure of carboplatin is similar to platin except that a single 1,1-cyclobutanedicarboxylate ion replaces the two chloride ligands in the structure of platin.

Draw the structures of,

- the 1,1-cyclobutanedicarboxylate ion
- carboplatin. [2]

[Total: 18 Marks]

Entropy changes are an important factor in determining the feasibility of reactions.

(a) You are provided with equations for four processes.

A $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
B $H_2O(l) \rightarrow H_2O(g)$
C $H_2(g) + ½O_2(g) \rightarrow H_2O(l)$
D $2C(s) + O_2(g) \rightarrow 2CO(g)$

For each process, explain why ΔS has the sign shown below.

A: sign of ΔS: negative

reason for sign:

B: sign of ΔS: positive

reason for sign:

C: sign of ΔS: negative

reason for sign

D: sign of ΔS: positive

reason for sign [4]

(b) Calcium oxide, CaO, is used to make cement. Calcium oxide is manufactured by the thermal decomposition of calcium carbonate.

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g) \qquad \Delta H = +178\,kJ\,mol^{-1}$$

Standard entropies of $CaCO_3(s)$, CaO(s) and $CO_2(g)$ are given in the table below.

substance	$CaCO_3(s)$	CaO(s)	$CO_2(g)$
S / J $K^{-1}mol^{-1}$	89	40	214

- Using the information in the table, show that the entropy change, ΔS, for the decomposition of calcium carbonate is $0.165\,kJ\,K^{-1}\,mol^{-1}$.
- Show that calcium carbonate is stable at room temperature (25 °C).
- Calculate the minimum temperature needed to decompose calcium carbonate.

Show all your working.

[7]

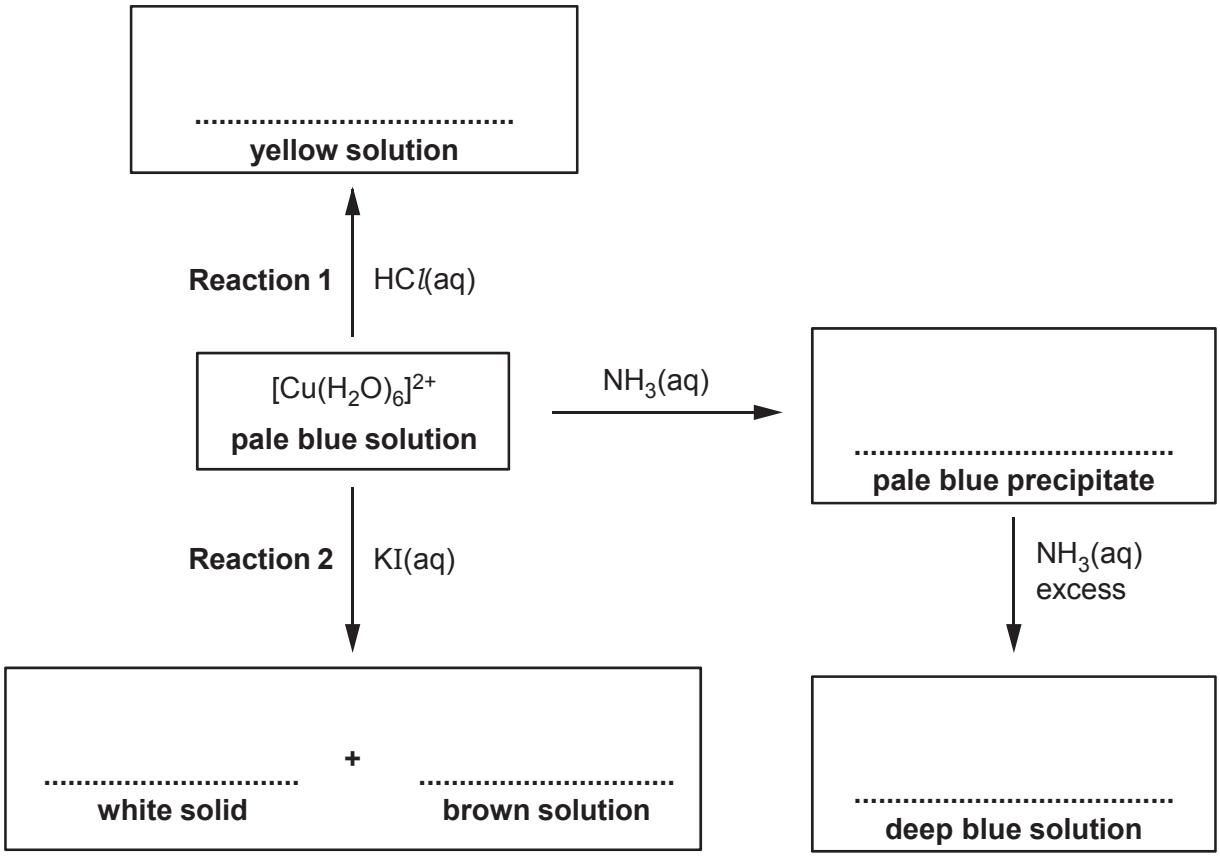
[Total: 11 Marks]

This question is about reactions of ions and compounds of transition elements.

(a) The flowchart shows reactions of the complex ion $[Cu(H_2O)_6]^{2+}$.

(i) In the boxes, write down the formulae of the species responsible for the observations.

[5]



(ii) Name the type of reaction for **Reaction 1** and **Reaction 2**.

[2]

(b)* A hydrated nickel(II) complex, **A**, is heated in a crucible to remove the water of crystallisation. The anhydrous complex **B** is formed. The results are shown below.

Mass of crucible + hydrated complex **A**	= 59.554g
Mass of crucible + anhydrous complex **B**	= 58.690g
Mass of crucible	= 51.257g

The anhydrous complex **B** is analysed and found to have a molar mass of 309.7 g mol^{-1} and to contain the following percentage composition by mass:

Ni, 18.95%; C, 23.25%; N, 27.12%; H, 7.75%; C*l*, 22.93%.

The anhydrous complex **B** contains a cation **C** comprising Ni, C, N and H only.

Cation **C** is six-coordinate, contains three molecules of the bidentate ligand **D**, and exists as optical isomers.

Determine the formula of **A**, **B**, **C** and **D** and show the 3D structures for the optical isomers of **C**.

Show **all** your working.

[6]

(Total 13 marks)