Oxford Cambridge and RSA

Tuesday 5 October 2021 – Afternoon

A Level Chemistry B (Salters)

H433/01 Fundamentals of Chemistry

Time allowed: 2 hours 15 minutes

You must have:
- the Data Sheet for Chemistry B

You can use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **110**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **32** pages.

ADVICE
- Read each question carefully before you start your answer.

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SECTION A

You should spend a maximum of 40 minutes on this section.

Write your answer to each question in the box provided.

Answer **all** the questions.

1 Chlorine-35 is an isotope of chlorine.

What is correct about an atom of chlorine-35?

A It has 35 electrons.

B It has 35 neutrons.

C It has 35 protons.

D It has 35 protons plus neutrons.

Your answer ☐ **[1]**

2 What is meant by 'heating to constant mass'?

A Heating a sample for a long time.

B Heating a sample, then weighing, then heating and weighing again several times.

C Weighing a sample several times after heating it.

D Weighing a sample several times before heating it.

Your answer ☐ **[1]**

3 Which of these provides evidence that electrons are arranged in shells within atoms?

A atomic spectra

B electrolysis

C the discovery of the neutron

D the Geiger-Marsden experiment

Your answer ☐ **[1]**

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4 Which equation represents the enthalpy change of formation of CO_2?

A $C(s) + 2O(g) \rightarrow CO_2(g)$

B $C(s) + O_2(g) \rightarrow CO_2(g)$

C $CO(g) + 0.5O_2(g) \rightarrow CO_2(g)$

D $C(g) + O_2(g) \rightarrow CO_2(g)$

Your answer ☐ **[1]**

5 What is correct about the polluting gases formed by a petrol engine?

A CO is formed by incomplete combustion of hydrocarbons and is toxic.

B CO_2 is formed by combustion of hydrocarbons and can be removed by a catalytic converter.

C NO_x is formed mainly when nitrogen compounds in petrol burn.

D SO_x is formed by the combustion of dissolved sulfur in petrol.

Your answer ☐ **[1]**

6 What is correct about the greenhouse effect?

A Greenhouse gases are found in a thin layer in the Earth's atmosphere.

B Infrared radiation causes bonds in greenhouse gases to break.

C The Earth absorbs more infrared radiation than it emits.

D Ultraviolet radiation is the main radiation absorbed by the Earth.

Your answer ☐ **[1]**

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7 $Fe^{2+}(aq)$ reacts with a mixture of $S_2O_8^{2-}$ ions and I^- ions in the following way:

$S_2O_8^{2-}(aq) + 2Fe^{2+}(aq) \longrightarrow 2Fe^{3+}(aq) + 2SO_4^{2-}(aq)$

then $2Fe^{3+}(aq) + 2I^-(aq) \longrightarrow 2Fe^{2+}(aq) + I_2(aq)$

What is correct?

A $Fe^{2+}(aq)$ is acting as a homogeneous catalyst.

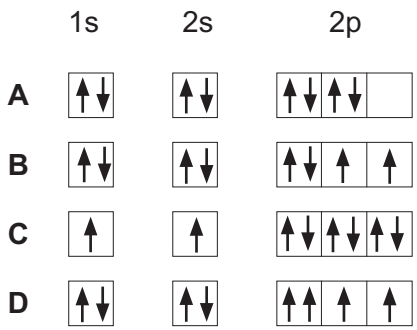
B $Fe^{2+}(aq)$ is acting as an oxidising agent.

C $I^-(aq)$ ions are being reduced.

D $S_2O_8^{2-}(aq)$ is acting as a reducing agent.

Your answer ☐ **[1]**

8 Which of these electron distributions is correct for an oxygen atom?



Your answer ☐ **[1]**

9 Element **W** is in Group 17 of the Periodic Table and element **X** is in Group 2.

What is correct?

A The outer sub-shell electron configuration of **W** is p^5.

B The outer sub-shell electron configuration of **X** is p^2.

C **W** and **X** react to form the compound $\mathbf{WX_2}$.

D **X** has 5 more electrons than **W**.

Your answer ☐ **[1]**

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10 Organic compound **Y** can be described as aliphatic, cyclic and unsaturated.

Which substance could be **Y**?

A benzene

B cyclohexane

C cyclohexene

D hexene

Your answer ☐ **[1]**

11 What is correct about catalysis?

A A catalyst poison slows a reaction without affecting the catalyst.

B A catalyst remains unchanged chemically at the end of the reaction.

C A catalyst speeds up a reaction but does not take part in the reaction.

D A heterogeneous catalyst is in the same state as the reactants.

Your answer ☐ **[1]**

12 What is correct about DNA?

A The backbone consists of a phosphate – base – phosphate sequence.

B The bases cytosine and guanine join by condensation reactions.

C The bases guanine and thymine pair by three hydrogen bonds.

D The monomers are nucleotides.

Your answer ☐ **[1]**

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13 The first ionisation enthalpies of magnesium and silicon are shown in the table below.

Element	1st IE / kJ mol^{-1}
Mg	+738
Si	+789

What explains this difference?

A A Si atom has a larger atomic radius than a Mg atom.

B A Si atom has more electrons than a Mg atom.

C A Si atom has more protons than a Mg atom.

D Mg forms 2+ ions.

Your answer ☐ **[1]**

14 What volume of 0.02 mol dm^{-3} potassium manganate(VII) solution is needed to oxidise 25.0 cm^3 of 0.15 mol dm^{-3} $FeSO_4$?

The equation for the reaction is: $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

A 3.33 cm^3

B 16.7 cm^3

C 37.5 cm^3

D 188 cm^3

Your answer ☐ **[1]**

15 A compound has the formula $C_6H_5CH_2OH$.

What is a correct reaction of this compound?

A dehydration to an alkene

B oxidation to a ketone

C oxidation to an aldehyde when heated under reflux

D reaction with an acid anhydride to form an ester

Your answer ☐ **[1]**

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16 An organic liquid is contaminated with acid. The liquid is placed in a separating funnel.

What is the correct sequence for the operations that follow?

A	neutralise	wash	separate organic layer	dry	distil
B	separate organic layer	neutralise	wash	dry	distil
C	separate organic layer	wash	neutralise	distil	dry
D	wash	neutralise	separate organic layer	distil	dry

Your answer ☐ **[1]**

17 4.6 g of ethanol (C_2H_5OH, M_r = 46) are converted to ethanal.
2.0 g of ethanal (CH_3CHO) are formed.

What is correct?

A The atom economy cannot be calculated from this data.

B The oxidation state of hydrogen changes in the process.

C The percentage yield of ethanal is 43%.

D The process is reduction.

Your answer ☐ **[1]**

18 Some triplet base codes for mRNA are shown on the Data Sheet.

What is correct about RNA codes?

A An anticodon for glutamine is GTT.

B Each amino acid has only one 1 triplet code (codon).

C mRNA and tRNA have bases in the same order for the same amino acid.

D The base sequence GCCCAAUCG in mRNA codes for the amino acid sequence AlaGluSer in a protein.

Your answer ☐ **[1]**

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19 What is correct for 0.1 mol dm^{-3} ethanoic acid and 0.1 mol dm^{-3} hydrochloric acid?

A Ethanoic acid and hydrochloric acid both dissociate fully in solution.

B Hydrochloric acid has a higher pH as it has more H^+ ions per dm^3.

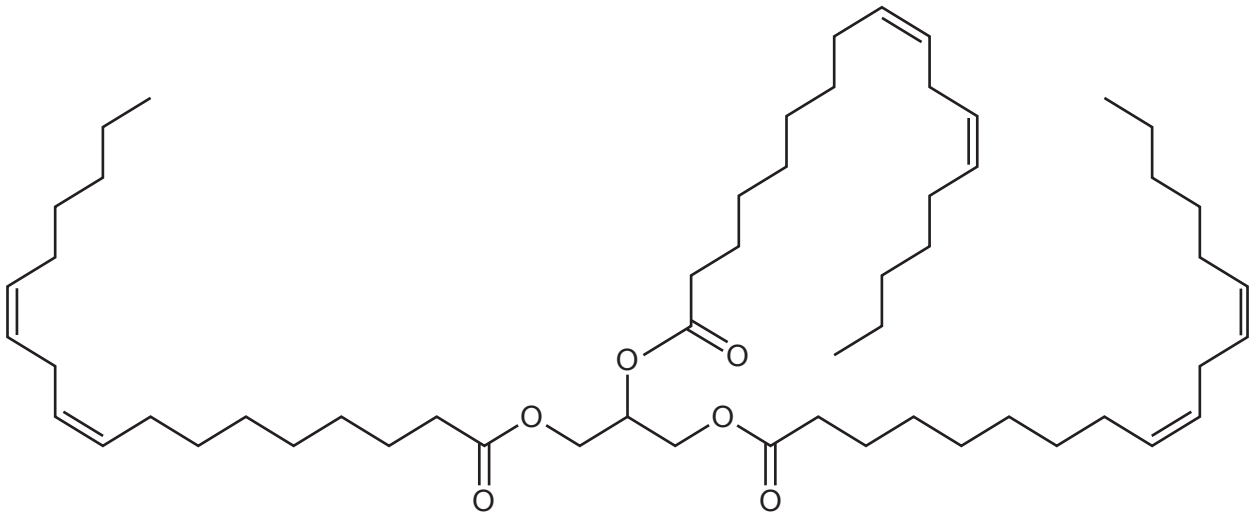
C The pH of ethanoic acid is given by –log (0.1).

D When equal volumes of the ethanoic acid and the hydrochloric acid react with magnesium, the same volume of hydrogen is produced.

Your answer ☐ **[1]**

20 The iodine number of an oil is a measure of its unsaturation.
The iodine number is the mass of iodine that will react with 100 g of the oil.

What is the iodine number of the oil shown below?



The oil has a relative molecular mass of 878.

A 87

B 130

C 173

D 260

Your answer ☐ **[1]**

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21 The decomposition of hydrogen peroxide is first order with respect to hydrogen peroxide.

The half-life for the decomposition is 900 seconds.

What percentage of the hydrogen peroxide will remain after 1 hour 15 minutes?

A 3.13%

B 6.25%

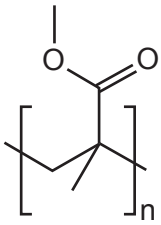
C 10.0%

D 20.0%

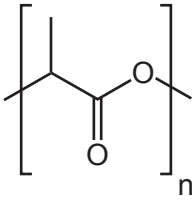
Your answer ☐ **[1]**

22 Which of the polymers shown is a condensation polymer?

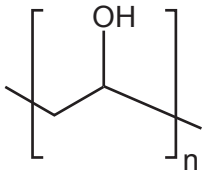
A



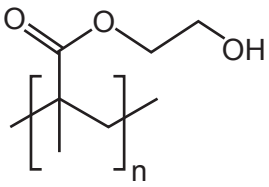
B



C



D



Your answer ☐ **[1]**

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23 A student determines the rate constant for a reaction at various temperatures and plots ln k against $1/T$. A straight line is produced.

The Arrhenius equation is $\ln k = -E_a/RT + \ln A$

What is correct for the straight line?

A E_a is the intercept on the y-axis.

B $E_a \times R$ is the gradient.

C $-E_a/R$ is the gradient.

D $-E_a$ is the gradient.

Your answer ☐ **[1]**

24 What is the reason that 1-chlorobutane has a lower boiling point than 1-iodobutane?

A 1-chlorobutane is less reactive.

B The hydrogen bonds are weaker in 1-chlorobutane.

C The instantaneous dipole – induced dipole forces are weaker in 1-chlorobutane.

D The permanent dipole – permanent dipole forces are weaker in 1-chlorobutane.

Your answer ☐ **[1]**

25 A student has 50 cm^3 of a 0.25 mol dm^{-3} solution.

What volume of water (in cm^3) should the student add to get a 0.10 mol dm^{-3} solution?

A 2.5

B 20

C 75

D 125

Your answer ☐ **[1]**

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26 What is correct about the laboratory preparation of hydrogen chloride gas?

A Chlorine is produced as a by-product.

B Concentrated sulfuric acid is used.

C NaC*l*(aq) is used.

D The HC*l* is collected over water.

Your answer ☐ **[1]**

27 What is correct about the structure shown below?

A The structure has a negative charge.

B The structure has one lone pair.

C The structure is linear.

D The bond angle is 107°.

Your answer ☐ **[1]**

28 Which of the following changes will result in a more sustainable process?

1 Increasing the temperature to get the products as fast as possible.

2 Reducing the number of steps in the process.

3 Designing a process using aqueous solutions instead of organic solvents.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

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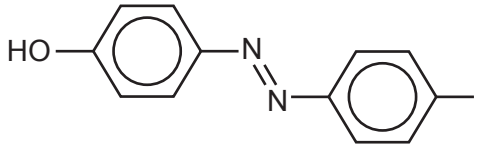
29 The molecule below is an orange dye.



Which group(s), when attached to a benzene ring in the dye, could change its colour?

1 OH

2 NH_2

3 CH_3

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

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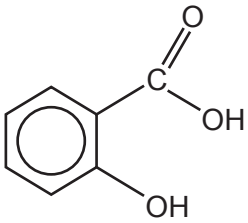
30 A substance **Z** reacts with aqueous sodium carbonate to produce carbon dioxide.

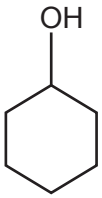
Which of the following could be substance **Z**?

1



2

3



A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

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SECTION B

Answer **all** the questions.

31 Nitrogen fertilisers usually contain ammonium ions, NH_4^+.

(a) **(i)** Draw a **dot-and-cross** diagram for a NH_4^+ ion. Show outer-shell electrons only.

[1]

(ii) Describe a test that students could do to confirm the presence of ammonium ions in a fertiliser.

.....

.....

..... **[1]**

(b) Plants cannot use nitrogen in the form of ammonium ions.

Nitrifying bacteria in the soil oxidise ammonium ions to nitrate ions using atmospheric oxygen.

(i) Give the oxidation state of nitrogen in ammonium ions and nitrate ions.

Oxidation state of nitrogen in ammonium ions, NH_4^+ .....

Oxidation state of nitrogen in nitrate ions, NO_3^- .....

[2]

(ii) Use the oxidation states to construct an equation for the oxidation of ammonium ions using atmospheric oxygen.

An acidic solution containing nitrate ions is formed.

[1]

(iii) When the oxygen concentration is low, denitrifying bacteria reduce nitrate ions to nitrogen monoxide, NO, which escapes from the soil as a gas.

Describe what is seen when the nitrogen monoxide reaches the atmosphere.

.....

..... **[1]**

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(c) Some students investigate a fertiliser containing ammonium sulfate $(NH_4)_2SO_4$.
The concentration of sulfate ions in a solution of the fertiliser can be determined by titration with barium chloride solution.

(i) Explain why one mole of sulfate ions reacts with one mole of barium ions in the titration.

.....

..... **[1]**

(ii) The students make up a solution containing 6.58 g of fertiliser in 0.250 dm^3 of deionised water.

25.0 cm^3 of this solution needs 15.50 cm^3 of 0.200 mol dm^{-3} barium chloride solution to reach the end point.

Calculate the percentage by mass of ammonium sulfate in the fertiliser.

Give your answer to an **appropriate** number of significant figures.

percentage of ammonium sulfate = ... % **[5]**

(iii) The solubility product of barium sulfate is 1.00×10^{-10} $mol^2\,dm^{-6}$.

Calculate the number of sulfate **ions** left in solution in the titration flask at the end point of a titration.

number of sulfate ions = ... **[3]**

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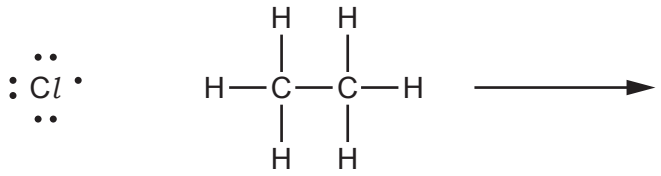
32 Chlorinated solvents were once widely used in industry.

Some are made by chlorinating ethane.

(a) The first substance to be formed is chloroethane, C_2H_5Cl.
The reaction occurs by a radical mechanism.

In the **initiation** step, chlorine radicals are formed.

Complete the equation for a **propagation** step by drawing half curly arrows and showing the products.



[2]

(b) **(i)** Chloroethane, C_2H_5Cl, reacts with concentrated ammonia.

Give the equation for the reaction.

[1]

(ii) Give two words that classify the reaction mechanism of the reaction in **(i)**.

..... **[2]**

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(c) Some students mix 5 cm^3 of ethanol and 5 cm^3 of silver nitrate solution in each of two test tubes and place them in a water bath at 50 °C. Five drops of chloroethane are added to one tube and five drops of iodoethane are added to the other at the same time.
The students see precipitates in both tubes.

(i) State the colours of the precipitates.

Colour from chloroethane .....

Colour from iodoethane .....
[1]

(ii) Write equations for the formation of the precipitate from iodoethane, C_2H_5I.

[2]

(iii) A student predicts that C–C*l* is more polar than C–I and therefore chloroethane will react faster than iodoethane.

Comment on the student's predictions.

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..... **[3]**

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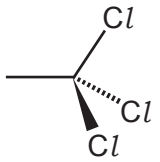
(d) Substance **A**, shown below, was once a widely used solvent.
It can be made by further chlorination of chloroethane.



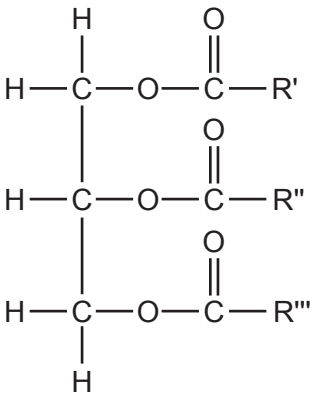
Substance **A**

(i) Give the systematic name of substance **A**.

..... **[1]**

(ii)* Substance **A** was a solvent used in the electronics industry. It can be used to dissolve polar organic solutes, such as fats, that do not dissolve well in hexane, C_6H_{14}.

State and explain the intermolecular bonding in hexane, fats and substance **A**. Use these ideas to explain why substance **A** dissolves fats better than hexane does.



An example of a fat

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..... **[6]**

Additional answer space if required

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33 Some students are investigating the reactions of copper(II) sulfate.

(a) In their first experiment they heat some crystals of copper(II) sulfate in a hot flame.

State the colour of the flame they see and explain how the heating produces the colour.

Colour of the flame .....

Effect of heating to produce colour .....

.....

..... **[2]**

(b) The students add ammonia solution to aqueous copper ions, $[Cu(H_2O)_6]^{2+}$.
First a pale blue precipitate is formed, followed by a dark blue solution containing $[Cu(NH_3)_4(H_2O)]^{2+}$ ions.

(i) Explain the formation of the pale blue precipitate in terms of a property of ammonia, writing equations.

Property of ammonia: .....

Equations:

[3]

(ii) The overall reaction between ammonia solution and aqueous copper ions is shown in the equation below.

$$[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Cu(NH_3)_4(H_2O)]^{2+}(aq) + 5H_2O(l)$$

Write an expression for the equilibrium constant for the reaction, giving the units.
Do not include the concentration of water.

K_c =

units ..... **[2]**

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(iii) The students mix 0.022 mol of $[Cu(H_2O)_6]^{2+}(aq)$ and 0.081 mol of ammonia in 1.0 dm^3 of solution.

They find that the concentration of the $[Cu(NH_3)_4(H_2O)]^{2+}$ complex is 0.020 mol dm^{-3} at equilibrium.

Calculate the concentrations of ammonia and $[Cu(H_2O)_6]^{2+}$ at equilibrium and the value of the equilibrium constant.

K_c = ... **[3]**

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(iv)* The students have available some solid $[Cu(NH_3)_4(H_2O)]\ SO_4$.
Describe how the students could use this solid and colorimetry to find the concentration of the complex in the equilibrium in **(iii)**.

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..... **[6]**

Additional answer space if required

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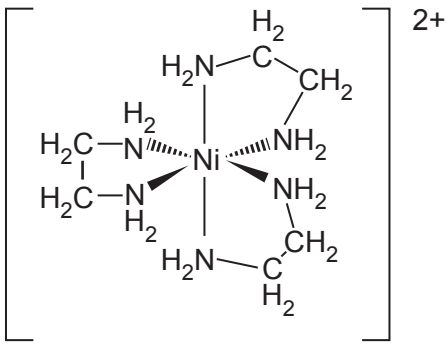
(c) 1,2-diaminoethane, $H_2NC_2H_4NH_2$, is a ligand that forms complexes with many transition metal ions.

For example, it forms complex ion **B** with Ni^{2+} ions.



Complex ion **B**

(i) What **type** of ligand is 1,2-diaminoethane?

..... **[1]**

(ii) Give the coordination number of complex ion **B**.
Name the shape and give the bond angle around the nickel.

Coordination number .....

Name of shape .....

Bond angle .....

[3]

(d) Some students want to find the formula of the complex ion formed between 1,2-diaminoethane ($H_2NC_2H_4NH_2$) and Cu^{2+} ions.
The students have a solution of 1,2-diaminoethane containing 4.5 g in 1.0 dm^3 of solution. They mix this solution with 0.050 mol dm^{-3} copper(II) sulfate solution in varying proportions.
A purple complex ion is formed.
The colour is most intense with 20 cm^3 1,2-diaminoethane and 15 cm^3 of copper(II) sulfate.

Use the students' results to calculate the formula of the complex ion.

formula is ..... **[4]**

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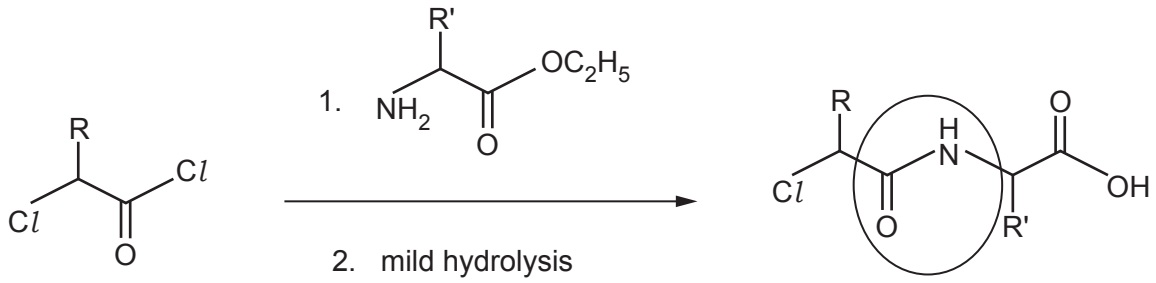
34 Some students investigate a method of synthesising polypeptides developed by Fischer in 1903.

(a) The first step consists of two reactions, the second being hydrolysis, as shown below.



(i) Name the **type** of reaction that occurs in reaction 1.

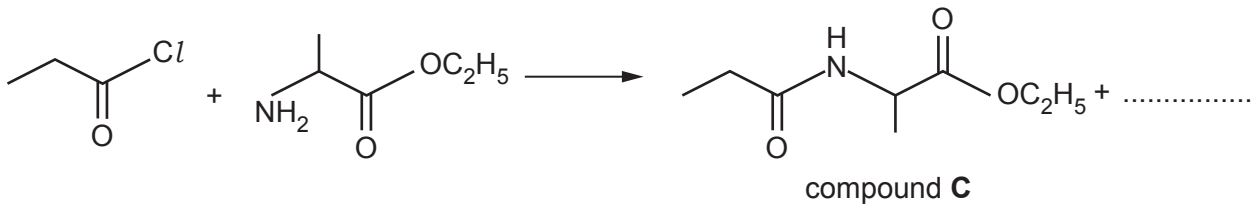
..... **[1]**

(ii) Name the functional group that is circled.

..... **[1]**

(b) The students carry out a similar reaction, as shown below.

Complete the equation for their reaction.



[1]

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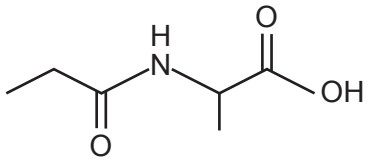
(c) One of the students suggests boiling compound **C** with dilute HC*l* to carry out the hydrolysis to compound **D**, below.
Another student says that other organic products would form as well as compound **D**.



Compound **D**

Comment on these statements, giving the formulae of any other compounds formed.

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.....

[4]

(d) The students' product, compound **C**, is a solid.

Explain how they could purify this solid by recrystallisation.

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..... **[3]**

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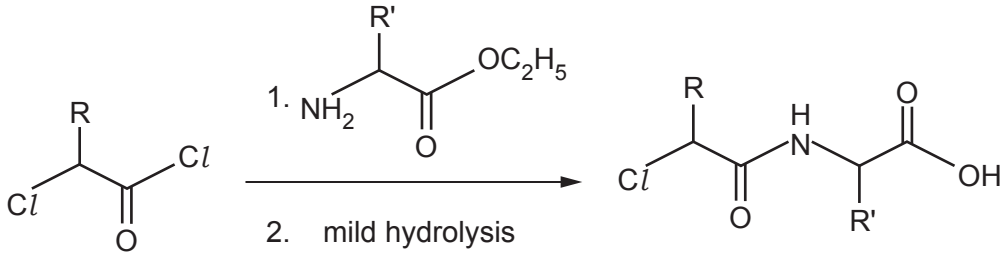
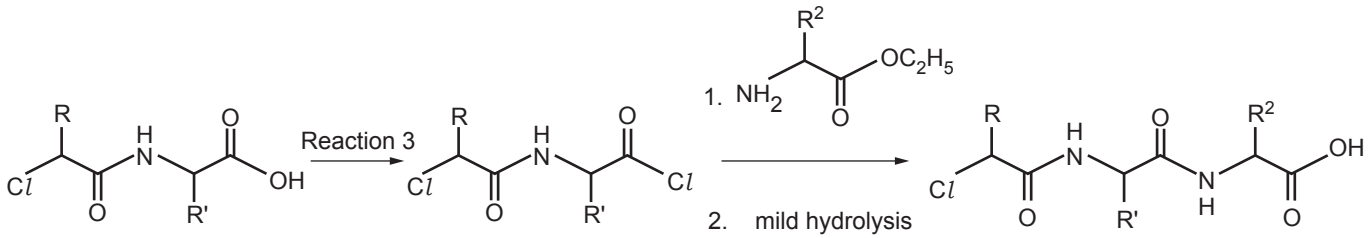
The first step from part **(a)** is:



(e) The next step in the formation of a polypeptide is:



(i) Use your Data Sheet to suggest a possible reagent for Reaction 3.

..... **[1]**

(ii) A polypeptide is a small portion of a protein chain.

Explain how the reactions shown above can lead to the formation of a polypeptide.

.....

..... **[1]**

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35 Some scientists investigate the decomposition of dinitrogen oxide, N_2O, according to the equation below.

$$2N_2O(g) \longrightarrow 2N_2(g) + O_2(g)$$

(a) They find some data for the rate of decomposition at different concentrations of N_2O.

Concentration of N_2O / mol dm^{-3}	**Rate of reaction / mol dm^{-3} s^{-1}**
1.0×10^{-6}	0.04×10^{-6}
2.0×10^{-6}	0.15×10^{-6}
3.0×10^{-6}	0.35×10^{-6}
4.0×10^{-6}	0.65×10^{-6}
5.0×10^{-6}	0.99×10^{-6}

(i) The scientists conclude that the reaction is **not** first order with respect to N_2O. Suggest why they conclude this.

.....

..... **[1]**

(ii) Plot a graph of rate against the **square** of concentration on the grid on page 29. **[3]**

(iii) Use your graph to complete the rate equation for the reaction.

Rate = k × ..... **[1]**

(iv) Use your graph to find a value for the rate constant, k, and give its units.

rate constant = ... units ..... **[3]**

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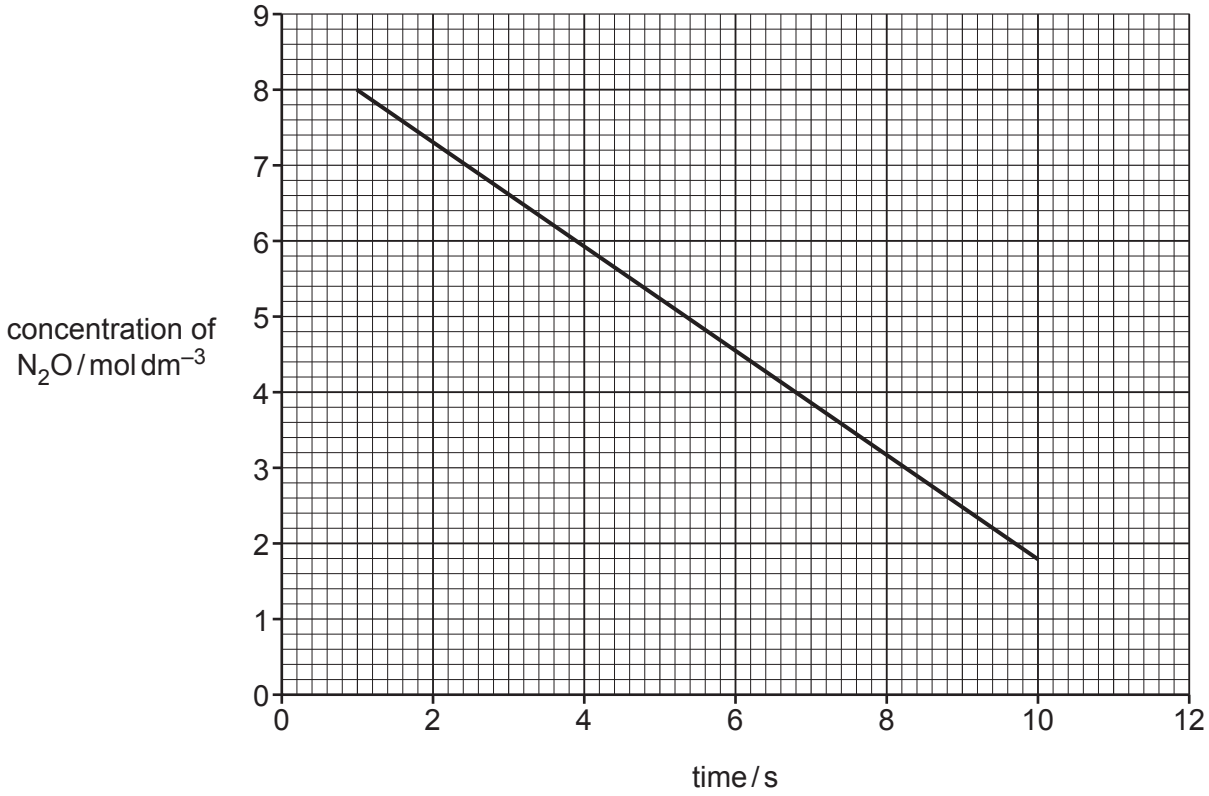
(b) The scientists are told that the rate of reaction increases if a heterogeneous catalyst of platinum is used.
They find some data on the catalysed reaction, using a higher concentration of N_2O.
They plot this data and their graph is shown below.



(i) Use the shape of the graph to give the order of the catalysed reaction with respect to N_2O.

Explain how you arrived at your answer.

.....

.....

..... **[2]**

(ii) Suggest an explanation for the order you have given.

.....

.....

..... **[1]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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