Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2026

CHEMISTRY – ORDINARY LEVEL

TUESDAY, 16 JUNE – AFTERNOON, 2:00 to 5:00

400 MARKS

Answer any **eight** questions.

All questions carry equal marks (50).

The information below should be used in your calculations.

Relative atomic masses (rounded): H = 1, O = 16, Na = 23, Mg = 24, Al = 27, Cl = 35.5

Avogadro constant = 6.0×10^{23} mol^{-1}

Molar volume at s.t.p. = 22.4 litres

The use of the *Formulae and Tables* booklet approved for use in the State Examinations is permitted. A copy may be obtained from the superintendent.

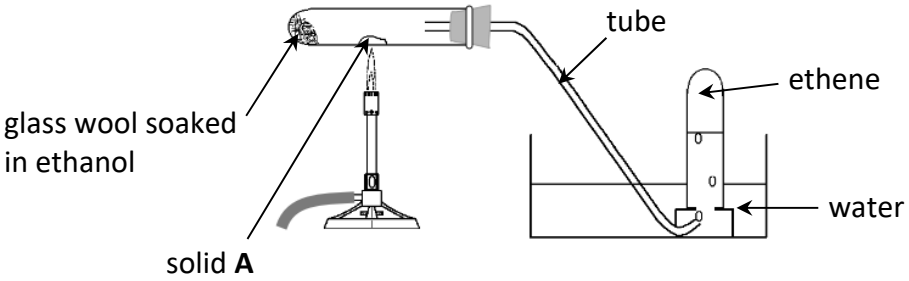
Do not hand this up.

This document will not be returned to the State Examinations Commission.

Section A

See page 1 for instructions regarding the number of questions to be answered.

1. The apparatus shown in the diagram below can be used to prepare and collect the hydrocarbon ethene (C_2H_4) in the laboratory.



(*a*) (*i*) Identify solid **A**.

(*ii*) What colour is solid **A**?

(*iii*) Explain why the tube should be removed from the water before the Bunsen burner is removed.

(*iv*) State one other precaution that should be taken when carrying out this experiment.

(*v*) State one property of ethene that allows it to be collected above water as shown. (21)

(*b*) (*i*) Ethene is an unsaturated hydrocarbon.
Explain what is meant by the term unsaturated.

(*ii*) Identify a reagent that could be used to show that ethene is unsaturated.

(*iii*) State the colour change observed when ethene is bubbled through this reagent. (15)

(*c*) (*i*) Explain what is meant by the term hydrocarbon.

(*ii*) Draw the molecular structure of ethene, including all atoms and bonds.

(*iii*) State one use for ethene. (14)

2. A student filled the piece of apparatus labelled **A**, shown on the right, with a solution of 0.2 M hydrochloric acid (**HCl**) and titrated it against 25 cm^3 portions of a sodium hydroxide (**NaOH**) solution of unknown concentration.
An approximate titration was carried out first and then two accurate titrations were carried out.


A

(*a*) (*i*) Identify the piece of apparatus labelled **A**.

(*ii*) Describe how **A** was washed before use.

(*iii*) Name the piece of apparatus that was used to transfer exactly 25 cm^3 of the **NaOH** solution to a conical flask. (15)

(*b*) (*i*) Name an indicator suitable for use in this titration.

(*ii*) State the colour change observed at the end point of this titration. (9)

The titration reaction is described by the following balanced chemical equation:

$$\mathbf{HCl + NaOH \rightarrow NaCl + H_2O}$$

The results of the titration are shown in the table below.

Approximate titration	First accurate titration	Second accurate titration
27.2 cm^3	26.5 cm^3	26.6 cm^3

(*c*) (*i*) Calculate the average volume of **HCl** needed to neutralise the **NaOH**.

(*ii*) Calculate the concentration of the **NaOH**, in moles per litre.

(*iii*) Calculate the concentration of the **NaOH**, in grams per litre. (18)

(*d*) Describe, with the aid of a labelled diagram, how a student could obtain a pure, dry sample of the sodium chloride (**NaCl**) produced during this reaction. (8)

3. (*a*) What is meant by the term rate of reaction? (5)

(*b*) A student measured the rate of production of oxygen gas ($\mathbf{O_2}$) by the decomposition of a dilute solution of hydrogen peroxide ($\mathbf{H_2O_2}$) in the presence of a suitable catalyst.

The reaction is described by the following balanced chemical equation:

$$\mathbf{2H_2O_2 \rightarrow 2H_2O + O_2}$$

(*i*) What is a catalyst?

(*ii*) Identify a suitable catalyst for the decomposition of $\mathbf{H_2O_2}$.

(*iii*) Draw a labelled diagram of a suitable apparatus for carrying out this experiment. (18)

The results are shown in the table below.

Time (seconds)	0	30	60	90	120	150
Volume of oxygen gas produced (cm^3)	0	24	36	42	47	47

(c) (*i*) Draw a graph on graph paper to show how the volume of oxygen gas produced varies with time.

(*ii*) Use your graph to estimate the time taken for 30 cm^3 of oxygen to be produced.

(*iii*) Calculate the average rate of reaction during the first 90 seconds.

(*iv*) How would you expect the initial rate of this reaction to be affected by using the same volume of a more concentrated **HCl** solution? Explain your answer. (27)

Section B

See page 1 for instructions regarding the number of questions to be answered.

4. Answer **eight** of the following (*a*), (*b*), (*c*), etc. (50)

(*a*) Name the scientist who is credited with the discovery of the nucleus.

(*b*) The combustion of octane ($\mathbf{C_8H_{18}}$) is described by the following balanced chemical equation:

$$\mathbf{2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O} \qquad \Delta H = -10\,940 \text{ kJ mol}^{-1}$$

Is this reaction exothermic or endothermic?
Justify your answer.

(*c*) What is meant by chromatography?

(*d*) Why is fluoride added to water during the water treatment process?

(*e*) How many (*i*) protons, (*ii*) electrons, are there in the ion $\mathbf{Be^{2+}}$?

(*f*) Explain why the relative atomic masses of most elements are not whole numbers.

(*g*) Sulfur is in the same group of the periodic table as oxygen.
Write down the formula for a compound formed between hydrogen (**H**) and sulfur (**S**).

(*h*) What is the name of the process used to extract eugenol (clove oil) from cloves?

(*i*) Calculate the percentage by mass of aluminium in $\mathbf{Al_2O_3}$.

(*j*) Draw the molecular structure of the aromatic compound benzene ($\mathbf{C_6H_6}$).

(*k*) Identify two alkali metals from the following list of elements:

magnesium lithium iron oxygen sodium

(*l*) Answer part **A** *or* part **B**.

A State one difference between a batch process and a continuous process in industrial chemistry.

or

B State two differences between metals and non-metals.

5. (*a*) (*i*) Explain what is meant by the term electronegativity.

(*ii*) Write down the electronegativity values for boron (**B**) and chlorine (**Cl**) from page 81 of the *Formulae and Tables* booklet.

(*iii*) The bonding in **BCl_3** is covalent. Use the electronegativity values you wrote down in (*ii*) to predict whether the bonding is *polar* covalent or *non-polar* covalent.
Justify your answer.

(*iv*) Draw a dot and cross diagram to show the arrangement of the valence electrons in a molecule of **BCl_3**.

(*v*) **BCl_3** is an example of a molecule of general formula **AX_3**. Name two possible shapes of a molecule of general formula **AX_3** from the following list of shapes:

v-shaped pyramidal linear triangular planar tetrahedral (30)

(*b*) (*i*) How do electronegativity values change across a period of the periodic table?
Explain this trend.

(*ii*) How do electronegativity values change down a group of the periodic table?
Explain this trend. (12)

(*c*) (*i*) Another type of bonding is ionic bonding. What is ionic bonding?

(*ii*) Identify an ionic compound. (8)

6. Answer the questions that follow with reference to compounds **A** to **E** in the table below.

A	**CH_4**
B	**C_2H_2**
C	**C_3H_8**
D	**C_4H_{10}**
E	**$C_6H_5CH_3$**

(*a*) (*i*) State the systematic IUPAC name of compound **A**.

(*ii*) State the systematic IUPAC name of compound **C**.

(*iii*) Identify a compound from the table that is an aromatic compound.

(*iv*) Identify two compounds from the table that are the main constituents of liquid petroleum gas (LPG). (15)

(*b*) (*i*) Name the homologous series to which compound **A** belongs.

(*ii*) Name the homologous series to which compound **B** belongs. (6)

(*c*) (*i*) When compound **B** burns completely in oxygen, two other compounds are produced. Copy, complete and balance the following chemical equation for the complete combustion of compound **B**.

$$C_2H_2 + O_2 \rightarrow$$

(*ii*) Describe the appearance of the flame of compound **B** when it burns in air. (15)

(*d*) (*i*) What is the name given to compounds that have the same chemical formula but different molecular structures?

(*ii*) **C_4H_{10}** has two possible molecular structures. Draw either of these molecular structures, including all the atoms and bonds.

(*iii*) State the systematic IUPAC name for the structure you have drawn. (14)

7. (*a*) A sample of water was taken from a river and several tests were carried out on the water.

(*i*) Describe how soap flakes could be used to test the hardness of the water.

(*ii*) A few drops of a solution of silver nitrate (**$AgNO_3$**) were added to a sample of the water to test for the presence of chloride (**Cl^-**) ions.
What observation would confirm that chloride ions were present in the water? (12)

(*b*) The water sample was determined to have high levels of both temporary hardness and permanent hardness.

(*i*) Identify a substance that causes temporary hardness in water.

(*ii*) Explain the difference between temporary hardness and permanent hardness.

(*iii*) Identify a method for removing permanent hardness from water.

(*iv*) State one disadvantage of hard water. (15)

(*c*) The pH of the water was tested and it was determined that it was acidic.

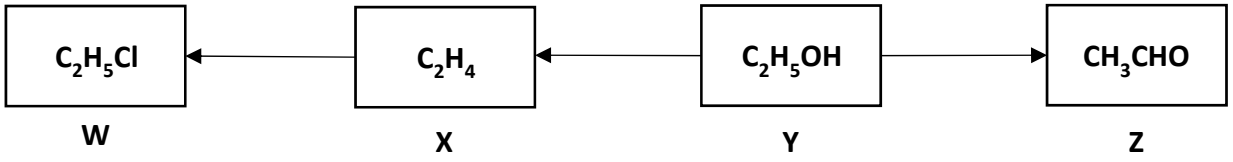
(*i*) What is an acid?

(*ii*) What is pH?

(*iii*) Describe how the pH of the water could be tested.

(*iv*) Suggest a possible pH value for the acidic water. (23)

8. Study the series of reactions shown below and answer the questions that follow.



(*a*) (*i*) State the systematic IUPAC name of compound **Y**.

(*ii*) State the systematic IUPAC name of compound **Z**.

(*iii*) Draw the molecular structure of compound **Z**, including all atoms and bonds.

(*iv*) Draw a circle around the carbonyl group of compound **Z**.

(*v*) How many tetrahedral carbons are there in a molecule of compound **Z**? (21)

(*b*) Reactions may be classified using the following terms:

addition substitution elimination oxidation

(*i*) Use one of these terms to classify the conversion of compound **X** to compound **W**.

(*ii*) Use one of these terms to classify the conversion of compound **Y** to compound **X**.

(*iii*) Use one of these terms to classify the conversion of compound **Y** to compound **Z**. (9)

(*c*) (*i*) Identify reagents that could be used to convert compound **Y** to compound **Z**.

(*ii*) Compound **Y** is highly soluble in water. Explain why. (12)

(*d*) (*i*) One of the four compounds **W**, **X**, **Y** and **Z** can be polymerised. Identify which one.

(*ii*) One of the four compounds **W**, **X**, **Y** and **Z** can be formed by the halogenation of $\mathbf{C_2H_6}$. Identify which one. (8)

9. (*a*) In the manufacture of sulfuric acid during the contact process, sulfur dioxide (**SO_2**) and oxygen (**O_2**) react in the presence of a catalyst to produce sulfur trioxide (**SO_3**).
An equilibrium is established.

The equilibrium is described by the following balanced chemical equation:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \qquad \Delta H = -198 \text{ kJ mol}^{-1}$$

(*i*) Explain what is meant by the term chemical equilibrium.

(*ii*) Write an expression for the equilibrium constant K_c for this reaction.

According to Le Châtelier's principle, if certain conditions are changed in an equilibrium system, the system adjusts to relieve the stress applied.

(*iii*) Predict the effect on the concentration of **SO_3** if the pressure is increased.
Justify your answer.

(*iv*) Predict the effect on the concentration of **SO_3** if the temperature is increased.
Justify your answer.

(*v*) Predict the effect on the concentration of **SO_3** if the catalyst is removed.
Justify your answer. (29)

(*b*) **SO_2** is a colourless gas, with a pungent smell, similar to the smell of a just-struck match.
If **SO_2** is released from its container, the room fills up with its smell.

(*i*) Name the process that is responsible for the spreading of gas particles to fill a room.

(*ii*) In which state of matter (solid, liquid or gas) do particles move around fastest? (6)

(*c*) Charles's law and Boyle's law are two of the gas laws that can be combined to make what is known as the combined gas law:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

(*i*) State Charles's law.

(*ii*) A sample of **SO_2** at a temperature of 298 K and a pressure of 2×10^5 Pa has a volume of 6.1 litres. Using the combined gas law shown above, calculate the volume occupied by the **SO_2** at standard temperature (273 K) and standard pressure (1×10^5 Pa). (15)

10. Answer any **two** of the parts (*a*), (*b*) and (*c*). (2 × 25)

(*a*) When chlorine gas is bubbled through a solution of iron(II) sulfate, the reaction that occurs may be described by the following balanced chemical equation:

$$\mathbf{Cl_2 + 2Fe^{2+} \rightarrow 2Fe^{3+} + 2Cl^-}$$

Oxidation and reduction occur during this reaction.

(*i*) In terms of electrons, explain what is meant by oxidation.

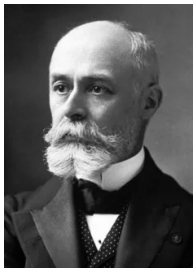
(*ii*) In terms of electrons, explain what is meant by reduction.

(*iii*) Identify the substance oxidised in this reaction.

(*iv*) Identify the oxidising agent.

(*v*) How many electrons are transferred when this chemical reaction occurs as described by the balanced equation? (25)

(*b*) Radioactivity is observed when the nucleus of a radioisotope decays to emit one or more types of radiation.



(*i*) The French scientist shown on the right discovered radioactivity while carrying out experiments on uranium salts in 1896.
Name this scientist.

(*ii*) Identify the three types of nuclear radiation.

(*iii*) Which of these types of nuclear radiation is most penetrating?

(*iv*) Uranium was the first radioactive element to be discovered.
Identify one other example of a radioactive element.

(*v*) State two uses of radioisotopes.

(*vi*) What is meant by the term half-life of a radioactive sample? (25)

(*c*) When 3.6 g of magnesium (**Mg**) metal reacts with hydrochloric acid (**HCl**), hydrogen ($\mathbf{H_2}$) gas is produced. This reaction is described by the following balanced chemical equation:

$$\mathbf{2HCl + Mg \rightarrow MgCl_2 + H_2}$$

(*i*) Calculate how many moles are in 3.6 g of **Mg**.

(*ii*) How many moles of **HCl** react with the **Mg**?

(*iii*) Calculate how many molecules of **HCl** react.

(*iv*) Calculate the mass of $\mathbf{MgCl_2}$ produced.

(*v*) Calculate the volume of $\mathbf{H_2}$ gas produced under conditions of s.t.p. (25)

11. Answer any **two** of the parts (*a*), (*b*), (*c*) and (*d*). (2 × 25)

(*a*) A flame test was carried out on a sample of potassium chloride (**KCl**).

(*i*) State two safety precautions that should be taken when carrying out a flame test.

(*ii*) Describe the steps involved in carrying out a flame test.

(*iii*) Name the colour of the flame for **KCl**.

A sample of sodium chloride (**NaCl**) was tested in a similar manner.

(*iv*) How could cross-contamination between the two salts be avoided?

(*v*) State the colour of the flame for **NaCl**. (25)

(*b*) Lead was first added to petrol in the 1920s to improve the efficiency of vehicles and raise the octane number of the fuel.

(*i*) What is meant by the term octane number?

(*ii*) Explain why the use of lead was discontinued.

(*iii*) Apart from using lead, state one other way of increasing the octane number of a fuel.

(*iv*) Petrol is one of the fractions separated from crude oil during fractional distillation in an oil refinery.
Name two other fractions and state a use for each one. (25)

(*c*) The following terms are omitted from the passage below which describes the stages of sewage treatment.

bacteria **nitrogen** **polluted** **phosphorus**

screening **settlement** **oxygen**

In your answerbook, write the term corresponding to each of the letters **A** to **G**.

Before sewage can be released into rivers, lakes or seas, it is treated in three separate processes. If untreated sewage was released into water, there would be a high demand for dissolved **A** and as a result the water would become **B**.

The first process in sewage treatment is called primary treatment. It is a mechanical process, where large solids are removed by **C** and suspended solids are removed by **D**.

Secondary treatment is where suspended and dissolved organic material is decomposed by **E** that use oxygen from the air.

Tertiary treatment involves the removal of compounds of **F** and **G** from the sewage. (25)

(*d*) Answer part **A** *or* part **B**.

A Choose <u>one</u> of the following chemical industries and answer the questions that follow:

- the manufacture of ammonia from natural gas, water vapour and air
- the manufacture of nitric acid from ammonia
- the manufacture of magnesium oxide from sea water

(*i*) State the chemical formula of a product in the industry you have chosen.

(*ii*) State where the manufacturing process happens or used to happen.

(*iii*) State two reasons why this location was chosen.

(*iv*) Explain how waste effluent is managed in the industry you have chosen.

(*v*) Describe how safety is promoted in the industry you have chosen. (25)

or

B The addition polymer poly(chloroethene), also known as polyvinyl chloride or PVC, is widely used to manufacture window frames, drainpipes, credit cards, and many other plastic objects.

(*i*) State one property of PVC that makes it suitable for manufacturing these objects.

Chloroethene monomers react to form the polymer PVC.

(*ii*) What is a monomer?

(*iii*) What is a polymer?

(*iv*) Name one other addition polymer.

(*v*) Outline the importance of recycling plastics.

(*vi*) Name any two of the five stages involved in the recycling of plastics. (25)

There is no examination material on this page.

Acknowledgements

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Leaving Certificate – Ordinary level

Chemistry

Tuesday, 16 June

Afternoon, 2:00 – 5:00