Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2024

CHEMISTRY – ORDINARY LEVEL

TUESDAY, 18 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, C = 12, N = 14, O = 16

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.

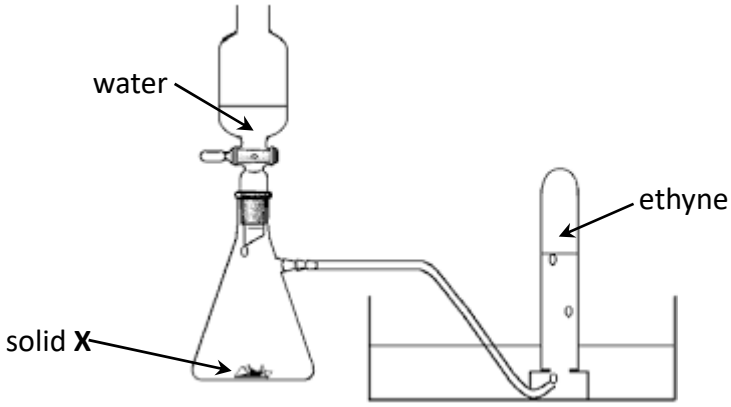
This document will not be returned to the State Examinations Commission.

The 2024 examination papers were adjusted to compensate for disruptions to learning due to COVID-19. This examination paper does not necessarily reflect the same structure and format as the examination papers of past or subsequent years.

Section A

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

1. The diagram below shows the apparatus used for the preparation of ethyne (C_2H_2) gas in the laboratory.



(*a*) Ethyne is an unsaturated hydrocarbon.

(*i*) In organic chemistry, what is meant by unsaturation?

(*ii*) What is a hydrocarbon? (12)

(*b*) (*i*) Identify solid **X**.

(*ii*) Why is water added dropwise rather than poured directly onto **X**?

(*iii*) What is observed when water is added to **X**?

(*iv*) State one property of ethyne that allows it to be collected above water as shown. (22)

(*c*) (*i*) Describe what would be observed when a sample of ethyne is burned in air.

(*ii*) Write a balanced chemical equation for the combustion of ethyne in oxygen (O_2).

(*iii*) State one use for ethyne. (16)

2. The concentration of hydrochloric acid (**HCl**) was found by titrating it against a 0.05 M solution of sodium carbonate (**Na_2CO_3**).

A

(*a*) The piece of apparatus labelled **A** was used to transfer exactly 25 cm^3 of **Na_2CO_3** to a conical flask.

(*i*) Identify **A**.

(*ii*) Describe the procedure used to wash and fill **A** and to use it to transfer 25 cm^3 of **Na_2CO_3** to the conical flask. (17)

An indicator was used to identify the endpoint of this titration.

(*b*) (*i*) What is meant by the term endpoint?

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

(*iii*) State the colour change observed.

(*iv*) State two precautions that should be taken to ensure an accurate result. (18)

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

$$\mathbf{Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2}$$

One approximate titration and two accurate titrations were carried out.
The results are shown in the table below.

Approximate titration	First accurate titration	Second accurate titration
20.9 cm^3	20.6 cm^3	20.5 cm^3

(*c*) (*i*) Calculate the average volume of **HCl** needed to neutralise the **Na_2CO_3**.

(*ii*) Calculate the concentration of **HCl** in moles per litre. (15)

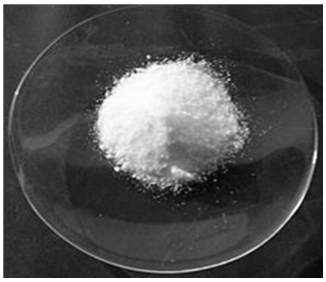
3. A student was given unlabelled samples of lithium chloride (**LiCl**), sodium chloride (**NaCl**) and potassium chloride (**KCl**).

(*a*) To identify the samples, the student carried out flame tests.

(*i*) Describe how the flame tests could have been carried out.

(*ii*) State the colour of the flame observed for each salt. (25)

(*b*) The student was given another set of samples of three different unknown compounds. The compounds were on clock glasses labelled **A**, **B** and **C**. The compounds were sodium chloride (**NaCl**), sodium sulfate ($\mathbf{Na_2SO_4}$) and sodium carbonate ($\mathbf{Na_2CO_3}$).



When a sample of compound **A** was mixed with dilute hydrochloric acid (**HCl**) fizzing was observed. The gas produced turned limewater milky.

(*i*) Draw a labelled diagram to show how the gas produced could have been tested with limewater.

(*ii*) Identify the gas produced.

(*iii*) Identify compound **A**.

When a sample of compound **B** was dissolved in water and mixed with a solution of barium chloride ($\mathbf{BaCl_2}$) a white precipitate was produced.

(*iv*) Identify compound **B**.

(*v*) Identify a reagent which could be used to confirm that compound **C** contained chloride ($\mathbf{Cl^-}$) ions. (25)

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*) A cup of coffee contains 0.095 g of caffeine ($\mathbf{C_8H_{10}N_4O_2}$).
Calculate the number of moles of caffeine in this cup.

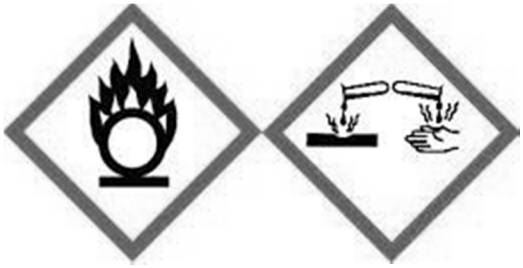
(*b*) What is an ionic bond?

(*c*) What are isotopes?

(*d*) Name a piece of apparatus used to measure the heat of combustion of a compound.

(*e*) Write a balanced chemical equation for the reaction of magnesium hydroxide ($\mathbf{Mg(OH)_2}$) with hydrochloric acid to produce magnesium chloride ($\mathbf{MgCl_2}$) and water.

(*f*) A chemical container had the warning symbols labelled **A** and **B** on it.
- (*i*) State the chemical hazard indicated by symbol **A**.
- (*ii*) State the chemical hazard indicated by symbol **B**.



A **B**

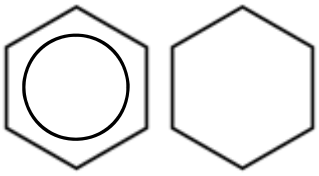
(*g*) Identify the carboxylic acid found in the stings of nettles and ants.

(*h*) Describe what happens during the primary stage of sewage treatment.

(*i*) When a small amount of air freshener is sprayed in a room it is soon detected in all parts of the room. Explain why this occurs.

(*j*) Define oxidation in terms of electron transfer.

(*k*) Molecular structures **X** and **Y** both represent cyclic hydrocarbons that contain six carbon atoms.
Which of these hydrocarbons is an aromatic compound?



X **Y**

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

A Explain the term "continuous process" in industrial chemistry.

or

B Name the scientist pictured who used X-ray crystallography to determine the structure of vitamin B12.

5. The periodic table on page 81 of the *Formulae and Tables* booklet shows the electronegativity values of the elements. Part of this table is shown in the diagram below.

1																	18
1 **H** 2.20	2											13	14	15	16	17	2 **He** – –
3 **Li** 0.98	4 **Be** 1.57											5 **B** 2.04	6 **C** 2.55	7 **N** 3.04	8 **O** 3.44	9 **F** 3.98	10 **Ne** – –
11 **Na** 0.93	12 **Mg** 1.31	3	4	5	6	7	8	9	10	11	12	13 **Al** 1.61	14 **Si** 1.90	15 **P** 2.19	16 **S** 2.58	17 **Cl** 3.16	18 **Ar** – –
19 **K** 0.82	20 **Ca** 1.00	21 **Sc** 1.36	22 **Ti** 1.54	23 **V** 1.63	24 **Cr** 1.66	25 **Mn** 1.55	26 **Fe** 1.83	27 **Co** 1.88	28 **Ni** 1.91	29 **Cu** 1.90	30 **Zn** 1.65	31 **Ga** 1.81	32 **Ge** 2.01	33 **As** 2.18	34 **Se** 2.55	35 **Br** 2.96	36 **Kr** – –

Electronegativity values increase across a period of the periodic table.

(*a*) (*i*) What is meant by the term electronegativity?

(*ii*) Explain why electronegativity values increase across a period.

(*iii*) Describe the trend in electronegativity values down a group.
Explain why this trend occurs. (22)

(*b*) Nitrogen trifluoride ($\mathbf{NF_3}$) is a greenhouse gas.

(*i*) Name another greenhouse gas.

(*ii*) Write the electron configuration for an atom of nitrogen (**N**).

(*iii*) Write the electron configuration for an atom of fluorine (**F**).

(*iv*) Draw a dot and cross diagram to show the arrangement of the valence electrons in a molecule of $\mathbf{NF_3}$.

(*v*) Use the table shown above to calculate the electronegativity difference between **N** and **F**.

(*vi*) Use your answer to (*v*) to predict the type of bonding between the fluorine atoms and the nitrogen atom in $\mathbf{NF_3}$.

(*vii*) Suggest a possible shape for a molecule containing 4 atoms, such as $\mathbf{NF_3}$. (28)

6. (*a*) Liquefied petroleum gas (LPG) is a fuel for some heating and cooking appliances. Isomers with the molecular formula $\mathbf{C_4H_{10}}$ are present in LPG.

(*i*) What are isomers?

(*ii*) Draw the molecular structure of each of the two isomers with the molecular formula $\mathbf{C_4H_{10}}$, including all atoms and bonds.

(*iii*) For each of the structures you drew in (*ii*), state the systematic IUPAC name of the isomer.

(*iv*) Identify a component of LPG which does not have the molecular formula $\mathbf{C_4H_{10}}$.

(*v*) Identify the sulfur-containing compounds which may be added to give LPG an unpleasant smell, warning of leaks. (25)

(*b*) E10 petrol is a fuel containing up to 10% bioethanol. In 2023, E10 petrol replaced E5 petrol in Ireland.

E10 petrol and E5 petrol have different octane numbers.

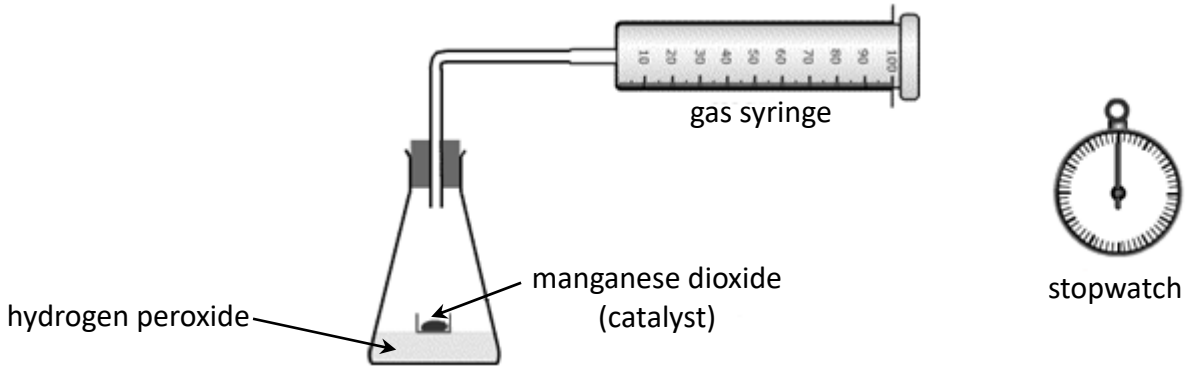
(*i*) What is meant by the term octane number?

(*ii*) State two ways of increasing the octane number of a fuel.

(*iii*) Explain the significance of the compounds heptane and 2,2,4-trimethylpentane in relation to octane number.

(*iv*) Petrol is obtained by the fractional distillation of crude oil. State one property that the molecules in the petrol fraction have in common with each other. (25)

7. The rate of decomposition of hydrogen peroxide (H_2O_2) using manganese dioxide as a catalyst was investigated using the apparatus shown below.



The oxygen (O_2) gas produced was collected in the gas syringe.

The results are shown in the table below.

Time (minutes)	0	2	4	6	8	10	12	14	16	18
Volume of O_2 (cm^3)	0	29	48	63	73	81	87	90	92	92

(*a*) (*i*) Define rate of reaction.

(*ii*) Draw a graph on graph paper to show how the volume of O_2 produced varies with time.

(*iii*) Use your graph to estimate the volume of oxygen collected during the first 7 minutes.

(*iv*) Calculate the average rate of reaction during the first 4 minutes. (27)

(*b*) (*i*) Explain why the reaction slows down as it proceeds.

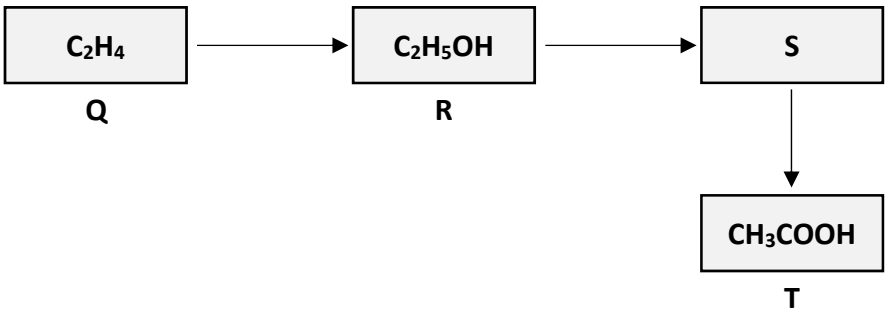
(*ii*) The results in the table above were obtained using a fine powder of manganese dioxide. How might the rate of reaction be different if the same mass of manganese dioxide was used but in the form of large pellets?
Explain your answer. (14)

(*c*) Liver contains an enzyme which can decompose hydrogen peroxide.

(*i*) What is an enzyme?

(*ii*) Name an enzyme. (9)

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



(*a*) (*i*) Compound **Q** is ethene. Name the homologous series to which compound **Q** belongs.

(*ii*) Name compound **R**.

(*iii*) Name compound **T**.

(*iv*) Is the conversion of compound **Q** to compound **R** classified as an addition reaction, a substitution reaction or an elimination reaction? (18)

(*b*) Compound **S** is an aldehyde. It reacts with Fehling's reagent to produce compound **T**.

(*i*) Identify compound **S**.

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

(*iii*) Describe the colour change that occurs when compound **S** reacts with Fehling's reagent.

(*iv*) Identify the metal element in Fehling's reagent which is responsible for the colour change observed. (21)

(*c*) A gas is produced when a clean piece of magnesium (**Mg**) ribbon is added to a test tube containing a solution of compound **T**.

(*i*) Name the gas produced.

(*ii*) What is observed when a lighted taper is held at the mouth of the test tube? (11)

9. (*a*) (*i*) What is a strong base?

(*ii*) When a strong base reacts with a strong acid, a neutralisation reaction occurs. Would you expect heat to be absorbed or released during neutralisation? (9)

(*b*) A neutralisation reaction occurs between 0.01 M hydrochloric acid (**HCl**) and a 0.01 M solution of sodium hydroxide (**NaOH**).

(*i*) Define pH.

(*ii*) Calculate the pH of the **HCl**.

(*iii*) Calculate the pH of the **NaOH** solution.

(*iv*) Outline one limitation of the pH scale. (18)

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

chlorination **filtration** **flocculation** **fluoridation**

pH adjustment **sedimentation** **screening**

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

Stage	**Description**
Stage **A**	Water is passed through a wire mesh to remove any floating debris.
Stage **B**	Chemicals are added to the water to help small suspended solids clump together.
Stage **C**	Suspended solids are allowed to settle to the bottom of large tanks.
Stage **D**	Water is passed through beds of sand to remove suspended solids.
Stage **E**	Harmful micro-organisms in the water are killed.
Stage **F**	Chemicals are added to the water which can help strengthen teeth.
Stage **G**	Small amounts of acid or base are added to the water.

(23)

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

(*a*) Multistriatin is an organic compound released by the female elm bark beetle when she has found a good source of food.

(*i*) Explain the underlined term.

Following analysis, a sample of multistriatin was found to contain 70.59 % carbon, 10.59 % hydrogen and 18.82 % oxygen by mass.

(*ii*) Calculate the empirical formula of multistriatin.

(*iii*) Multistriatin has a relative molecular mass of 170. Calculate its molecular formula.

(*iv*) Identify a chemical compound that has the same molecular formula as its empirical formula. (25)

(*b*) Consider the equilibrium described by the following balanced chemical equation:

$$\mathbf{2NO_2}_{(g)} \rightleftharpoons \mathbf{N_2O_4}_{(g)} \qquad \Delta H = -57.2 \text{ kJ mol}^{-1}$$

Nitrogen dioxide (**NO_2**) has a dark brown colour. Dinitrogen tetroxide (**N_2O_4**) is colourless.

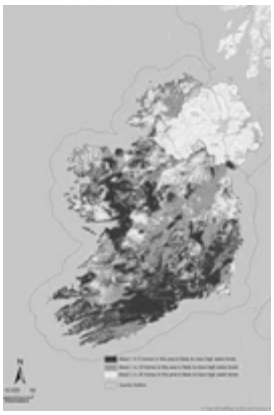
(*i*) Write the equilibrium constant (K_c) expression for this equilibrium.

A mixture of **NO_2** and **N_2O_4** is allowed to reach equilibrium.
The mixture has a light brown colour.

(*ii*) What would be observed in the equilibrium mixture if the temperature was increased? Justify your answer.

(*iii*) What would be observed in the equilibrium mixture if the pressure was increased? Justify your answer. (25)

(*c*) In Ireland, high levels of radon–222 ($^{222}_{86}$**Rn**) are found in areas such as Galway and Wicklow, which have a lot of granite rock.



Radon–222 is the most stable isotope of radon, with a half-life of approximately 3.8 days. It decays by emitting an alpha particle.

(*i*) Explain the underlined term.

(*ii*) How many protons are present in an atom of $^{222}_{86}$**Rn**?

(*iii*) How many neutrons are present in an atom of $^{222}_{86}$**Rn**?

(*iv*) How many electrons are present in a neutral atom of $^{222}_{86}$**Rn**?

(*v*) What is an alpha particle?

(*vi*) State one property of an alpha particle. (25)

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

(*a*) (*i*) Name the British scientist who proposed a model of the atom as a sphere of positive charge with electrons embedded in it, also known as the plum pudding model.

(*ii*) Name the New Zealand scientist who proposed that an atom is mainly empty space with a dense nucleus at the centre, following his experiments using gold foil.

(*iii*) Name the Russian scientist who proposed the periodic law and produced a periodic table of elements.

(*iv*) Describe how the elements are ordered in the modern periodic table.

(*v*) The elements of group 1 of the periodic table are called the alkali metals and include lithium (**Li**), sodium (**Na**) and potassium (**K**).
State one property that these elements have in common.

(*vi*) The elements of group 18 of the periodic table are called the noble gases and include helium (**He**), neon (**Ne**) and argon (**Ar**).
Describe what is common to the electronic structure of these elements. (25)

(*b*) (*i*) Name the Irish scientist who proposed the law describing the relationship between the pressure (*P*) and volume (*V*) of a fixed mass of gas at constant temperature (*T*).

(*ii*) Name the French scientist who proposed the law describing the relationship between the volume (*V*) and temperature (*T*) of a fixed mass of gas at constant pressure (*P*).

(*iii*) Write the equation for the combined gas law.

(*iv*) A sample of a gas was found to occupy a volume of 253 cm^3 at a temperature of 300 K and a pressure of 95 kPa.
Calculate the volume that the gas would occupy at a temperature of 350 K and a pressure of 105 kPa. (25)

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

(*ii*) Describe how chromatography could be used to separate a mixture of chemical indicators. (A labelled diagram may help your answer.)

(*iii*) HPLC is an advanced instrumental method of separation which uses chromatography.
What is meant by HPLC?

(*iv*) Name one other instrumental method of separation or analysis. (25)

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

A (*i*) Name a chemical industry which you have studied.

(*ii*) Identify the raw materials used for this industry.

(*iii*) Describe the quality control processes for this industry.

(*iv*) Describe any one safety issue for this industry.

(*v*) State one factor taken into account when choosing a location for this industry. (25)

or

B (*i*) State two differences between metals and non-metals.

(*ii*) What is an alloy?

(*iii*) State one example of an alloy.

(*iv*) State the composition of the alloy you have named.

(*v*) Suggest a reason why alloys can be more useful than pure metals. (25)

There is no examination material on this page.

Acknowledgements

Images

Image on page 4	wikipedia.org
Images on page 5	stackoverflow.com; npg.org.uk
Image on page 7	alamy.com
Image on page 11	gsi.ie

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Leaving Certificate – Ordinary level

Chemistry

Tuesday, 18 June

Afternoon, 2:00 – 5:00