Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2012

CHEMISTRY – ORDINARY LEVEL

TUESDAY, 19 JUNE – AFTERNOON 2.00 TO 5.00

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400 MARKS

Answer **eight** questions in all

These **must** include at least **two** questions from **Section A**

All questions carry equal marks (50)

Information

Relative atomic masses: H = 1, C = 12, O = 16, Cl = 35.5

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

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

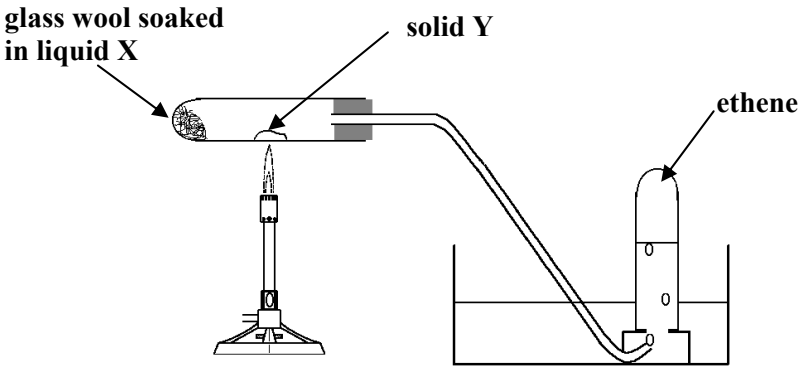
The use of the formulae and tables booklet approved for use in the State Examinations is permitted. A copy may be obtained from the examination superintendent.

Section A

Answer at least <u>two</u> questions from this Section [see page 1 for full instructions].

1. Answer the questions below in relation to the following organic compounds: ethene ($\mathbf{C_2H_4}$) and ethyne ($\mathbf{C_2H_2}$).

(*a*) The apparatus shown in the diagram may be used for the preparation of ethene in the school laboratory.



Identify: (*i*) liquid **X**,

(*ii*) solid **Y**. (8)

(*b*) How would you prevent a 'suck-back' occurring when carrying out this experiment?

What risk does a 'suck-back' present? (12)

(*c*) Name the type of organic reaction involved in the preparation of ethene from liquid **X** according to the following equation.

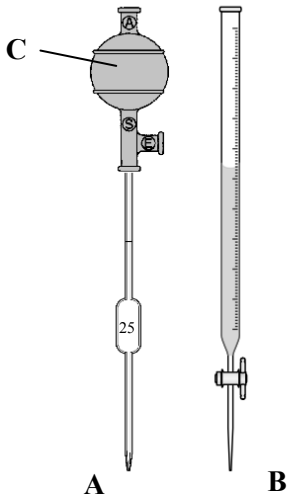
$$\mathbf{X} \rightarrow \mathbf{C_2H_4} + \mathbf{H_2O}$$ (6)

(*d*) Draw a labelled diagram for the preparation and collection of ethyne gas in the school laboratory. Indicate clearly on the diagram the names *or* formulas of the substances used in the preparation. (12)

(*e*) Explain what is meant by saying that ethene and ethyne are *unsaturated* compounds.

In the case of either one of the compounds, describe a test to show that it is unsaturated. (12)

2. The three pieces of equipment, **A**, **B** and **C**, shown are used in volumetric analysis.



(*a*) Name the pieces of equipment **A** and **B**.
Why is it advisable to use **C** when measuring a solution with **A**? (11)

(*b*) Describe the procedure for rinsing **A** and **B** before they are used to measure the solutions used in a titration. (12)

(*c*) If the volume of solution delivered using **A** is to be accurate, the last drop of solution must not be blown or shaken out.

Explain why this is so. (6)

Using **A**, **B** and **C**, and some other pieces of equipment, it was found by titration that, on average, 25.0 cm^3 of a solution of sodium hydroxide (**NaOH**) exactly neutralised 20.0 cm^3 of a 0.08 M solution of hydrochloric acid (**HCl**). The equation for the titration reaction is:

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

(*d*) Name **one** other piece of equipment used in carrying out the titrations. (3)

(*e*) Name a suitable indicator for this titration and state the colour change at the end point. (9)

(*f*) Calculate the concentration of the sodium hydroxide solution in moles per litre. (9)

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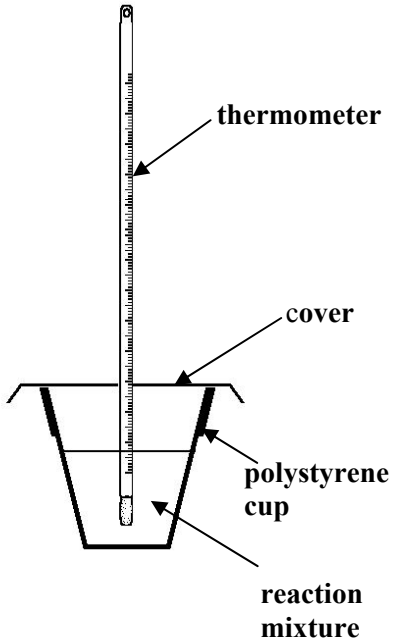
3. In an experiment to measure the heat of reaction (**Δ*H***) for the reaction between hydrochloric acid (**HCl**) and sodium hydroxide (**NaOH**), 100 cm^3 of 2M **HCl** were added to 100 cm^3 of 2M **NaOH** in the apparatus shown in the diagram. The rise in temperature was noted and the heat produced was found to be 11.4 kJ. The equation for the reaction is:



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

(*a*) Explain the underlined term. (8)

(*b*) What is an *exothermic reaction*?

State the evidence that shows that the reaction between hydrochloric acid and sodium hydroxide is exothermic. (9)

(*c*) Indicate **two** features of the apparatus that help to minimise heat lost to the surroundings.

In the case of **either** feature, explain how it does this. (9)

(*d*) Calculate:

(*i*) the number of moles of **HCl** in 100 cm^3 of 2M **HCl**,

(*ii*) how many kilojoules of heat would be produced if 1 mole of **HCl** reacted fully with **NaOH**.

What is the heat of reaction (**Δ*H***) for this reaction? (18)

(*e*) The symbol shown on the right is found on bottles of hydrochloric acid. What does this symbol signify? (6)

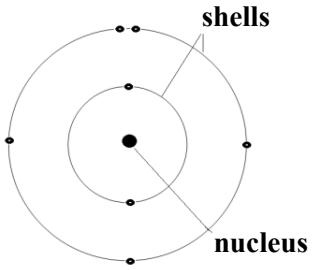
Section B

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

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

(*a*) Name the three states of matter.

(*b*) The diagram on the right shows the arrangement of electrons in the main energy levels (shells) in an atom of a particular element in its ground state.



Identify the element.

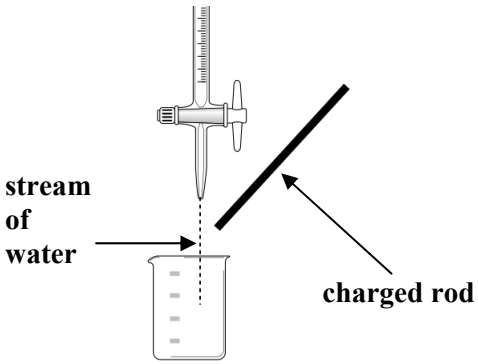
(*c*) What do you understand by the term *chemical compound*?

(*d*) What colour is given to the Bunsen flame by
(*i*) a lithium salt, (*ii*) a copper salt?

(*e*) Define *electronegativity*.

(*f*) What reagents are used in the brown ring test for nitrates?

(*g*) What effect, if any, would the charged rod have on the stream of water in the test shown in the diagram at right?



(*h*) What is the shape of the ammonia (NH_3) molecule?

(*i*) What is the mass of 11.2 litres of oxygen gas (O_2) at s.t.p.?

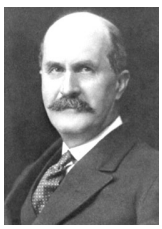
(*j*) State **one** use of a mass spectrometer.

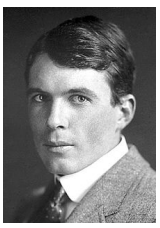
(*k*) Answer part **A** *or* part **B**.

A Explain the term *co-product* in industrial chemistry.

or

B The father and son in the pictures on the right pioneered the technique of x-ray crystallography. Give their surname.





5. (*a*) Define (*i*) *atom*, (*ii*) *molecule*. (8)

(*b*) Atoms are made up of the subatomic particles protons, neutrons and electrons.

Copy the following table into your answer book and fill in the missing information. (21)

PARTICLE	RELATIVE MASS	RELATIVE CHARGE	LOCATION
		–1	
	1	**0**	
proton			**nucleus**

(*c*) The values of the *atomic number* and of the *mass number* for the most abundant isotope of the element hydrogen, **H**, are both 1.

What does this fact tell us about the composition of the **H** nuclei? (6)

(*d*) Naturally-occurring carbon consists mainly of carbon-12 atoms but it also contains a small percentage of carbon-14 atoms.

In terms of their subatomic particles, state **two** ways in which these carbon atoms are similar, and **one** way in which they differ. (9)

(*e*) The scientist who discovered the atomic nucleus is shown in the photograph on the right. What was his name? (6)

6. Crude oil is a complex mixture consisting mainly of hydrocarbons. It is fractionally distilled in oil refineries to produce a wide range of useful materials.

(*a*) What are *hydrocarbons*? (5)

(*b*) Name any **two** of the fractions obtained by the fractional distillation of crude oil in an oil refinery.

Give **one** use of each fraction you have named. (15)

(*c*) The octane number of a fuel is an indication of its tendency to cause auto-ignition (knocking). Octane numbers are based on two reference hydrocarbons: heptane and 2,2,4-trimethylpentane (*iso*-octane).

(*i*) What are the octane numbers of these reference hydrocarbons?

(*ii*) Write the structural formula of either **one** of the reference hydrocarbons.

(*iii*) State **one** way in which the octane number of a fuel can be increased. (18)

(*d*) Benzene, an aromatic compound, is present in crude oil and in other hydrocarbon sources.

(*i*) Draw the structural formula of benzene.

(*ii*) What health concern is associated with the presence of benzene in fuels? (12)

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7. (*a*) Define pH. (5)

Calculate the pH of:

(*i*) a 0.01 M sodium hydroxide (**NaOH**) solution,

(*ii*) a solution of hydrochloric acid (**HCl**) of concentration 3.65 grams per litre. (12)

(*b*) One of the stages in the purification of water for drinking is pH adjustment.

What substance would you add to the water

(*i*) if the pH needed to be raised,

(*ii*) if the pH needed to be lowered? (9)

(*c*) *Flocculation* is another stage in the water purification process.

Name a flocculating agent and explain how it helps in the purification process. (9)

(*d*) Some water is described as hard.

(*i*) What is meant by *hardness of water*?

(*ii*) Distinguish between *temporary* and *permanent* hardness in water.

(*iii*) Suggest **one** advantage and **one** disadvantage of hard water. (15)

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8. Alkanes, alcohols and carboxylic acids are *homologous series* studied in organic chemistry.

(*a*) Explain the underlined term. (8)

(*b*) In the case of any **two** of the homologous series above, give the name and structural formula of **one** member of the series. (18)

(*c*) Give **one** common use for each of the compounds you have named in (*b*). (6)

(*d*) Alcohols can be readily converted to carboxylic acids.

What type of organic reaction is involved? (6)

(*e*) Give the name or formula of the gas produced when moist sodium carbonate (**Na_2CO_3**) reacts with a carboxylic acid.

What simple test could be carried out on this gas to confirm its identity? (12)

9. (*a*) Define (*i*) *oxidation*, (*ii*) *reduction*, in terms of electron transfer. (8)

(*b*) Identify (*i*) the substance oxidised, (*ii*) the oxidising agent, in the reaction between sodium and chlorine to produce sodium chloride. The equation for the reaction is:

$$\mathbf{Na + \tfrac{1}{2}Cl_2 \rightarrow NaCl} \quad (6)$$

(*c*) Name the type of chemical bond that exists between the chlorine atoms in a chlorine molecule.
Give **one** other example of a molecule having this type of bond.
State **two** properties of substances having this type of bond. (12)

(*d*) What type of bonding occurs in sodium chloride?
Give **one** other example of a compound having this type of bonding.
State **two** properties of substances which contain this type of bond. (12)

(*e*) Describe what you would observe when a small piece of sodium is put in a dish of water.
Name **one** product of the reaction that occurs. (12)

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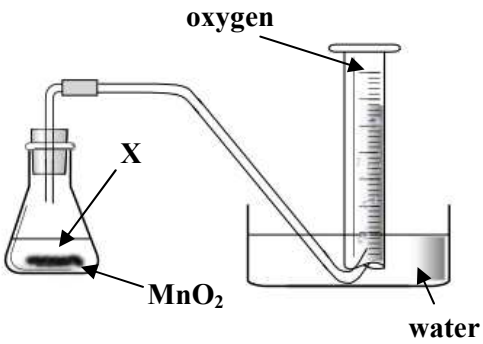
10. Answer any **two** of the parts (*a*), (*b*) and (*c*). (2 × 25)

(*a*) The volume of oxygen liberated from liquid **X** in the presence of manganese(IV) oxide ($\mathbf{MnO_2}$) as catalyst was measured at one-minute intervals using the apparatus shown in the diagram. The results obtained are shown in the following table.



Time (min)	0	1	2	3	4	5	6	7
Volume of oxygen (cm^3)	0	36	54	64	69	71	72	72

(*i*) Give the name *and* formula of liquid **X**. (7)

(*ii*) Plot, on graph paper, a graph of volume (*y*-axis) *versus* time (*x*-axis). (12)

(*iii*) From your graph estimate the volume of gas liberated after 2.5 minutes. (6)

(*b*) What do you understand by the *relative molecular mass* ($\boldsymbol{M_r}$) of a compound? (7)
Calculate the relative molecular mass of the glucose molecule ($\mathbf{C_6H_{12}O_6}$). (6)
Find the percentage by mass of hydrogen in glucose. (6)
How many moles are there in 9 grams of glucose? (6)

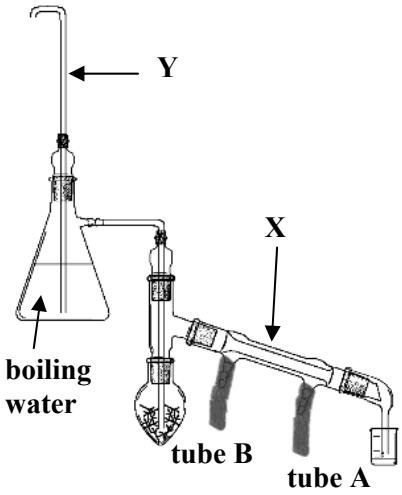
(*c*) The following scientists all played a part in the development of our knowledge of elements.

Boyle **Mendeleev** **Moseley** **The Greeks** **Davy**

Write in your answer book the name corresponding to each of the numbers from **1** to **5** in the statements below. (25)

It was thought by **1** that matter was made up of four elements: earth, air, fire and water. In the 17th century **2** defined an element as a simple substance that cannot be split into simpler substances. Early in the 19th century the elements, sodium and potassium, were isolated by **3**. Later in the 19th century the known elements were arranged in a table by **4**. In the 20th century the table of the elements was modernised as a result of the discovery of atomic number by **5**.

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



(*a*) (*i*) What type of distillation is carried out using the apparatus shown in the diagram on the right? (4)

(*ii*) Name the part of the apparatus labelled **X**. (6)

(*iii*) Which of the tubes, **A** or **B**, is connected to the cold water tap? (6)

(*iv*) What is the function of tube **Y**? (6)

(*v*) What substance did you extract using the apparatus shown in the diagram? (3)

(*b*) A stage in the manufacture of sulfuric acid involves the following equilibrium:

$$\mathbf{2SO_2 + O_2 \rightleftharpoons 2SO_3 \quad \Delta H = -196\ kJ}$$

(*i*) What do you understand by *chemical equilibrium*? (7)

(*ii*) Write the equilibrium constant ($\boldsymbol{K_c}$) expression for the above reaction. (6)

(*iii*) State *Le Châtelier's principle*.

Explain, using Le Châtelier's principle, why an increase in temperature would lower the concentration of sulfur trioxide ($\mathbf{SO_3}$) in the above equilibrium. (12)

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

A (*i*) Name the main product of the industry on which you carried out a case study.

State **one** important use of this product. (7)

(*ii*) Where in Ireland is the industry located?

Give any **two** reasons why this is a suitable location for the industry. (9)

(*iii*) State **one** way in which safety is promoted in the industry. (3)

(*iv*) Suggest **one** way in which costs are minimised in the industry. (6)

or

B (*i*) Copy the table below into your answer book and use it to compare the properties of metals and non-metals under the headings given. (15)

PROPERTY	METALS	NON-METALS
Hardness		
Lustre		
Conduction of heat		
Conduction of electricity		
Ductility		

(*ii*) What is an *alloy*? Give **one** example. (10)

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