Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2017

CHEMISTRY – ORDINARY LEVEL

TUESDAY, 20 JUNE – AFTERNOON 2:00 to 5:00

400 MARKS

Answer **eight** questions in all.

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

All questions carry equal marks (50).

The information below should be used in your calculations.

Relative atomic masses (rounded): H = 1.0, N = 14, O = 16, Na = 23

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. (*a*) A student prepared ethene (C_2H_4) gas and bubbled it into a coloured solution in a test-tube to test it for unsaturation.

(*i*) What reagent is used to test ethene for unsaturation?

(*ii*) What colour change is a positive result in this test? (9)

(*b*) The student was given ethyne (C_2H_2) gas in a stoppered test-tube, a burning taper and a bottle of limewater.

(*i*) Describe how to carry out a combustion test on the ethyne.

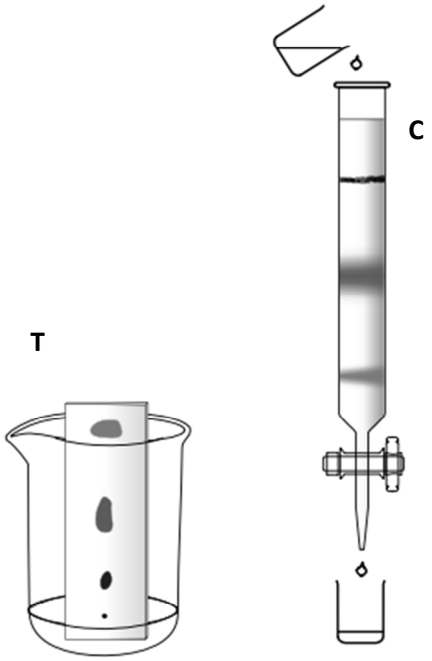
(*ii*) Describe the flame observed.

(*iii*) Copy, complete and balance the following equation for the complete combustion of ethyne in oxygen.

$$C_2H_2 + 2\tfrac{1}{2}\,O_2 \rightarrow \_\_\_\_\_ + \_\_\_\_\_$$

(*iv*) What is the purpose of the limewater in the test? (21)

(*c*) A mixture of indicators was separated by chromatography using two different methods **T** and **C**, as shown.



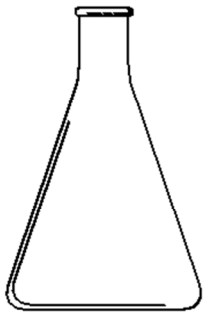
(*i*) Copy *either* **T** *or* **C** into your answer book.
Label the mobile phase and the stationary phase.
Label with an **X** where the mixture of indicators was applied at the start of the procedure.

(*ii*) How many different indicators were separated in the process shown?

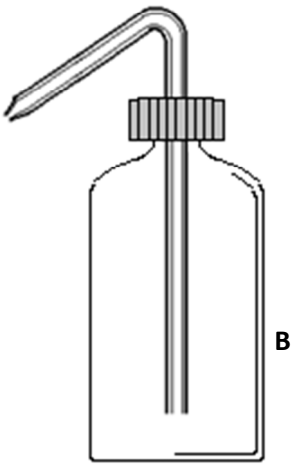
(*iii*) Label with an **F** the component carried fastest by the mobile phase.

(*iv*) Explain why the indicators were carried at different rates by the mobile phase. (20)

2. Hydrochloric acid (**HCl**) of known concentration was added from a burette to neutralise 25.0 cm^3 portions of sodium hydroxide (**NaOH**) solution of unknown concentration in apparatus **A**. Each portion of sodium hydroxide solution had been measured out using a pipette. One rough titration and a number of accurate titrations were carried out. The piece of equipment **B** was used during each titration.



(*a*) (*i*) Name the piece of apparatus **A**.
(*ii*) How was it rinsed before each titration? (8)



(*b*) (*i*) Name the piece of apparatus **B**.
(*ii*) Explain what **B** is used for in this experiment. (9)

(*c*) (*i*) Name a suitable indicator for use in the titrations.
(*ii*) Why is it advisable to place apparatus **A** on a white tile during the titrations? (9)

(*d*) (*i*) What is the advantage of carrying out a rough titration?

The burette readings noted in this experiment were 19.9 cm^3 **HCl** for the rough titration and 19.6 cm^3 and 19.5 cm^3 for the following two accurate titrations.

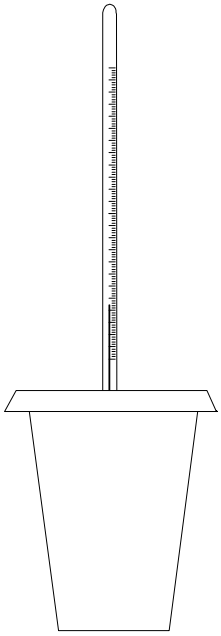
(*ii*) What average hydrochloric acid volume should be used in calculations? (9)

(*e*) The equation for the titration reaction is:

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

The concentration of the hydrochloric acid solution was 0.10 M.
Calculate the concentration of the sodium hydroxide solution
(*i*) in moles per litre,
(*ii*) in grams per litre. (15)

3. In an experiment to measure the heat of reaction (ΔH) for the neutralisation of hydrochloric acid and sodium hydroxide solution, 100 cm^3 of 1 M **HCl** solution was added to 100 cm^3 of 1 M **NaOH** solution in a polystyrene container with a cardboard lid.



The equation for the reaction that took place was:

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

Both solutions were initially at room temperature. A thermometer was used to measure the temperature changes of the reaction mixture. The initial rise in temperature was 6.8 °C and this was followed by a gradual fall in temperature because of heat loss to the surroundings. The temperature rise was used to calculate the heat of reaction and the result obtained for ΔH was –57 kJ per mole of **HCl** neutralised.

(*a*) Was heat released or absorbed when the **HCl** and **NaOH** solutions reacted? Justify your answer. (11)

(*b*) What features of the apparatus described help prevent heat loss to the surroundings?
Why should the mixture be stirred before taking temperature readings? (12)

(*c*) Name a piece of apparatus that could have been used to measure accurately 100 cm^3 of each of the solutions. (6)

(*d*) The **NaOH** solution used should have the warning pictogram shown on the right on its container.
(*i*) What chemical hazard is indicated by this symbol?
(*ii*) Describe one precaution taken to ensure safe handling of this solution. (12)

(*e*) The experiment was repeated with 100 cm^3 of 1 M **HCl** added to 100 cm^3 of 0.5 M **NaOH**.
(*i*) What temperature rise would you expect to record?
(*ii*) Justify your answer. (9)

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 pictured on the right who was awarded two Nobel prizes for her work on radioactivity which helped her isolate two new elements.

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(*b*) Rutherford bombarded gold foil with alpha particles. He discovered that most went straight through but some were reflected back. He concluded that atoms consist of two parts.
Name these two parts of an atom.

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

(*d*) Why do atomic radii become *smaller* across a row of the periodic table?

(*e*) According to Charles' law, what is the relationship between the temperature (on the Kelvin scale) and the volume of a fixed mass of gas at constant pressure?

(*f*) Write a balanced equation for the reaction that occurs when magnesium burns in oxygen.

(*g*) Methane reacts with chlorine in strong sunlight or in ultraviolet light as follows:

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

Classify this reaction as an *addition*, an *elimination* or a *substitution*.

(*h*) When the perfume bottle shown on the right was opened, the scent spread through the air due to the movement of the perfume molecules.
What term is used for the spreading of the perfume molecules in this way?

(*i*) A 100 cm^3 sample of lake water contained 0.016 g of suspended solids. Express this concentration in parts per million (p.p.m. *or* mg per litre).

(*j*) Name *and* give a use for one of the products of the electrolysis of acidified water.

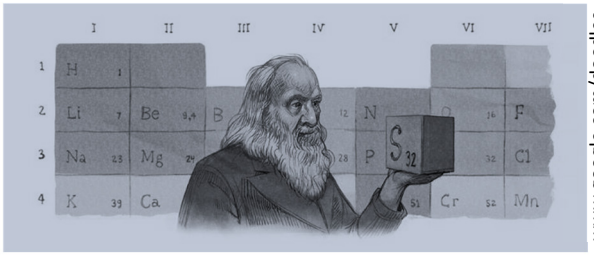
(*k*) Answer part **A** *or* part **B**.

A State one method by which nitrogen is fixed in nature.

or

B Name the non-metallic element that is always present in steel, in quantities up to about 1.7% by mass.

5. The ancient Greeks argued that all matter was made up of just four 'elements': earth, air, fire and water. We now know that there are over 100 elements that are listed in the periodic table of the elements. Earth, air, fire and water are not included, as none of them is actually an element.



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(*a*) (*i*) What is the modern definition of an element?

(*ii*) Name the Russian chemist, shown above, who around 1869, drew up the first successful periodic table of the elements and predicted the properties of some elements that had not been discovered at the time. (11)

(*b*) Define *atomic number*. (6)

(*c*) Both $^{12}_{6}$**X** and $^{14}_{6}$**X** are atoms of the same element **X**.

(*i*) In terms of subatomic particles, how do $^{12}_{6}$**X** and $^{14}_{6}$**X** differ?

(*ii*) What term is used to refer to these different forms of the same element?

(*iii*) How many electrons are present in each of these atoms?

(*iv*) Identify element **X**. (18)

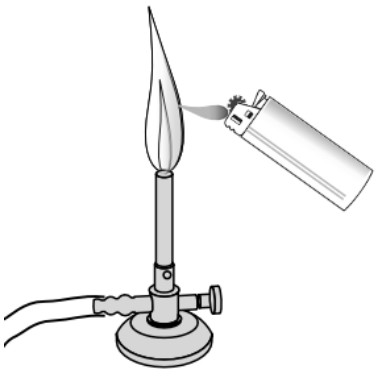
(*d*) Draw diagrams to show the arrangement of electrons in the main energy levels in

(*i*) a neon atom,

(*ii*) a fluorine atom.

Referring to the arrangements of electrons, explain which of these two elements is the *more* chemically reactive. (15)

6. The diagram shows a butane (C_4H_{10}) gas lighter being used to ignite methane (CH_4) gas in a Bunsen burner.



(*a*) Why are both of these fuels classed as hydrocarbons? (5)

(*b*) Give one natural source of methane.

Why are mercaptans added to methane gas before it is piped to customers? (12)

(*c*) To which homologous series do both methane and butane belong?

Name one other member of this series and draw the structure of one of its molecules. (15)

(*d*) Name the oil refining process used to separate the hydrocarbons in crude oil. (6)

(*e*) What is meant by the *octane number* of a fuel?

Name one method by which the octane number of a hydrocarbon fuel can be improved. (12)

7. (*a*) The following words or phrases are omitted from the passage below.

ionic	**negatively-charged**	**electrons**
crystal lattice	**positively-charged**	**molecules**

Write in your answer book the omitted word or phrase corresponding to each of the numbers (**1** to **6**). (26)

When sodium and chlorine react together __**1**__ are transferred from the sodium atoms to the chlorine atoms. The sodium atoms are converted into __**2**__ ions and the chlorine atoms are converted into __**3**__ ions. The oppositely-charged ions attract each other forming __**4**__ bonds. The compound formed does not exist in the form of __**5**__ but exists as a network of ions called a __**6**__.

(*b*) (*i*) Describe the procedure for carrying out a flame test on a salt.

(*ii*) What colour would a sodium salt give to a fireworks display? (18)

(*c*) A white precipitate is formed immediately when a solution of silver nitrate is mixed with a solution of a sodium salt.
Name a salt of sodium that would give this result. (6)

8. Ethanol is broken down in the human body as shown in the scheme on the right.

ethanol → ethanal → ethanoic acid → CO_2 + H_2O

(*a*) Draw the structure of an **ethanol** molecule.
Circle its functional group.
Explain why ethanol is very soluble in water. (17)

(*b*) To which homologous series does **ethanal** belong? (6)

(*c*) Which of the compounds ethanol, ethanal and ethanoic acid,
(*i*) is found in vinegar,
(*ii*) produces a red precipitate when heated with blue Fehling's reagent,
(*iii*) results in fizzing when magnesium metal is added to a solution of it in cold water? (15)

(*d*) Name *or* give the formula of a reagent that could be used to oxidise a sample of ethanol in the school laboratory. (6)

(*e*) Select *one* of the following instrumental methods of analysis that can be used to detect ethanol in a blood sample: colorimetry, carbon-14 dating, gas chromatography (GC), mass spectrometry. (6)

9. Raw liver contains an enzyme which catalyses the decomposition of hydrogen peroxide. In an investigation into the rate of decomposition of hydrogen peroxide by minced raw liver, the volume of oxygen gas collected was measured at intervals after the liver was added to the hydrogen peroxide solution and the results in the table were obtained.
The reaction that took place was:

$$2H_2O_2 \xrightarrow{enzyme} 2H_2O + O_2$$

Time (minutes)	0	1	2	3	4	5	6
Volume (cm^3)	0	50	75	84	87	88	88

(*a*) Copy and complete in your answer book the following statement.
'The faster the rate of a chemical reaction the …….. the time needed to make a certain …….. of one of the products of the reaction.' (5)

(*b*) (*i*) What is a *catalyst*?
(*ii*) What is an *enzyme*?
(*iii*) Identify a black powder that could be used as a catalyst for this reaction. (15)

(*c*) Draw a labelled diagram of a suitable apparatus for this investigation, showing how
(*i*) the liver could be added quickly to the hydrogen peroxide solution,
(*ii*) the oxygen gas produced could be collected and measured. (9)

(*d*) On graph paper, plot a graph of volume of oxygen (*y*-axis) *versus* time. (15)

(*e*) From your graph, estimate the volume of oxygen gas produced in the first 1.5 minutes of the reaction. (6)

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

(*a*) Waste water undergoes sewage treatment before discharge into rivers, lakes or the sea.

(*i*) How are most of the suspended solid wastes removed during sewage treatment?

(*ii*) *Secondary treatment is a biological process*. Describe what happens during the secondary treatment of sewage.

(*iii*) At what stage of sewage treatment are nitrates and phosphates removed?

(*iv*) What could happen in a lake as the result of the addition of large quantities of nitrates and phosphates? (25)

(*b*) The atoms in a water molecule are joined by <u>covalent bonds</u>.

(*i*) Explain the underlined term.

(*ii*) Draw a dot and cross diagram showing the bonding in a water molecule.

(*iii*) What is the shape of a water molecule?

(*iv*) Define *electronegativity*.

(*v*) Use electronegativity values (page 81 *Formulae and Tables* booklet) to explain why the bonds in water are *polar* covalent and not *pure* covalent. (25)

(*c*) When a car airbag is activated a small quantity of solid sodium azide (**NaN_3**) reacts very quickly to produce enough nitrogen gas to inflate a nylon bag that cushions a car occupant from injury. The balanced equation for the reaction that takes place is:

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$$NaN_3 \rightarrow Na + 1\tfrac{1}{2}\ N_2$$

(*i*) State the law of conservation of mass.

(*ii*) What is the mass in grams of one mole of sodium azide (**NaN_3**)?

(*iii*) How many moles of sodium azide are there in 130 g of this solid?

(*iv*) When 130 g of sodium azide react according to the equation above, 46 g of sodium are formed.
What mass of nitrogen gas is formed?

(*v*) A driver's airbag holds 67.2 litres of nitrogen gas when fully inflated at s.t.p.
How many moles of nitrogen gas are needed to fill it? (25)

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

(*a*) When oxygen (**O_2**) and sulfur dioxide (**SO_2**) react in a closed vessel, sulfur trioxide (**SO_3**) is formed and a chemical equilibrium is reached as described by the following balanced equation:

$$2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)}$$

(*i*) Does the reaction stop when equilibrium is reached? Explain your answer.

(*ii*) Write the equilibrium constant (K_c) expression for this reaction. (13)

According to Le Châtelier's principle, changing the pressure may disturb an equilibrium.

(*iii*) Predict the effect on the yield of sulfur trioxide of *increasing* the pressure.

(*iv*) Give another way to change the yield of sulfur trioxide – other than by changing the pressure. (12)

(*b*) The Danish chemist Sørensen introduced the concept of pH in 1909 to measure the acidity of solutions while working in the Carlsberg brewery in Copenhagen.

Define (*i*) an acid, (*ii*) pH.

What is the relationship between pH and pOH? (13)

Calculate the pH of 0.3 M hydrochloric acid (**HCl**) solution.

List, in order of their increasing acidity:
a beer with a pH of 3.9,
tap-water with a pH of 7.5,
a mouthwash with a pH of 8.0 and
coffee that has a pH of 5.0. (12)

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

A

The greenhouse effect and the ozone layer are natural phenomena that are favourable to the existence of life on planet Earth.

However, in recent years, there have been concerns about human activities that are *increasing* the greenhouse effect and that have caused *damage* to the ozone layer.

How does

(*i*) the greenhouse effect,

(*ii*) the ozone layer,

help make conditions favourable for life on Earth? (12)

Give one way that human activities have *caused* an increase in the greenhouse effect in recent years.

What possible *outcome* of an increased greenhouse effect is causing concern at the present time? (9)

How have humans changed their behaviour in recent years to reduce the rate of ozone depletion? (4)

or

B

The five metals in the following list are given in the order in which they occur in the electrochemical series.

sodium, **aluminium**, **zinc**, **iron**, **gold**

(*i*) Suggest a reason why gold is used in jewellery more commonly than the other metals. (7)

(*ii*) Which one of these metals corrodes most readily?

How is this metal stored in the school laboratory? (6)

(*iii*) What name is usually given to the corrosion of iron?

Hot-dip *galvanising* is a cheap way of protecting everyday iron objects from corrosion.

The objects are dipped in molten metal **M** and become coated with a protective layer of **M**.

Which of the metals listed above is **M**? (6)

(*iv*) Why is the recycling of aluminium strongly recommended? (6)

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