Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2019

CHEMISTRY – ORDINARY LEVEL

TUESDAY, 18 JUNE – AFTERNOON 2:00 to 5:00

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400 MARKS

This examination will be marked on screen.

The superintendent will give you a special answerbook.

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): O = 16, S = 32, Zn = 65, Ag = 108

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

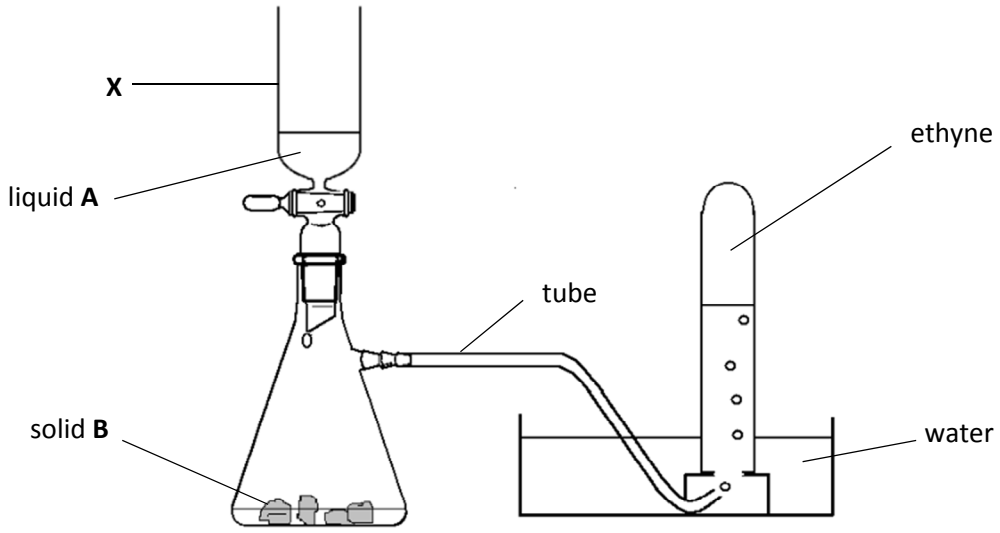
Avogadro constant = 6.0×10^{23} mol^{-1}

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

Section A

Answer at least <u>two</u> questions from this section. See page 1 for full instructions.

1. A student prepared ethyne (C_2H_2) gas by dropping liquid **A** onto solid **B** and collecting the gas in test tubes over water. The apparatus used is shown in the diagram.



(*a*) Identify

(*i*) the piece of apparatus labelled **X**,

(*ii*) liquid **A**,

(*iii*) solid **B**. (11)

(*b*) (*i*) Describe what was observed when liquid **A** was dropped onto solid **B**.

(*ii*) Why did the student *not* carry out any tests on the first few test tubes of gas collected? (12)

(*c*) (*i*) What was observed when the student added some bromine (Br_2) solution to a test tube of ethyne and then stoppered and shook the test tube?

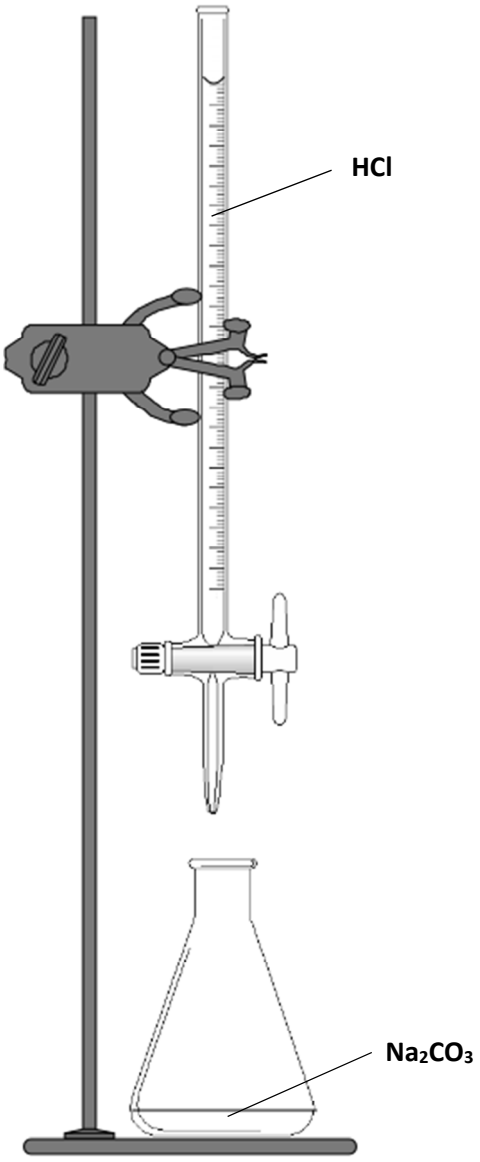
(*ii*) What did the result of this test tell the student about the structure of an ethyne molecule?

(*iii*) Give the name *or* formula of another organic compound that you would expect to react in a similar way with bromine solution. (15)

(*d*) What did the student observe when a lighting taper was inserted into a test tube of ethyne? (6)

(*e*) Give a common use of ethyne gas. (6)

2. A student used a 0.05 M solution of sodium carbonate (**Na_2CO_3**), a primary standard, to find the concentration of a hydrochloric acid (**HCl**) solution by titration. A pipette was used to measure 25.0 cm^3 portions of the **Na_2CO_3** solution into a conical flask and the **HCl** was added from a burette.



(*a*) Why would a beaker *not* be a suitable alternative to the conical flask? (5)

(*b*) What is the correct procedure for rinsing
(*i*) the pipette,
(*ii*) the conical flask? (9)

(*c*) The clamp shown in the diagram is designed to keep the burette vertical.
State another precaution a student should take to ensure accuracy when reading the volume of **HCl** added from the burette during a titration. (6)

(*d*) (*i*) Give one property of the chemical **Na_2CO_3** that makes it suitable for use as a primary standard.
(*ii*) The 0.05 M solution of sodium carbonate is a standard solution.
Explain the underlined term. (12)

(*e*) (*i*) Name an indicator suitable for use in this titration.
(*ii*) State the colour change observed at the end point. (9)

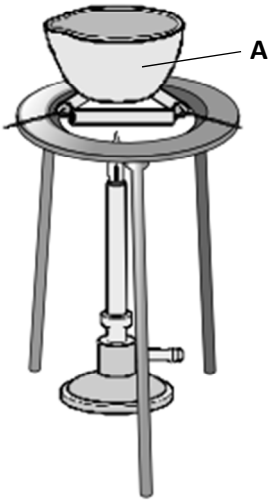
(*f*) The equation for the titration reaction is:

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$$

The student carried out a number of titrations and noted that, on average, 22.6 cm^3 of the hydrochloric acid solution reacted with 25.0 cm^3 of the 0.05 M **Na_2CO_3** solution.
Calculate, in moles per litre, the concentration of the **HCl** solution. (9)

3. A student was asked to confirm that a sample of water from the Dead Sea, a lake in Israel, had a very high concentration of dissolved solids including sodium chloride (**NaCl**).

The student first filtered the water. A 200 cm^3 portion of the filtered lake water was then measured out accurately and the water was removed by heating, using *one* of the two methods shown, leaving a solid residue either in container **A** *or* **B**.



(*a*) Why was the lake water filtered first? (5)

(*b*) Name a suitable piece of apparatus to measure accurately 200 cm^3 of the filtered water. (6)

(*c*) (*i*) Name the container, **A** *or* **B**, in which the 200 cm^3 sample was heated to dryness.

(*ii*) Give one safety precaution taken during this part of the experiment. (9)

(*d*) (*i*) Describe a procedure for carrying out a flame test on the solid residue left in **A** *or* in **B**.

(*ii*) What flame colour confirms the presence of sodium compounds in the residue? (15)

(*e*) The mass of the container used was 135.4 g. The total mass of the container and the residue from the filtered water was 201.1 g.

(*i*) What was the mass of dissolved solids in 200 cm^3 of filtered water?

(*ii*) Calculate the concentration of dissolved solids in grams per litre. (9)

(*f*) Silver nitrate (**$AgNO_3$**) solution was added to a small sample of the lake water to test it for the presence of the chloride ion.

What colour precipitate indicates the presence of the chloride ion? (6)

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 Danish scientist pictured on the right who was the first, around 1913, to describe the way electrons move in orbits around the nucleus in an atom.

(*b*) What is the relationship between the pressure and the volume of a fixed mass of gas at constant temperature?

(*c*) Supply the two missing words in the following sentence.
'An alpha particle consists of two _____ and two _____ .'

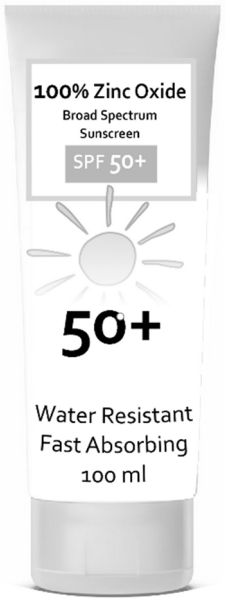
(*d*) When magnesium ribbon is burned in oxygen the reaction that takes place is:

$$\mathbf{Mg + \tfrac{1}{2}O_2 \rightarrow Mg^{2+} + O^{2-}}$$

(*i*) Which element is reduced?

(*ii*) Give a reason for your answer.

(*e*) When a small piece of sodium is dropped into water they react to form sodium hydroxide and hydrogen gas, i.e.
sodium + water → sodium hydroxide + hydrogen.
Write a balanced equation using chemical formulae for this reaction.



(*f*) What term is used for a catalyst that takes part in a chemical reaction in a living organism?

(*g*) Calculate the percentage by mass of zinc in zinc oxide (**ZnO**), a white compound used in total sunblock creams.

(*h*) What does the octane number of a fuel tell us about the fuel?

(*i*) What happens during the *secondary* stage of sewage treatment?

(*j*) What type of water hardness can be removed by boiling?

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

A Which **two** substances in the following list make rain water acidic?
CO **CO_2** **O_3** **CFC (chlorofluorocarbon)** **SO_2**

or

B Which **two** metals in the following list are transition elements?
iron **magnesium** **calcium** **copper** **potassium**

5. Refer to pages 79 and 81 of the *Formulae and Tables* booklet when answering this question.

Water is a compound of the elements hydrogen and oxygen.
X is a compound of two other elements.

(*a*) What is an *element*? (5)

(*b*) Draw diagrams to show the arrangement of electrons in:
(*i*) a hydrogen atom,
(*ii*) an oxygen atom. (9)

(*c*) (*i*) Define *electronegativity*.
(*ii*) Write down the electronegativity values of hydrogen and oxygen.
(*iii*) Use these values to predict the type of bonding in a water molecule.
(*iv*) Draw a diagram to show the arrangement of electrons in a water molecule. (18)

(*d*) The electronegativity values of the elements that make up compound **X** are 0.93 and 3.16.
(*i*) What type of bonding would you expect compound **X** to have?
(*ii*) Would you expect compound **X** to have a high melting point?
(*iii*) Would you expect compound **X** to be soluble in water? (12)

(*e*) UNESCO has designated 2019 as the International Year of the Periodic Table of Chemical Elements.

Why did Mendeleev's original table of 1869 *not* include any of the noble gases? (6)

6. Consider hydrocarbons **A**, **B**, **C** and **D** and answer the questions that follow.

CH_4	C_2H_4	$CH_3CH_2CH_2CH_3$	C_6H_6
A	**B**	**C**	**D**

(*a*) To which homologous series do both **A** and **C** belong? (5)

(*b*) Give the systematic IUPAC names for **A**, **B**, **C** and **D**. (12)

(*c*) The forklift truck shown uses LPG as a fuel.

(*i*) What do the letters LPG stand for?

(*ii*) Which one of the compounds listed above is a major component of LPG?

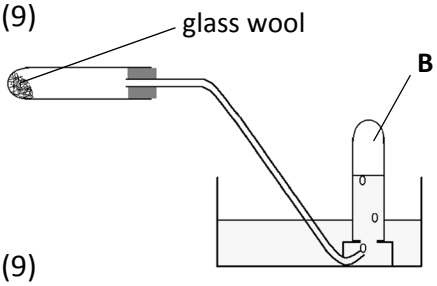
(*iii*) What is the other main component of LPG? (15)

(*d*) Which of the compounds **A**, **B**, **C** *or* **D**

(*i*) is produced in refuse dumps and slurry pits,

(*ii*) is carcinogenic? (9)

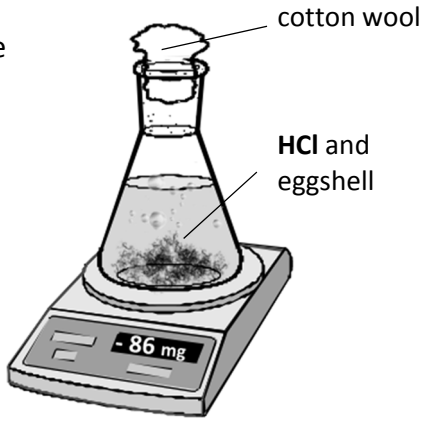
(*e*) The apparatus shown is used to prepare hydrocarbon **B** from ethanol and aluminium oxide (**Al_2O_3**).
Copy the diagram into your answerbook.
Indicate on your diagram the location of
(*i*) the ethanol, (*ii*) the **Al_2O_3**, (*iii*) the heat source,
during the preparation. (9)



7. A student investigated the rate of the reaction that took place between a solution of **HCl** and the calcium carbonate (**$CaCO_3$**) in broken eggshell. The reaction that took place was:

$2HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$

The student added 50 cm^3 of **HCl** solution to 2.5 g of eggshell pieces in a flask standing on a mass balance as shown; the **CO_2** product escaped from the flask. The mass of **CO_2** gas produced was determined at one-minute intervals and these masses are given in the table below.



Time (minutes)	0	1	2	3	4	5	6	7
Mass **CO_2** (mg)	0	45	70	86	94	99	101	101

(*a*) (*i*) Plot a graph, on graph paper, of mass (in mg) of **CO_2** (*y*-axis) *versus* time.

(*ii*) Use your graph to find the mass of gas produced in the first 3.5 minutes. (21)

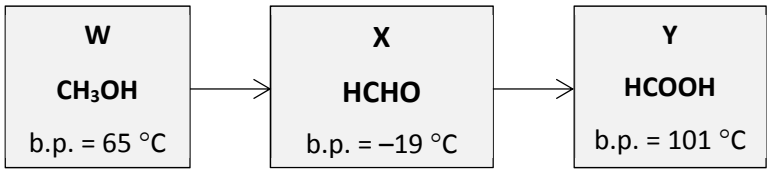
(*b*) Does the rate of this reaction increase or decrease with time?
Give a reason for your answer. (6)

(*c*) (*i*) Suggest a method for crushing broken eggshell to a powder.

(*ii*) Predict *and* explain the effect on the rate of reaction of reducing the size of the eggshell pieces. (18)

(*d*) State the effect on the rate of reaction of increasing the temperature by 10 °C. (5)

8. Study the reaction scheme below and answer the questions that follow.



(*a*) Name the alcohol **W**, the aldehyde **X** and the carboxylic acid **Y**. (9)

(*b*) Which one of the three compounds

(*i*) is present in the sting of nettles,

(*ii*) makes up about 10% of methylated spirit,

(*iii*) is gaseous at room temperature? (11)

(*c*) Draw the structure of a molecule of **X** showing all the atoms and bonds present. (6)

(*d*) (*i*) Which one of the molecules **W**, **X** *or* **Y** has a tetrahedrally bonded carbon atom?

(*ii*) What term is used to describe the geometry around the carbon atom in the other two molecules? (9)

(*e*) The same reagent can be used to convert **W** to **X** and **X** to **Y**.

(*i*) State the type of organic reaction involved in these conversions.

(*ii*) Identify a suitable reagent for these conversions. (9)

(*f*) **$CH_3OH + 1½O_2 \rightarrow$ _____ + _____**

Copy, complete, and balance the equation above to show the complete combustion of **W** in oxygen. (6)

9. (*a*) Define (*i*) an acid, (*ii*) a base. (12)

(*b*) (*i*) Define pH.

(*ii*) Copy and complete the following equation to show the relationship between pH and pOH:

pH + pOH =

(*iii*) The pH of pure neutral water is 7. What is its pOH?

(*iv*) Calculate the pH of a 0.01 M sodium hydroxide (**NaOH**) solution. (18)

(*c*) Four of the main stages in the purification of a water supply for drinking are:

flocculation **chlorination** **fluoridation** **pH adjustment**

(*i*) What happens during the flocculation stage?

(*ii*) What is the purpose of chlorinating the water supply?

(*iii*) Why are fluorine compounds added to the water?

Chemicals are used to adjust the pH of the water supply if tests show that it is too acidic or too basic.

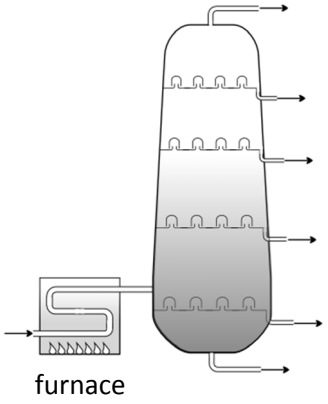
(*iv*) What chemical is added when the pH of the water is too low? (20)

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

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

residue **smaller** **hydrocarbon** **top**
base **crude oil** **larger**

Write in your answerbook the omitted word(s) corresponding to each of the numbers (**1** to **7**).



In oil refining __1__ is pre-heated in a furnace before being pumped into a fractionating column, like that shown in the diagram, where it separates into different useful __2__ fractions. The temperature at the __3__ of the column is higher than it is at the __4__. Near the top of the column the __5__ molecules with lower boiling points separate. Farther down the column the __6__ molecules with higher boiling points separate. The __7__ that collects at the base of the column can be used for tarring roads. (25)

(*b*) In the manufacture of **SO_3** a chemical equilibrium is reached according to the following balanced equation.

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

(*i*) Explain the underlined term.

(*ii*) Is the formation of **SO_3** an *exothermic* or an *endothermic* reaction?
Give a reason for your answer.

(*iii*) Write the equilibrium constant (K_c) expression for the reaction.

(*iv*) Supply the missing words in the following statement of Le Châtelier's principle:
'When a system in equilibrium is disturbed, e.g. by changing the __1__ or the __2__, reaction will occur to __3__ the effect of the disturbance.' (25)

(*c*) Silver metal reacts with hydrogen sulfide (**H_2S**) to form solid silver sulfide (**Ag_2S**) according to the following balanced equation.

$$2Ag + H_2S \rightarrow Ag_2S + H_2$$

When a silver teapot was exposed to **H_2S** in moist air over a period of time, 10.8 g of **Ag** was converted to **Ag_2S** which appeared as a black tarnish on the surface of the teapot.

(*i*) What is the mass of one mole of silver?
How many moles are there in 10.8 g of silver?

(*ii*) What is the ratio of moles of **Ag** to moles of **H_2** in the equation above?
How many moles of **H_2** are produced when 10.8 g of **Ag** react in this way?
What volume does this amount of **H_2** occupy at s.t.p.?

(*iii*) What mass of **Ag_2S** is formed when 10.8 g of **Ag** react? (25)

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

(*a*) Define (*i*) *atomic number*, (*ii*) *mass number*. (12)

Consider an atom of magnesium, $^{25}_{12}$**Mg**.

(*iii*) State the atomic number of magnesium.

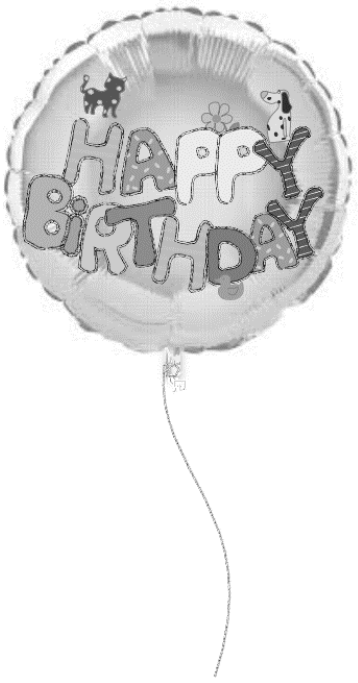
(*iv*) How many neutrons has an atom of $^{25}_{12}$**Mg**?

An atom of $^{25}_{12}$**Mg** has one neutron more than most atoms of magnesium.

(*v*) What term is used to refer to atoms of the same element with different numbers of neutrons?

(*vi*) How many electrons are present in every neutral magnesium atom? (13)

(*b*) Balloons like the one shown float in air when filled with a gas less dense than air. Such balloons contain a very large number of molecules when inflated. The gas molecules are so tiny that they can escape through the foil of the balloon over time.



If the volume of an inflated balloon is 22.4 litres at s.t.p., how many molecules of gas does it contain? (6)

The gases hydrogen, helium, and methane are all less dense than air. Which of these gases

(*i*) is the main constituent of natural gas,

(*ii*) exists as diatomic molecules,

(*iii*) exists as single atoms? (9)

Which one of these gases is chemically unreactive?

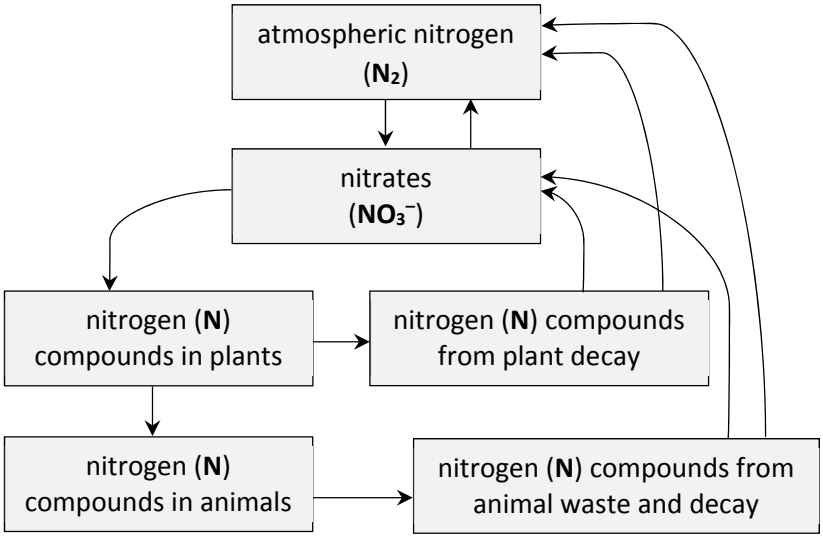
Explain why this gas is chemically unreactive.

Suggest a reason why the balloon shown in the diagram should *not* be filled with either of the other two gases. (10)

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

A

Consider the simplified version of the nitrogen cycle shown in the diagram.



(*i*) Nitrogen is the most abundant gas in the Earth's atmosphere. What is the percentage, by volume, of nitrogen in the air we breathe? (6)

(*ii*) Nitrogen gas is unreactive and is converted into more reactive nitrates. Give one method of natural fixation of nitrogen. (6)

(*iii*) How are nitrogen compounds absorbed by most plants? (3)

(*iv*) How are nitrogen compounds transferred from plants to animals? (3)

(*v*) What use do plants and animals make of the nitrogen compounds they absorb? (3)

(*vi*) Why are all these conversions together called the nitrogen *cycle*? (4)

or

B

The figure of *Eros* standing in Piccadilly Circus in London since 1893, and shown in the photograph, is made of aluminium metal.

(*i*) Explain the term *corrosion* of a metal. (6)

(*ii*) How well do you think the figure of *Eros* would have resisted corrosion if it had been made of iron instead of aluminium? (6)

(*iii*) How is iron extracted from its ores? (9)

(*iv*) Why is the recycling of aluminium strongly recommended? (4)

Leaving Certificate – Ordinary Level

Chemistry

Tuesday, 18 June

Afternoon, 2:00 – 5:00

Image Q4(*a*) on page 5: from the George Grantham Bain Collection, Library of Congress, Washington, accessed 11 October 2018

Image Q5 on page 6: logo of official website www.iypt.org of the International Year of the Periodic Table of Chemical Elements, accessed 15 January 2019

Image Q6 on page 7 from commons.wikimedia.org/wiki/
File: In-vehicle LPG bottle 011.jpg, accessed 11 October 2018, CC-BY-SA-3.0

Image Q8 on page 8: Michael Gasperl, from commons.wikimedia.org/wiki/
File: Urtica dioica (Blüten).jpg, accessed 11 October 2018, CC-BY-SA-3.0

Image Q11(*c*) B on page 11: from pixabay.com/en
File: eros-statue-love-struck-blue-sky 669373.jpg, accessed 11 October 2018