Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2015

CHEMISTRY – ORDINARY LEVEL

TUESDAY, 16 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): C = 12, O = 16, Ne = 20, Na = 23

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

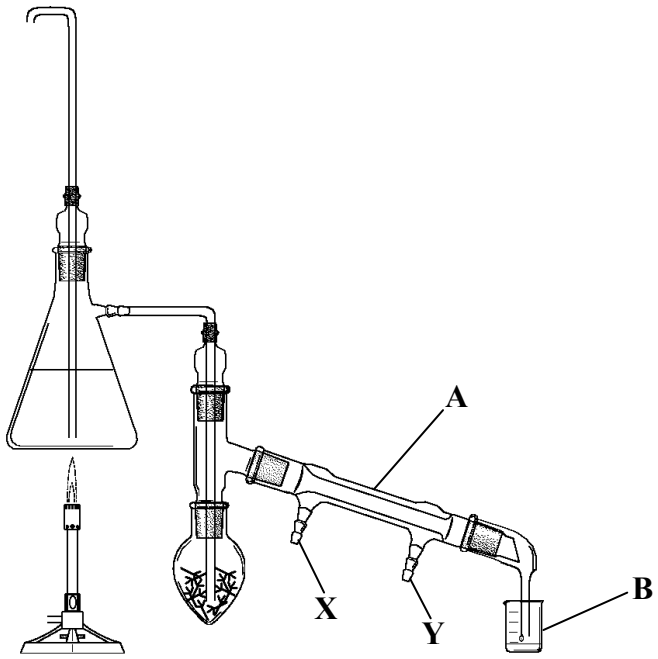
Avogadro constant = 6.0×10^{23} mol^{-1}

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*) The distillation apparatus shown in the diagram below was used to extract clove oil from cloves.



(*i*) What term is used to describe the *type* of distillation used in this extraction?

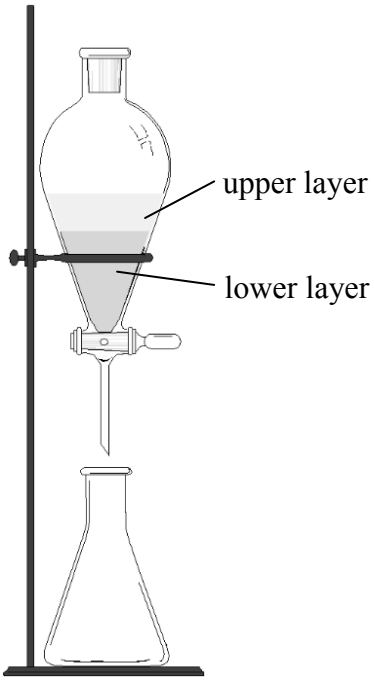
(*ii*) Name the part of the apparatus labelled **A**.

(*iii*) What is the purpose of **A** in this experiment?

(*iv*) Should the cold water flow enter at **X** or at **Y**?

(*v*) Describe the appearance of the emulsion of clove oil and water collected at **B**. (20)

(*b*) In order to isolate the clove oil, the emulsion was first poured into a separating funnel like that shown in the diagram on the right and some cyclohexane solvent was added.



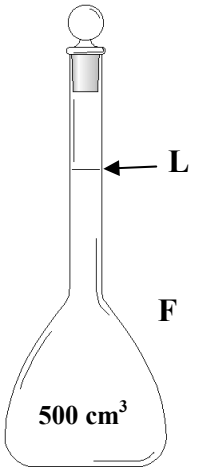
(*i*) Draw the structure of a cyclohexane ($\mathbf{C_6H_{12}}$) molecule.

(*ii*) The density of water is 1.0 g per cm^3; the density of cyclohexane is 0.8 g per cm^3. Can the upper layer in the diagram be described as *aqueous* or *organic*?

(*iii*) Describe what should be done to ensure that all of the clove oil in the emulsion ended up in the organic layer.

(*iv*) How was the clove oil then isolated from the cyclohexane? (30)

2. A solution of sodium carbonate was prepared by dissolving a known mass of anhydrous sodium carbonate ($\mathbf{Na_2CO_3}$) in deionised water in a beaker and transferring it to **F** a 500 cm^3 flask like that shown in the diagram.



(*a*) What name is given to the type of flask labelled **F**? (5)

(*b*) State one precaution taken to ensure that *all* of the sodium carbonate in the beaker ended up in **F**. (3)

(*c*) Sketch flask **F** in your answer book and show clearly the surface of the solution near line **L** when the flask is filled to exactly 500 cm^3. (6)

(*d*) Explain why flask **F** must be inverted several times after filling to line **L** and stoppering. (3)

(*e*) Calculate the mass of anhydrous sodium carbonate ($\mathbf{Na_2CO_3}$) required to prepare exactly 500 cm^3 of a solution of concentration 0.05 moles per litre. (9)

It was found by titration that 25.0 cm^3 of the 0.05 M solution of sodium carbonate required 22.7 cm^3 of a hydrochloric acid solution for neutralisation according to the following balanced equation:

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

(*f*) Name the piece of equipment used to measure out
(*i*) 25.0 cm^3 of the sodium carbonate solution,
(*ii*) 22.7 cm^3 of the hydrochloric acid solution required for neutralisation. (6)

(*g*) Name a suitable indicator for this titration.
State the colour change of the indicator at the end point. (9)

(*h*) Find the concentration of the hydrochloric acid solution in moles per litre. (9)

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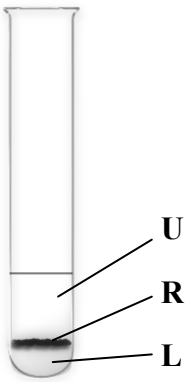
3. In a school laboratory a group of students carried out investigations on water from a nearby river.

(*a*) A flame test was carried out to test for potassium ions in the water from potassium nitrate ($\mathbf{KNO_3}$) in the run-off of fertiliser from farms in the area.
What colour flame would indicate the presence of potassium? (5)



(*b*) The diagram shows the result of a test for the nitrate ion in the river water.
(*i*) What colour ring **R** is a positive test for the nitrate ion?
(*ii*) What acid is added during the test and makes up the lower layer **L**?
(*iii*) What salt is used as the reagent in the upper layer **U**?
(*iv*) What problem could arise in the river as a result of fertiliser run-off? (15)

(*c*) Describe the steps the students could have taken to measure the concentration of *suspended* solids in the river water. (9)

(*d*) Describe *with the aid of a labelled diagram* how the concentration of *dissolved* solids could have been measured. (9)

(*e*) The students found that 500 cm^3 of the river water contained 0.03 g of suspended solids and that 200 cm^3 of the water contained 0.13 g of dissolved solids.
Find the concentration
(*i*) of suspended solids in grams per litre,
(*ii*) of dissolved solids in grams per litre *and* in mg per litre (p.p.m.). (12)

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*) The element with atomic number 101, *Mendelevium*, is named in honour of the Russian scientist Dmitri Mendeleev. What was Mendeleev's contribution to Chemistry that led to this honour?

(*b*) According to Bohr's atomic theory, what happens to an electron in a hydrogen atom after it reaches an excited state?

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

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

(*e*) How many electrons are shared between the atoms in (*i*) a single covalent bond, (*ii*) a triple covalent bond?

(*f*) State Boyle's law.

(*g*) Name *or* give the symbol of a metallic element used as a catalyst in the catalytic converter of a car.

(*h*) Give the name *or* formula of the carboxylic acid in vinegar.

(*i*) At which of the three stages of sewage treatment are phosphates and nitrates removed?

(*j*) Name the separation technique in which a mobile phase carrying a mixture is caused to move in contact with a selectively adsorbent stationary phase. The mixture may contain coloured or colourless components.

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

A Identify **two** greenhouse gases in the following list:
oxygen **carbon dioxide** **nitrogen** **methane**

or

B Identify **two** metals in the following list that corrode easily when exposed to air:
calcium **gold** **mercury** **sodium**

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5. The diagram shows a small part of a sodium chloride (**NaCl**) crystal, made up of sodium ions and chloride ions electrostatically attracted to each other. Sodium chloride crystals can be dissolved in water and the resulting solution conducts electricity.

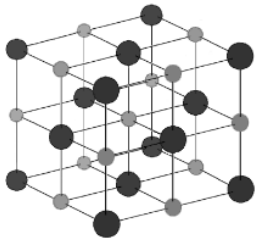
(*a*) What is an ion? (5)

(*b*) Draw a diagram to show the arrangement of electrons in a sodium atom.
Explain in words how a sodium *atom* becomes a sodium *ion*. (9)

(*c*) Draw a diagram to show the arrangement of all 17 electrons in a chlorine atom.
Explain in words how a chlorine *atom* becomes a chloride *ion*. (9)

(*d*) Why are chlorine atoms smaller than sodium atoms? (6)

(*e*) Define *electronegativity*.
Use electronegativity values (page 81 *Formulae and Tables* booklet) to predict the type of bonding in a water molecule.
Explain why
(*i*) sodium chloride can be dissolved in water,
(*ii*) sodium chloride solution can conduct electricity. (21)



6. Consider the compounds **A** to **E** in the table on the right and answer the questions below.

A	CH_4
B	C_2H_2
C	C_3H_6
D	C_3H_8
E	$C_6H_5CH_3$

(*a*) Why can all of these compounds be described as hydrocarbons? (5)

(*b*) Give the IUPAC names for any **three** of these compounds. (9)

(*c*) Which of the five compounds
(*i*) is used in oxyacetylene cutting and welding of metals,
(*ii*) is the main component of natural gas,
(*iii*) is an alkene,
(*iv*) is a component of LPG (liquefied petroleum gas)? (18)

(*d*) Each of these compounds burns in excess oxygen to produce the same **two** products.
Give the names *or* formulae of these two products. (6)

(*e*) Compound **E** is aromatic. Explain *aromatic* in terms of chemical structure.
Would you expect compound **E** to have a high octane number? Explain your answer. (12)

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7. (*a*) Define (*i*) an acid, (*ii*) a base. (8)

(*b*) (*i*) Define pH.
(*ii*) Solutions **A**, **B** and **C** have pH values of 1, 6 and 4 respectively. Arrange the solutions in order of *increasing* acidity.
(*iii*) Calculate the pH of a 0.03 M solution of sulfuric acid ($\mathbf{H_2SO_4}$). (18)

(*c*) The treatment of water for drinking may involve the following procedures:

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

(*i*) What is flocculation?
(*ii*) Why is drinking water chlorinated? Give one disadvantage of adding too much chlorine during drinking water treatment.
(*iii*) State one problem that could arise if the pH of drinking water were too low. What is added to the water if the pH is too low? (24)

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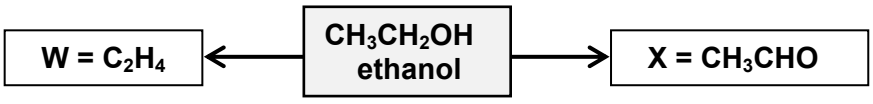
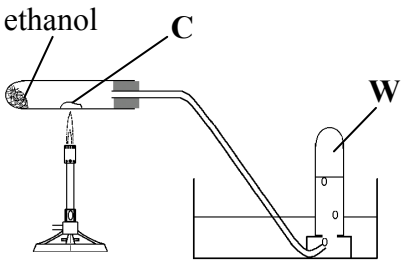
8. Study the reaction scheme below and answer the questions that follow.



(*a*) Give the IUPAC name for **W** and draw its molecular structure. (8)

(*b*) The diagram shows the preparation of **W** from ethanol.

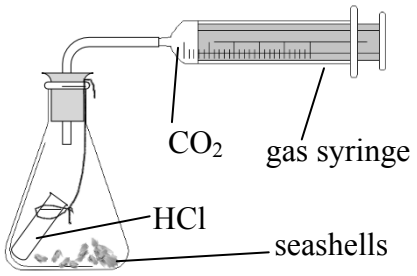


(*i*) Give the name *or* formula for compound **C**.
(*ii*) Classify the reaction type as an addition, an oxidation or an elimination. (12)

(*c*) (*i*) Explain what is meant by describing **W** as *unsaturated*.
(*ii*) Describe how you would test to confirm that **W** is unsaturated. (15)

(*d*) Compound **X** is formed in the human body when ethanol is metabolised.
(*i*) Name compound **X**.
(*ii*) Is the conversion of ethanol to **X** an addition, an oxidation or a substitution reaction?
(*iii*) Which one of the two compounds, **W** or ethanol, would you expect to be more soluble in water? Why? (15)

9. The rate of production of carbon dioxide from the reaction between hydrochloric acid solution (**HCl**) and the calcium carbonate (**$CaCO_3$**) in broken seashells was investigated. Using the apparatus shown, the acid was poured onto the seashells to start the reaction. The volume of gas collected was measured at one minute intervals using a gas syringe and the results are given in the table below.



Time (minutes)	0	1	2	3	4	5	6	7	8
Volume (cm^3)	0	21	36	46	53	57	59	60	60

(*a*) Define *rate of reaction*. (5)

(*b*) Plot, on graph paper, a graph of volume (*y*-axis) against time (*x*-axis). (15)

(*c*) Explain why the rate of the reaction decreases with time. (6)

(*d*) When carrying out the experiment, how do you know that the reaction has ended? (6)

(*e*) (*i*) Use your graph to find out what volume of carbon dioxide had been produced after 3.5 minutes.

(*ii*) Calculate the average rate of carbon dioxide produced in cm^3 per minute over the first 3.5 minutes. (9)

(*f*) How would the rate of reaction have been affected by

(*i*) the use of seashells crushed to a powder in place of the broken seashells,

(*ii*) replacing the acid with the same volume of a more concentrated **HCl** solution,

(*iii*) placing the reaction flask in ice-water? (9)

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

(*a*) Copy and complete the table. (15)

Isotope	Atomic Number	Mass Number	Number of Neutrons
$^{10}_{5}\mathbf{B}$			
$^{11}_{5}\mathbf{B}$			

(*i*) Some elements have radioactive isotopes. Define the underlined term. (6)

(*ii*) In the experiment in which the atomic nucleus was discovered, Rutherford bombarded a thin metal foil with alpha-particles from a radioactive isotope. Of what element was the metal foil made? (4)

(*b*) What is an exothermic reaction?

Name the instrument used to accurately measure the calorific values of different foods. (10)

Define *heat of combustion* of a substance.

Two moles of hexane (**C_6H_{14}**) burn in air according to the following balanced equation.

$$\mathbf{2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O} \qquad \mathbf{\Delta H = -8326\ kJ}$$

Calculate the heat of combustion of hexane.

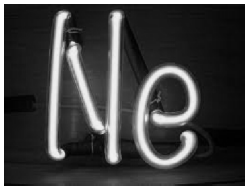
Is this reaction exothermic? Give a reason for your answer. (15)

(*c*) (*i*) What is the mass of one mole of neon (**Ne**)? (7)

(*ii*) How many moles are there in 5 g of neon gas? (6)

(*iii*) How many atoms are there in this quantity of neon? (6)

(*iv*) What volume does this quantity of neon gas occupy at s.t.p.? (6)



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

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

zinc **gained** **lost** **oxidised** **reduced** **redox**

Write in your answer book the omitted word corresponding to each number (**1** to **6**).

In a __1__ reaction electrons are transferred from one substance to another. When electrons are __2__ the substance is said to be oxidised and when electrons are __3__ the substance is reduced. In the reaction

$$\mathbf{Zn + CuSO_4 \rightarrow ZnSO_4 + Cu}$$

the copper ions are __4__ and __5__ acts as the reducing agent. Therefore zinc is more easily __6__ than copper.

State **one** observation made when zinc reacts with copper sulfate. (25)

(*b*) A chemical equilibrium between nitrogen gas, hydrogen gas and ammonia gas is set up at a certain temperature and pressure according to the following balanced equation.

$$\mathbf{N_2 + 3H_2 \rightleftharpoons 2NH_3}$$

Explain the underlined term. (7)

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

What effect would an increase in pressure have on the yield of ammonia at equilibrium? Explain your answer.

This equilibrium is used in the Haber process to make ammonia industrially.
Give one reason why extremely high pressures are **not** used in the Haber process. (12)

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

A

(*i*) Oxygen gas ($\mathbf{O_2}$) is produced industrially by liquefaction and fractional distillation of air. What other gas is the major product of this process?
What is the approximate percentage of this second gas in the atmosphere?
Give a widespread use for this second gas. (10)

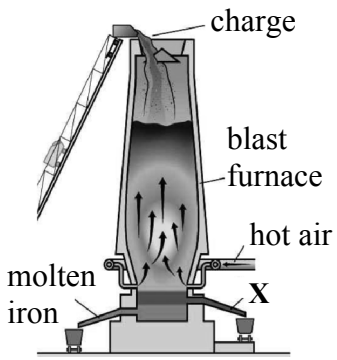
(*ii*) Name the other form of oxygen gas ($\mathbf{O_3}$) formed in the stratosphere.
What environmentally beneficial effect does $\mathbf{O_3}$ have?
Identify a group of chemicals that damages $\mathbf{O_3}$. (15)

or

B

The diagram shows a blast furnace used to extract iron metal from iron ore. Iron ore is added in the charge at the top while hot air is pumped in at the bottom as shown. Molten iron trickles down and is removed at the bottom. Molten impurities that float on the iron are removed at outlet **X**.

(*i*) Give the name *or* formula of an ore of iron.
Name another substance added in the charge with the iron ore.
What name is given to the impurity removed at **X**? (15)



Most of the iron produced is converted to an alloy of iron.

(*ii*) Name this alloy.
What other element is always present in this alloy? (10)

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