Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2020

CHEMISTRY – ORDINARY LEVEL

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3 hours

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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).

The information below should be used in your calculations.

Relative atomic masses (rounded): H = 1.0, C = 12, O = 16, Si = 28

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

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

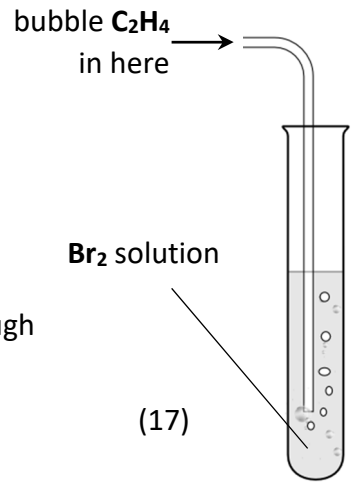
The use of the *Formulae and Tables* booklet approved for use in the State Examinations is permitted. A copy may be obtained from the superintendent.

Section A

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

1. Simple tests carried out on organic chemicals in a laboratory can be very informative.

(*a*) Ethene (C_2H_4) is a colourless, gaseous, unsaturated hydrocarbon. To confirm that ethene is unsaturated, a sample of it is bubbled through bromine (Br_2) solution as shown.



(*i*) What colour is the bromine solution used in the test?

(*ii*) What change is observed when the gas bubbled through the bromine solution is unsaturated?

(*iii*) What is meant by an *unsaturated* hydrocarbon? (17)

(*b*) Ethyne (C_2H_2) is another colourless gas. It burns with a distinctive flame.

(*i*) Describe how you carried out a combustion test on a sample of ethyne provided in a stoppered test-tube.

(*ii*) Describe the flame observed. (12)

(*c*) To find out which of two batches **X** and **Y** of benzoic acid (a white crystalline compound) was purer, a student measured the melting point (m.p.) of a very small sample of each batch and obtained the results shown in the table.

Batch	m.p.
X	117 – 120 °C
Y	120 – 122 °C

(*i*) Which was the purer batch of the two?

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

(*iii*) Benzoic acid crystals are much more soluble in hot water than in cold.
Name the procedure that could have been used to purify the impure batch based on this fact. (12)

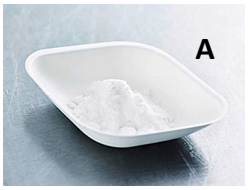
(*d*) In your answerbook match each substance **A**, **B**, **C** and **D** referred to in the table below with one of the substances in the following list:

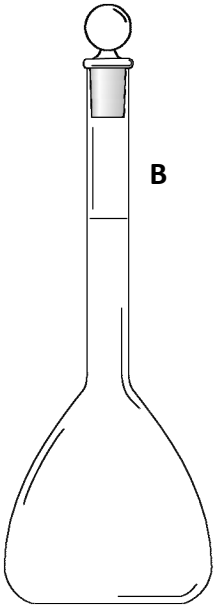
soap **ethanoic acid** **ethanal** **clove oil**

Test	Result
Shake a little of **A** with water in a test tube	Lather forms
Shake a little of **B** with water in a test tube	White emulsion forms
Add 3 cm freshly-sanded magnesium ribbon to **C**	Bubbles of gas form
Warm a little of **D** gently with Fehling's reagent	A brick-red precipitate appears

(9)

2. To prepare a litre of 0.05 M sodium carbonate solution, a student measured accurately a certain mass of solid anhydrous sodium carbonate (**Na_2CO_3**) in a plastic weighing boat **A** like that shown in the photograph. The student then dissolved the solid in deionised water in a beaker, transferred this solution to flask **B**, shown in the diagram, and made the solution in **B** carefully up to the mark with deionised water. **B** was then stoppered and inverted several times.





(*a*) (*i*) Name the type of flask shown on the right.

(*ii*) How could the student have ensured that *all* of the solid in weighing boat **A** ended up in flask **B**? (14)

The student then used the sodium carbonate solution in flask **B** to find the concentration of a hydrochloric acid (**HCl**) solution by titration.

One rough titration and three further titrations were carried out. For each titration 25.0 cm^3 of the sodium carbonate solution were measured into a conical flask using a pipette. A suitable indicator was added and then just enough of the hydrochloric acid solution was added to the conical flask to neutralise the sodium carbonate.

(*b*) Name the piece of equipment used in each titration to add the hydrochloric acid to the conical flask. (6)

(*c*) (*i*) Name an indicator suitable for use in these titrations.

(*ii*) State the colour change observed at the end point. (9)

The equation for the titration reaction is:

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

The table below shows the titration results, i.e. the volumes of **HCl** solution added.

Titration 1 (Rough Titration)	Titration 2	Titration 3	Titration 4
28.3 cm^3	27.7 cm^3	28.1 cm^3	27.8 cm^3

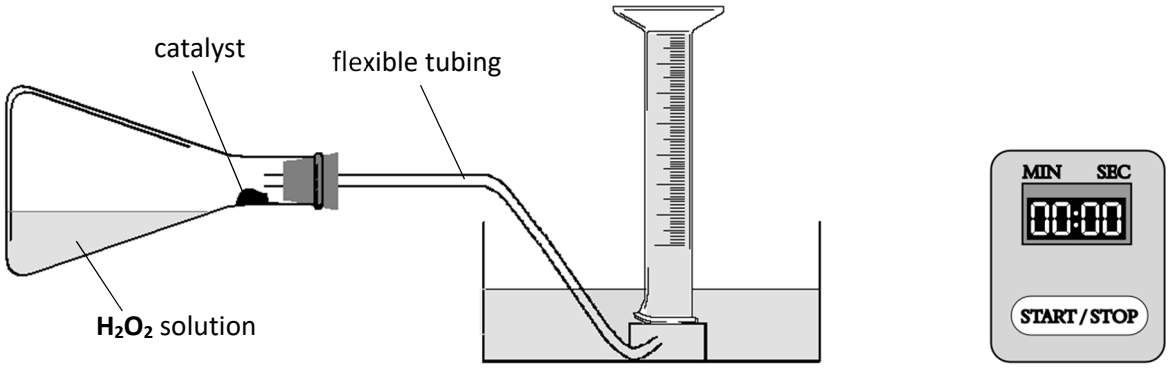
(*d*) (*i*) Why was it necessary to carry out Titration 4?

(*ii*) Which two volumes in the table should be used to calculate the average volume of the **HCl** solution required to neutralise 25.0 cm^3 of 0.05 M **Na_2CO_3** solution?

(*iii*) Calculate this average volume.

(*iv*) Calculate, in moles per litre, the concentration of the **HCl** solution. (21)

3. An arrangement of apparatus similar to that shown below was used to investigate the rate of decomposition of a hydrogen peroxide (H_2O_2) solution, in the presence of a solid catalyst, releasing oxygen gas. The reaction and the timer were started together and the volume of oxygen collected was measured at intervals over an 8 minute period.



A set of results obtained in such an investigation is given in the table.

Time (minutes)	0	1	2	3	4	5	6	7	8
Volume O_2 (cm^3)	0	35	61	81	96	105	108.5	109	109

(*a*) The equation for the decomposition reaction is:

$$2H_2O_2 \xrightarrow{\text{catalyst}} 2H_2O + O_2$$

(*i*) Identify a catalyst that could have been used in this investigation.

(*ii*) Describe the appearance of the catalyst you identified. (8)

(*b*) Labels on containers of hydrogen peroxide solutions should carry the hazard warning pictogram shown.

(*i*) What chemical hazard is indicated by this pictogram?

(*ii*) Give a safety precaution that should be taken when using hydrogen peroxide solutions. (12)

(*c*) Referring to the diagram of apparatus above, state how the decomposition reaction could have been started at the same instant that the timer was switched on. (6)

(*d*) Plot a graph (on graph paper) of volume of O_2 *versus* time (*x*-axis). (15)

(*e*) From your graph find the volume of oxygen produced

(*i*) in the first 2.5 minutes,

(*ii*) in the last 2.5 minutes of the 8 minutes.

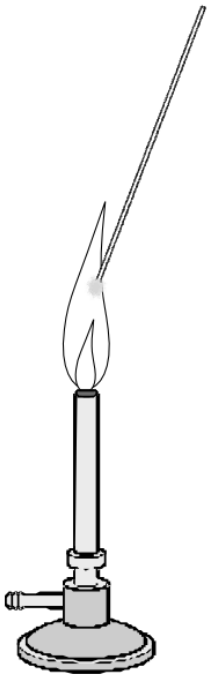
Explain why there is a difference in these volumes. (9)

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*) State one *physical* and one *chemical* property common to the elements in Group 1 of the periodic table.



(*b*) Name the group in the periodic table whose elements are chemically unreactive because they have stable electron configurations.

(*c*) What colour is given to a Bunsen flame by

(*i*) a sodium salt,

(*ii*) a copper salt?

(*d*) Identify the two gases produced during the electrolysis of acidified water using inert electrodes.

(*e*) Use the valencies of hydrogen and silicon to predict the chemical formula of silicon hydride.

(*f*) Why are chlorine compounds often added to swimming pool water?

(*g*) Define *heat of combustion*.

(*h*) In oil refining why is catalytic cracking of gas oil carried out?

(*i*) Sachets of silica gel (SiO_2) are often used to absorb moisture inside packaging. Calculate the percentage by mass, to the nearest whole number, of the element silicon in silica gel.

(*j*) Name the separation technique in which the components of a mixture are carried at different rates by a mobile phase in contact with a stationary phase.

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

A State two factors that would make a certain location suitable for a chemical factory.

or

B State two properties by which metals generally differ from non-metals.

5. Study the table of information below about the element carbon and answer the questions that follow.

Element	carbon		
Symbol	**C**		
Naturally occurring isotopes	carbon–12	carbon–13	carbon–14
Symbol of isotope	$^{12}_{6}\mathbf{C}$	$^{13}_{6}\mathbf{C}$	$^{14}_{6}\mathbf{C}$
Abundance of isotope in nature	about 99%	about 1%	trace
Stability of isotope	stable	stable	radioactive

(*a*) An element is composed of atoms all of which have the same <u>atomic number</u>.
Define the underlined term. (5)

(*b*) Every carbon atom contains protons, neutrons and electrons. Most of the mass of a carbon atom is concentrated at one location.
Name the location within a carbon atom of:
(*i*) its protons,
(*ii*) its electrons,
(*iii*) most of its mass.
(*iv*) Why is most of the mass of a carbon atom concentrated at one location within the atom?
(*v*) Why are all carbon atoms electrically neutral? (21)

(*c*) The element carbon has three naturally occurring isotopes.
(*i*) What are isotopes?
How many neutrons are there:
(*ii*) in an atom of carbon–13,
(*iii*) in an atom of carbon–14? (12)

(*d*) Radioactivity is the process by which an unstable part of an atom decays or loses energy, emitting one or more types of radiation.
Name one type of radiation emitted in radioactive decay. (6)

(*e*) (*i*) What is the relative atomic mass, correct to two decimal places, of the element carbon? Refer to page 79 of the *Formulae and Tables* booklet.
(*ii*) Why is the relative atomic mass of carbon close to, but not exactly, 12? (6)

6. Consider the following chemical fuels:

H_2 **CH_4** **LPG** **petrol** **kerosene**

These fuels burn <u>exothermically</u> in air.

(*a*) Explain the underlined term. (5)

(*b*) Identify a fuel from the list above that

(*i*) is often used in a Bunsen burner,

(*ii*) causes the least environmental impact when burned,

(*iii*) is used in jet aircraft engines and in some central-heating boilers. (9)

(*c*) **CH_4** is the main component of natural gas.

(*i*) Give the systematic IUPAC name for **CH_4**.

(*ii*) What is the shape of a **CH_4** molecule?

(*iii*) To which homologous series does **CH_4** belong?

(*iv*) Why are small quantities of mercaptans added to natural gas before supplying it to consumers?

(*v*) Copy, complete and balance the following equation for the complete combustion of **CH_4** in oxygen: **$CH_4 + O_2 \rightarrow$** (24)

(*d*) Propane (**C_3H_8**) is one of the two main components of liquid petroleum gas (**LPG**).

(*i*) Draw the expanded molecular structure of propane,
i.e. show the arrangement of all the atoms and bonds in a propane molecule.

(*ii*) Identify the hydrocarbon that is the second main component of **LPG**. (12)

7. (*a*) What is a base? (6)

(*b*) Define pH.

Calculate the pH of a 0.05 M **NaOH** solution correct to one decimal place. (12)

(*c*) What is hard water? (6)

(*d*) The label on a bottle of mineral water gave the information shown in the table.

Information	
pH at source	7.2
calcium	164 mg/l
magnesium	50 mg/l
hydrogencarbonate	243 mg/l
nitrate	3 mg/l
sulfate	410 mg/l
chloride	50 mg/l

(*i*) Is the water at source acidic or basic?

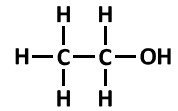
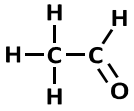
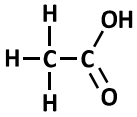
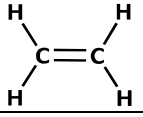
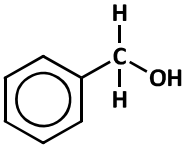
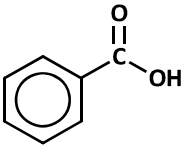
(*ii*) How does the label indicate that the water is hard?

(*iii*) How does the label indicate that the water contains *temporary* hardness?

(*iv*) Drops of barium chloride (**$BaCl_2$**) solution were added to a few cm^3 of the mineral water in a test-tube.
What observation confirms the presence of sulfate ions in the mineral water?

(*v*) Give an advantage of drinking this water instead of tap-water. (26)

8. **A** is present in wines, beers and spirits.
The first step in the metabolism of **A** in the body produces **B**.
Bacteria in wine use enzymes to change **B** to **C** giving wine left standing in air a sour taste.
E can be converted to benzoic acid (**F**) using **$KMnO_4$** in alkaline conditions.

A	
B	
C	
D	
E	
F	

(*a*) (*i*) Give the IUPAC names for **A**, **B** and **C**.

(*ii*) Which two compounds in the table are alcohols?

(*iii*) Is **D** soluble in water?

(*iv*) Which compound in the table is used to make poly(ethene)?

(*v*) Identify an aromatic compound in the table. (27)

(*b*) (*i*) What is an *enzyme*?

(*ii*) Supply the missing word in the following statement.

'The conversions **A** to **B**, **B** to **C** and **E** to **F** can all be classified as _____ reactions.' (12)

(*c*) **D** is the gaseous product of the reaction that occurs when the vapour of **A** passes over hot aluminium oxide (**Al_2O_3**).

(*i*) Draw a labelled diagram of the arrangement of apparatus used to carry out this reaction and collect **D**.

(*ii*) Classify the conversion of **A** to **D** as an *elimination*, an *addition* or a *substitution* reaction. (11)

9. Refer to page 79 of the *Formulae and Tables* booklet when answering this question.

(*a*) What is the number of electrons in each of the main energy levels (shells)

(*i*) in an oxygen atom,

(*ii*) in a magnesium atom? (12)

(*b*) Define (*i*) *oxidation*, (*ii*) *reduction*, in terms of electron transfer. (12)

(*c*) When magnesium metal burns in air with a bright white flame, the following reaction takes place forming magnesium oxide, an ionic substance.

$$\mathbf{2Mg + O_2 \rightarrow 2MgO}$$

(*i*) Which element is reduced?

(*ii*) Which substance is the reducing agent?

(*iii*) Give two characteristic properties of ionic substances. (21)

(*d*) When a piece of magnesium metal is placed in a blue solution of copper(II) sulfate, the following reaction takes place, the blue colour fades, and copper metal is formed.

$$\mathbf{Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu}$$

What does this result tell you about how easily magnesium metal is oxidised compared to copper metal? (5)

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

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

biological aerobically chemical eutrophication nutrients physical microorganisms sludge

Write in your answerbook the omitted word corresponding to each of the numbers (**1** to **8**).

In sewage treatment the first or primary treatment stage is **1**. Its purpose is to remove most of the solid matter using meshes, grit channels and primary settlement tanks. Secondary treatment is **2** where the remaining organic matter in the sewage is broken down **3** by **4**. Settlement tanks are often used again at the end of secondary treatment. Tertiary treatment, involving **5** processes, is expensive and is only used when it is necessary to remove **6** that could cause **7**. The treated water is released to the sea, a river or a lake. The semi-solid by-product of sewage treatment is called **8**. (25)

(*b*) In which state of matter, solid, liquid *or* gas, are the particles

(*i*) moving around fastest,

(*ii*) farthest apart?

(*iii*) What term is used to describe the spreading out, as shown in the photograph, of the smoke spewed out by an erupting volcano?

The combined gas law states that

$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$ = constant for a fixed mass of gas.

A gas has a volume of 120 cm^3 at a temperature of 819 K and a pressure of 2×10^5 Pa.

(*iv*) Use the combined gas law to calculate the volume of the gas at standard temperature of 273 K and standard pressure of 1×10^5 Pa.

(*v*) The combined gas law is based on other gas laws.
Name and state one of these laws. (25)

(*c*) When the leaves of a tree were exposed to sunlight for a certain length of time 18.0 g of glucose ($C_6H_{12}O_6$) were made from carbon dioxide and water as a result of photosynthesis, and oxygen gas was also produced according to the following balanced equation.

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

(*i*) What is the mass of one mole of $C_6H_{12}O_6$?
How many moles are there in 18.0 g of glucose?

(*ii*) What is the ratio of moles of glucose to moles of O_2 in the equation above?
How many moles of O_2 were produced when 18.0 g of glucose were made?
What volume does this O_2 occupy at s.t.p.?

(*iii*) What mass of CO_2 was used up when 18.0 g of glucose were made? (25)

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

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

Ammonia ($\mathbf{NH_3}$) is produced when urine decomposes. Ammonia is a colourless gas with a characteristic, pungent smell. Each ammonia molecule consists of a nitrogen atom bonded covalently to three hydrogen atoms.

(*i*) Draw a dot and cross diagram to show the arrangement of the electrons in one ammonia molecule. (The electrons in nitrogen's first shell need *not* be shown.) (9)

(*ii*) Define *electronegativity*.

(*iii*) Write down the electronegativity values for nitrogen and hydrogen and use these values to predict whether the bonding in an ammonia molecule is polar covalent or non-polar (pure) covalent.

(*iv*) Would you expect ammonia gas to be water-soluble?
Explain your answer. (16)

(*b*) Hydrogen gas is manufactured industrially when the following <u>chemical equilibrium</u> is set up between $\mathbf{CH_4}$, steam, carbon monoxide and hydrogen.

$$\mathbf{CH_4}_{(g)} + \mathbf{H_2O}_{(g)} \rightleftharpoons \mathbf{CO}_{(g)} + \mathbf{3H_2}_{(g)} \qquad \boldsymbol{\Delta H} = \mathbf{206\ kJ}$$

(*i*) Explain the underlined term.

(*ii*) Write the equilibrium constant ($\boldsymbol{K_c}$) expression for the reaction. (13)

(*iii*) Supply the missing word in the following statement:
'The use of a catalyst does not affect the yield of hydrogen at equilibrium but it reduces the _____ for equilibrium to be reached.'

(*iv*) According to Le Châtelier's principle, disturbing the reaction conditions would affect the percentage yield of hydrogen at equilibrium.
To what reaction conditions does Le Châtelier's principle refer? (12)

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

A

The process carried out in a particular chemical plant is a <u>continuous process</u>.

(*i*) Explain the underlined term.

In a chemical industry process what name is given to

(*ii*) the substances which react to form the main product,

(*iii*) any other substances made in the reaction in addition to the main product,

(*iv*) the analysis of materials used up or made in the process to verify their identities and measure their purity,

(*v*) the procedures taken to avoid damage to local soil or waterways? (25)

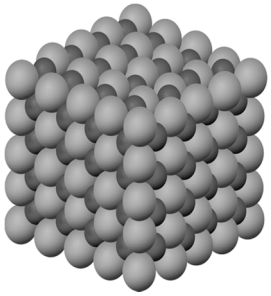
or

B

A crystal consists of a regular repeating pattern of particles.
These particles can be *atoms*, *ions* or *molecules*.

(*i*) The photograph on the right shows sodium chloride (**NaCl**) crystals. The diagram below represents the arrangement of minute particles that make up part of a sodium chloride crystal. What particles, *atoms*, *ions* or *molecules*, make up a sodium chloride crystal?

(*ii*) Diamond and graphite are macromolecular covalent crystals. What particles, *atoms*, *ions* or *molecules*, are covalently bonded in diamond and graphite?



(*iii*) What particles, *atoms*, *ions* or *molecules,* become free to move around when ice crystals melt?

(*iv*) Why can metallic crystals conduct electricity?

(*v*) What type of electromagnetic radiation did William and Lawrence Bragg first use to determine crystal structures? (25)

Leaving Certificate – Ordinary Level

Chemistry

3 hours

Image Q6 on page 7: from commons.wikimedia.org/wiki/
File: IBE-refueling-gua.jpg, accessed 17 September 2019, CC-BY-SA-3.0

Image Q7 on page 7: from www.eauvation.co.uk
File: glass-bottle, accessed 12 December 2019

Image Q10(*b*) on page 9: by Skeeze on www.pixabay.com
File: photos/volcano-erupting-landscape-scenic-1056526, accessed 14 December 2019

Image Q11(*a*) on page 10: from nicepik.com
File: grayscale-photography-baby-sleeping-196719.jpg, accessed 12 September 2019

Image Q11(*c*) A on page 11: from www.kbr.com/en-au/experience/mary-turkmenistan-ammonia-plant, accessed 17 September 2019

Image Q11(*c*) B on page 11: from www.flickr.com/photos/wlodi/252462355,
accessed 17 September 2019, CC-BY-SA-2.0

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