



Coimisiún na Scrúduithe Stáit State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2014

CHEMISTRY – ORDINARY LEVEL

TUESDAY, 17 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: H = 1, O = 16, Na = 23, S = 32

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

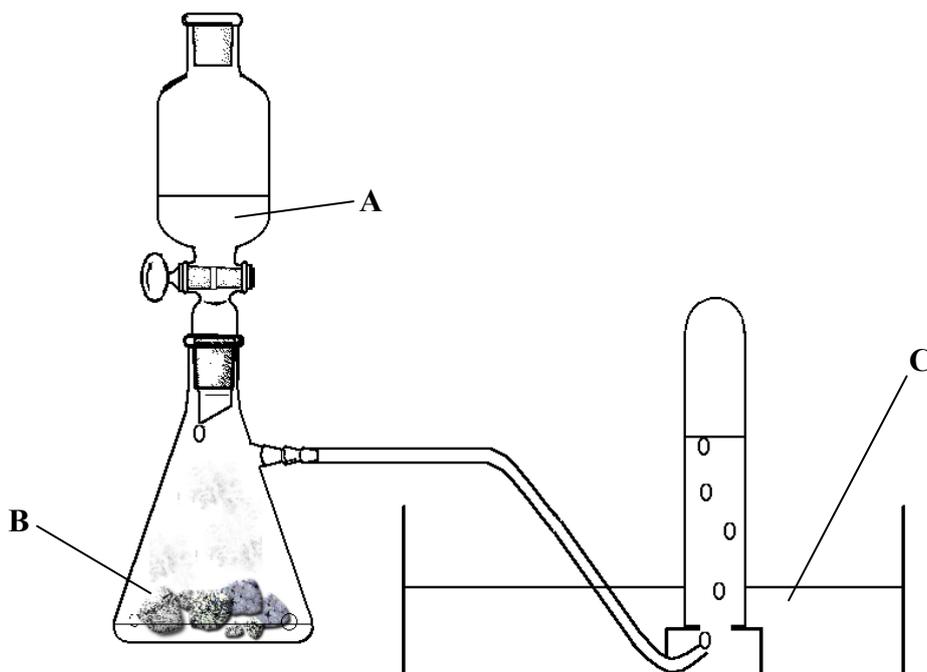
Avogadro constant = $6.0 \times 10^{23} \text{ mol}^{-1}$

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 two questions from this section [see page 1 for full instructions].

1. Ethyne (acetylene) gas (C_2H_2) is the first member of a homologous series of unsaturated hydrocarbons. The diagram below shows the arrangement of apparatus used for the preparation of ethyne in a school laboratory.



- (a) Explain the term *hydrocarbon*.
To which homologous series does ethyne belong? (11)
- (b) Identify
(i) the liquid **A**,
(ii) the solid **B**,
(iii) the liquid **C**. (9)
- (c) Why should the first few test-tubes of gas collected be discarded? (6)
- (d) What is meant by saying that ethyne is *unsaturated*?
Describe a test that would show that ethyne is an unsaturated compound. (12)
- (e) Describe the flame observed when a test-tube of ethyne is burned in air.
Burning a mixture of ethyne gas and oxygen gas produces a flame with temperatures in excess of $3000\text{ }^{\circ}\text{C}$.
Give a use for this very hot flame. (12)

2. A piece of glassware labelled **A** in the diagram below was filled with a standard solution of hydrochloric acid (**HCl**) that had a concentration of 0.13 M. This solution was used to find by titration the concentration of a solution of sodium hydroxide (**NaOH**).
Two other pieces of equipment used, **B** and **C**, are also shown in the diagram.

(a) Explain the underlined term. (5)

(b) Name the pieces of equipment **A**, **B** and **C**. (9)

(c) Name another piece of glassware required to carry out the titration experiment.

What use is made in the experiment of the piece of glassware you have named? (6)

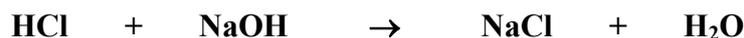
(d) Describe the procedure for rinsing **B** before using it to measure the sodium hydroxide solution. (6)

(e) State **one** use made of **C** during the titrations. (3)

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

(g) It was found that 25.0 cm³ of the sodium hydroxide solution were exactly neutralised by 17.4 cm³ of the 0.13 M solution of hydrochloric acid.

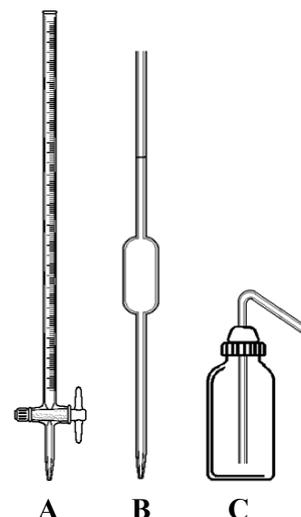
The equation for the titration reaction is:



Find the concentration of the sodium hydroxide solution

(i) in moles per litre,

(ii) in grams per litre.



3. Hydrogen peroxide (**H₂O₂**) decomposes rapidly in the presence of a suitable catalyst to form water and a colourless gas. The rate of this reaction was investigated by measuring the volume of gas produced at half-minute intervals using a suitable arrangement of apparatus. The results are shown in the table below.

| | | | | | | | |
|--------------------------------|-----|------|------|------|------|------|------|
| Time (minutes) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 |
| Volume (cm³) | 0.0 | 13.0 | 21.0 | 25.0 | 27.0 | 27.5 | 27.5 |

(a) What is a catalyst?

Suggest a suitable catalyst for the decomposition reaction. (11)

(b) What gas was produced in the reaction? (3)

(c) Draw a labelled diagram of a suitable apparatus for carrying out this experiment. (12)

(d) Plot, on graph paper, a graph of volume (*y*-axis) *versus* time (*x*-axis).
Estimate, from your graph, the volume of gas produced after 1.25 minutes. (18)

(e) Does the rate of reaction increase *or* decrease with time?
Give a reason for your answer. (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) How many neutrons are there in an atom of ${}^7_3\text{Li}$?
 (b) Define *electronegativity*.
 (c) What is the shape of an ammonia (NH_3) molecule?
 (d) The following equation shows the heat of reaction for the formation of benzene:



Is this reaction exothermic *or* endothermic? Explain your answer.

- (e) A thin stream of liquid is attracted towards a charged plastic rod as shown on the right. What does this test tell you about the type of bonding in the liquid?
 (f) Why is chlorine added to the water in swimming pools?
 (g) Which of the following particles carry the electric current through a solution during electrolysis?

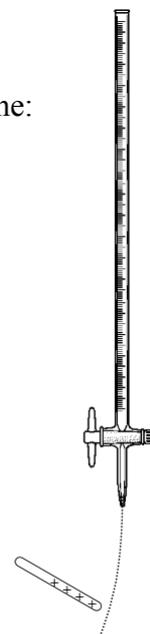
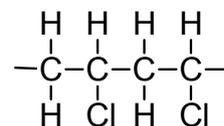
atoms electrons ions molecules

- (h) Name the type of nuclear radiation that consists of positively-charged particles that are identical to helium nuclei.
 (i) Calculate the percentage by mass of sulfur in sulfur trioxide (SO_3).
 (j) State **one** way that the melting point of an impure organic substance differs from the melting point of a pure sample of the same substance.
 (k) Answer part **A** *or* part **B**.

A State **one** way in which safety may be promoted in a chemical plant.

or

B Two repeating units of a well-known addition polymer are shown on the right. Name the polymer.



5. (a) Define *atomic number*. (5)

(b) Consider the elements of the second and third periods of the periodic table of the elements (**Li** to **Ne** and **Na** to **Ar**). See page 79 of the *Formulae and Tables* booklet.

In terms of the distribution of electrons, what common feature is found in

- (i) atoms of elements in the same group, e.g. lithium and sodium,
 (ii) atoms of elements in the same period, e.g. carbon and nitrogen?

Why do the elements of group 18 (noble gases) have very low chemical reactivity? (18)

(c) What is the arrangement of electrons in the main energy levels (shells) in
 (i) an atom of magnesium (**Mg**), (ii) an atom of oxygen (**O**)? (12)

(d) Write the name *and* formula of the compound formed between magnesium (**Mg**) and oxygen (**O**).

In the formation of this compound, electrons are transferred from magnesium atoms to oxygen atoms. Name the type of bond formed between magnesium and oxygen.

Give **one** characteristic of compounds with this type of bond. (15)

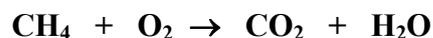
6. Compounds **A**, **B**, **C** and **D** in the table are found in fuels.

(a) Name compounds **A** and **B**. (8)

(b) Compound **A** is a greenhouse gas. (6)

Name a source that releases **A** into the atmosphere.

When burned, compound **A** combines with oxygen to form carbon dioxide and water.



Copy the equation into your answer book and balance it. (6)

(c) Compound **B** is obtained from oil refining and is used as a component of LPG.

What do the letters LPG stand for?

Name another substance found in LPG. (12)

(d) What is meant by the *octane number* of a fuel? (6)

Would you expect compound **C** or compound **D** to have the higher octane number?

Give a reason for your answer.

Why were lead compounds added to motor fuel in the past?

Why was the addition of lead compounds to motor fuel discontinued? (12)

| | |
|----------|--|
| A | $\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$ |
| B | $\begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ |
| C | $\begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ |
| D | $\begin{array}{cccccc} \text{H} & \text{CH}_3 & \text{H} & \text{H} & \text{H} & \\ & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ |

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

What is meant by the term *neutralisation*? (9)

(b) Define pH. (6)

How would you measure the pH of a dilute solution of hydrochloric acid? (6)

(c) Calculate the pH of (i) a 0.01 M solution of hydrochloric acid (**HCl**),
(ii) a 0.01 M solution of sodium hydroxide (**NaOH**). (12)

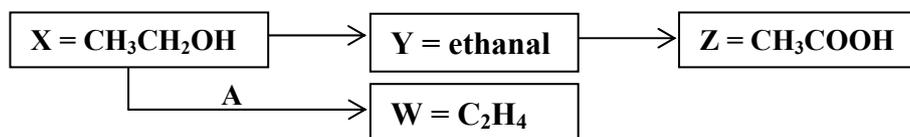
(d) The pH of a particular beer is 3.9, the pH of pure water is 7.0, and the pH of saliva is about 7.4.

Which of these substances (i) is neutral, (ii) is basic?

If a large volume of pure water were added to the beer, would the pH of the diluted beer be higher or lower than 3.9, or would it remain at 3.9? (9)



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



(a) Give the systematic (IUPAC) names for **W** and **X**. (8)

(b) Describe, including a labelled diagram, how you would prepare **W** using reaction **A** and how you would collect it in test-tubes. (15)

(c) Which of the compounds

(i) is found in vinegar,

(ii) is often produced by the fermentation of sugars in fruit, e.g. grapes,

(iii) produces a red precipitate when heated with Fehling's solution? (15)

(d) What gas is produced when an aqueous solution of compound **Z**, a carboxylic acid, reacts with solid sodium carbonate (**Na₂CO₃**)?

How could you test for this gas?

What other carboxylic acid occurs as an irritant in the stings of ants and nettles? (12)

9. (a) What is *hard water*? (6)
 Would you expect the water supply in a limestone district to be hard?
 Give a reason for your answer.
 Distinguish between *temporary hardness* and *permanent hardness* of water.
 State **one** advantage and **one** disadvantage of a hard water supply. (24)

- (b) The following words that relate to sewage treatment are omitted from the passage below.
nitrates solid sedimentation eutrophication micro-organisms
 Write in your answer book the omitted word corresponding to each number (1 to 5).
 In primary treatment, sewage is passed through grids and over grit channels to remove 1 material and is then transferred to 2 tanks where suspended solids are allowed to settle. In secondary treatment the sewage undergoes biological oxidation by 3. Tertiary treatment removes 4 and phosphates which could cause 5 in rivers and lakes. (20)

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

- (a) You are asked to test a white crystalline solid to confirm that it is lithium chloride (**LiCl**).

(i) Describe how to carry out a flame test on the solid. (12)

(ii) What reagent is used to test for the chloride ion? (6)

(iii) Copy the table into your answer book and complete it with the expected results of the tests. (7)

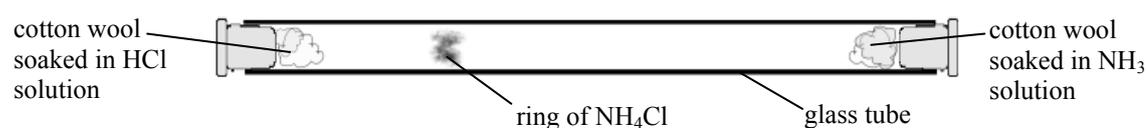
| Solid | Flame Test Result | Chloride Test Observation |
|-------|-------------------|---------------------------|
| LiCl | | |

- (b) In which state of matter – solid, liquid *or* gas – do the particles move around fastest? (6)
 State *Boyle's law*. (6)

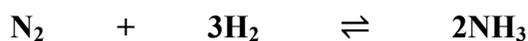
A sample of ammonia (**NH₃**) gas occupies 11.2 litres at s.t.p.

How many (i) moles of ammonia, (ii) molecules of ammonia, are in the sample? (6)

Name the process that results in the formation of a white ring of ammonium chloride (**NH₄Cl**) from ammonia (**NH₃**) gas and hydrogen chloride (**HCl**) gas as shown in the diagram. (7)



- (c) The reaction between hydrogen gas and nitrogen gas produces gaseous ammonia, according to the following chemical equilibrium.



(i) Explain the underlined term. (7)

(ii) Write the equilibrium constant (**K_c**) expression for the reaction. (6)

The French industrial chemist, pictured on the right, devised a principle that is used to predict the effect, if any, on a chemical equilibrium of a change in temperature, pressure or concentration.

(iii) Name the industrial chemist. (6)

(iv) Use his principle to predict the effect on the equilibrium yield of ammonia in the reaction above of increasing the pressure. (6)



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

(a) Consider the following six terms.

refluxing **fractionation** **recrystallisation**
distillation **chromatography** **steam distillation**

In your answer book, match any *five* of the terms above with their corresponding descriptions (A to F) in the table below. (25)

| | |
|----------|---|
| A | Separation of the coloured components of a mixture using a solvent as the mobile phase and a suitable solid as the stationary phase |
| B | Separation of two liquids on the basis of their different boiling points |
| C | Dissolving impure crystals in the minimum amount of hot solvent and then filtering the mixture after allowing it to cool |
| D | Separation of several substances in crude oil on the basis of difference in boiling points |
| E | Boiling a reaction mixture without loss of material, thus giving time for reaction to occur |
| F | Extraction of clove oil from cloves (or similar extraction of another oil) |

(b) Define (i) *oxidation*, (ii) *reduction*, in terms of electron transfer. (6)

When a zinc rod is dipped into a blue solution of copper(II) sulfate, the following oxidation-reduction reaction takes place.



Identify (iii) the species oxidised, (iv) the species reduced, (v) the oxidising agent. (12)

Is zinc (**Zn**) placed above *or* below copper (**Cu**) in the electrochemical series?

Give a reason for your answer. (7)

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

A

Chemical processes are usually either *batch* processes or *continuous* processes.

Distinguish between the two. (6)

Suggest **one** way of reducing energy costs in a chemical industry. (4)

Answer the following questions in relation to the chemical process taken as your case study based on the Irish chemical industry.

(i) State the location in Ireland of the process that was the subject of your case study.

Suggest **two** reasons in support of the suitability of this location. (9)

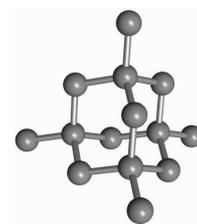
(ii) Name the product of the chemical process you studied.

Give a use for this product. (6)

B

Carbon exists in different physical forms (allotropes), e.g. diamond.

Part of the structure of diamond, a covalent macromolecular crystal, is shown on the right.



(i) What particles occupy the lattice points in diamond crystals?

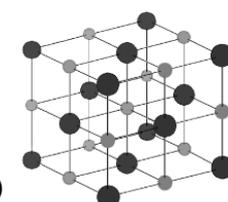
(ii) Name another physical form (allotrope) of carbon. (10)

A small part of the cubic crystal lattice of sodium chloride is also shown.

(iii) What particles occupy the lattice points in sodium chloride crystals?

(iv) What are the binding forces in a sodium chloride crystal?

(v) What technique is used to study the internal structures of crystals? (15)



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