# Coimisiún na Scrúduithe Stáit
# State Examinations Commission

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## LEAVING CERTIFICATE EXAMINATION, 2025

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# CHEMISTRY – ORDINARY LEVEL

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TUESDAY, 17 JUNE – AFTERNOON, 2:00 to 5:00

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**400 MARKS**

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Answer any **eight** questions.

All questions carry equal marks (50).

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**The information below should be used in your calculations.**

Relative atomic masses (rounded): H = 1, B = 11, C = 12, O = 16

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

**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.**

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The 2025 examination papers were adjusted to compensate for disruptions to learning due to COVID-19. This examination paper does not necessarily reflect the same structure and format as the examination papers of past or subsequent years.

# Section A

**See page 1 for instructions regarding the number of questions to be answered.**

**1.** Soap is a product of the reaction between a solution of sodium hydroxide (**NaOH**) and a common household substance **A**.

A student mixed suitable amounts of substance **A** with solid **NaOH** in a solvent mixture of water and ethanol. The mixture was heated gently for about 20 minutes using a hot-water bath, as shown in **Diagram 1**.

Ethanol was then removed from the reaction mixture as shown in **Diagram 2**.

Some boiling water was used to transfer the residue in the round-bottomed flask into brine in a beaker, precipitating soap.

**Diagram 1**

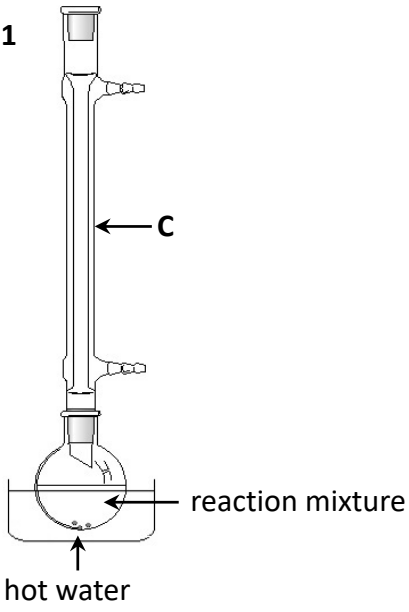
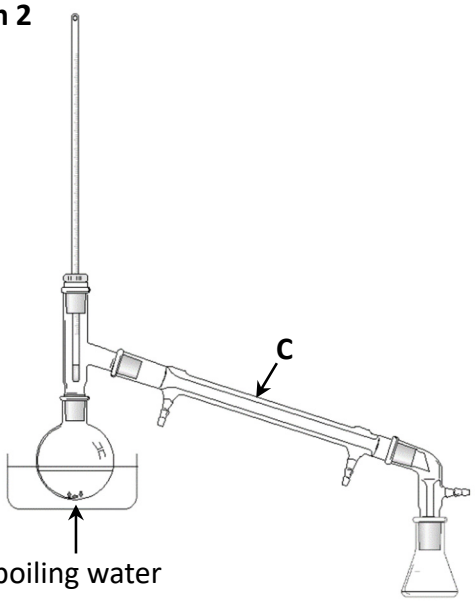



**Diagram 2**




(*a*) Identify substance **A**. (6)

(*b*) (*i*) Name the technique shown in **Diagram 1**, which is used to heat the reaction mixture without loss of solvent.

(*ii*) Name the technique shown in **Diagram 2**, which is used to separate the ethanol from the reaction mixture. (12)

(*c*) (*i*) Name the piece of apparatus labelled **C** in the diagrams.

(*ii*) Identify the change of state that occurs in **C**. (12)

(*d*) (*i*) What is brine?

(*ii*) Describe how the soap precipitate could have been separated from the brine. (12)

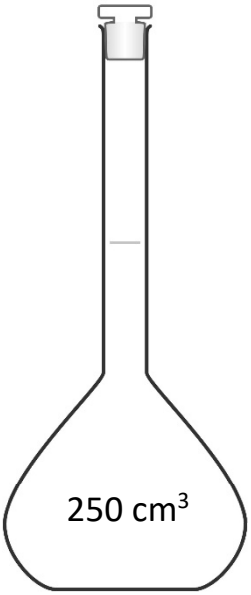
Warning pictograms found on containers of NaOH and ethanol are shown on the right.

(*e*) State the chemical hazard indicated by each of these pictograms. (8)

**NaOH** **Ethanol**

**2.** A student used a standard solution of sodium carbonate (**$Na_2CO_3$**) to find the concentration of a solution of hydrochloric acid (**HCl**) by titration.

The sodium carbonate solution was supplied in the piece of apparatus labelled **P**. Some of this solution was placed in a clean, dry beaker. 25.0 $cm^3$ portions were measured using another piece of apparatus and then transferred to a conical flask. The solution was titrated against **HCl**, which was added from a burette. A number of titrations were carried out.



**P**

(*a*) The sodium carbonate solution used was a <u>standard solution</u>. Explain the underlined term. (5)

(*b*) (*i*) Identify the piece of apparatus labelled **P**.

(*ii*) Name a suitable piece of apparatus that can be used to accurately measure out a 25.0 $cm^3$ portion of the sodium carbonate solution.

(*iii*) Describe how the burette was rinsed before use.

(*iv*) State one precaution that could be taken to ensure accuracy when taking a burette reading. (24)

(*c*) A few drops of an indicator solution were added to the **$Na_2CO_3$** in the conical flask before carrying out each titration.

(*i*) Name a suitable indicator.

(*ii*) State the colour change observed in the conical flask at the end point using this indicator.

(*iii*) Why is it helpful to place the conical flask on a white tile during the titration? (12)

(*d*) On average, it was found that 25.0 $cm^3$ portions of a 0.05 M **$Na_2CO_3$** solution required 18.4 $cm^3$ of a **HCl** solution for neutralisation.

The titration reaction is described by the following balanced chemical equation:

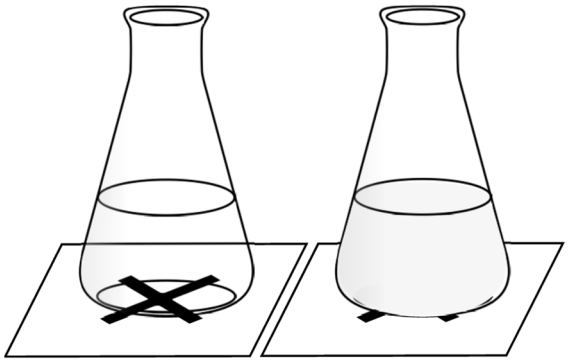
$$\mathbf{2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2}$$

Calculate the concentration, in moles per litre, of the **HCl** solution. (9)

**3.** 10 $cm^3$ of 3 M hydrochloric acid (**HCl**) were added to a flask containing 100 $cm^3$ of sodium thiosulfate ($Na_2S_2O_3$) solution. The flask was swirled to mix the solutions.

The solution gradually turned pale yellow and cloudy.

A timer was used to find the time taken in minutes for a cross marked on a piece of paper placed under the flask to become obscured when looking down through the reaction mixture.



cross visible initially

cross obscured after *t* seconds

The reaction observed in the flask is described by the following balanced chemical equation:

$$Na_2S_2O_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + SO_{2(g)} + S_{(s)} + H_2O_{(aq)}$$

The rate of reaction (1/minutes) for a number of different concentrations of $Na_2S_2O_3$ was measured and the data recorded in the table below. All other reaction conditions were kept constant.

| Concentration of $Na_2S_2O_3$ (M) | 0 | 0.02 | 0.04 | 0.06 | 0.08 | 0.1 |
|---|---|---|---|---|---|---|
| Rate of reaction (1/minutes) | 0 | 0.4 | 0.8 | 1.2 | 1.6 | 2.0 |

(*a*) (*i*) Identify the reaction product that causes the cross to become obscured.

(*ii*) Name a suitable piece of apparatus that could be used to measure out 10 $cm^3$ of **HCl**.

(*iii*) State one reaction condition which was kept constant. (17)

(*b*) (*i*) Plot a graph, on graph paper, of concentration of $Na_2S_2O_3$ versus the rate of reaction.

(*ii*) Use your graph to estimate the rate of reaction when the concentration of $Na_2S_2O_3$ was 0.05 M.

(*iii*) State whether the rate of reaction increases or decreases as the concentration of $Na_2S_2O_3$ increases. Give a reason for your answer.

(*iv*) How would you expect the rate of reaction to be affected by cooling the solutions used? Give a reason for your answer. (33)

# 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 metal responsible for the yellow colour of the flame in a flame test.

(*b*) Describe the trend in the size of atomic radii going down Group 1 of the periodic table of elements. Give a reason for your answer.

(*c*) State the shape of a molecule of ammonia (**$NH_3$**).

(*d*) State the relationship between the temperature (*T*) on the kelvin scale and the volume (*V*) of a fixed mass of gas at constant pressure according to Charles' law.

(*e*) What is meant by electronegativity?

(*f*) Calculate the percentage of carbon by mass in heptane (**$C_7H_{16}$**).

(*g*) Explain why mercaptans are added to natural gas before it is supplied to customers.

(*h*) Copy and complete the following sentence:

'Chromatography is a separation technique in which the components of a mixture are carried at different _____ by a mobile phase in contact with a _____ phase.'

(*i*) State one difference between temporary hardness and permanent hardness in water.

(*j*) The molecular formula of ethanoic acid is **$C_2H_4O_2$**.
What is the empirical formula for ethanoic acid?

(*k*) Diffusers are used to perfume a room. The fragrant oils in the solution evaporate and diffuse into the air.
What is diffusion?

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

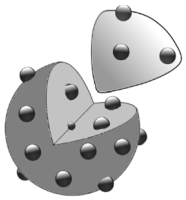
**A** Write the chemical formula for ozone.

*or*

**B** Name the English scientist who discovered in 1807 that the elements sodium and potassium could be extracted from their salts by electrolysis.

**5.** Between 1808 and 1913 scientists gave different descriptions for the structure of the atom. Each description was 'correct' when it was first stated, because it was based on the evidence available at the time. Each description was an improvement on the previous one because it accounted for more facts known at the time.

In 1808 Dalton described atoms as indivisible.



By 1897 it had been discovered that all atoms contain negative particles. From this, it was proposed that the atom is spherical, with small negative particles embedded in positive matter.

In 1909 Rutherford discovered that the electrons in an atom occupy an electron cloud surrounding a nucleus.

In 1913 Bohr described the arrangement of the electrons in fixed paths in the electron cloud.

(*a*) (*i*) Name the scientist who discovered that all atoms contain negative particles.

(*ii*) State one property of the nucleus as discovered by Rutherford.

(*iii*) State the term used for the fixed paths described in Bohr's model of the atom. (14)

(*b*) Consider atoms of the element carbon. Not all carbon atoms are identical.

(*i*) Name the two different types of subatomic particles found in the nuclei of all carbon atoms.

(*ii*) Explain why all carbon atoms have an atomic number of 6.

(*iii*) Show the arrangement of the electrons in a carbon atom.

(*iv*) Why are all carbon atoms electrically neutral? (24)

(*c*) (*i*) What term is used to describe atoms of the same element that have different mass numbers?

(*ii*) In terms of subatomic particles, explain why carbon atoms can have different mass numbers, i.e. 12, 13 or 14. (12)

**6.** The chemical formulae of six hydrocarbons are listed below.

The list includes three alkanes, one alkene, one alkyne and one aromatic hydrocarbon.

| | | |
|---|---|---|
| $CH_4$ | $C_2H_2$ | $C_3H_6$ |
| $C_4H_{10}$ | $C_5H_{12}$ | $C_6H_6$ |

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

(*b*) (*i*) From the list above identify two alkanes.

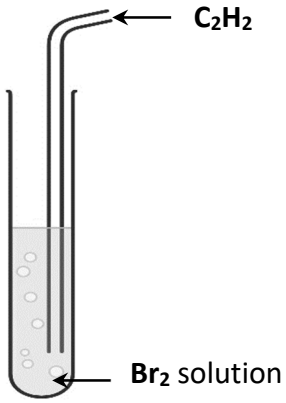
(*ii*) From the list above identify one aromatic compound.

(*iii*) Draw the molecular structure of $C_3H_6$ including all atoms and bonds.

(*iv*) What is the systematic IUPAC name for the hydrocarbon $C_3H_6$? (21)

(*c*) (*i*) State one major use for the gaseous hydrocarbon $C_2H_2$.

When $C_2H_2$ is bubbled through a solution of bromine ($Br_2$), as shown in the diagram, the orange-coloured solution decolourises.




(*ii*) What information does this give about the nature of the bonding in a molecule of $C_2H_2$? (12)

(*d*) In your answerbook, copy, complete and balance the following chemical equation:

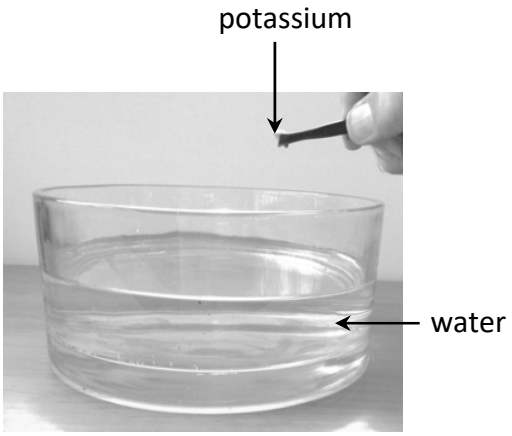
$$CH_4 + O_2 \rightarrow \_\_\_\_ + \_\_\_\_$$

(12)

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

(*b*) A tiny piece of potassium metal is added to water.

The potassium reacts vigorously with the water to produce soluble potassium hydroxide and bubbles of hydrogen gas.




The reaction is described by the following word equation:

**potassium + water → potassium hydroxide + hydrogen gas**

(*i*) In your answerbook, replace the words in the word equation above with chemical formulae.

(*ii*) Balance your equation from (*i*).

(*iii*) Describe how the solution of potassium hydroxide formed could be tested to show that it was basic. (18)

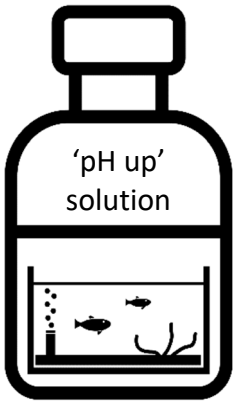
(*c*) (*i*) Define pH.

(*ii*) State the expected pH of a solution that is described as neutral.

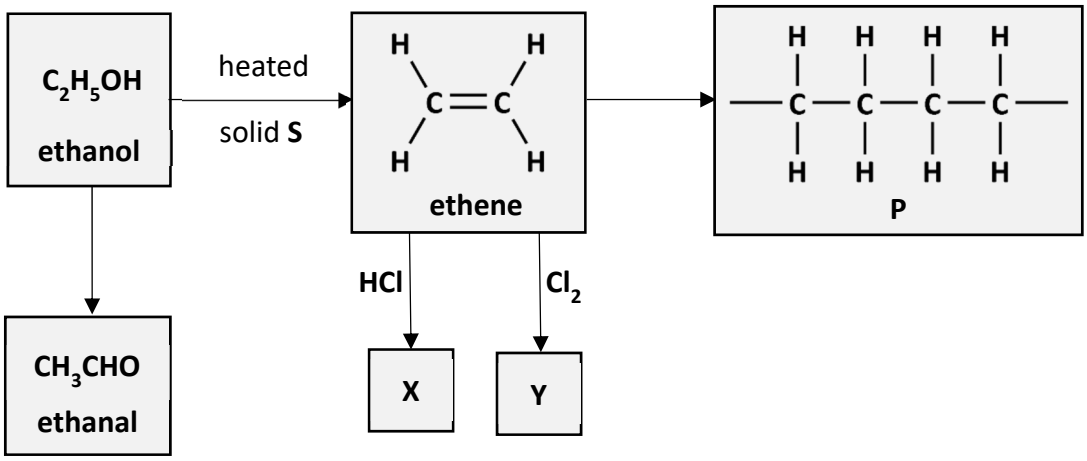
(*iii*) Calculate the pH of a **HCl** solution of concentration 0.1 M.

The pH of the water in an aquarium was adjusted from 6.3 to 7.0 by adding a suitable quantity of a 'pH up' solution.

(*iv*) Is the 'pH up' solution acidic or basic?
Give a reason for your answer. (24)



**8.** The reaction scheme below shows some of the reactions of ethene.




(*a*) (*i*) Is the geometry around the carbon atoms in a molecule of ethene planar or tetrahedral?

(*ii*) Draw the structure of a molecule of ethanol, showing all the atoms and bonds.

(*iii*) Name polymer **P**, two repeating units of which are shown in the reaction scheme.

(*iv*) Identify a carbonyl compound from the reaction scheme. (18)

(*b*) (*i*) When ethanol vapour is passed over a heated white solid **S** it is converted to ethene. Identify **S**.

(*ii*) Classify this conversion of ethanol to ethene as an acid-base reaction, a substitution reaction or an elimination reaction. (12)

(*c*) Addition reactions may be used to convert ethene to compound **X** and to compound **Y**.

(*i*) Identify compound **X**, which is produced when **HCl** is added to ethene.

(*ii*) Identify compound **Y**, which is produced when **$Cl_2$** is added to ethene. (12)

(*d*) The reaction scheme shows that ethanol can be converted into ethanal by a redox reaction.

(*i*) Is ethanol oxidised or reduced during this conversion?

(*ii*) Identify a suitable reagent that could be used to carry out this conversion. (8)

**9.** (*a*) Define (*i*) oxidation, (*ii*) reduction, in terms of electron transfer. (8)

(*b*) When a piece of zinc metal is placed into a solution of copper(II) sulfate the redox reaction that occurs is described by the following balanced chemical half equations:

$$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$$

$$Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$$

The overall displacement reaction that occurs is described by the following equation:

$$CuSO_{4(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + ZnSO_{4(aq)}$$

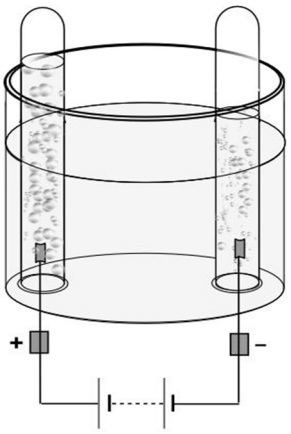
(*i*) Classify the copper half equation as an oxidation or a reduction.

(*ii*) Identify the reducing agent in the overall reaction.

(*iii*) Describe **one** observation made when zinc reacts with copper(II) sulfate.

(*iv*) Is zinc below or above copper in the electrochemical series?
Give a reason for your answer. (21)

(*c*) Water can be split into its elements by electrolysis using <u>inert</u> electrodes. The electrolyte is water, acidified with a few drops of sulfuric acid.
The electrodes are connected to the positive and negative terminals of a direct current power supply. When the circuit is switched on, bubbles of gas form at both electrodes.
During the electrolysis the volume of gas collected at the negative electrode is twice the volume of the gas collected at the positive electrode.




(*i*) What is meant by the underlined term?

(*ii*) Suggest a suitable material that can be used as inert electrodes.

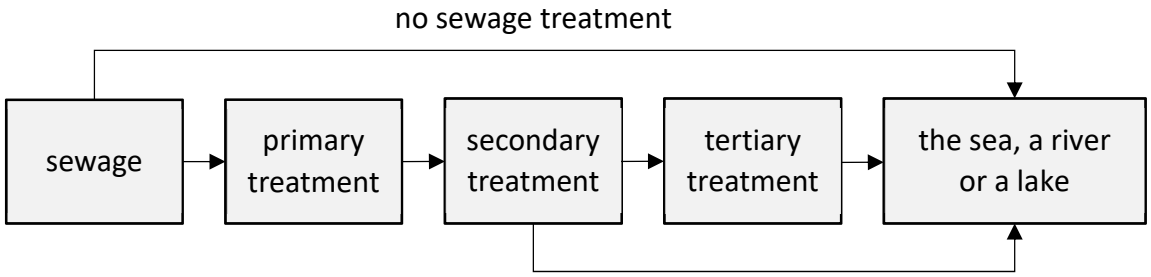
(*iii*) Why must a few drops of acid be added to the water before starting the electrolysis?

(*iv*) Identify the two gases collected during the electrolysis of water.

(*v*) Which of these gases is formed by reduction at the negative electrode? (21)

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

(*a*) The flow chart below shows the stages of sewage treatment.




(*i*) Settling tanks are used at different stages of sewage treatment.
What happens in a settling tank?

(*ii*) At what stage of sewage treatment (primary, secondary or tertiary) is the organic biodegradable matter broken down by bacteria?

(*iii*) What is the specific purpose of the tertiary stage of sewage treatment?

(*iv*) Describe a problem that arises when sewage is not treated before discharging it into the sea, a river or a lake. (25)

(*b*) Matter is composed of three different types of tiny particles: atoms, molecules and ions.

(*i*) Name the three states of matter.

(*ii*) What is meant by the term ion?

(*iii*) Classify helium (**He**) as an atom, a molecule or an ion.

(*iv*) Name two states of matter that exist at the melting point of a substance.

(*v*) In which state of matter do the particles vibrate around fixed positions? (25)

(*c*) Boron carbide (**$B_4C$**) is an extremely hard ceramic used in some padlocks. It is made by heating boron trioxide (**$B_2O_3$**) with carbon (**C**) in an electric furnace.

In a reaction, 140 g of **$B_2O_3$** was heated in the presence of excess carbon to give **$B_4C$** and carbon monoxide (**CO**) according to the following balanced chemical equation:

$$\mathbf{2B_2O_3 + 7C \rightarrow B_4C + 6CO}$$

The relative molecular mass ($M_r$) of **$B_2O_3$** is 70.

(*i*) Calculate the number of moles of **$B_2O_3$** in 140 g.

(*ii*) Calculate the number of moles of **$B_4C$** produced.

(*iii*) Calculate the mass of **$B_4C$** produced.

(*iv*) Calculate the number of moles of **CO** produced.

(*v*) Calculate the volume (in litres) of this quantity of **CO** gas, measured at s.t.p. (25)

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

(*a*) Refer to the periodic table of the elements on page 79 of the *Formulae and Tables* booklet when answering this question.

The names of the following seven elements are omitted from the passage below.

| | | | | | | |
|---|---|---|---|---|---|---|
| **beryllium (Be)** | **fluorine (F)** | **gallium (Ga)** | **hydrogen (H)** | **lithium (Li)** | **neon (Ne)** | **selenium (Se)** |

Write in your answerbook the omitted element corresponding to each of the numbers 1 to 7.

The first element of the periodic table of the elements is **1**. The element sodium is in the same group as **2**. The alkaline earth metals make up Group 2 and include the element **3**.

The existence and properties of the element **4** in the same group as aluminium and the same period as **5** was predicted by Mendeleev before its actual discovery in 1875.

Group 18 of the modern table contains the noble gases, including **6**. There were no noble gases in Mendeleev's original table.

The photograph shows Clarice Phelps, recognised as one of the scientists whose work led to the discovery in 2009 of element 117 that is in the same group as **7**. (25)

(*b*) Study the substances below and answer the questions that follow:

| substance | formula | bonding |
|---|---|---|
| sodium chloride | **NaCl** | ionic |
| hydrogen chloride | **HCl** | polar covalent |
| nitrogen | **$N_2$** | covalent |

(*i*) Identify the substance formed by the complete transfer of electrons between atoms.

(*ii*) Identify the substance formed by equal sharing of pairs of electrons by atoms.

(*iii*) Identify the substance formed by unequal sharing of pairs of electrons by atoms.

(*iv*) Identify the substance you would expect to be the most soluble in a non-polar solvent such as cyclohexane.

(*v*) Identify the substance you would expect to be highly soluble in water.

(*vi*) Draw a dot and cross diagram to show the arrangement of the valence shell electrons in any one of these substances. (25)

(*c*) Hydrogen (**$H_2$**) and iodine (**$I_2$**) form a chemical equilibrium when mixed together in a sealed container. The reaction may be described by the following balanced chemical equation:

$$\mathbf{H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}}$$

(*i*) What is meant by chemical equilibrium?

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

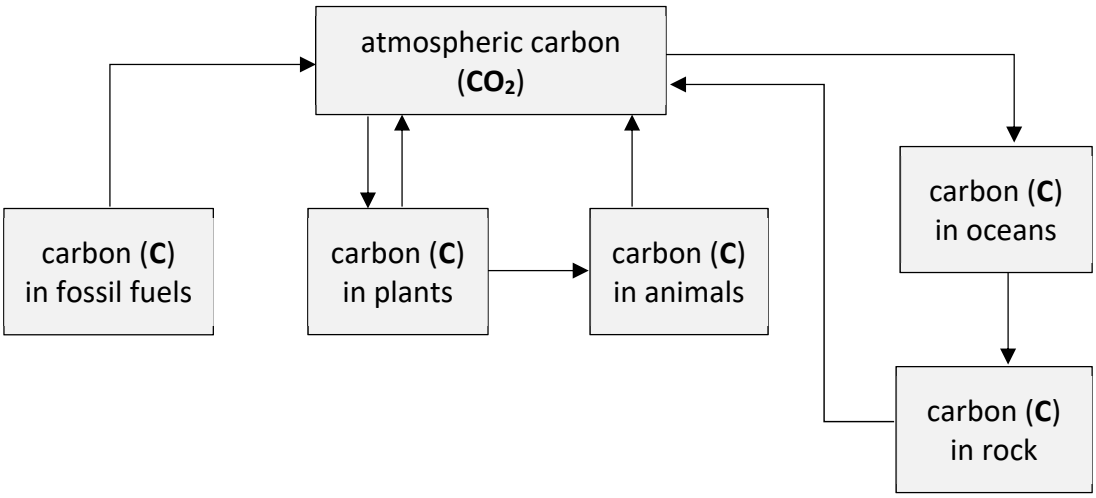
(*iii*) State Le Châtelier's principle.

(*iv*) Use Le Châtelier's principle to predict the effect on the yield of **HI** of adding more iodine.
Give a reason for your answer. (25)

*This question continues on the next page.*

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

**A** Consider the simplified version of the Earth's carbon cycle shown in the diagram.




(*i*) Explain how the carbon in fossil fuels becomes $CO_2$ in the atmosphere.

(*ii*) Identify one natural process by which $CO_2$ is removed from the atmosphere.

(*iii*) Name the environmental effect which results in heat from the Sun being trapped in Earth's atmosphere by gases including $CO_2$.

(*iv*) Suggest a reason why the Earth's atmospheric $CO_2$ concentrations have been increasing over the last 200 years.

(*v*) Suggest one way in which humans could change their behaviour to help reduce atmospheric $CO_2$ concentrations. (25)

*or*

**B** Households are encouraged to recycle cans. These cans are usually made either of steel coated with a thin layer of tin, or of aluminium.

(*i*) Aluminium cans resist corrosion.
What is corrosion of a metal?

(*ii*) Explain how coating iron with a protective layer of paint (or of another metal) protects the iron from corrosion.

(*iii*) Identify the metal used when iron is galvanised.

(*iv*) State an advantage of recycling aluminium in preference to extracting more of the metal from its ores.

(*v*) Name a process involved in the manufacture of steel. (25)

**Acknowledgements**

**Images**

| | |
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| Image on page 14 | flickr.com |

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Leaving Certificate – Ordinary level

# Chemistry

Tuesday, 17 June

Afternoon, 2:00 – 5:00