Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2018

CHEMISTRY – ORDINARY LEVEL

TUESDAY, 19 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): $H = 1.0$, $N = 14$, $O = 16$

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

Avogadro constant = $6.0 \times 10^{23}$ 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 two questions from this section. See page 1 for full instructions.

1. A student prepared and collected ethene (C₂H₄) gas using the arrangement of
   apparatus and chemicals shown below. A few stoppered test-tubes of the gas were
   kept to examine the properties of ethene.

![Diagram of the apparatus]

(a) Identify the white solid A. (5)

(b) (i) Describe the appearance of the gas collected.
    (ii) Explain why the first few test-tubes of gas collected are not then used. (9)

(c) There is a risk of suck-back while carrying out this experiment.
    (i) What is suck-back?
    (ii) Why is suck-back hazardous?
    (iii) What precaution should be taken to avoid suck-back? (12)

(d) In a test for unsaturation a few drops of a coloured solution were added to a
test-tube of ethene gas. The test-tube was re-stoppered and shaken.
    (i) Identify a reagent used to test ethene for unsaturation.
    (ii) What colour change is a positive result in this test using the reagent you
         identified? (9)

(e) A combustion test was carried out on another test-tube of ethene.
    (i) How was the combustion test carried out?
    (ii) Describe the flame observed.
    (iii) Copy, complete and balance the following equation for the complete combustion
          of ethene in oxygen:

          \[ \text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow \underline{\text{_______}} + \underline{\text{_______}} \] (15)
2. A 0.05 M solution of sodium carbonate (Na₂CO₃) was prepared and then used to find the concentration of a hydrochloric acid (HCl) solution by titration. Some pieces of apparatus used in the experiment are shown below. For each titration 25.0 cm³ of the sodium carbonate solution were measured into a conical flask and the table shows the volumes of hydrochloric acid solution added.

<table>
<thead>
<tr>
<th>Rough titration</th>
<th>First accurate titration</th>
<th>Second accurate titration</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.2 cm³</td>
<td>22.7 cm³</td>
<td>22.6 cm³</td>
</tr>
</tbody>
</table>

(a) Name the pieces of apparatus A, B and C. (11)

(b) Which piece of apparatus, A, B or C, was used:
(i) in making up the 0.05 M solution of Na₂CO₃,
(ii) to measure 25.0 cm³ of the Na₂CO₃ solution,
(iii) to measure the hydrochloric acid in each titration? (9)

(c) The wash bottle was used to rinse A, B, C and the conical flask with deionised water. Identify one of these pieces of apparatus that was rinsed again with a second liquid. (3)

(d) The 0.05 M Na₂CO₃ solution is a standard solution. Explain the underlined term. (6)

(e) (i) Name a suitable indicator for use in the titrations.
(ii) What colour change was observed at the end point? (9)

(f) The equation for the titration reaction is:

\[
2 \text{HCl} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2
\]

Using figures from the table above, calculate, in moles per litre, the concentration of the HCl solution that was titrated against 25.0 cm³ portions of the 0.05 M Na₂CO₃ solution. (12)
3. A student investigated the rate of decomposition of a hydrogen peroxide (H₂O₂) solution using manganese dioxide (MnO₂) as a catalyst. The equation for the reaction is:

\[
2H_2O_2 \xrightarrow{\text{MnO}_2} 2H_2O + O_2
\]

(a) The student measured out 5 cm³ of hydrogen peroxide solution A, diluted it to 25 cm³ with deionised water and then transferred the diluted solution into a conical flask. Name a suitable piece of apparatus to measure out 5 cm³ of hydrogen peroxide solution A. (6)

(b) Describe the appearance of the MnO₂ catalyst. (6)

(c) Copy into your answerbook the diagram of the arrangement of apparatus shown in the box below.

![Diagram of apparatus](image)

Complete your diagram and label it to show:

(i) the location of the catalyst just before the reaction is started,

(ii) how the oxygen gas can be collected and its volume measured at intervals over several minutes. (9)

(d) The data obtained are given in the table.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume O₂ (cm³)</td>
<td>0</td>
<td>20</td>
<td>31</td>
<td>36.5</td>
<td>39</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

(i) Plot a graph (on graph paper) of volume of O₂ (y-axis) versus time. (15)

(ii) Why does the rate of this reaction slow down as the minutes go by? (3)

(iii) Use your graph to find the volume of gas collected in the first 2.5 minutes. (6)

(iv) On the same sheet of graph paper sketch the curve that you would expect to plot if the experiment were repeated using 2.5 cm³ of hydrogen peroxide solution A diluted to 25 cm³. (5)
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) Give one difference between Mendeleev's periodic table of the elements and the modern periodic table.

(b) Give the symbol of a metallic element used as a catalyst in the catalytic converter of a car.

(c) The electrolysis of water, acidified with a few drops of sulfuric acid, was carried out in an apparatus like that shown. Inert (platinum) electrodes were used. Identify gas X and gas Y.

(d) Write a balanced equation for the reaction that occurs when hydrogen gas reacts with chlorine gas producing hydrogen chloride.

(e) Calculate the pH of 0.15 M sulfuric acid (H₂SO₄) correct to one decimal place.

(f) An equation for the combustion of methanol in oxygen is:

\[ 2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O} \quad \Delta H = -1451 \text{ kJ} \]

Is this reaction exothermic or endothermic? Give a reason for your answer.

(g) The molecular formula of glucose is C₆H₁₂O₆. Write the empirical formula for glucose.

(h) What happens during the primary stage of sewage treatment?

(i) A 500 cm³ sample of swimming pool water contained 0.11 g of dissolved solids. Express this concentration in parts per million (p.p.m. or mg per litre).

(j) Identify the process defined as 'emission of an electron by an unstable nucleus'.

(k) Answer part A or part B.

A Name the soccer-ball shaped molecule made up of 60 carbon atoms that was discovered in 1985.

or

B Why are industrial reaction vessels often made of steel?
5. (a) Argon (Ar) is a gaseous unreactive element that exists as single atoms. Why is this element unreactive? (5)

(b) Fluorine and oxygen are gaseous elements that exist as the diatomic molecules F₂ and O₂. Draw dot and cross diagrams to show the covalent bonding in F₂ and in O₂. (12)

(c) Define electronegativity. (6)

(d) The table gives the melting points and boiling points of water and of three simple pure substances A, B and C.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Melting point (°C)</th>
<th>Boiling point (°C)</th>
<th>Electronegativity difference between atoms in constituent bonds</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-210</td>
<td>-196</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>-114</td>
<td>-85</td>
<td>0.96</td>
</tr>
<tr>
<td>water</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>730</td>
<td>1380</td>
<td></td>
</tr>
</tbody>
</table>

Use the properties given in the table to identify which substance, A, B, C or water, is most likely to:

(i) have ionic bonding,
(ii) be gaseous and have polar covalent bonding,
(iii) have pure covalent bonding.

Explain your reasoning in each case. (21)

(e) What is the shape of a water molecule? (6)
6. (a) What general term is used for compounds, like those shown in the table, that contain only carbon and hydrogen atoms? (5)

<table>
<thead>
<tr>
<th>A</th>
<th>( \text{H} \text{H-C-H} \text{H} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>( \text{H-H-C-C-H} \text{H} )</td>
</tr>
<tr>
<td>C</td>
<td>( \text{H-H-C-C-C} \text{H} )</td>
</tr>
<tr>
<td>D</td>
<td>( \text{H-C=C} \text{H} )</td>
</tr>
<tr>
<td>E</td>
<td>( \text{H-C=C-H} )</td>
</tr>
</tbody>
</table>

(b) Give the IUPAC names for A, C and D. (9)

(c) To which homologous series:
   (i) do both A and B belong, (6)
   (ii) does D belong?

(d) (i) Which compound in the table is aromatic? (ii) Write the molecular formula of this compound. (iii) Why is this compound not in common use? (12)

(e) Which compound in the table, when burned in oxygen, produces a very high temperature flame used for cutting and welding metal? (6)

(f) Which compound in the table is produced by anaerobic bacteria decomposing animal waste? Why is the concentration of this compound in the atmosphere a cause for concern? (12)

7. (a) (i) What is hard water? (ii) What type of water hardness can be removed by boiling? Name, or give the formula, of a substance that causes this type of water hardness. (iii) Identify a problem caused by hard water. (iv) Give an advantage of hard water. (24)

(b) Consider the following chemicals and materials used in the purification of a drinking water supply.

<table>
<thead>
<tr>
<th>Al₂(SO₄)₃</th>
<th>sand and gravel</th>
<th>chlorine</th>
<th>NaF</th>
<th>lime (CaO)</th>
</tr>
</thead>
</table>

(i) What term is used to describe the use of \( \text{Al}_2(\text{SO}_4)_3 \) causing suspended particles in the water to clump together? (ii) Give the purpose of sand and gravel in water purification. (iii) What is the purpose of adding chlorine to the water supply? (iv) Why is NaF added to the water? (v) Under what circumstance would lime (CaO) be added to the water supply? (26)
8. Study the reaction scheme below and answer the questions that follow.

![Reaction Scheme]

(a) Name the compounds W, X and Y. (15)
(b) Draw the structure of an ethanol molecule. (6)
(c) In which one of the molecules, W, ethanol, X or Y, are all the carbon atoms in planar geometry? (6)
(d) Classify as an addition, as a substitution or as an oxidation reaction:
   (i) the conversion of W to ethanol,
   (ii) the conversion of X to Y. (9)
(e) Describe what is observed when X reacts with Fehling’s reagent. (9)
(f) Give a common use for Y in the food industry. (5)

9. (a) Define (i) oxidation, (ii) reduction, in terms of electron transfer. (12)
(b) Potassium metal reacts violently with chlorine gas to form a white salt, potassium chloride, according to the following balanced equation.

\[ 2K + Cl_2 \rightarrow 2KCl \]

(i) Which element is oxidised? (ii) Which substance is the oxidising reagent? (12)
(c) (i) Describe a procedure for carrying out a flame test on the white salt.
    (ii) What flame colour confirms the presence of potassium in this salt? (15)
(d) A little of the KCl salt is dissolved in water in a test-tube and a few drops of silver nitrate (AgNO_3) solution are added to confirm the presence of the chloride ion.
    What is observed in the test-tube? (6)
(e) Give a reason why potassium metal reacts more violently than sodium metal with chlorine gas. (5)
10. Answer any two of the parts \( (a), (b) \) and \( (c) \). \hspace{1cm} (2 \times 25)

\( (a) \) An acid is defined as a substance that produces 1 ions in aqueous solution and a base as a substance that produces 2 ions in aqueous solution. An acid and a base react together to produce 3 and 4 in a process called 5. Indigestion remedies are often bases that react with excess 6 in the stomach. The base 7 is used in many oven cleaners and drain cleaners to dissolve grease.

The following words and formulae are omitted from the passage above.

\[
\begin{align*}
\text{OH}^- & \quad \text{neutralisation} & \text{water} & \quad \text{H}^+ \\
\text{HCl} & \quad \text{salt} & \text{NaOH}
\end{align*}
\]

Write in your answerbook the omitted word or formula corresponding to each of the numbers (1 to 7). \hspace{1cm} (25)

\( (b) \) Define (i) atomic number, (ii) mass number, (iii) isotopes.

Refer to the periodic table of the elements on page 79 of the *Formulae and Tables* booklet and answer the following questions.

\( (iv) \) What is the atomic number of chlorine?

\( (v) \) How many electrons occupy each of the main energy levels (shells) in a chlorine atom?

\( (vi) \) What is the relative atomic mass of chlorine?

\( (vii) \) Why is the relative atomic mass of chlorine not a whole number? \hspace{1cm} (25)

\( (c) \) The gas dinitrogen oxide \( (\text{N}_2\text{O}) \) can be used as an anaesthetic. It can be made by decomposing ammonium nitrate \( (\text{NH}_4\text{NO}_3) \) using heat according to the following balanced equation.

\[
\text{NH}_4\text{NO}_3 \rightarrow \text{N}_2\text{O} + 2\text{H}_2\text{O}
\]

\( (i) \) Copy and complete in your answerbook the following statement.

‘One mole of \( \text{N}_2\text{O} \) has a mass of \( ............... \) grams, contains ............... \( \text{N}_2\text{O} \) molecules and occupies a volume of \( ............. \) litres at s.t.p.’

\( (ii) \) What is the mass in grams of one mole of ammonium nitrate \( (\text{NH}_4\text{NO}_3) \)?

\( (iii) \) When 16 g of \( \text{NH}_4\text{NO}_3 \) react according to the equation above, how many moles of water are formed?

What volume does the \( \text{N}_2\text{O} \) gas produced occupy at s.t.p.? \hspace{1cm} (25)
11. Answer any two of the parts (a), (b) and (c). (2 × 25)

(a) Matter is composed of tiny particles which may be atoms, molecules or ions. Name the three states of matter.

What is the difference:
(i) between an atom and an ion,
(ii) between an atom and a molecule? (11)

Diffusion is evidence for the movement of tiny particles in a liquid or in a gas. Give an example of diffusion.

Supply the missing words in the following statement of Boyle’s law: ‘The 1 of a certain mass of gas is inversely proportional to its 2 at constant 3.’ (14)

(b) Sulfuryl chloride (SO₂Cl₂) decomposes when heated to form equal volumes of chlorine (Cl₂) gas and sulfur dioxide (SO₂) gas. When some SO₂Cl₂ vapour was heated in a closed container at a certain temperature a chemical equilibrium was reached according to the following balanced equation.

\[ \text{SO}_2\text{Cl}_2{(g)} \rightleftharpoons \text{Cl}_2{(g)} + \text{SO}_2{(g)} \]

colourless green colourless

(i) Explain the underlined term.
(ii) Write the equilibrium constant (\(K_c\)) expression for this reaction. (13)

According to Le Châtelier’s principle, changing certain factors causes stress to a system in equilibrium.

(iii) Predict the effect on the colour of this equilibrium mixture of increasing the pressure by compressing the gases as shown.

(iv) Give another way to change the colour of this equilibrium mixture – other than by changing its pressure. (12)

(c) Answer part A or part B.

A

How do most metals compare to most plastics in terms of (i) hardness, (ii) lustre?
Copper is used as a building material for roofing, plumbing and wiring. The plastic poly(chloroethene), or PVC, is used for plumbing and in electrical cable.

What property of the plastic PVC makes it suitable for use in electrical cable? (15)

Give an advantage of using PVC for plumbing in place of copper pipes.

What metallic property allows copper to be:
(iii) hammered or rolled into sheets for use in roofing,
(iv) drawn into long strands for use in wiring? (10)
B

Answer the questions below about any one of these three case studies:

industrial production of **ammonia**,  
industrial production of **nitric acid**,  
industrial production of **magnesium oxide**.

(i) State the formula of the main product of the industry you studied.  
(ii) What is the major use of this product?  
(iii) Select, from the left of the scheme below, two feedstock materials for the industry you studied.  
(iv) Select an infrastructural feature from the right of the scheme below and explain how it is essential in the industry you studied.  
(v) How does the industry you studied deal with either emissions or waste effluent?