Instructions to candidates

1. Write your name and Index Number in the space provided above.
2. Answer ALL questions in the spaces provided in the question paper.
3. Mathematical tables and electronic calculators may be used.
4. ALL working must be clearly shown where necessary.

For Examiner’s use only

<table>
<thead>
<tr>
<th>Questions</th>
<th>Maximum Score</th>
<th>Candidate’s Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 30</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

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KENYA CERTIFICATE OF SECONDARY EDUCATION
1. (a) Write the electronic configuration of Calcium (atomic number 20) and magnesium (atomic number 12).

Calcium ____________________________________________________________ (1/2 marks)
Magnesium __________________________________________________________ (1/2 marks)

(b) Why is calcium more reactive than magnesium? (2 marks)
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

2. Study the scheme below and answer the questions that follow.

Name:

(i) The reagents used in process R. (1 mark)
__________________________________________________________________

(ii) Process S (1 mark)
__________________________________________________________________

(iii) Compound Q. (1 mark)
__________________________________________________________________
3. A weighed sample of crystalline Sodium carbonate \((\text{Na}_2\text{Co}_3, n\text{H}_2\text{O})\) was heated in a crucible until there was no further change in mass. The mass of the sample reduced by 14.5%. Calculate the number of moles \((n)\) of the water of crystallisation.

\[(\text{Na} = 23, \text{O} = 16, \text{C} = 12, \text{H} = 1)\]

(3 marks)

4. (a) Give the name and formula of one chief ore of aluminium metal.

(1 mark)

(b) Aluminium metal is extracted through electrolysis process. Write the equation of the reaction at the cathode during the process.

(1 mark)

(c) Why is it not advisable to store Sodium hydroxide solution in an aluminium container.

(1 mark)

5. Below are cross-sections of two pieces coated with zinc and copper respectively.

Which piece would rust when the holes were filled with water and left for sometimes?

Explain.

(2 marks)
6. A dynamic equilibrium between diachromate and chromate ions is established as shown in the equation below.

\[
\text{Cr}_2\text{O}_7^{2-} (\text{aq}) + 2\text{OH}^- (\text{aq}) \rightleftharpoons 2\text{CrO}_4^{2-} (\text{aq}) + \text{H}_2\text{O} (l)
\]

(a) What is meant by a dynamic equilibrium. (1 mark)

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(b) State and explain the observation that would be made if a few pellets of sodium hydroxide are added to the equilibrium mixture. (2 marks)

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7. The scheme below show the industrial preparation of nitric acid.

(a) What is the oxidation state of nitrogen in;

(i) \( \text{NH}_3 \) .......................................................... (1/2 marks)

(ii) \( \text{HNO}_3 \) .......................................................... (1/2 marks)

(b) Write a balanced chemical equation for the reaction taking place in.

(i) Chamber I (1 mark)

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(ii) Chamber II (1 mark)

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________________________________________________________________________
________________________________________________________________________
8. The diagram below represents an experiment which was carried out by a student to investigate the effect of passing an electric current on molten sodium chloride.

![Diagram of an experiment setup with a beaker, graphite electrode, and molten sodium chloride](image)

(i) Molten Sodium chloride is a binary electrolyte. State the meaning of the term binary electrolyte. (1 mark)

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________________________________________________________________________

(ii) State the observations made at the anode. (1 mark)

________________________________________________________________________

________________________________________________________________________

(iii) Write an equation to show what happens at the cathode. (1 mark)

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9. Briefly explain how you would obtain a pure sample of lead chloride from a mixture of lead chloride and silver chloride. (3 marks)

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10. A given volume of Ozone (O$_3$) diffused from a certain apparatus in 96 seconds. Calculate the time taken by an equal volume of carbon (IV) oxide (CO$_2$) to diffuse under the same conditions. (O = 16, C = 12) (3 marks)

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11. The diagram below shows a structure of water molecules.

(i) Name the bonds labelled a and b. (1 mark)

________________________________________________________________________

(ii) Using dots (●) and cross (x) diagram, show the bonding in the compound phosphonium ion PH$_4^+$. (H = 1, P = 15) (2 marks)

12. Study the information in the table below and answer the questions that follow.

(The letters do not represent the actual symbols of the elements).

<table>
<thead>
<tr>
<th>Substance</th>
<th>Melting point (°C)</th>
<th>Boiling point (°C)</th>
<th>Solubility in water</th>
<th>Density of room temperature g/cm$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>-117</td>
<td>78.5</td>
<td>Very soluble</td>
<td>0.8</td>
</tr>
<tr>
<td>J</td>
<td>-78</td>
<td>-33</td>
<td>Very Soluble</td>
<td>0.77 x 10$^{-3}$</td>
</tr>
<tr>
<td>K</td>
<td>-23</td>
<td>77</td>
<td>Insoluble</td>
<td>1.6</td>
</tr>
<tr>
<td>L</td>
<td>-219</td>
<td>-183</td>
<td>Slightly Soluble</td>
<td>1.33 x 10$^{-3}$</td>
</tr>
</tbody>
</table>
(i) Which substance would dissolve in water and would be separated from the solution by fractional distillation? Give a reason. (1 mark)
__________________________________________________________________
__________________________________________________________________

(ii) Which substance is a liquid at room temperature and when mixed with water, two layers would be formed. (1 mark)
__________________________________________________________________

(iii) Which letter represents a substance that is a gas at room temperature and which can be collected over water. Explain (1 mark)
__________________________________________________________________
__________________________________________________________________

13. 3.4g of an element X on complete combustion produced heat which raised the temperature of 120cm$^3$ of water from 22°C to 62°C. Determine the molar heat of combustion of X. (Atomic mass of X = 34. Density of H$_2$O = 1 g/cm$^3$ (specific heat capacity of water = 4.2J/gk$^{-1}$)) (3 marks)
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

14. (a) The column below was used to soften hard water.

Hard water

Permutit (contains Na$^+$)

Soft water containing Na$^+$ ions
(i) Explain how the hard water was softened as it passed through the column. (1 mark)

(ii) After sometimes, the material in the column is not able to soften hard water. How can the material be re-activated. (1 mark)

(b) Give one advantage of using hard water for domestic purposes. (1 mark)

15. In an experiment, the quantity of electricity passed to deposit 1.2 grammes of metal Q from its salt was 3860 Coulombs. (RAM of Q = 120, 1 Faraday = 96500 Coulombs)

(a) How many Faradays of electricity are required to deposit 1 mole of Q? (2 marks)

(b) One of the ions present in the solutions of salt Q has the formula Q\(^{y+}\). What is the numerical value of Y. (1 mark)

16. The set-up below was used to investigate the effect of dry hydrogen gas on hot Copper (II) Oxide powder.

![Diagram of the experiment]

Explain what is observed in the combustion tube during the experiment. (3 marks)
17. The table below gives the energy required to remove the outermost electrons for some group I elements.

<table>
<thead>
<tr>
<th>Element</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy KJ mol(^{-1})</td>
<td>494</td>
<td>418</td>
<td>519</td>
<td>376</td>
</tr>
</tbody>
</table>

Arrange the elements in the order of their reactivity starting with least reactive. (2 marks)

18. A polymer has the following structure.

\[
\begin{align*}
\text{CH}_2 \overset{\text{CH}}{\longrightarrow} \text{CH} \overset{\text{CH}_2}{\longrightarrow} \text{CH} \overset{\text{CH}_2}{\longrightarrow} \text{CH} \overset{\text{CH}_2}{\longrightarrow} \text{CH} \overset{\text{CH}_2}{\longrightarrow} \text{CH} \overset{\text{CH}_2}{\longrightarrow} \text{CH} \overset{\text{Br}}{\longrightarrow} \text{Br} \overset{\text{Br}}{\longrightarrow} \text{Br} \overset{\text{Br}}{\longrightarrow} \text{Br} \overset{\text{Br}}{\longrightarrow} n
\end{align*}
\]

(a) Draw the structural formula of the monomer. (1 mark)

(b) Determine the number of monomers in the polymer.

\((C = 12, H = 1, Br = 80)\) (2 marks)

19. The table below gives the rate of decay for the radioactive element P.

<table>
<thead>
<tr>
<th>Number of hours</th>
<th>mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>384</td>
</tr>
<tr>
<td>270</td>
<td>48</td>
</tr>
</tbody>
</table>
(a) Calculate the half life of the radioactive element P. (2 marks)

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________________________________________________________________________
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(b) Write a balanced equation for the decay of \(^{238}_{92}U\) after it loses 2\(\beta\) - particles and 3\(\alpha\) - particles to form a stable nuclide \(^a_bX\) where \(a\) and \(b\) are whole numbers. (1 mark)
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________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

20. The following data gives PH values of solutions P, Q and R.

<table>
<thead>
<tr>
<th>Solution</th>
<th>PH</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>13.6</td>
</tr>
<tr>
<td>Q</td>
<td>6.9</td>
</tr>
<tr>
<td>R</td>
<td>1.3</td>
</tr>
</tbody>
</table>

(i) Which solution will produce Carbon (IV) Oxide when reacted with marble chips. (1 mark)
________________________________________________________________________

(ii) What would be the colour of solution P after adding a few drops of phenolphthalein. (1 mark)
________________________________________________________________________
________________________________________________________________________

21. The table below shows the solubility of a salt at various temperatures.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Solubility (g/100g water)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>40</td>
<td>33</td>
</tr>
<tr>
<td>80</td>
<td>27</td>
</tr>
<tr>
<td>110</td>
<td>22</td>
</tr>
</tbody>
</table>

What would happen if a sample of saturated solution of the salt at 40\(^\circ\)C is heated to 80\(^\circ\)C? (2 marks)
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
22. Sulphuric acid is manufactured in large scale by the contact process. The basic reaction in the contact process is the catalytic oxidation of Sulphur (IV) Oxide.

(a) Name the catalyst used. (1 mark)

(b) Write the equation for the reaction. (1 mark)

(c) State one large scale use of sulphuric acid. (1 mark)

23. The following two tests were carried out on chlorine water contained in two test tubes.

(a) A piece of blue flower was dropped into the first test tube. Explain why the flower was bleached. (2 marks)

(b) The second test tube was corked and exposed to sunlight. After a few days, it was found to contain a gas that rekindled a glowing splint. Write an equation for the reaction which produced the gas. (1 mark)

24. Describe how a solid sample of lead (II) chloride can be prepared using the following reagents. Dilute nitric acid, dilute hydrochloric acid and lead carbonate. (3 mark)
25. 20.0\text{cm}^3\text{ of a solution containing 4g per litre of sodium hydroxide was neutralised by 8.0\text{cm}^3\text{ of dilute sulphuric acid. Calculate the concentration of sulphuric acid in moles per litre. (Na = 23, O = 16, H = 1)} (3\text{ marks})

26. Ammonia can be converted to nitrogen (I) oxide as shown in the equation below.

\[ 4 \text{NH}_3(g) + 5\text{O}_2(g) \rightleftharpoons 4\text{NO}(g) + 6\text{H}_2\text{O}(l) \]

The energy level diagram for the above reaction is as shown below.

(a) Explain how an increase in temperature would affect the yield of nitrogen (I) oxide. (2\text{ marks})

(b) On the diagram, sketch the energy level diagram that would be obtained if the reaction is carried out in presence of a catalyst. (1\text{ mark})
27. The grid below represents part of the periodic table. The letters do not represent the actual elements.

(a) Write the electronic arrangement for the ions formed by elements Q and S. (1 mark)
__________________________________________________________________
__________________________________________________________________

(b) Compare the melting points of P and U. Explain. (1 mark)
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__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

(c) Select the most reactive non-metal. Give a reason for your answer. (1 mark)
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

28. Use the information below to answer the questions that follow.

\[ E^\circ \text{ Volts} \]

\[ \text{Zn}^{2+} (aq) + 2e^- \rightleftharpoons \text{Zn}(s) \quad -0.76 \]

\[ \text{Al}^{3+} (aq) + 3e^- \rightleftharpoons \text{Al}(s) \quad -1.66 \]

\[ \text{Fe}^{2+} (aq) + 2e^- \rightleftharpoons \text{Fe}(s) \quad -0.44 \]

Calculate the \( E^\circ \) value for the electrochemical cell represented below. (1 mark)

\[ \text{Al}(s) \rightleftharpoons \text{Al}^{3+} (aq) \rightleftharpoons \text{Fe}^{2+} (aq) \rightleftharpoons \text{Fe}(s) \]
29. When steam was passed over heated charcoal as shown in the diagram below, hydrogen and carbon (II) oxide gases were formed.

(a) Write the equation for the reaction which takes place. (1 mark)

(b) Name one use of carbon (II) oxide which is also a use of hydrogen gas. (1 mark)

30. The simplified flow chart below shows some of the steps in the manufacture of sodium carbonate by the solvay process.

(a) Identify substance L. (1/2 marks)

(b) Name the process taking place to step II. (1/2 marks)

(c) Write an equation for the process which takes place in step III. (1 mark)