Name ____________________________ Index No. ____________________________
2601/102
2602/102
2603/102
PHYSICAL SCIENCE, MECHANICAL SCIENCE AND ELECTRICAL ENGINEERING PRINCIPLES
June/July 2015
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRICAL AND ELECTRONICS ENGINEERING (POWER OPTION) (TELECOMMUNICATION OPTION) (INSTRUMENTATION OPTION) MODULE I

PHYSICAL SCIENCE, MECHANICAL SCIENCE AND ELECTRICAL ENGINEERING PRINCIPLES

3 hours

INSTRUCTIONS TO CANDIDATES

Write your name and index number in the spaces provided above.
Sign and write the date of the examination in the spaces provided above.
You should have mathematical tables/scientific calculator for this examination.
This paper consists of EIGHT questions in THREE sections; A, B and C.
Answer TWO questions from Section A, ONE question from Section B and TWO questions from Section C in the spaces provided in this question paper.
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
Do NOT remove any pages from this booklet.
Candidates should answer the questions in English.
Take $U^r = 4\pi \times 10^{-7} \text{H/m}$ and $\varepsilon = 8.85 \times 10^{-12} \text{F/m}$

<table>
<thead>
<tr>
<th>Question</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>
<th>TOTAL SCORE</th>
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<tbody>
<tr>
<td>Candidate’s Score</td>
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</tbody>
</table>
SECTION A: PHYSICAL SCIENCE

Answer TWO questions from this section.

1. (a) The table 1 shows some elements and electronic arrangement of their ions. (letters are not actual symbols of elements).

<table>
<thead>
<tr>
<th>Elements</th>
<th>Ion</th>
<th>Ion electronic configuration</th>
<th>Atomic radius (mm)</th>
<th>Ionic radius (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>P^{2+}</td>
<td>2.8.8</td>
<td>0.197</td>
<td>0.099</td>
</tr>
<tr>
<td>Q</td>
<td>Q^-</td>
<td>2.8</td>
<td>0.072</td>
<td>0.136</td>
</tr>
<tr>
<td>R</td>
<td>R^+</td>
<td>2.8.8</td>
<td>0.231</td>
<td>0.133</td>
</tr>
<tr>
<td>S</td>
<td>S^{3+}</td>
<td>2.8</td>
<td>0.143</td>
<td>0.050</td>
</tr>
<tr>
<td>T</td>
<td>T^{2+}</td>
<td>2.8.18</td>
<td>0.133</td>
<td>0.074</td>
</tr>
<tr>
<td>U</td>
<td>U^{2+}</td>
<td>2.8</td>
<td>0.160</td>
<td>0.065</td>
</tr>
<tr>
<td>V</td>
<td>V^+</td>
<td>2.8</td>
<td>0.186</td>
<td>0.095</td>
</tr>
<tr>
<td>W</td>
<td>W^-</td>
<td>2.8</td>
<td>0.156</td>
<td>0.060</td>
</tr>
<tr>
<td>X</td>
<td>X^-</td>
<td>2.8.8</td>
<td>0.099</td>
<td>0.181</td>
</tr>
</tbody>
</table>

(i) State the atomic number of elements P and S.

(ii) Select the most reactive metallic element. Explain.

(iii) Select three elements that would react with cold water.

(iv) Identify three elements from same group 7 of the periodic table.

(v) Write the chemical formula of a compound of S and oxygen, V and X.

12 marks

(b) Figure 2 shows a list of some simple members of a homologous series.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Physical state at room temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄</td>
<td>gas</td>
</tr>
<tr>
<td>C₂H₂</td>
<td>gas</td>
</tr>
<tr>
<td>C₃H₄</td>
<td>gas</td>
</tr>
<tr>
<td>C₄H₁₀</td>
<td>gas</td>
</tr>
<tr>
<td>C₅H₁₂</td>
<td>liquid</td>
</tr>
<tr>
<td>C₆H₁₄</td>
<td>liquid</td>
</tr>
</tbody>
</table>
2. (a) State two uses of X-rays in medicine. (2 marks)
(b) Figure 1 shows the features of an X-ray tube.

(i) name the parts labelled A, B and C;
(ii) name the suitable material for the part labelled C;
(iii) explain how X-rays are produced in this tube?
(iv) why is it necessary to have oil cooling the anode;

(c) The accelerating potential in certain X-ray tube is 15 kV. Determine the maximum frequency of the emitted X-rays.

Take: charge on an electron, e = $1.6 \times 10^{-19}\text{C}$, 
Plank's constant, h = $6.62 \times 10^{-34}\text{Js}$. (3 marks)
(d) (i) Identify the possible radiations in each of the following nuclear reactions.

I \( \text{C}^{12} \rightarrow \text{C}^{12} + \text{radiation} \)

II \( \text{Ra}^{228} \rightarrow \text{Rn}^{226} + \text{radiation} \)

III \( \text{C}^{14} \rightarrow \text{V}^{14} + \text{radiation} \)

(ii) A sample of a radioactive substance has \(8.12 \times 10^{30}\) atoms. The half-life of the substance is 21 minutes. Determine the number of atoms remaining undecayed after 84 minutes.

3. (a) An immersion heater rated 2.5 kW is placed in a liquid of mass 2 kg. When the heater is switched on for 5 minutes, the temperature of the liquid rises from 20 °C to 70 °C. Determine the specific heat capacity of the liquid.

(b) Define the term “specific latent heat of vaporization” of a substance.

(c) Figure 2 shows a simplified diagram of a domestic refrigerator. A volatile liquid circulates through the capillary tube under the action of compression pump.

![Diagram of a domestic refrigerator](image)

**Fig. 2**
(i) Give the reason why a volatile liquid is used.
(ii) Explain how the volatile liquid is made to vaporize in the cooling compartment and condense in the cooling fins.
(iii) Explain how cooling takes place in the refrigerator.
(iv) Explain the purpose of the double wall. (8 marks)

(d) Steam of mass 4.0 g at 100 °C is passed into water of mass 450 g at 10 °C. The final temperature of the mixture rises to T °C, and the container carrying temperature absorbs negligible heat:

(i) derive an expression for the heat lost by the steam as it condenses to water at temperature T °C;
(ii) derive an expression for the heat gained by the water;
(iii) determine the value of T.

specific Latent heat of vaporization of steam = 2260 kJkg⁻¹;
specific heat capacity of water = 4.100 Jkg⁻¹K⁻¹. (6 marks)

SECTION B: MECHANICAL SCIENCE

Answer ONE question from this Section.

4. A pile driver of mass 300 kg is used to drive a pile of mass 500 kg vertically into the ground. The pile driver falls freely through a distance of 54.0 m, rebounding with a velocity relative to the pile and equal to the relative velocity immediately before impact. Determine:

(a) the velocity of the driver immediately before impact; (4 marks)
(b) the velocity of the pile immediately after the impact; (7 marks)
(c) the depth of penetration of the pile after impact given that the ground resisting force is constant and equal to 115 kN; (4 marks)
(d) the time taken for the penetration. (5 marks)

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Turn over
5. (a) Differentiate between a flywheel and a speed governor. (4 marks)

(b) Describe the following characteristics of governors:
   (i) sensitivity;
   (ii) stability;
   (iii) isochronous. (6 marks)

(c) The following figures were obtained during a tensile test of mild steel:

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Original diameter</td>
<td>12.5 mm</td>
</tr>
<tr>
<td>Gauge length</td>
<td>200 mm</td>
</tr>
<tr>
<td>Final length</td>
<td>257 mm</td>
</tr>
<tr>
<td>Diameter at structure</td>
<td>-7.85 mm</td>
</tr>
<tr>
<td>Load at yield point</td>
<td>34575 N</td>
</tr>
<tr>
<td>Maximum load</td>
<td>49023 N</td>
</tr>
</tbody>
</table>

Determine;

(i) tensile strength;
(ii) stress at yield point;
(iii) percentage reduction in area;
(iv) percentage elongation. (10 marks)

SECTION C: ELECTRICAL ENGINEERING PRINCIPLES

Answer TWO question from this Section.

6. (a) State the meaning of each of the following:
   (i) ohmic conductors;
   (ii) electric power;
   (iii) electrical energy. (6 marks)

(b) Two resistors are connected in series across a 24 V supply and a current of £A flour in the circuit. If one of the resistors has a resistance of 2 Ω determine:
   (i) the value of the other resistor;
   (ii) the p.d across the 2 Ω resistor;
   (iii) the amount of energy consumed if the circuit is connected for 50 hours. (8 marks)
Figure 3 shows a direct current circuit.

![Diagram of a direct current circuit with resistors R1, R2, R3, and voltages V1, V2, V3.]

Fig. 3

Determine:

(i) the battery voltage V and the total resistance of the circuit;

(ii) the values of resistors R1, R2 and R3 given that the p.d across R1, R2 and R3 are 5 V, 2 V and 6 V respectively.  

(6 marks)

7. (a) Name five quantities that a cathode ray oscilloscope is capable of measuring.  

(5 marks)

(b) State three other instruments which also measure various quantities. Indicate the quantities measured by each.  

(6 marks)

(c) Explain the principle of operation of a single phase transformer.  

(9 marks)

8. (a) (i) State three ways in which the capacitance of a capacitor can be varied.  

(ii) Name three types of capacitors.  

(6 marks)

(b) A capacitor of 20 μF charged to 500 V is connected in parallel with another of 10 μF capacitance charged to 200 V. Determine the energy loss.  

(10 marks)

(c) Differentiate between permanent and temporary weights.  

(4 marks)