**THE UNINTED REPUBLIC OF TANZANIA**

**NATIONAL EXAMINATIONS COUNCIL**

**FORM TWO NATIONAL ASSESSMENT**

**080 ELECTRICAL ENGINEERING**

**Time: 2:30 Hours** **ANSWERS** **Year: 2015**

**Instructios:**

1. this paper consists of sections A and B with total of eleven questions
2. answer all questions in section A. In section B answer all questions in either part I or part II depending on the area of your specialization.
3. All answers must be written in spaces provided.

1.

(i) Coulomb is the measure of:
A. potential difference
B. electron flow
C. quantity of charge stored
D. electric current
Correct answer: C
Reason: A coulomb is the SI unit of electric charge and is used to measure the quantity of charge stored.

(ii) In an electromagnet, the polarity of the magnet will depend upon the:
A. magnitude of current
B. number of turns in the coil
C. direction of the current flow
D. core material used
Correct answer: C
Reason: The polarity of an electromagnet is determined by the direction of the current flow through its coil.

(iii) Resistance of a piece of wire depends on one of the following factors:
A. Cross-sectional area
B. Turns ratio
C. Life span of the wire
D. Colour coding of the material

Correct answer: A
Reason: Resistance is inversely proportional to the cross-sectional area of the wire. A larger area reduces resistance.

(iv) Cells are connected in parallel in order to:
A. increase the voltage available
B. reduce cost of wire
C. increase the current available
D. reduce the time required to fully charge them after use
Correct answer: C
Reason: Connecting cells in parallel increases the current available without changing the voltage.

(v) Which of the following generating stations has the minimum running cost?
A. Hydro-electric station
B. Nuclear power station
C. Thermal power station
D. Diesel power plant
Correct answer: A

Reason: Hydro-electric stations have the lowest running costs as they use water, a renewable resource, without significant fuel costs.

(vi) The Q-factor of a coil is given by:
A. its power-factor cos φ
B. ratio of maximum energy stored and energy dissipated per cycle
C. reciprocal of its power-factor
D. ratio of R to Z
Correct answer: B
Reason: The Q-factor quantifies the energy efficiency of a coil by comparing the energy stored to the energy dissipated in a cycle.

(vii) The combined resistance of two equal resistors connected in parallel is equal to:
A. one half the resistance of one resistor
B. twice the resistance of one resistor
C. four times the resistance of one resistor
D. one fourth the resistance of one resistor
Correct answer: A
Reason: For resistors of equal resistance connected in parallel, the combined resistance is half the value of one resistor.

(viii) If the number of valence electrons of an atom is four, the substance is usually:
A. a conductor
B. an insulator
C. a semiconductor
D. an alloy
Correct answer: C
Reason: Elements with four valence electrons, such as silicon, are semiconductors due to their balanced conductivity.

(ix) Two electric bulbs rated for the same voltage have powers of 200 W and 100 W. If their resistances are R1 and R2 respectively, then:
A. R1 = R2
B. R2 = 4R1
C. R2 = 2R1
D. R1 = 4R2
Correct answer: D
Reason: Power is inversely proportional to resistance for a constant voltage. The higher power bulb has lower resistance.

(x) The basic requirement for inducing e.m.f in a coil is that:
A. magnetic flux should link the coil
B. there should be change in magnetic flux linking the coil

C. coil should form a closed loop
D. magnetic core should provide maximum flux
Correct answer: B
Reason: Electromagnetic induction occurs when there is a change in magnetic flux linking the coil.

2. (a) Define the followings:

(i) Voltage
Voltage is the electric potential difference between two points in a circuit. It represents the energy per unit charge needed to move charges between the two points. The unit of voltage is the volt (V).

(ii) Current
Current is the rate of flow of electric charge in a circuit. It is measured in amperes (A) and can be expressed as the movement of electrons through a conductor.

(iii) Resistance
Resistance is the opposition offered by a material to the flow of electric current. It is measured in ohms (Ω) and depends on the material's properties, length, and cross-sectional area.

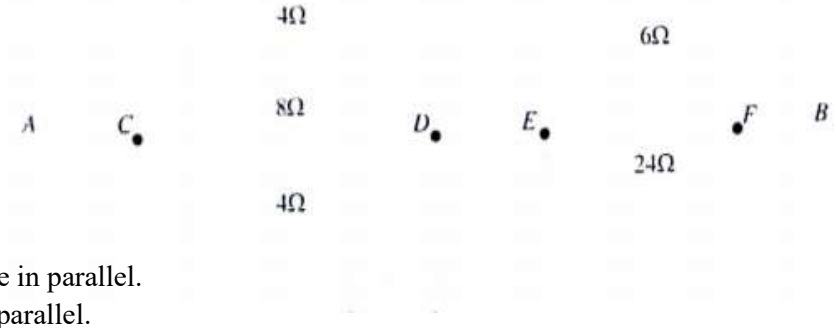
(iv) One ampere
One ampere is the unit of electric current. It is defined as the current that flows when one coulomb of charge passes through a point in a circuit in one second.

(b) (i) State Ohm's Law:
Ohm's Law states that the current flowing through a conductor between two points is directly proportional to the voltage across the two points and inversely proportional to the resistance of the conductor. Mathematically,
$V = I \times R$,
where V is voltage, I is current, and R is resistance.

(ii) What is the maximum voltage that can be applied across a 100 , 10 W resistor in order to keep within the resistors power rating?
Maximum voltage for a resistor:
The power formula is given by:
$P = V^2 / R$,
where $P = 10$ W, $R = 100$ Ω.
Rearranging for V:
$V = \sqrt{(P \times R)}$
$V = \sqrt{(10 \times 100)}$
$V = \sqrt{1000}$
$V \approx 31.62$ V.

Therefore, the maximum voltage is approximately 31.62 volts.

(iii) Read carefully the circuit in figure one and then you calculate the resistance between a and b and the total current flowing in the circuit.




Circuit analysis: .

Step 1: Analyze the circuit
- Resistors 4 Ω, 8 Ω, and 4 Ω are in parallel.
- Resistors 6 Ω and 24 Ω are in parallel.
- The two parallel combinations are in series.

Step 2: Calculate the equivalent resistance of 4 Ω, 8 Ω, and 4 Ω in parallel
Using the formula for parallel resistance:
$1 / R_{parallel} = 1 / R_1 + 1 / R_2 + 1 / R_3$

$1 / R_{123} = 1 / 4 + 1 / 8 + 1 / 4$
$1 / R_{123} = 0.25 + 0.125 + 0.25$
$1 / R_{123} = 0.625$
$R_{123} = 1.6\ \Omega$

Step 3: Calculate the equivalent resistance of 6 Ω and 24 Ω in parallel
Using the same formula:
$1 / R_{parallel} = 1 / R_1 + 1 / R_2$
$1 / R_{45} = 1 / 6 + 1 / 24$
$1 / R_{45} = 0.1667 + 0.0417$
$1 / R_{45} = 0.2084$
$R_{45} \approx 4.8\ \Omega$

Step 4: Add the equivalent resistances in series
The total resistance of the circuit:
$R_{total} = R_{123} + R_{45}$
$R_{total} = 1.6 + 4.8$
$R_{total} = 6.4\ \Omega$

Step 5: Calculate the total current
Using Ohm's Law:
$I = V / R_{total}$
Assuming the voltage supply is 240 V:
$I = 240 / 6.4$
$I = 37.5$ A

(c) State the application of the following tools as used in electrical works:

(i) Long nose plier: Used for bending, cutting, and holding small components or wires in tight spaces during electrical works.

(ii) Side cutter: Used for cutting wires and small pins in electrical circuits.

(iii) Bench vice: Used to hold objects securely in place for cutting, drilling, or assembling components.

(iv) Files: Used for smoothing rough edges on materials, such as metals or plastics, after cutting.

(v) Desoldering pump: Used to remove molten solder from printed circuit boards during repair or assembly.

(d) State laws of magnetic force:

1. Magnetic force acts along the lines of a magnetic field and follows the right-hand rule for the direction of force.
2. The force between two magnetic poles is directly proportional to the product of their pole strengths and inversely proportional to the square of the distance between them (Coulomb's Law for magnetism).
3. Like poles repel, and unlike poles attract.

(e) Define the following terms as used in electromagnetism:

(i) Self-inductance of a coil: It is the property of a coil that allows it to oppose changes in the current flowing through it by generating an opposing voltage due to its own magnetic field.

(ii) Mutual inductance of a coil: It is the property of a coil by which it induces a voltage in a neighboring coil when there is a change in current flowing through it.

(e) Draw electrical symbols for the following components:

(i) Air-cored inductor: A simple coil symbol with no additional core marking.

(ii) Iron-cored inductor: A coil symbol with a parallel line representing the iron core inside it.

3.(a) (i) Define three categories of materials mainly used in electricity:

1. Conductors: These are materials that allow electric current to pass through them easily due to the presence of free electrons. Examples include copper and aluminum. They are primarily used in wires and cables for transmitting electrical energy efficiently.

2. Insulators: These are materials that resist the flow of electric current, providing safety and preventing leakage. Examples include rubber, glass, and plastic. Insulators are used in cable coatings and switchboards to protect users from electrical shocks.

3. Semiconductors: These materials have electrical conductivity that lies between conductors and insulators. They are primarily used in electronic devices like diodes and transistors. Examples include silicon and germanium. Their conductivity can be controlled and used for specific applications like signal amplification.

(ii) What is the major function of insulation?

The primary function of insulation is to prevent the leakage of electrical current from live wires or components to unintended areas. This protects users from electric shocks, prevents short circuits, and enhances the safety and reliability of the electrical system.

(iii) Mention two ways of mechanically cable protection used in installation works:

1. Conduit pipes: Cables are placed inside PVC or metallic conduits to shield them from mechanical damage and environmental factors like moisture or pests.

2. Cable trays: These are structures used to hold and organize cables, providing both protection and accessibility for maintenance in industrial and commercial setups.

(b) What is the function of each of the following accessories?

(i) Lamp holders:
Lamp holders are designed to hold light bulbs securely in place and establish an electrical connection with the bulb. They allow safe operation and replacement of light sources in a variety of lighting systems.

(ii) Plugs and socket-outlets:
These accessories enable the connection of electrical appliances to the main power supply. The plug transfers electricity to the appliance, while the socket provides the point of access to the power system. They are designed to ensure safety and compatibility.

(c) Briefly explain how you can perform the basic test of the installation to earth:

The earth continuity test verifies whether the installation is properly grounded to ensure safety. The process involves:
1. Turning off the main power supply to avoid risks.
2. Using an insulation resistance tester or a multimeter.
3. Connecting one probe of the tester to the earth terminal and the other to the metallic conductive parts (e.g., sockets, appliances).

4. Measuring the resistance. A low resistance value indicates a good earth connection, ensuring that any fault current can safely pass to the ground.

(d) State any six points that should be considered in selecting the wiring system for a particular installation:

1. Type of Building: The nature of the building (residential, commercial, or industrial) determines the complexity and type of wiring required.
2. Environmental Conditions: Factors like humidity, temperature, and exposure to chemicals or physical damage affect the choice of materials and methods for wiring.
3. Load Requirements: The expected electrical load influences the size and capacity of cables and wiring systems to ensure efficiency and safety.
4. Safety Standards: Compliance with national and international electrical standards ensures the wiring system is safe and reliable.
5. Aesthetic Considerations: Concealed wiring may be chosen for modern homes for a cleaner look, while surface wiring is often used in industrial settings for easy access.
6. Cost: Budget constraints can influence the selection of wiring systems and materials while balancing performance and safety.

(e) Name two common methods of wiring:

1. Surface Wiring: Wires are laid on the surface of walls or ceilings, typically enclosed in conduits for protection. It is cost-effective and allows easy modification or repairs.
2. Concealed Wiring: Wires are embedded inside walls, ceilings, or floors, making the system aesthetically pleasing and safe from external damage. However, it is more expensive and harder to modify.

4. (a) Define “Cell” as applied in chemical effects of electrical current:

A cell is a device that converts chemical energy into electrical energy through a chemical reaction. It typically consists of two electrodes immersed in an electrolyte, where one electrode acts as the positive terminal and the other as the negative terminal. This process generates a potential difference, allowing the flow of electric current when connected in a circuit.

(b) Mention two common types of cells:

1. Primary Cells: These are non-rechargeable cells that are used once and then discarded, such as alkaline batteries.
2. Secondary Cells: These are rechargeable cells, such as lithium-ion and lead-acid batteries, that can be used multiple times.
(c) Give three advantages of using Leclanché cell “dry” type:

1. Portability: Leclanché dry cells are compact and lightweight, making them easy to transport and use in portable devices.
2. Low Maintenance: Unlike wet cells, they do not require periodic topping up of the electrolyte.

3. Safety: They have a reduced risk of leakage and spillage, making them safer for use in various applications.

(d) A Leclanché wet cell, with e.m.f 1.5 V, and internal resistance 1 Ω, supplies current to a single-stroke electric bell of resistance 5 Ω. Calculate the steady current in the circuit and the potential difference of the cell.

Steady Current (I):
Using Ohm's Law:
$I = E / (R + r)$,
where $E = 1.5$ V, $R = 5$ Ω, and $r = 1$ Ω.
$I = 1.5 / (5 + 1) = 1.5 / 6 = 0.25$ A.

Potential Difference (V):
$V = E - Ir$,
$V = 1.5 - (0.25 \times 1) = 1.5 - 0.25 = 1.25$ V.

5. (a) Define the following earth terms:

(i) Earth Electrode:
An earth electrode is a conductive material, such as a metal rod or plate, buried in the ground to provide a low-resistance path for fault current to flow into the earth.
(ii) Earthing Lead:
The earthing lead is a conductor used to connect the electrical system or equipment to the earth electrode, ensuring that fault currents are safely diverted to the ground.

(b) (i) Why are charcoal and salt used during the installation of earth electrodes?

1. Charcoal increases the conductivity around the earth electrode by absorbing moisture and retaining electrolytic properties.
2. Salt enhances the conductivity of the soil by ionizing and providing a better path for fault current to dissipate into the ground.

(ii) State two factors that have to be considered in determining the size of a fuse wire in installation:

- Current Rating: The fuse must be able to handle the normal operating current without melting while protecting the circuit from excessive current.
- Circuit Voltage: The fuse wire must be capable of safely interrupting the maximum voltage in the circuit.

(iii) State two kinds of protection offered by a fuse:

- Overcurrent Protection: Fuses prevent damage to the circuit by breaking the connection when excessive current flows.
- Short Circuit Protection: Fuses interrupt the current flow in case of a short circuit, protecting the equipment and users.

6. (a) (i) Apart from the stated value, what are the three necessary factors to be considered when choosing a resistor?

- Power Rating: Ensure the resistor can handle the power dissipation without overheating or failing.
- Tolerance: Select a resistor with an appropriate tolerance level to meet the precision required in the circuit.
- Material Type: Choose the right material (e.g., carbon, metal film) based on the resistor's application and environmental conditions.

(ii) A resistance of 8000 Ω is required to be reduced to 5000 Ω by adding a resistance in parallel. What value should the added resistance have?

Using the formula for parallel resistance:
1 / R_total = 1 / R1 + 1 / R2

Where:
R_total = 5000 Ω,
R1 = 8000 Ω,
R2 = unknown.

Rearranging the formula:
1 / R2 = 1 / R_total - 1 / R1

1 / R2 = 1 / 5000 - 1 / 8000
1 / R2 = 0.0002 - 0.000125
1 / R2 = 0.000075

R2 = 1 / 0.000075
R2 = 13,333.33 Ω

The added resistance should be approximately 13,333.33 Ω.

(b) Draw symbols for the following components:

(i) Fixed Resistor: A rectangle or zigzag line.
(ii) Variable Capacitor: Two parallel lines with an arrow crossing them diagonally.
(iii) Semiconductor Diode: A triangle pointing to a line.

(iv) Dust-Cored Transformer: Two coils with a dotted line between them, indicating the dust core.
(v) Iron-Cored Inductor: A coil with lines indicating the iron core.

7. (a) Define the following terms used in semiconductor theory:

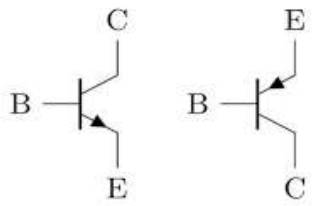
(i) Intrinsic Semiconductor: A pure semiconductor material (e.g., silicon or germanium) without any impurities added. It has equal numbers of electrons and holes as charge carriers.
(ii) Doping: The process of adding impurities to a semiconductor to increase its conductivity by introducing free electrons or holes.
(iii) Reverse Bias: A condition where the p-n junction diode is connected such that the p-side is at a lower potential than the n-side, restricting the flow of current.
(iv) Free Electron: An electron that is not bound to an atom and is free to move within a conductor or semiconductor.
(v) Ionization: The process of adding or removing electrons from an atom or molecule, resulting in the formation of an ion.

(b) (i) What is rectification?
Rectification is the process of converting alternating current (AC) into direct current (DC) using diodes or other rectifying devices.

(ii) Mention the component that is mainly used for rectification and give a reason for your answer.
Component: Diode
Reason: Diodes allow current to flow in one direction only, making them ideal for converting AC to DC.

8. (a) The component mainly used for signal amplification in a radio receiver is:
Transistor
A transistor is widely used in radio receivers for amplifying weak signals to a level that can be processed further. It acts as an amplifier by using a small input current to produce a larger output current.

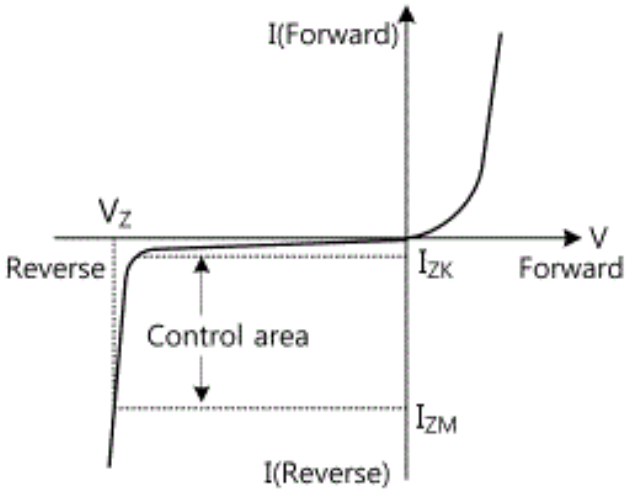
(b) Draw transistor symbols for:
(i) NPN: The symbol consists of three terminals - emitter, base, and collector. The emitter has an arrow pointing outward.
(ii) PNP: The symbol consists of three terminals - emitter, base, and collector. The emitter has an arrow pointing inward.



(c) (i) Draw a symbol for a zener diode and provide one major application of it in electronic power supplies.

The symbol of a zener diode is similar to a regular diode, but it has bent edges at the end of the line perpendicular to the triangle.
A major application is in ,voltage regulation, where the zener diode maintains a constant output voltage despite changes in load or input voltage.

(ii) Draw a well-labeled characteristic curve of a zener diode.




The characteristic curve of a zener diode shows the forward region (normal diode behavior) and the reverse breakdown region, where the diode conducts in reverse to regulate voltage.