THE UNINTED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

FORM TWO NATIONAL ASSESSMENT

080 ELECTRICAL ENGINEERING

Time: 2:30 Hours **ANSWERS** **Year: 2016**

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) What is the equivalent capacitance of 6 µF, 4 µF, and 3 µF capacitors connected in series?
A. 2 µF
B. 3 µF
C. 9 µF
D. 13 µF
Correct answer: A. 2 µF
Reason: For capacitors in series, the reciprocal of the total capacitance (Ceq) is equal to the sum of the reciprocals of the individual capacitances.
$1 / Ceq = 1 / 6 + 1 / 4 + 1 / 3$
$1 / Ceq = (2 + 3 + 4) / 12 = 9 / 12$
$Ceq = 12 / 9 = 4 / 3$ µF ≈ 2 µF

(ii) The magnetic material used in permanent magnets is:
A. Iron
B. Soft steel
C. Nickel
D. Hardened steel
Correct answer: D. Hardened steel
Reason: Hardened steel retains magnetism and is commonly used for permanent magnets due to its high coercivity.

(iii) What is the value of the temperature coefficient of a semiconductor?
A. Zero
B. Negative
C. Positive
D. Infinite
Correct answer: B. Negative
Reason: Semiconductors exhibit a negative temperature coefficient because their resistance decreases as temperature increases.

(iv) Which of the following electrical quantities is measured in Amperes?
A. Current
B. Resistance
C. Voltage
D. Impedance
Correct answer: A. Current
Reason: Amperes (A) is the SI unit for measuring electrical current.

(v) The electrons in the last orbit of an atom are called:
A. Free electrons
B. Bond electrons
C. Valence electrons
D. Thermionic electrons

Correct answer: C. Valence electrons
Reason: Valence electrons are located in the outermost shell of an atom and determine its chemical properties.

(vi) What will be the current in the circuit when the resistance is doubled, and the voltage is kept constant?
A. The current will be halved
B. The current will be doubled
C. The current will be the same
D. The current will be improved
Correct answer: A. The current will be halved
Reason: Current is inversely proportional to resistance (Ohm's Law: $I = V / R$).

(vii) The purpose of a load in an electric circuit is:
A. To utilize electrical energy
B. To increase the circuit current
C. To decrease the circuit current
D. To block both a.c. and d.c. currents
Correct answer: A. To utilize electrical energy
Reason: The load in a circuit converts electrical energy into another form, such as light, heat, or mechanical energy.

(viii) Which of the following systems apply only Kirchhoff's current law?
A. Closed loops in a network
B. Electronic circuits
C. Junctions in a network
D. Open loops in a circuit
Correct answer: C. Junctions in a network
Reason: Kirchhoff's Current Law (KCL) states that the sum of currents entering and leaving a junction equals zero.

(ix) What is the combined resistance of two equal resistors connected in parallel?
A. Twice the resistance of one resistor
B. Four times the resistance of one resistor
C. One half of the resistance of one resistor
D. One fourth of the resistance of one resistor
Correct answer: C. One half of the resistance of one resistor
Reason: For resistors in parallel, the combined resistance (R) is given by $R = R1 / n$, where n is the number of equal resistors.

(x) What is a transformer?
A. It is an a.c. machine that converts electrical energy to mechanical energy.
B. It is an a.c. machine that converts mechanical energy into electrical energy.
C. It is a machine that converts one level of voltage to another level.

D. It is a machine that converts d.c. power to a.c. power.
Correct answer: C. It is a machine that converts one level of voltage to another level.
Reason: Transformers work on the principle of electromagnetic induction to step up or step down voltage levels.

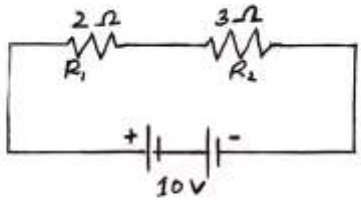
2. (a) What is the SI unit of the following quantities?
(i) Current: Ampere (A)
(ii) Power: Watt (W)
(iii) Energy: Joule (J)
(iv) Charge: Coulomb (C)
(v) Resistance: Ohm (Ω)

(b) If a current of 4 A flows through a conductor of resistance 2 Ω:

(i) What is the potential difference across the conductor?
Using Ohm's law: $V = I \times R$
$V = 4 \times 2 = 8$ V
The potential difference across the conductor is 8 V.

(ii) Calculate the heat dissipated in the conductor.
Using the formula: $H = I^2 \times R \times t$
Assume time t = 1 second (if not given):
$H = 4^2 \times 2 \times 1 = 16 \times 2 = 32$ J
The heat dissipated in the conductor is 32 Joules.

(iii) Study the circuit given in Figure 1 and calculate the power dissipated in each resistor.



To calculate the power dissipated in each resistor, use the formula:
$P = V^2 / R$ for each resistor.
For R1, $P = 100^2/2 = 5000$ W
For R2, $P = 100^2/3 = 333.3$ W

(c) When two equal resistors are connected in series across a 200 V supply, the power dissipated is 40 W.
(i) Calculate the resistance of each resistor.
The total power dissipated is given by: $P = V^2 / R_{total}$
$R_{total} = V^2 / P = 200^2 / 40 = 40000 / 40 = 1000$ Ω
Since the resistors are equal and in series: $R_{total} = 2R$

R = Rtotal / 2 = 1000 / 2 = 500 Ω
The resistance of each resistor is 500 Ω.

(ii) Calculate the current from the supply.
Using Ohm's law: I = V / Rtotal
I = 200 / 1000 = 0.2 A

(d) If a 12 V lamp is operated from a 240 V a.c. mains step-down transformer:
(i) What will be the turns ratio of the transformer windings?
Turns ratio = Primary voltage / Secondary voltage
Turns ratio = 240 / 12 = 20
The turns ratio is 20.

(ii) How many turns are on the primary winding if the secondary winding has 80 turns?
Using the turns ratio:
Np / Ns = Primary voltage / Secondary voltage
Np / 80 = 240 / 12
Np = (240 / 12) × 80 = 20 × 80 = 1600 turns
The primary winding has 1600 turns.

(iii) What is the current in the primary coil if the current through the lamp is 2 A?
Using the power equivalence principle: Pprimary = Psecondary
Vp × Ip = Vs × Is
240 × Ip = 12 × 2
Ip = (12 × 2) / 240 = 24 / 240 = 0.1 A
The current in the primary coil is 0.1 A.

(e) Give five types of capacitors according to the dielectric used.
- Ceramic capacitors
- Electrolytic capacitors
- Paper capacitors
- Film capacitors
- Mica capacitors

3. (a) Define the following terms:

(i) Fuse element:
A fuse element is the part of a fuse that melts and breaks the circuit when excessive current flows through it, protecting electrical devices from damage.

(ii) Fuse:

A fuse is a protective device used in electrical circuits to prevent excessive current from flowing through the circuit. It contains a metal wire or strip that melts when the current exceeds a certain limit, interrupting the circuit.

(iii) Insulator:
An insulator is a material that resists the flow of electric current. It is used to protect electrical components and individuals from electric shocks. Examples include rubber, plastic, and ceramic.

(iv) One-way switch:
A one-way switch is a simple electrical device used to control the flow of electricity in a circuit. It allows the user to turn the electrical current on or off from one location.

(b) Give standard sizes of the following cables commonly used in electrical works:

(i) Cables used for lighting circuits: 1.5 mm^2
(ii) Cables for electric circuits: 2.5 mm^2
(iii) Cables for ring circuits: 2.5 mm^2
(iv) Cables for radial circuits: 4 mm^2

4. (a) Give the names of the insulations suitable for:

(i) Cooker wiring circuit cable: Heat-resistant PVC
(ii) Electric iron wiring circuit cable: Heat-resistant flexible rubber
(iii) Lighting circuit cable: PVC-insulated cables
(iv) Ring circuit cable: PVC-insulated cables

(b) Mention four advantages of metal conduits:

- They provide excellent mechanical protection for electrical wiring.
- They are durable and resistant to external physical damage.
- They offer superior grounding and shielding against electrical interference.
- They are fire-resistant and can contain sparks or flames within the conduit.

5. (a) List three possible electric faults that can occur in electrical circuits:
- Short circuit
- Open circuit
- Overcurrent

(b) Give the meaning of the following terms:

(i) Electrical power:
Electrical power is the rate at which electrical energy is transferred or converted into another form, such as heat or light. It is measured in watts (W).

(ii) Ampere:
An ampere (A) is the unit of electric current in the International System of Units (SI). It represents the amount of electric charge flowing past a point in a circuit per second.

(iii) Electrical energy:
Electrical energy is the energy generated or consumed by an electrical device or system. It is calculated as the product of power and time and is measured in joules (J) or kilowatt-hours (kWh).

(c) A piece of resistance wire 100 m long and of cross-sectional area 0.1 mm², at a temperature of 10°C, passes a current of 5 A when connected to a d.c supply at 230 V. Calculate the resistivity of the wire.

Resistance:
$R = V / I = 230 / 5 = 46\ \Omega$

Using the formula for resistivity:
$\rho = (R \times A) / L$

Where:
$R = 46\ \Omega$
$A = 0.1\ mm^2 = 0.1 \times 10^{-6}\ m^2$
$L = 100\ m$

$\rho = (46 \times 0.1 \times 10^{-6}) / 100$
$\rho = 4.6 \times 10^{-8}\ \Omega \cdot m$

The resistivity of the wire is $4.6 \times 10^{-8}\ \Omega \cdot m$.

6. (a) Name two groups of electronic components, and for each group give one example:

(i) Active components: Transistor
(ii) Passive components: Resistor

(b) Write two types of fixed resistors:
(i) Carbon film resistor
(ii) Metal film resistor

(c) Tabulate the values of colours used in resistors for colour coding:

Red - 2
Green - 5
Blue - 6
Black - 0

Violet - 7
White - 9
Brown - 1
Orange - 3
Yellow - 4
Gray - 8

7. (a) (i) Define the term "Semiconductor material":
A semiconductor material is a type of material whose electrical conductivity lies between that of a good conductor (like copper) and an insulator (like glass). It can conduct electricity under certain conditions, making it essential for creating electronic components such as diodes, transistors, and integrated circuits.

(ii) Mention two common semiconductor materials:
- Silicon: Widely used in the electronics industry due to its abundance and excellent electrical properties.
- Germanium: Used in early semiconductor devices and in specialized applications like high-speed electronics.

(iii) Name two kinds of extrinsic semiconductors:
- n-type semiconductor: This is formed when a pentavalent impurity, such as phosphorus, is added to a pure semiconductor, creating an excess of free electrons for conduction.
- p-type semiconductor: This is formed when a trivalent impurity, such as boron, is added to a pure semiconductor, creating holes that facilitate electrical conduction.

(b) (i) Mention three leads of a bipolar junction transistor:
- Emitter: Emits carriers (electrons or holes) into the base region.
- Base: Controls the flow of carriers from the emitter to the collector.
- Collector: Collects carriers from the emitter through the base, enabling current flow through the transistor.

(ii) If a collector current (Ic) is 30 mA and that of the emitter (Ie) is 35 mA, calculate the base current (Ib):
Solution:
Using the formula:
$Ie = Ic + Ib$
$Ib = Ie - Ic$

Substitute values:
$Ib = 35\ mA - 30\ mA = 5\ mA$
The base current (Ib) is 5 mA.

(iii) The current in a collector terminal (Ic) is 19 mA and the emitter current (Ie) is 20 mA. What is the current amplification factor (β)?
Using the formula:
$\beta = Ic / Ib$

First, calculate Ib:
Ib = Ie - Ic
Ib = 20 mA - 19 mA = 1 mA

Now, substitute into the formula:
β = 19 mA / 1 mA = 19

The current amplification factor (β) is 19.

8. (a) (i) What is soldering?
Soldering is a joining process in which a filler metal (solder) is melted to connect metal components. It is commonly used in electronics to create electrical connections between components and circuit boards. The process ensures a strong and conductive bond without melting the base materials.

(ii) Which tool is used to remove molten solder from the PCB?
- Solder sucker (desoldering pump): This tool uses suction to remove molten solder. It is helpful when desoldering components.

(iii) Give two materials used to make an alloy of a solder wire:
- Tin: Provides strength and resistance to oxidation in solder.
- Lead: Enhances the melting point and workability of solder. (Note: Lead-free solder is also used in modern electronics.)

(c) Study the figure carefully then answer the questions that follows

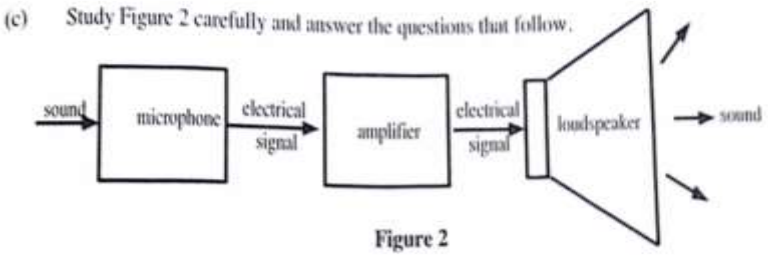


Figure 2

(i) Functions of the parts in the block diagram:
Microphone:
The microphone converts sound waves into electrical signals. It acts as a transducer by capturing audio input and transforming it into an electrical signal for further processing.

Amplifier:
The amplifier increases the strength (amplitude) of the electrical signal received from the microphone. This ensures that the signal is strong enough to drive the loudspeaker effectively.

Loudspeaker:
The loudspeaker converts the amplified electrical signal back into sound waves. It functions as a transducer that emits sound for listeners to hear.

(ii) Two transducers found in Figure 2:
- Microphone: Converts sound waves into electrical signals.
- Loudspeaker: Converts electrical signals back into sound waves.