**THE UNINTED REPUBLIC OF TANZANIA**

**NATIONAL EXAMINATIONS COUNCIL**

**FORM TWO NATIONAL ASSESSMENT**

**080 ELECTRICAL ENGINEERING**

**Time: 2:30 Hours** **ANSWERS** **Year: 2009**

**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.

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(i) The first step to assist a shocked person is to:
A. call an ambulance
B. give the victim cold water
C. give the victim a mouth-to-mouth resuscitation
D. remove the victim from accident place by hand
Answer: D. Remove the victim from the accident
Reason: The priority in any accident is to remove the victim from immediate danger before administering first aid. If they remain in a hazardous situation, further injuries could occur.

(ii) The electrician's head is protected from falling objects by using:
A. a cap
B. a protective mask
C. a safety helmet
D. safety goggles
Answer: C. a safety helmet
Reason: A safety helmet is specifically designed to protect the head from falling objects, which is a common hazard in electrical and construction work.

(iii) The SI unit of electromotive force is:
A. coulomb
B. farad
C. joule
D. volt
Answer: D. volt
Reason: The electromotive force (EMF) is measured in volts, as it represents the energy provided per unit charge to move the charges through a circuit.

(iv) The central part of an atom consists of:
A. ions and electrons
B. electrons and protons
C. neutrons and electrons
D. protons and neutrons
Answer: D. protons and neutrons
Reason: The nucleus of an atom contains protons and neutrons, while electrons orbit around the nucleus.

(v) The color of a live wire in a 3-wire cable is:
A. black
B. blue
C. orange
D. red
Answer: D. red
Reason: In electrical systems, the live wire is typically red to indicate its role in carrying current.

(vi) The purpose of a transformer is to:
A. change magnetic field
B. change the voltage
C. convert a.c to d.c
D. generate electrical power
Answer: B. change the voltage
Reason: A transformer is used to increase or decrease the voltage level in an alternating current (AC) electrical circuit.

(vii) When two bodies of like charges are brought close to each other:
A. there will be no reaction
B. the bodies will attract each other
C. the bodies will be discharged
D. the bodies will repel each other
Answer: D. the bodies will repel each other
Reason: Like charges repel each other due to the electrostatic force of repulsion.

(viii) Two resistors each having resistance of 2 Ω can be connected in series or in parallel. What is the difference in terms of equivalent resistance between connections which are in series and in parallel?
A. 1 Ω
B. 3 Ω
C. 4 Ω
D. 5 Ω
Answer: B. 3 Ω
Reason:
In series: R_series = R1 + R2 = 2 Ω + 2 Ω = 4 Ω
In parallel: 1/R_parallel = 1/R1 + 1/R2 = 1/2 + 1/2 = 2/2, so R_parallel = 1 Ω
Difference = R_series - R_parallel = 4 Ω - 1 Ω = 3 Ω

(ix) Which of the following is the best fuse for an electric cooker rated 240 V, 4.5 kW?
A. 1.8 A
B. 5.3 A
C. 18.5 A
D. 53.3 A
Answer: C. 18.5 A
Reason:
Current I = P/V = 4500 W / 240 V = 18.75 A
The best fuse rating slightly exceeds the operating current, so 18.5 A is the most appropriate choice.

(x) When the cross-section area of an electric conductor is increased, its resistance will:
A. be negligible
B. decrease
C. increase


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D. remain the same
Answer: B. decrease
Reason:
Resistance R = ρ(L/A), where A is the cross-sectional area. As the area increases, the resistance decreases, since they are inversely proportional.

(a)(i) Define a cell.
Answer: A cell is a single electrical power source that converts chemical energy into electrical energy to produce an electric current. It consists of two electrodes (an anode and a cathode) and an electrolyte.

(ii) Mention three differences between a cell and a battery.

| Cell | Battery. |
|---|---|
| (1) A single unit producing electricity. | (1) A collection of cells connected together. |
| (2) Produces low voltage. | (2) Produces higher voltage. |
| (3) Used in small devices like watches. | (3) Used in larger applications like cars. |

(iii) A primary cell with an e.m.f of 1.4 V and internal resistance of 0.1 Ω is connected to a circuit of resistance 0.4 Ω. Calculate the current in the circuit.

Answer:
Using Ohm's law:
$I = E / (R + r)$
Where:
I = Current
E = Electromotive force (1.4 V)
R = External resistance (0.4 Ω)
r = Internal resistance (0.1 Ω)

$I = 1.4 / (0.4 + 0.1)$
$I = 1.4 / 0.5$
$I = 2.8$ A
The current in the circuit is 2.8 A.

(b)(i) Define a magnet.
Answer: A magnet is a material or object that produces a magnetic field, which attracts ferromagnetic materials like iron, nickel, and cobalt and can attract or repel other magnets.

(ii) Name two types of magnets.
Answer:
- Permanent magnet
-Electromagnet


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(iii) Calculate the rate of change of flux which is required to induce an e.m.f. of 20 kV in an ignition coil consisting of 1200 turns.

Answer:
Using Faraday's Law:
$E = -N \times (d\Phi/dt)$
Where:
E = Induced e.m.f (20,000 V)
N = Number of turns (1200)
$d\Phi/dt$ = Rate of change of flux

Rearranging for $d\Phi/dt$:
$d\Phi/dt = E / N$
$d\Phi/dt = 20,000 / 1200$
$d\Phi/dt = 16.67$ Wb/s

The rate of change of flux is 16.67 Wb/s.

(c)(i) List down three important features of a current measuring instrument.
Answer:
(1) High sensitivity to measure small currents accurately.
(2) Low resistance to avoid significant voltage drop in the circuit.
(3) A clear and easily readable scale to ensure accurate readings.

(ii) Electric current produces chemical, magnetic, and heating effects. Give two examples which are found in our daily life for each of the above cases.
Chemical effects:
(1) Electroplating: The process of depositing a layer of metal on an object.
(2) Electrolysis: Used in extracting metals like aluminum.
Magnetic effects:
(1) Electric bell: Uses a magnetic field to produce sound.
(2) Electric motor: Converts electrical energy into mechanical energy through magnetism.

Heating effects:
(1) Electric iron: Converts electricity into heat for ironing clothes.
(2) Electric kettle: Converts electricity into heat to boil water.

(iii) Briefly describe the construction of a moving coil instrument.
Answer: A moving coil instrument consists of a rectangular coil of wire wound on an aluminum frame. The coil is mounted on a pivot between the poles of a permanent magnet. The current passes through the coil, which experiences a torque due to the magnetic field, causing it to move. The movement is indicated by a pointer on a calibrated scale, measuring current or voltage.


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(d)(i) Calculate the minimum allowable cross-section area of a PVC copper cable which will supply a 240 V distribution fuse board, 50 m from the supply point if the total load is 50 A. Take resistivity of copper to be 1.7 μΩcm.

Answer:
We use the formula for resistance:
$R = \rho \times (L / A)$

Where:
R = Resistance of the conductor
$\rho$ = Resistivity of copper = 1.7 μΩcm = $1.7 \times 10^{-8}$ Ωm
L = Length of the cable (round trip, 50 m × 2 = 100 m)
A = Cross-sectional area of the conductor

The allowable voltage drop is 5% of 240 V:
Voltage drop = 0.05 × 240 = 12 V

From Ohm's law:
$R = V / I = 12 / 50 = 0.24\ \Omega$
Substitute into the formula for resistance:
$0.24 = (1.7 \times 10^{-8}) \times (100 / A)$
$A = (1.7 \times 10^{-8} \times 100) / 0.24$
$A = 7.08 \times 10^{-7}\ m^2$
$A = 7.08\ mm^2$
The minimum allowable cross-sectional area is 7.08 mm²

(ii) A heating element can boil 16 liters of water from 10°C to 70°C in 2 hours. Find its rating if its working efficiency is 60%. Assume the specific heat capacity of water is 4187 J/kg°C.

Answer:
Data:
Mass of water = 16 liters = 16 kg
Temperature change = $\Delta T = 70 - 10 = 60°C$
Specific heat capacity = 4187 J/kg°C
Efficiency = 60% = 0.6
Time = 2 hours = 7200 seconds
Energy required to heat water:
$Q = mc\Delta T$
$Q = 16 \times 4187 \times 60$
$Q = 4{,}021{,}440\ J$

Power input (P):
$P = Q / (\text{efficiency} \times \text{time})$


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P = 4,021,440 / (0.6 × 7200)
P = 930.11 W

The heating element's rating is approximately 930 W.

(iii) What is the cost of using an electric iron rated 240 V, 2000 W for 10 hours if the cost of electric energy given by TANESCO is 150/= per unit (1 unit ≈ 1 kWh)?

Answer:
Energy consumed = Power × Time
Energy = 2000 W × 10 hours
Energy = 20,000 Wh = 20 kWh

Cost = Energy × Cost per unit
Cost = 20 × 150
Cost = 3000 /=

The cost of using the electric iron is 3000 /=

3. (a) State the use of each of the following tools:

(i) Combination plier
Answer: A combination plier is used for gripping, bending, cutting wires, and tightening or loosening small objects like bolts and nuts.

(ii) Side cutter
Answer: A side cutter is used for cutting wires and small cables cleanly without crushing them.

(iii) Screwdriver
Answer: A screwdriver is used to drive screws into materials or remove screws from materials by turning them clockwise or counterclockwise.

(iv) Hacksaw
Answer: A hacksaw is used for cutting metals, plastics, and other materials with precision, using its fine-toothed blade.

(b) symbol for each of the following accessories:

(i) Electric buzzer
Answer: The symbol for an electric buzzer consists of a small rectangle or oval shape with sound wave lines emanating from it.

(ii) One-way three-gang switch


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Answer: The symbol shows three individual switches connected in parallel, each controlled by a single point.

(iii) Main switch
Answer: The symbol for a main switch usually consists of a rectangle with two dots representing the terminals connected by a straight line.

(iv) Twin fluorescent
Answer: The symbol for twin fluorescent lamps consists of two parallel lines representing the tubes, each connected to a circuit.

4. (a)(i) Define the term "earth lead."
Answer: An earth lead is a conductor that connects electrical devices or installations to the earth to ensure safety by providing a low-resistance path for fault currents to dissipate into the ground.

(ii) Name one application of an Earth Leakage Circuit Breaker (ELCB).
Answer: An Earth Leakage Circuit Breaker is used in residential and commercial buildings to protect against electric shocks by disconnecting the power supply when it detects current leakage to the ground.
(b)(i) What is the use of sheaths in a sheathed wiring system?
Answer: Sheaths in a sheathed wiring system are used to:

- Provide insulation and prevent electrical leakage.
- Protect wires from mechanical damage, moisture, and corrosion.
- Enhance the durability and lifespan of the wiring system.

(ii) Briefly explain how catenary wiring is done in residential areas.
Answer: Catenary wiring involves suspending insulated wires along a supporting cable using hooks or rings. The supporting cable is anchored at two ends and tensioned to reduce sagging. This method is commonly used in open areas or where underground wiring is impractical. The suspended wires carry electricity to supply power to residential buildings.

5. (a)(i) Give the differences between a conduit and a trunk.

- A conduit is a cylindrical pipe used to enclose and protect electrical wires WHILE a Trunk is a rectangular channel used for routing and protecting multiple cables.
- Often made of metal or plastic and installed in walls or ceilings. WHILE Trunk is installed on walls or floors and can be opened to add or remove cables.
- A conduit is Suitable for both exposed and concealed wiring. WHILE a Trunk is Primarily used for surface wiring.

(ii) Briefly explain the operation of a bimetallic strip.
Answer: A bimetallic strip consists of two metals with different coefficients of thermal expansion bonded together. When heated, the strip bends toward the metal with the lower expansion rate because the other

metal expands more. This bending motion is used in devices like thermostats and circuit breakers to activate or deactivate a mechanism based on temperature changes.

(b)(i) Design a circuit which can operate two lamps independently.
Answer: To operate two lamps independently, each lamp should have its own switch connected in parallel to the power supply. Closing one switch will light up the corresponding lamp without affecting the other.

(ii) The resistance of a coil at 20°C was 20 Ω. What current will it draw from a 10 V supply when operating in a cold room at 0°C? ($\alpha = 0.0043/°C$).

Answer:
Resistance at a new temperature can be calculated using the formula:
$R = R_0(1 + \alpha\Delta T)$

Where:
$R_0$ = Resistance at 20°C = 20 Ω
$\alpha$ = Temperature coefficient = 0.0043/°C
$\Delta T$ = Change in temperature = 0°C - 20°C = -20°C

$R = 20(1 + 0.0043 \times -20)$
$R = 20(1 - 0.086)$
$R = 20 \times 0.914$
$R = 18.28\ \Omega$

Current, $I = V / R$
$I = 10 / 18.28$
$I \approx 0.547$ A
The current drawn is approximately 0.547 A.

6. (a)(i) What is a "heat sink"?
Answer: A heat sink is a device made of metal, often aluminum or copper, designed to absorb and dissipate heat from electronic components such as transistors, processors, and diodes to prevent overheating.

(ii) What is the importance of using a heat sink?
Answer:
1. Prevents overheating of electronic components.
2. Enhances the performance and reliability of electronic devices.
3. Prolongs the lifespan of components by maintaining safe operating temperatures.

(b) Sketch a neat symbol for each of the following:

(i) Photodiode


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Answer: The symbol for a photodiode is a diode symbol with two arrows pointing towards it, indicating light entering the diode.

(ii) Light dependent resistor (LDR)
Answer: The symbol for an LDR is a resistor symbol with two arrows pointing towards it, representing light affecting its resistance.

(iii) Electrolytic capacitor
Answer: The symbol for an electrolytic capacitor consists of two parallel lines, one straight and one curved, indicating the polarity (straight for positive and curved for negative).

(iv) Temperature dependent resistor
Answer: The symbol for a temperature-dependent resistor (thermistor) is a resistor symbol with a diagonal line intersecting it and a small "T" to indicate temperature.

7. (a)(i) A certain resistor is identified by its color code as follows: RED, RED, BLACK, GOLD. What is the working range of the resistor?

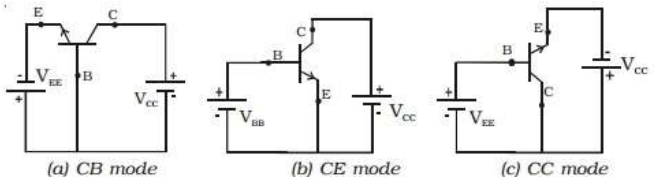
Answer:
The color code corresponds to:
1st Band: Red = 2
2nd Band: Red = 2
Multiplier: Black = 10^0 = 1
Tolerance: Gold = ±5%
Resistance = 22 Ω ± 5%
Tolerance range = 22 × 0.05 = 1.1 Ω
Working range = 22 - 1.1 Ω to 22 + 1.1 Ω
Working range = 20.9 Ω to 23.1 Ω

The working range of the resistor is 20.9 Ω to 23.1 Ω.

(ii) Write down the actual value of each resistor shown below if F = ±1%, G = ±2%, J = ±5%, K = ±10%, and M = ±20%.

- R33M: 33 × 10^6 Ω ± 20% = 33 MΩ ± 6.6 MΩ
- 4R7K: 4.7 Ω ± 10% = 4.7 Ω ± 0.47 Ω
- 6K8F: 6.8 kΩ ± 1% = 6.8 kΩ ± 68 Ω
- 6K8G: 6.8 kΩ ± 2% = 6.8 kΩ ± 136 Ω
- 6K8J: 6.8 kΩ ± 5% = 6.8 kΩ ± 340 Ω

(b)(i) Sketch the three transistor configurations:



(a) CB mode (b) CE mode (c) CC mode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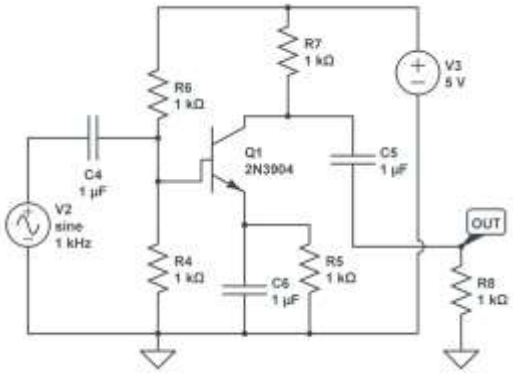
- Common Emitter: The base is common to both input and output. Input is at the base-emitter junction, and output is at the collector-emitter junction.
- Common Base: The base is common to both input and output. Input is applied to the emitter-base junction, and output is taken from the collector-base junction.
- Common Collector: The collector is common to both input and output. Input is at the base-collector junction, and output is taken from the emitter-collector junction.

(ii) Draw a transistor amplifier in CE mode with coupling and decoupling components included.




8. (a)(i) What type of flux is used in soldering?
Answer: The type of flux used in soldering is rosin-based flux. It helps to remove oxidation, improves the wetting properties of the solder, and ensures a good electrical connection.

(ii) List two tools used in soldering:
Answer:
1. Soldering iron
2. Desoldering pump

(iii) Name five materials used in soldering:
Answer:
1. Solder (lead-tin alloy)
2. Flux
3. Solder wick
4. Soldering iron tip cleaner
5. Heat-resistant mat

(b)(i) What is a resonance frequency?
Answer: Resonance frequency is the frequency at which the inductive reactance and capacitive reactance of a circuit are equal in magnitude but opposite in phase, resulting in the impedance being purely resistive. At this frequency, the circuit oscillates at its maximum amplitude.
(ii) Calculate the resonance frequency when a 2 mH inductor and an 80 pF capacitor are connected in series.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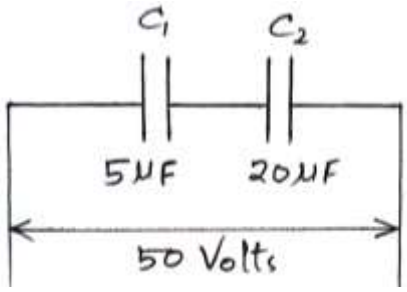
Answer:
The resonance frequency is calculated using the formula:
$f = 1 / (2\pi\sqrt{(L \times C)})$

Where:
$L = 2\ mH = 2 \times 10^{-3}\ H$
$C = 80\ pF = 80 \times 10^{-12}\ F$

$f = 1 / (2\pi\sqrt{(2 \times 10^{-3} \times 80 \times 10^{-12})})$
$f = 1 / (2\pi\sqrt{(1.6 \times 10^{-13})})$
$f = 1 / (2\pi \times 1.26 \times 10^{-6})$
$f \approx 1.26 \times 10^{6} / (2\pi)$
$f \approx 200\ kHz$
The resonance frequency is approximately 200 kHz.

(iii) From the circuit shown below, calculate the charge on capacitor C1 and C2.




Answer:
Given:
C1 = 5 μF
C2 = 20 μF
Voltage = 50 V
Capacitors in series have an equivalent capacitance:
$1 / Ceq = 1 / C1 + 1 / C2$
$1 / Ceq = 1 / 5 + 1 / 20$
$1 / Ceq = 4 / 20 + 1 / 20$
$1 / Ceq = 5 / 20$
$Ceq = 20 / 5 = 4\ \mu F$

Charge (Q) is the same for series capacitors:
$Q = Ceq \times Voltage$
$Q = 4 \times 10^{-6} \times 50$
$Q = 200 \times 10^{-6}\ C$
$Q = 200\ \mu C$

The charge on each capacitor is the same:
$Q1 = Q2 = 200\ \mu C$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Voltage across each capacitor:
$V1 = Q / C1 = 200 \times 10^{-6} / 5 \times 10^{-6} = 40$ V
$V2 = Q / C2 = 200 \times 10^{-6} / 20 \times 10^{-6} = 10$ V

The charge on both capacitors is 200 μC.


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