THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

082 **ELECTRICAL ENGINEERING SCIENCE**

(For Both School and Private Candidates)

Time : 3 Hours **ANSWERS** **Year : 2018**

Instructions

1. This paper consists of sections A, B and C.
2. Answer all questions in section A and B and **three (3)** questions from section C.
3. Non-programmable calculators may be used.
4. Communication devices and any unauthorised materials are **not** allowed in the examination room.
5. Write your **Examination Number** on every page of your answer booklet(s).

1. For each of the items (i) – (x), choose the correct answer from among the given alternatives and write its letter beside the item number in the answer booklet provided.

(i) In D.C. generators the lamination of the core is generally made of

A. cast iron

B. carbon

C. silicon steel

D. stainless steel copper

E. iron steel

Correct answer: C. silicon steel

Reason: Silicon steel laminations are used in DC machines to minimize hysteresis losses in the core.

(ii) What will be the frequency for a one cycle of an a.c. waveform that occurs in every two milliseconds?

A. 1000 Hz

B. 500 Hz

C. 50 Hz

D. 100 Hz

E. 60 Hz

Correct answer: A. 1000 Hz

Reason: Time period T = 2 ms = 2×10^{-3} s, Frequency f = 1/T = 1 / 0.002 = 500 Hz. Wait correction: the question says "every two milliseconds," so T = 0.002 s, f = 500 Hz. Therefore correct answer: B. 500 Hz.

(iii) The total luminous flux required in any lighting scheme is inversely depends on

A. illumination

B. surface area

C. space/height ratio

D. utilization factor

E. candela

Correct answer: D. utilization factor

Reason: Required flux depends inversely on utilization factor, which represents how much of the emitted light is effectively used.

(iv) Which of the following factors is to be considered when determining the power factor of an alternator?

A. Speed

B. Excitation

C. Powerful engine

D. Prime mover

E. Load

Correct answer: E. Load

Reason: Power factor of an alternator depends mainly on the load connected, not on prime mover or speed.

(v) If two 4 Ω resistors are connected in parallel, the effective resistance of the circuit is

A. 2 Ω

B. 4 Ω

C. 8 Ω

D. 1 Ω

E. 5 Ω

Correct answer: A. 2 Ω

Reason: Effective resistance in parallel is $R = (R \times R)/(R + R) = (4 \times 4)/(4 + 4) = 16/8 = 2$ Ω.

(vi) The readings from a repulsive moving iron instrument used in A.C. circuits are known as:

A. Equivalent d.c. values of currents

B. R.M.S. value of current

C. Peak value of a current

D. Mean value of a current

E. Average value of a current

Correct answer: B. R.M.S. value of current

Reason: Moving iron instruments measure rms values because their deflection depends on the square of the current.

(vii) Which of the following is the application of a DC series motor?

A. It is suitable for regulating high voltage

B. Used to control the wide range of speed

C. It is suitable for driving machine tools

D. Acceptable where low starting torque is required

E. It is best suited for driving cranes and hoists

Correct answer: E. It is best suited for driving cranes and hoists

Reason: DC series motors provide very high starting torque, making them suitable for traction, cranes and hoists.

(viii) Mutual inductance between two magnetically-coupled coils depends on

A. permeability of the core

B. the number of their turns

C. cross-sectional area of their common core

D. coupling conductance

E. resistance of coils

Correct answer: A, B, and C collectively affect mutual inductance, but from given choices the best is A. permeability of the core

Reason: Mutual inductance is proportional to $\mu \times N \times A / l$, hence permeability of the core is key.

(ix) Most electrical cables are constructed in three parts which are

A. insulation, copper and aluminium

B. conductor, insulation and flexible cord

C. conductor, insulation and sheath

D. inner sheath, outer sheath and protection

E. conductor, insulation and neutral

Correct answer: C. conductor, insulation and sheath
Reason: Cables consist of conductor for carrying current, insulation for protection, and sheath for mechanical safety.

(x) Eddy current losses in a transformer-core can be reduced by
A. reducing air gap in the magnetic circuit
B. increasing the air gap in the magnetic circuit
C. increasing the thickness of laminations
D. reducing the thickness of laminations
E. reducing the number of turns in the secondary winding

Correct answer: D. reducing the thickness of laminations
Reason: Thin laminations increase resistance to eddy currents, reducing the circulating current losses.

2. List three effects of an electric current.

Heating effect, where current produces heat in conductors due to I^2R loss.
Chemical effect, where current produces chemical changes in electrolytes such as electrolysis.
Magnetic effect, where current produces a magnetic field that can deflect a compass needle or magnetize material.

3. (a) State Lens's law of electromagnetism.

Lenz's law states that the direction of induced current is such that it opposes the change in magnetic flux that produces it.

(b) A coil of 500 turns is linked by a flux of 0.4 mWb. If the flux is reversed in 0.01 second, find e.m.f induced in the coil.

$\Phi = 0.4 \times 10^{-3}$ Wb, $N = 500$, $\Delta\Phi = 2 \times 0.4 \times 10^{-3} = 0.0008$ Wb, $t = 0.01$ s
$e.m.f = N\Delta\Phi / \Delta t = (500 \times 0.0008) / 0.01 = 40$ V

4. (a) Give two advantages of doing modification of a simple primary cell.

It reduces polarization effect by using depolarizers like manganese dioxide.
It increases the cell's life and efficiency by reducing internal resistance.

(b) Name the instrument used to measure specific gravity of the battery.

Hydrometer.

5. Give the meaning of the following terms as used in electrical networks:
   (a) Branch
   A branch is a single circuit element such as a resistor, inductor, capacitor, or source connected between two nodes.
   (b) Node
   A node is a point in a circuit where two or more elements are connected.
   (c) Circuit
   A circuit is a closed conducting path through which current can flow.

6. State two laws of illumination.

   Illumination is inversely proportional to the square of the distance from the source (Inverse Square Law).
   Illumination is directly proportional to the luminous intensity of the source (Lambert's Cosine Law when at an angle).

7. (a) Give the major function of a transformer in electrical system.

   A transformer is used to step up or step down alternating voltage levels while maintaining frequency constant.

   (b) List two types of transformer test commonly used in electrical works.

   Open circuit test, used to measure core (iron) losses and no-load parameters.
   Short circuit test, used to measure copper losses and equivalent impedance.

8. Mention three areas where shaded pole motors can be used.

They are used in electric fans, small blowers, and refrigerator motors.

9. (a) What type of DC generator is suitable for constant voltage applications?

Shunt DC generator, since its terminal voltage remains almost constant with varying load.

(b) A 220 V (dc) generator has an armature resistance of 0.5 Ω. If the full load armature current is 20 A, find the induced e.m.f of the generator.

Induced emf Eg = V + IaRa = 220 + (20 × 0.5) = 220 + 10 = 230 V

10. Convert 212 °F into degree Celsius.

°C = (°F – 32) × 5/9 = (212 – 32) × 5/9 = 180 × 5/9 = 100 °C

11. Outline three essential requirements in which conductor and insulator should possess.

A conductor should have low resistivity to allow current to flow easily. It should have high mechanical strength to withstand stresses. It should have good ductility to allow it to be drawn into wires.

An insulator should have very high resistivity to prevent current leakage. It should have high dielectric strength to withstand high voltages. It should have resistance to heat and moisture to maintain insulation properties.

12. (a) Give three ways on which cells of batteries may be connected.

Cells may be connected in series, which increases the total voltage while current capacity remains the same.
Cells may be connected in parallel, which increases the current capacity while voltage remains the same.
Cells may be connected in series-parallel, which increases both voltage and current capacity depending on the arrangement.

(b) A primary cell with e.m.f of 2.0 V and internal resistance of 2 Ω is connected to a circuit of 0.7 Ω. Calculate the current in the circuit.

Total resistance = r + R = 2 + 0.7 = 2.7 Ω
I = E / (R + r) = 2 / 2.7 = 0.741 A

(c) (i) Mention two methods of charging lead acid batteries.

Constant current method, where charging current is kept constant by adjusting supply voltage.
Constant voltage method, where a fixed voltage is applied and current gradually reduces as charging proceeds.

(ii) Twenty nickel-cadmium cells each of discharge capacity of 50 A for 6 hours are to be charged at constant current for 7 hours. If the supply is 250 V (d.c), calculate the value of the variable charging resistance required. Consider 80% ampere hour efficiency of nickel cadmium and back e.m.f of each cell at the beginning and end of charging to be 1.35 V and 1.7 V respectively.

Capacity = 50 × 6 = 300 Ah per cell
Effective capacity to be supplied = 300 / 0.8 = 375 Ah
Charging current = 375 / 7 = 53.6 A

Total back emf at beginning = 20 × 1.35 = 27 V
At end = 20 × 1.7 = 34 V

At beginning: R = (V – Eb) / I = (250 – 27) / 53.6 = 223 / 53.6 = 4.16 Ω
At end: R = (250 – 34) / 53.6 = 216 / 53.6 = 4.03 Ω
Hence, variable charging resistance should vary around 4.2 Ω to 4 Ω.

13. (a) Define the following illumination terminologies used in electrical engineering science:
    (i) Luminous flux
    Luminous flux is the total amount of visible light emitted by a source per unit time, measured in lumens.
    (ii) Luminous intensity
    Luminous intensity is the luminous flux emitted by a source per unit solid angle in a given direction, measured in candela.

(b) The series connected neon-outline of a sign has a total length of 18 m. The length and diameter per tube is 3 m and 15 mm respectively. If the lumens per watt is 12.5 and the lamp carries a current of 35

mA with a power factor of 0.8; assuming the voltage drop per pair and for 15 mm diameter to be 300 V and 400 V respectively, determine:
(i) the secondary voltage of the step-up transformer
(ii) its output power in volt-amperes
(iii) power in watts
(iv) the total lumens

Total tubes = 18 / 3 = 6
Number of pairs = 3 (since each pair has 2 tubes)
Voltage drop = 300 + 400 + 300 = 1000 V

(i) Secondary voltage = 1000 V

(ii) Apparent power S = V × I = 1000 × 0.035 = 35 VA

(iii) Power in watts P = VI cos φ = 1000 × 0.035 × 0.8 = 28 W

(iv) Total lumens = P × lumens/watt = 28 × 12.5 = 350 lumens

14. (a) Mention three different types of electrical measuring instruments according to the utility.

Ammeters for measuring current.
Voltmeters for measuring voltage.
Wattmeters for measuring power.

(b) A moving coil element with resistance of 5 Ω requires a potential difference of 75 mV D.C to give full scale deflection. Calculate:
(i) The shunt resistance which enable the instrument to work as an ammeter giving a full scale deflection of 20 A.

Ifsd = V/R = 0.075 / 5 = 0.015 A
I = 20 A
Ish = 20 – 0.015 = 19.985 A
Rsh = (Ifsd × Rm) / Ish = (0.015 × 5) / 19.985 = 0.075 / 19.985 = 0.00375 Ω

(ii) The series resistance which allow the instrument to work as a voltmeter with a full scale deflection of 240 V.

I = 0.015 A

Required total resistance = V / I = 240 / 0.015 = 16000 Ω

Series resistance = 16000 – 5 = 15995 Ω

15. Three equal impedances each of resistance 25 Ω and reactance 40 Ω are connected in star to a 400 V, 3-phase, 50 Hz system, calculate the:
    (a) line current
    (b) power factor
    (c) power consumed

$Z = \sqrt{(R^2 + X^2)} = \sqrt{(25^2 + 40^2)} = \sqrt{(625 + 1600)} = \sqrt{2225} = 47.2\ \Omega$

Phase voltage $V_{ph} = V_L / \sqrt{3} = 400 / 1.732 = 231$ V

Phase current $I_{ph} = V_{ph} / Z = 231 / 47.2 = 4.9$ A

Line current $I_L = I_{ph} = 4.9$ A

(a) Line current = 4.9 A

(b) Power factor $\cos \varphi = R / Z = 25 / 47.2 = 0.53$

(c) Power consumed $= \sqrt{3} \times V_L \times I_L \times \cos \varphi = 1.732 \times 400 \times 4.9 \times 0.53 = 1790$ W

16. (a) List three methods of transferring heat from one body to another.

Conduction, transfer of heat through direct contact.

Convection, transfer of heat through fluid movement.

Radiation, transfer of heat through electromagnetic waves.

(b) A storage heater contains 0.1 m³ of water. The 240 V heating element produces a temperature rise of 85 °C in 1½ hours and the efficiency of the device is 82%. Calculate:

(i) the rating of heater in kilowatts

(ii) the resistance of the heating element in ohms

Mass of water = $0.1 \times 1000 = 100$ kg

Heat required = $mc\Delta T = 100 \times 4200 \times 85 = 35{,}700{,}000$ J

Time = 1.5 h = 5400 s

Input energy = Output / efficiency = $35.7 \times 10^6 / 0.82 = 43.54 \times 10^6$ J

Power = Energy / Time = $43.54 \times 10^6 / 5400 = 8053$ W = 8.05 kW

(i) Rating of heater = 8.05 kW

(ii) Resistance $R = V^2 / P = 240^2 / 8053 = 57600 / 8053 = 7.15\ \Omega$