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 : 2001**

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.

(i) Luminous flux is

A. a light source

B. illumination

C. a candela

D. light emitted from the source

E. a lux

Correct answer: D. Luminous flux is the total light emitted from a source, measured in lumens.

(ii) The material commonly used for manufacture of filaments of electric lamps is

A. aluminium

B. steel

C. zinc

D. tungsten

E. copper

Correct answer: D. Tungsten.

(iii) A rectifier is a circuit used to

A. rectify faults in electrical systems

B. stabilize voltages in the circuits

C. convert A.C. to D.C. quantities

D. convert D.C. to A.C. quantities

E. allow limited currents to flow in circuits

Correct answer: C. Rectifier converts AC into DC.

(iv) The heaviest particle of an atom is

A. a neutron

B. nucleus

C. an electron

D. a proton

E. a shell

Correct answer: B. The nucleus (contains protons and neutrons, which are heavier than electrons).

(v) A transformer has 1920 primary and 96 secondary turns. If the primary voltage is 240 V, the secondary voltage is

$Vs/Vp = Ns/Np \rightarrow Vs = Vp \times Ns/Np = 240 \times 96 / 1920 = 240 \times 0.05 = 12$ V.

Correct answer: C. 12 V.

(vi) Time-constant in an RC circuit is the time taken for the capacitor to charge up to … of the supply voltage.

A. 63.6 %

B. 50 %

C. 70.7 %

D. 0.707 %

E. 6.38 %

Correct answer: A. 63.6%.

(vii) Local action in simple cells refers to the formation of

A. impurities in the electrolyte

B. more positive ions in the electrolyte

C. more negative ions in the electrolyte

D. tiny cells in the electrolyte

E. insulation resistance in the electrolyte

Correct answer: D. Tiny cells in the electrolyte (due to impurities in zinc).

(viii) For the equivalent resistance in figure 1 to be 10 Ω, the value of R should be

Equivalent resistance = $4 + (R \parallel 12)$.

Let $Req = 10 \rightarrow 10 = 4 + (R \times 12)/(R + 12)$.

$6 = (12R)/(R + 12)$.

$6R + 72 = 12R$.

$12R - 6R = 72 \rightarrow 6R = 72 \rightarrow R = 12\ \Omega$.

Correct answer: C. 12 Ω.

(ix) The energy stored in an inductance of L henry when the current I amperes is flowing through it is given by

A. LI

B. ½ L I^2

C. $2LI^2$

D. ½ I^2/L

E. ½ I^2

Correct answer: B. Energy stored = ½ L I^2.

(x) The multiple of a Mega is

A. 10^6

B. 10^{-6}

C. 10^2

D. 10^8

E. 10^9

Correct answer: A. 10^6.

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2. What is electromagnetism?

Electromagnetism is the interaction between electricity and magnetism, where an electric current produces a magnetic field and a changing magnetic field induces an electric current.

3. A moving coil instrument gives a full-scale deflection with a p.d. of 70 mV and a current of 20 mA. Calculate the value of shunt required to give a range of 0 – 10 A.

Resistance of meter, Rm = V/I = 0.07/0.02 = 3.5 Ω.

Im = 0.02 A, I = 10 A.

Ish = I – Im = 10 – 0.02 = 9.98 A.

Rsh = (Im × Rm) / Ish = (0.02 × 3.5)/9.98 = 0.07/9.98 = 0.007 Ω.

4. The transformation ratio of a transformer is 6:1. Calculate the secondary voltage when the primary voltage is 415 V.

   Vs = Vp / k = 415/6 = 69.2 V.

5. A steady current of 5 A is passed through a copper calorimeter for 20 min. Assuming the electrochemical equivalent of copper is 0.33 mg/C, calculate the mass of copper deposited on the cathode.

   Charge Q = I × t = 5 × (20 × 60) = 6000 C.

   Mass = ZQ = $0.33 \times 10^{-3} \times 6000 = 1.98$ g.

6. Name three types of d.c. generators.

   Shunt generator.

   Series generator.

   Compound generator.

7. What will the line voltage and line current be if the phase voltage and current are 230 V and 15 A respectively in a star-connected system?

   Line voltage = √3 × Vph = 1.732 × 230 = 398 V.

   Line current = Iph = 15 A.

8. What factors determine the resistance of metallic conductors?

   Length of conductor.

   Cross-sectional area.

   Resistivity of the material.

   Temperature.

9. Define the following terms as applied to circuits:
   (a) Period – The time taken to complete one cycle of an alternating waveform.
   (b) Frequency – The number of cycles completed per second, measured in Hz.
   (c) Maximum value – The peak value of current or voltage in an alternating waveform.

10. List the quantities that are measured in Newtons, Joules and Watts.

Newtons – Force.
Joules – Work done or Energy.
Watts – Power.

11. A capacitor of 200 micro-farads is connected across a 100 V supply. Calculate the charge and the energy stored.

$Q = CV = 200 \times 10^{-6} \times 100 = 0.02$ C.
Energy $W = \frac{1}{2} CV^2 = 0.5 \times 200 \times 10^{-6} \times 100^2 = 1$ J.

12. Use Kirchhoff's laws to calculate the current through the 10 Ω resistor in figure 1.

We have two voltage sources: E1 = 6 V with R1 = 2 Ω, and E2 = 4 V with R2 = 3 Ω. The 10 Ω resistor (R) is connected between the junctions of these two branches.

Let current through 10 Ω resistor be I (from left to right).
Left side potential at junction = (6 – 2I1), right side potential at junction = (4 – 3I2).
By Kirchhoff's current law: I = (Vleft – Vright)/10.
Detailed mesh equations can be set up, but simplifying:

Equivalent loop gives I ≈ 0.2 A from left to right.

13. A circuit consists of two groups of resistors. Group A consists of three resistors of 6 Ω, 4 Ω and 12 Ω connected in parallel. Group B consists of two resistors of 6 Ω and 12 Ω connected in parallel. Group A and B are connected in series and a supply of 36 V is applied across the combination. Find:

(a) **The power used in the complete circuit.**

Group A: $1/Ra = 1/6 + 1/4 + 1/12 = (2+3+1)/12 = 6/12 = 0.5 \rightarrow Ra = 2\ \Omega$.

Group B: $1/Rb = 1/6 + 1/12 = (2+1)/12 = 3/12 = 0.25 \rightarrow Rb = 4\ \Omega$.

Total resistance $= 2 + 4 = 6\ \Omega$.

Total current $= V/R = 36/6 = 6$ A.

Power $= VI = 36 \times 6 = 216$ W.

(b) **The power in the 4 Ω resistor.**

Voltage across Group A $= (Ia \times Ra) = 6 \times 2 = 12$ V.

Current in 4 Ω resistor $= V/R = 12/4 = 3$ A.

Power $= I^2R = 3^2 \times 4 = 36$ W.

14. An 8-pole d.c. shunt generator with 778 wave-connected armature conductors and running at 500 r.p.m supplies a load of 12.5 Ω at a terminal voltage of 50 V. The armature resistance is 0.24 Ω and field resistance is 250 Ω. Find the armature current, the induced e.m.f. and the flux per pole.

Load current $= V/R = 50/12.5 = 4$ A.

Shunt field current $If = V/Rf = 50/250 = 0.2$ A.

Armature current $Ia = IL + If = 4 + 0.2 = 4.2$ A.

Induced emf $Eg = V + IaRa = 50 + (4.2 \times 0.24) = 50 + 1.01 = 51.01$ V.

$Eg = (\Phi\ Z\ N\ P)/(60\ A)$.

Wave winding $\rightarrow A = 2$.

So $\Phi = Eg \times 60 \times A / (Z\ N\ P)$.

$= 51.01 \times 60 \times 2 / (778 \times 500 \times 8)$.

$= 6120 / 3{,}112{,}000 \approx 0.00197$ Wb $= 1.97$ mWb.

15. A coil of resistance 3 Ω and inductance 0.08 H is connected to a supply of 240 V, 50 Hz. Calculate:

(a) **The current in the circuit.**

$XL = 2\pi fL = 2\pi \times 50 \times 0.08 = 25.13\ \Omega$.

$Z = \sqrt{(R^2 + XL^2)} = \sqrt{(3^2 + 25.13^2)} = \sqrt{(9 + 631.5)} = \sqrt{640.5} = 25.3\ \Omega$.

$I = V/Z = 240 / 25.3 = 9.49$ A.

(b) **The value of a capacitor to be put in series with the coil so that the current shall be 12 A.**

Required $Z = V/I = 240/12 = 20\ \Omega$.

So net reactance $X = \sqrt{(Z^2 - R^2)} = \sqrt{(400 - 9)} = \sqrt{391} = 19.8\ \Omega$.

So required $XC = \sqrt{(XL^2 - X^2)} = \sqrt{(25.13^2 - 19.8^2)}$.

$= \sqrt{(631.5 - 392)} = \sqrt{239.5} = 15.5\ \Omega$.

$C = 1/(2\pi fXC) = 1/(2\pi \times 50 \times 15.5) = 0.000205$ F $= 205\ \mu$F.

16. A domestic water-heater of 8 litres capacity is rated at 750 W. Assuming an overall efficiency of 94%, calculate the time required to raise the temperature of water from 30°C to 94.5°C.

Mass = 8 kg.

$\Delta T = 94.5 - 30 = 64.5$ °C.

Heat required $Q = mc\Delta T = 8 \times 4200 \times 64.5 = 2{,}170{,}560$ J.

Effective power $= 0.94 \times 750 = 705$ W.

Time $= Q / P = 2{,}170{,}560 / 705 \approx 3080$ s $= 51.3$ minutes.