higher education
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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T460(E)(N13)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

ELECTRO-TECHNOLOGY N3

(11040343)

13 NOVEMBER 2014 (Y-Paper)
13:00–16:00

This question paper consists of 7 pages and a formula sheet of 3 pages.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTRO-TECHNOLOGY N3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Keep subsections of questions together, for example QUESTION 1, 1.1, 1.2, et cetera.
5. Rule off on completion of each question.
6. Sketches and diagrams must be done in pencil and must be neat, reasonably large and fully labelled.
7. Use the correct units for answers.
8. The correct information must be copied from the question paper and substituted for the correct symbol.
9. The answers must be round off to THREE decimal places.
10. Write neatly and legibly to avoid being penalised for untidy and illegible work.

QUESTION 1

State TWO functions of each of the following as applicable to DC machines:

1.1 Brushes

1.2 Field winding

1.3 Laminated iron sheets

1.4 Main frame

1.5 Pole core

(5 × 2) **[10]**

QUESTION 2

2.1 State FOUR uses of a cumulative-compound motor. (4)

2.2 The current through the field coils is determined by the supply voltage and the field resistance.

Write down the formula that indicates this information. (2)

2.3 Briefly define *residual magnetism* as applicable to DC machines. (2)

2.4 Name TWO safety devices which are found in series-starter motors. (2)
[10]

QUESTION 3

3.1 An 8-pole DC motor is connected to a 440 V supply and takes an armature current of 40 A. The resistance of the armature circuit is 0,6 Ω. The armature is wave-wound with 512 conductors and the useful flux per pole is 56 mWb.

Determine the following:

3.1.1 The motor back EMF in kV (3)

3.1.2 The torque developed by the armature in kN.m (4)

3.2 Name THREE components of a DC starter motor that can be affected by a high starting current if it is not limited. (3)
[10]

QUESTION 4

4.1 Tests were performed on two identical 380 V, 178,6 kW generators. The current between the machines is equal to the full-load current and an additional 50 000 mA are taken from the supply.

Determine the approximate efficiency of each machine. (6)

4.2 Briefly explain the term *embedded brushes* as applicable to DC machines. (3)

4.3 State ONE purpose of a shunt generator. (1)
[10]

QUESTION 5

5.1 An alternating quantity is represented by the following equation:

$i = 47 \text{ Sin } 314{,}2\, t$.

Determine the following:

5.1.1 The maximum value and its unit (1)

5.1.2 The frequency (2)

5.1.3 The instantaneous value 1 millisecond after zero (3)

5.1.4 The average value (1)

5.1.5 The effective value (1)

5.2 Briefly define the *mid-ordinate rule.* (2)
[10]

QUESTION 6

6.1 An RC circuit consists of a resistor of 55 Ω and a capacitor of 45 μf connected in series across a 240 V supply. The current flowing in the circuit is 4A.

Determine the frequency of the circuit. (7)

6.2 The induced EMF is 22,5 V. A coil has an effective length of 400 mm and moves at a right angle with a flux at 50 m/s.

Calculate the magnetic field density in Wb/m^2. (3)
[10]

QUESTION 7

7.1 A 190 kW, three-phase alternating-current motor is connected in star and the supply voltage is 440 V with a power factor of 0,91.

Determine the following:

7.1.1 The phase current of the motor (4)

7.1.2 The phase voltage in kV (3)

7.2 State THREE effects of a low power factor. (3)
[10]

QUESTION 8

8.1 A three-phase transformer has a delta-star connection. The primary phase voltage is 4,4 kV and the secondary phase voltage is 254 V.

Calculate the following:

8.1.1 The secondary line voltage (2)

8.1.2 The primary line current when the secondary line is 0,52 kA (3)

8.2 Briefly describe the term *induced electro-motive force* and motivate the answer with a neat, labelled sketch. (5)
[10]

QUESTION 9

9.1 Name THREE mechanisms that are found in electrical measuring instruments. (3)

9.2 Study FIGURE 1 below and answer the questions.

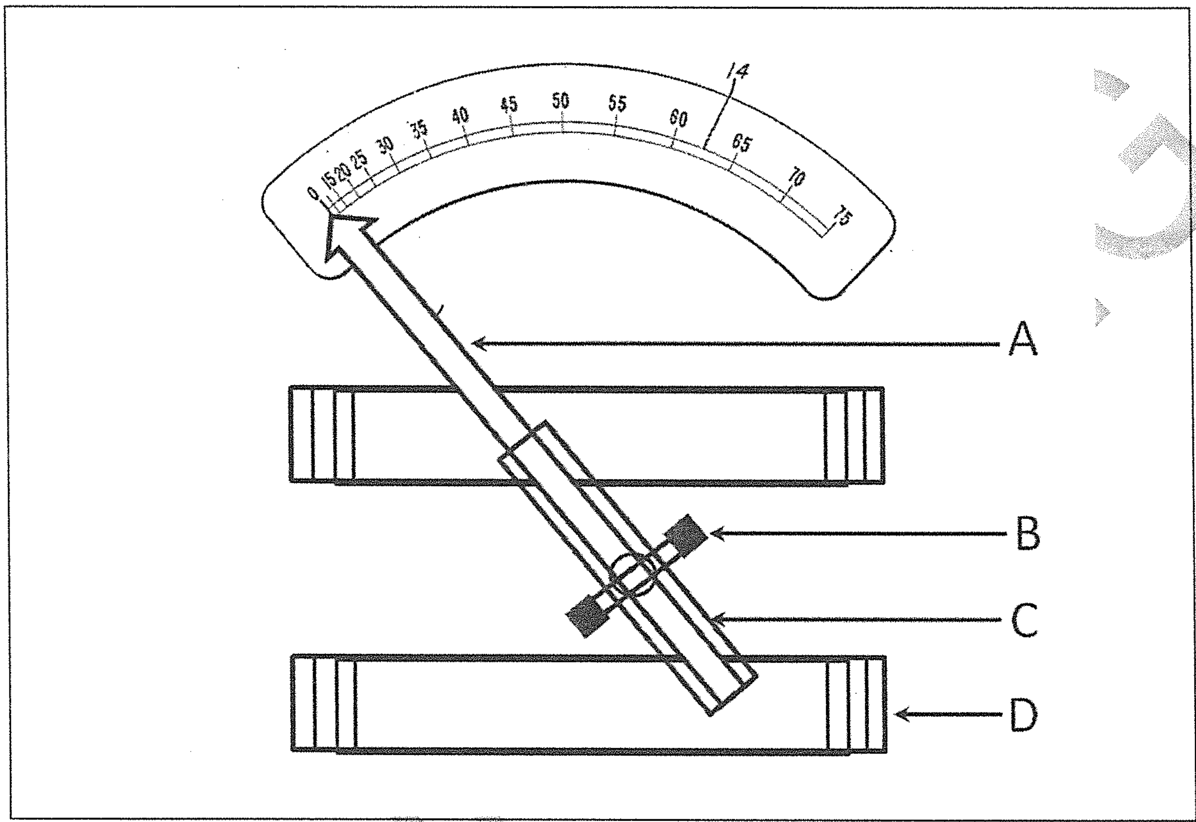

FIGURE 1

9.2.1 Name the instrument in FIGURE 1 above.

9.2.2 Name the part indicated by A.

9.2.3 Name the part indicated by B.

9.2.4 Name the part indicated by C.

9.2.5 Name the part indicated by D

(5 × 1) (5)

9.3 State TWO disadvantages of the instrument in FIGURE 1 above. (2)

[10]

QUESTION 10

10.1 Change the following decimal numbers to binary and show all necessary steps:

10.1.1 $11{,}5_{10}$

10.1.2 $15{,}25_{10}$

(2 × 2) (4)

10.2 Subtract the answer to QUESTION 10.1.1 from the answer to QUESTION 10.1.2 and leave the answer in binary number. (2)

10.3 Draw the IEC symbols for the following logic gates:

10.3.1 AND gate

10.3.2 NOR gate

(2 × 1) (2)

10.4 Illustrate, with the aid of a neat sketch, what you understand by the term *reverse bias*. No explanation is required. (2)

[10]

TOTAL: 100

ELECTRO-TECHNOLOGY N3

FORMULA SHEET

Any other applicable formula may also be used.

1. $E = V - I_a R_a$

2. $E = V + I_a R_a$

3. $E = 2p\Phi \dfrac{ZN}{60c}$

4. $N = \dfrac{V}{K\Phi}$

5. $T = \dfrac{0{,}318 I_a Zp\Phi}{C}$

6. Efficiency/Rendement $= \dfrac{VI}{VI + I_a^{\,2} R_a + I_s V + C} \times 100\%$

7. Efficiency/Rendement $= \dfrac{VI - (I_a^{\,2} R_a + I_s V + C)}{VI} \times 100\%$

8. Efficiency/Rendement $= \dfrac{2\pi N (W - S) r}{60 VI} \times 100\%$

9. Efficiency/Rendement $= \sqrt{\dfrac{I_1}{I_1 + I_2}} \times 100\%$

10. E = Blv

11. e = E_m Sin2цft

12. i= I_m Sin2цft

13. $e_{ave/gem}$ or/of $i_{ave/gem}$ = 0,637 E_m or/of I_m

14. $e_{rms/wgk}$ or/of $i_{rms/wgk}$ = 0,707 E_m or/of I_m

-2-

15. $E_{ave/gem} = \dfrac{e_1 + e_2 + e_3 + e_4 + \ldots + e_n}{n}$

Or/of

$I_{ave/gem} = \dfrac{i_1 + i_2 + i_3 + \ldots + i_n}{n}$

16. $E_{rms/wgk} = \sqrt{\dfrac{e_1{}^2 + e_2{}^2 + e_3{}^2 + \ldots + e_n{}^2}{n}}$

Or/of

$I_{rms/wgk} = \sqrt{\dfrac{i_1{}^2 + i_2{}^2 + i_3{}^2 + \ldots + i_n{}^2}{n}}$

17. Form factor / Vormfaktor = $\dfrac{E_{rms/wgk}}{E_{ave/gem}}$ or/of $\dfrac{I_{RMS/WGK}}{i_{AVE/GEM}}$

18. Crest factor/Kruinfaktor = $\dfrac{E_m}{E_{rms/wgk}}$ or/of $\dfrac{I_m}{I_{rms/wgk}}$

19. $I = \dfrac{V}{R}$

20. X_L = 2цfL; $i = \dfrac{V}{X_L}$

21. X_C = 2цfC; $i = \dfrac{V}{X_C}$

22. $Z = \sqrt{R^2 + X_L{}^2}$; $Z = \sqrt{R^2 + X_C{}^2}$; $I = \dfrac{V}{Z}$

23. Tan $\theta = \dfrac{X_L}{R}$; Tan $\theta = \dfrac{X_C}{R}$

24. $V_R = I \times R$; $V_L = I \times X_L$; $V_C = I \times X_C$

25. $Z = \sqrt{R^2 + (X_L - X_C)^2}$; $Z = \sqrt{R^2 + (X_C - X_L)^2}$

26. Tan $\theta = \dfrac{X_L - X_C}{R}$; Tan $\theta = \dfrac{X_C - X_L}{R}$

27. $P = V \times I$; $P = I^2 R$; $P = \dfrac{V^2}{R}$

28. $P = VI\cos\theta$

29. $\cos\theta = \dfrac{R}{Z}$; $\cos\theta = \dfrac{W or/of kW}{VA or/of kVA}$

30. $I_{active/aktief} = I\cos\theta$; $I_{reactive/reaktief} = I\sin\theta$

31. P = VI Cos θ

Q = VI Sin θ

32. $f_r = \frac{1}{2\pi\sqrt{LC}}$

33. $I = \sqrt{I_R^2 + I_L^2}$; Tan θ = $\frac{I_L}{I_R}$

34. $I = \sqrt{I_R^2 + I_C^2}$; Tan θ = $\frac{I_C}{I_R}$

35. $I = \sqrt{I_R^2 + (I_L - I_C)^2}$; Tan θ = $\frac{I_L - I_C}{I_R}$

36. $I = \sqrt{I_R^2 + (I_C - I_L)^2}$; Tan θ = $\frac{I_C - I_L}{I_R}$

37. Cos θ = $\frac{I_R}{I}$

38. $V_L = V_p$; $I_L = \sqrt{3} I_p$

39. $V_L = \sqrt{3} V_p$; $I_L = I_p$

40. $W = \sqrt{3} V_L I_L Cos\theta \times \eta$

41. $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$

42. kVA = $\frac{\sqrt{3} V_L I_L}{1000}$

43. $V_{shunt / sjunt} = V_{meter}$; $I_s R_s = I_m R_m$

44. $I_T = I_m + I_s$

45. $I_t = \frac{V_t}{R_t}$

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MARKING GUIDELINE

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This marking guideline consists of 9 pages.

QUESTION 1

1.1 Used to deliver ✓ or collect ✓current from the armature of the DC machine. (2)

1.2 Used **for excitation**✓ to supply the **field flux**
Induces field flux✓ (2)

1.3
- Used to insulate sheet separately
- Keeps eddy current paths apart

(2)

1.4
- Protects the inner parts of the machine
- Forms the **outer casing** of the machine
- Supports the **main field system**. (Any 2 × 1 mark) (2)

1.5
- Holds the field coils in position
- Increases the efficiency of the magnetic field

(2)
[10]

QUESTION 2

2.1
- For driving machines e.g. a printing press.
- In steel rolling mills
- In guillotines
- In punch machines.
- In shearing machines. (Any 4 × 1) (4)

2.2 $I = \frac{V_s}{R}$ (2)

2.3 It is the **magnetism which remains in the iron**✓ even after the current has been **switched off.**✓ (2)

2.4
- No volt relay
- Overload relay

(2)
[10]

QUESTION 3

3.1 Given: P = 4; V = 440 V; I_a = 40 A; R_a = 0,6 Ω; C = 2;Z = 512;Φ = 0,056 Wb

3.1.1 Motor back EMF

$$= V - I_a R_a$$
$$= 440 - (40 \times 0,6) \checkmark$$
$$= 416 \text{ V} \checkmark$$
$$= 0,416 \text{ kV} \quad \text{Answer}\checkmark$$

(3)

3.1.2 Torque developed [T] =

$$\frac{0,318 I_a Z p \phi}{C}$$
$$= \frac{0,318 \times 40 \times 512 \times 4 \times 0,056 Wb}{2} \checkmark\checkmark$$
$$= 729,416 \text{ N.m} \checkmark$$
$$= 0,729 \text{ kN.m} \longrightarrow \text{Answer}\checkmark$$

(4)

3.2
- Armature winding
- Commutator
- Brushes

(3)
[10]

QUESTION 4

4.1 Given: V = 380 V; P = 178,6 kW; I_2 = 50 000 mA = 50 A; η = ?

$$\text{Power} = VI_1$$
$$I_1 = \frac{178,6 \times 10^3}{380} \checkmark$$
$$= 470 \text{ A} \longrightarrow \checkmark$$

$$\therefore \quad \text{Efficiency } [\eta] = \sqrt{\frac{I_1}{I_1 + I_2}} \times 100\%$$
$$= \sqrt{\frac{470}{470 + 50}} \times 100\% \checkmark\checkmark$$
$$= \sqrt{0,904} \times 100\% \checkmark$$
$$= 95,079\ \% \longrightarrow \text{Answer}\checkmark$$

(6)

4.2
- Brushes are ground **with emery paper/sand paper**✓ so that brushes **take the arc of the commutator**✓ to **increase the total contact area of the brushes.**✓
- **OR** To ensure maximum current flow
- **OR** The brushes are ground to take the shape of the commutator (arch) (3)

4.3
- Battery charging
- Excitation for ac generator
- Where the distance from the generator to its load is short (Any 1 × 1) (1)

[10]

QUESTION 5

5.1 Given: i = 47 Sin 314,2 t

5.1.1 47 A (Answer) (1)

5.1.2 $\omega = 2\pi f$

$$f = \frac{314,2}{2 \times 3,142} \checkmark$$

= 50 Hz ⟶ Answer✓ (2)

5.1.3 i = 47 Sin (314,2 x 0,001 x 57,3°) ✓
= 47 Sin 18,004✓
= 14,527 A ⟶ Answer✓ (3)

5.1.4 Average value = 0,637 x 47
= 29,939 A ⟶ Answer ✓ (1)

5.1.5 RMS value = 0,707 x 47
= 33,229 A ⟶ Answer ✓ (1)

5.2 Mid-ordinate rule is to find the AVERAGE OR EFFECTIVE/ACTUAL/RMS value✓ of a non-sinusoidal waveform. ✓ (2)

[10]

QUESTION 6

6.1 Given: R = 55 Ω ; C = 45 uf; V_t = 240 V; Z = ? ; F = ? I_t = 4 A

$$Z = \frac{V_t}{I_t} = \frac{240V}{4A} \checkmark$$
$$= 60\ \Omega \longrightarrow \checkmark$$

$$Z = \sqrt{R^2 + X_C{}^2}$$
$$X_C = \sqrt{60^2 - 55^2} \checkmark$$
$$= \sqrt{575} \checkmark$$
$$= 23{,}979\ \Omega \longrightarrow \checkmark$$

Therefore: $X_C = \frac{1}{2\Pi fC}$

$$F = \frac{1}{2 \times 3{,}142 \times 45 \times 10^{-6} \times 23{,}979} \checkmark$$
$$= 147{,}476\ \text{Hz} \longrightarrow \text{Answer} \checkmark$$ (7)

6.2 Given: EMF = 22,5 V; L = 400 mm = 0,4 m; V = 50 m/s

$$E_{MAX} = Blv$$
$$B = \frac{22{,}5V}{50m/s \times 0{,}4m} \checkmark\checkmark$$

$$= 1{,}125\ \text{Wb/m}^2 \longrightarrow \text{Answer} \checkmark$$ (3)

[10]

QUESTION 7

7.1 Given: Input voltage = 440 volts; power factor = 0,91

7.1.1 Power = $\sqrt{3} V_L I_L Cos\theta$

$$I_L = \frac{190\,000}{\sqrt{3} \times 440 \times 0{,}91} \checkmark$$
$$= 273{,}967\ A \checkmark$$

But $I_L = I_p$ in the star connection✓

Therefore I_p = 273,967 A ⟶ Answer✓ (4)

7.1.2 $V_{PH} = \frac{440}{\sqrt{3}} \checkmark$

= 254,034 V✓
= 0,254 kV ⟶ Answer✓ (3)

7.2
- Large cables are required to carry a larger current.
- Losses in the transmission lines increase ($I^2 R$).
- The power factor decreases when kVA increases.
- Switches, switchgear, transformers and instruments must be capable of operating under the large current. (Any 3 × 1) (3)

[10]

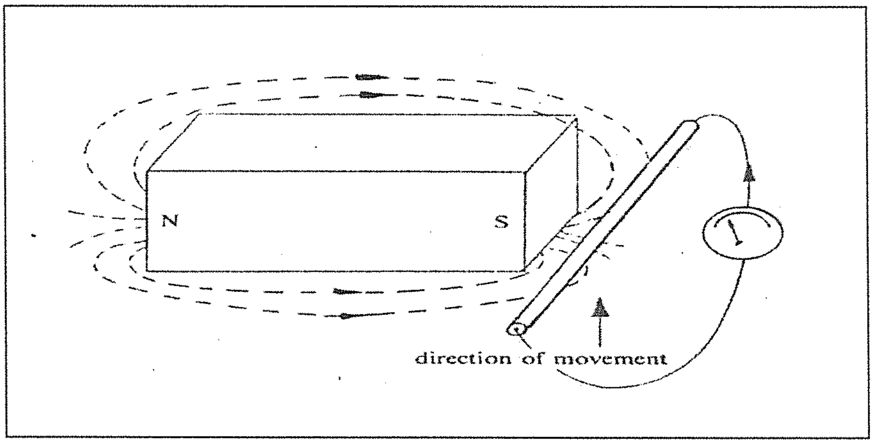
QUESTION 8

8.1 Given: $V_{1L} = V_{1ph} =$ 4,4 kV = 4 400 V [Delta connection] – Primary
V_{2ph} = 254 V [Star connection] – Secondary

8.1.1
$$V_{2L} = \sqrt{3}\ 254\ V ✓$$
$$= 439{,}941\ V \longrightarrow \text{Answer}✓$$
(2)

8.1.2
$$\frac{V_{1ph}}{V_{2ph}} = \frac{I_{2L}}{I_{1L}}$$
$$I_{1L} = \frac{I_{2L} \times V_{2ph}}{V_{1ph}}$$
$$= \frac{520\ A \times 254\ V}{4\ 400} \quad ✓✓$$
$$= 30{,}018\ A \longrightarrow \text{Answer}✓$$
(3)

8.2 When a conductor cuts magnetic lines of force,✓ an EMF or voltage is induced in the conductor.✓ The magnitude of the EMF is directly proportional to the rate at which the magnitude field cuts the conductor.✓



(2 marks for correct sketch) (5)

[10]

QUESTION 9

9.1
- Deflecting mechanism
- Controlling mechanism
- Damping mechanism

(3)

9.2
9.2.1 Dynamometer
9.2.2 Pointer
9.2.3 Balance weight
9.2.4 Moving coil
9.2.5 Fixed coil

(5 × 1) (5)

9.3
- It has a non-linear scale (uneven)
- It is expensive.

(2)
[10]

QUESTION 10

10.1 10.1.1

2	11
2	5
2	2
2	1

remainder 1 $0{,}5 \times 2 = 1$ ✓
remainder 1
remainder 0 ✓
remainder 1

$11{,}5_{10} = 1011{,}1_2$ ⟶ Answer✓ (2)

10.1.2

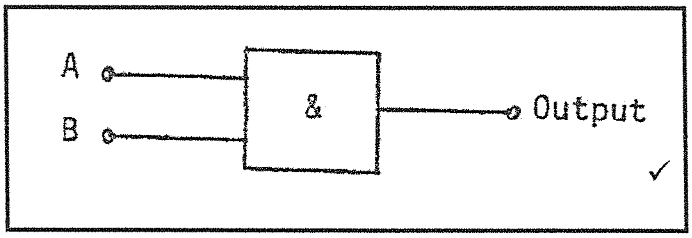
2	15
2	7
2	3
2	1

remainder 1 $0{,}25 \times 2 = 0$ ✓
remainder 1 $0{,}5 \times 2 = 1$
remainder 1 ✓
remainder 1

$15{,}25_{10} = 1111{,}01_2$ ⟶ Answer ✓ (2)

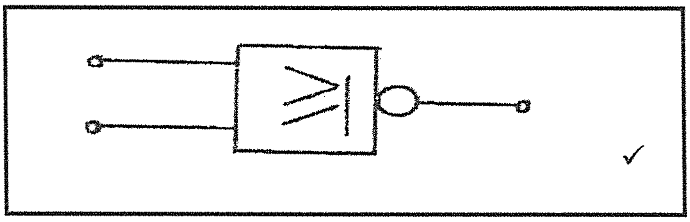
10.2
$$\begin{array}{r} 1111{,}01 \\ -\ \underline{1011{,}10} \\ \underline{0011{,}11_2} \end{array}$$
✓ ⟶ Answer✓ (2)

10.3 10.3.1



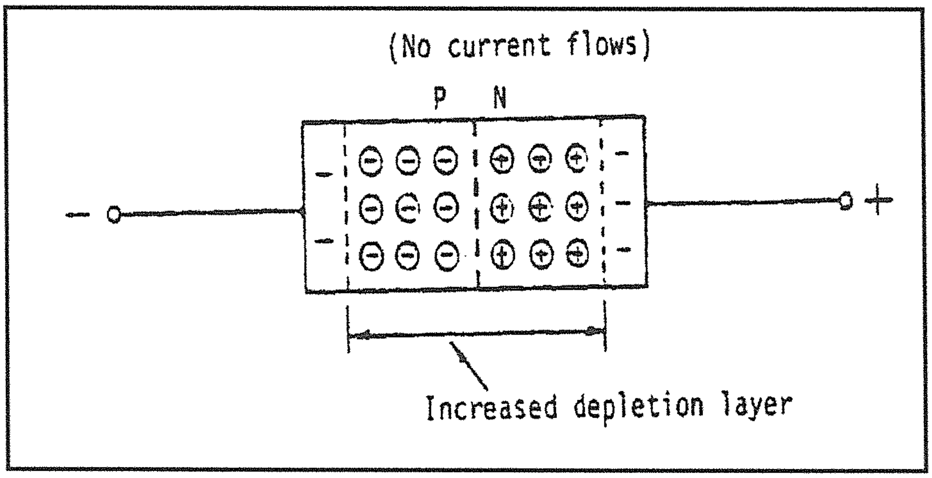
AND gate (1)

10.3.2



NOR gate (1)

10.4



✓✓for correct sketch

REVERSE BIAS (2)

[10]

TOTAL: 100