higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T460(E)(M26)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

ELECTRO-TECHNOLOGY N3

(11040343)

26 March 2014 (Y-Paper)
13:00–16:00

This question paper consists of 6 pages and 1 formula sheet of 3 pages.

ENGINEERING

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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. The correct information must be copied from the question paper and substituted for the correct symbol.
7. Sketches and diagrams must be done in pencil and must be neat, reasonably large and fully labelled.
8. Round off the answers to THREE decimal places after the comma.
9. Use the correct units for answers.
10. Write neatly and legibly to avoid being penalised for untidy and illegible work.

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QUESTION 1

Choose ONE correct option from those given in brackets. Write only the correct option next to the question number (1.1–1.5) in the ANSWER BOOK.

1.1 The voltage drop in the load characteristics of a separately excited generator is due to (residual magnetism, armature reaction, hysteresis).

1.2 When the ampere turns of the two windings oppose each other, the machine is said to be (cumulatively compounded, compound-connected, differentially compounded).

1.3 Pole pitch is the (metres, distance, displacement) between the centres of the poles.

1.4 (Wave-wound, Lap-wound, Armature winding) is for heavy-current machines.

1.5 It has its field windings connected in series with the armature (compound-connected, series-connected, self-excited-connected).

(5 x 2) **[10]**

QUESTION 2

2.1 Name TWO generators which are dependent on the excitation process in order to operate. Support the answer with TWO relevant sketches. (6)

2.2 State FOUR factors on which the magnitude of the induced EMF in a conductor depends. (4)

[10]

QUESTION 3

3.1 Draw neat, labelled schematic diagrams to explain how the direction of the following DC motors can be reversed.

3.1.1 Shunt motor

3.1.2 Compound motor

(2 x 2) (4)

3.2 What is the purpose of a starter resistor which is connected in series with the armature? (2)

3.3 A DC motor has a full-load current of 45 A and an armature resistance of 0,65 Ω. The supply voltage is 180 V.

Determine the back EMF in kV. (4)

[10]

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QUESTION 4

A brake test was performed on a DC motor and the following information was obtained:

The effective radius	= 300 mm
Drum speed	= 420 r/min
Effective load	= 0,425 kN.m
Supply voltage	= 220 V
Current absorbed by the motor	= 33 000 mA

Determine the following:

4.1 Input power of the motor in kW (3)

4.2 Output power of the motor in kW (4)

4.3 The motor efficiency (3)
[10]

QUESTION 5

5.1 A resistor, an inductor and a capacitor are *each in turn* connected to a 220 V, 60 Hz supply (that is not in parallel or series).

Calculate the current flow in each of the following:

5.1.1 40 mH inductor (2)

5.1.2 130 µF capacitor (2)

5.1.3 70 Ω resistor (1)

5.2 If the components in QUESTION 5.1 are connected in parallel, determine:

5.2.1 The total current flowing in the circuit (3)

5.2.2 The circuit impedance (2)
[10]

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QUESTION 6

An inductor is connected in series to an 80 W, 100 V, incandescent lamp so that it can operate from a 240 V, 60 Hz supply.

Determine the following:

6.1 The current flow in the circuit (2)

6.2 The resistance of the lamp (2)

6.3 The impedance of the circuit (2)

6.4 The inductance value of the circuit (4)
[10]

QUESTION 7

7.1 An alternating voltage of 230 V at a frequency of 90 Hz is applied to a circuit consisting of a resistor of 12 Ω, an inductor of 0,02 H and a capacitor of 70 µF connected in series.

Determine the resonance frequency of the circuit. (6)

7.2 Name TWO disadvantages of a low power factor. (2)

7.3 Name TWO components that can be used to correct a low power factor. (2)
[10]

QUESTION 8

8.1 A single-phase transformer has 350 windings on the primary coil which is connected to a 210 V supply. The secondary voltage and current is 42 V and 8 A respectively.

Calculate the following:

8.1.1 The number of windings on the secondary side

8.1.2 The primary current

8.1.3 The rating of the transformer in VA

(3 x 2) (6)

8.2 State the dual purpose of the oil-immersed transformer. (2)

8.3 Name TWO iron losses that occur in the transformer. (2)
[10]

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QUESTION 9

9.1 State ONE function of the following devices as applicable to electrical measuring instruments:

9.1.1 Deflecting torque

9.1.2 Controlling torque

9.1.3 Damping torque

(3 x 1) (3)

9.2 A moving-coil instrument gives a full-scale deflection if 25 mA flows through it. The resistance of the coil is 50 Ω.

Determine the following:

9.2.1 Voltage across the meter (1)

9.2.2 The resistance required to use the instrument as an ammeter for a 1 A current flow (3)

9.2.3 The series resistance required to use it as a voltmeter up to 12 V (3)
[10]

QUESTION 10

10.1 Name THREE configurations where a transistor is used as an amplifier. (3)

10.2 How many valence electrons does a P-type material have? (1)

10.3 State the main advantage of a cathode-ray oscilloscope as compared to other electrical measuring instruments. (2)

10.4 State ONE component which is used in the filtering circuit. (2)

10.5 Draw a truth table of an AND gate with TWO inputs logic. (2)
[10]

TOTAL: 100

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FORMULA SHEET

Any 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. $Efficiency/Rendement = \dfrac{VI}{VI + Ia^2 Ra + IsV + C} \times 100$

7. $Efficiency/Rendement = \dfrac{VI - (Ia^2 Ra + IsV + C) \times 100}{VI}$

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

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

10. $E = Blv$

11. $e = E_m Sin2\pi ft$

12. $i = I_m Sin2\pi ft$

13. $e_{ave/gem}$ *of/or* $i_{ave/gem} = 0{,}637$ *Em or/of Im*

14. $e_{rms/wgk}$ *or/fr* $i_{rms/wgk} = 0{,}707$ *Em or/of Im*

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

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

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

or/of $I_{rms/wgk} = \sqrt{\frac{i_1^2 + i_2^2 + i_3^2 + ... + i_n^2}{n}}$

17. $Form\ factor/Vormfaktor = \frac{E_{rms/wgk}}{E_{ave/gem}}\ or/of\ \frac{I_{rms/wgk}}{I_{ave/gem}}$

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

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

20. $X_L = 2\pi fL\ ;\ i = \frac{V}{X_L}$

21. $X_C = \frac{1}{2\pi fC}\ ;\ i = \frac{V}{X_C}$

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

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

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

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

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

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

28. $P = VI \text{ Cos } \theta$

29. $\text{Cos } \theta = \frac{R}{Z}\ ;\ Cos\ \theta = \frac{W\ or/of\ KW}{VA\ or/of\ KVA}$

30. $I_{active/aktief} = I\ cos\ \theta$

$I_{reactive/reaktief} = I \sin \theta$

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31. $P = VI \text{ Cos } \theta$

$Q = VI \text{ Sin } \theta$

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

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

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

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

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

37. $Cos\ \theta = \frac{I_R}{I}$

38. $V_L = V_P$; $I_L = \sqrt{3}\, Ip$

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

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. $KVA = \frac{\sqrt{3}\, V_L I_L}{1\,000}$

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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ELECTRO-TECHNOLOGY N3

26MARCH 2014

This marking guideline consists of 8 pages.

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QUESTION 1

1.1 Armature reaction

1.2 Differentially compounded

1.3 Distance

1.4 Lap-wound

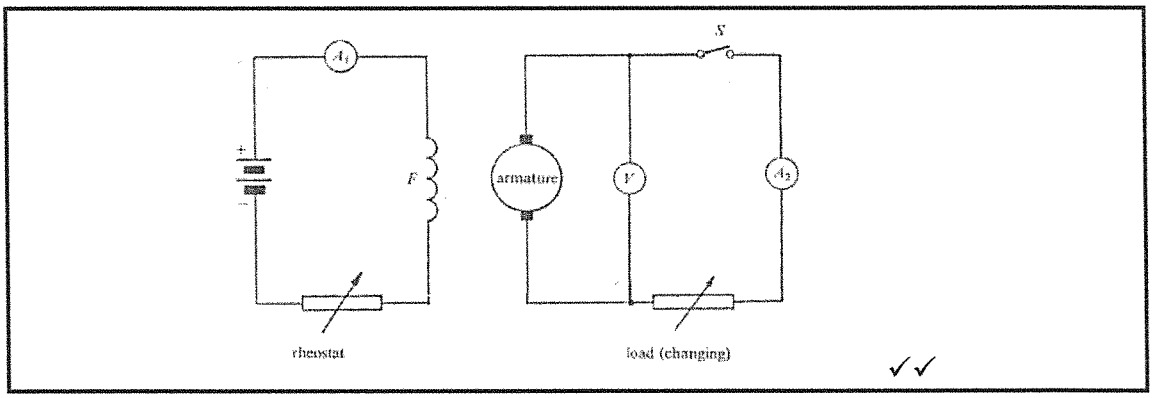
1.5 Series-connected

(5 x 2) **[10]**

QUESTION 2

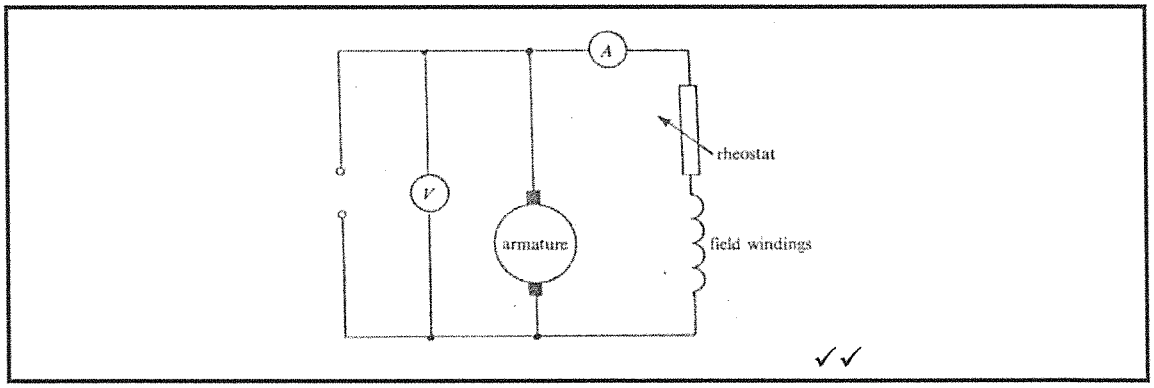
2.1
- Separately excited generator✓
- Self-excited generator✓

(2)



✓✓

SEPARATELY EXCITED GENERATOR (2)



✓✓

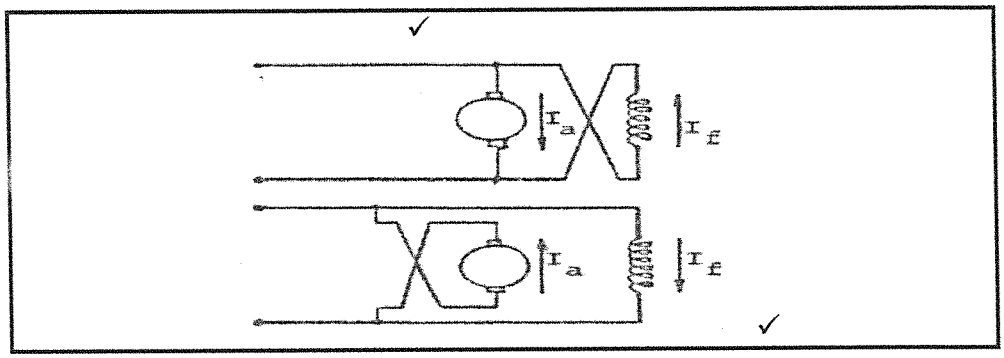
SELF-EXCITED GENERATOR (2)

2.2
- The number of active conductors connected in series.✓
- The number of pairs of poles used.✓
- The strength of the magnetic field or flux.✓
- The rate at which the magnetic flux is cut by moving conductors.✓ (4)

[10]

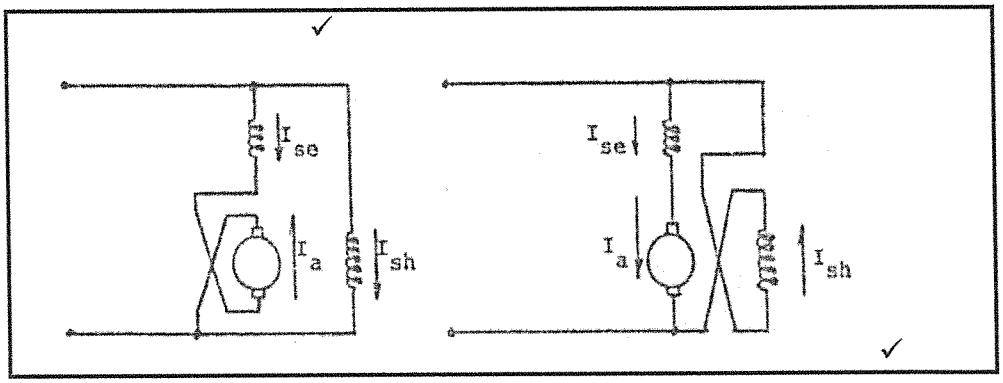
QUESTION 3

3.1 3.1.1



SHUNT MOTOR (2)

3.1.2



COMPOUND MOTOR (2)

3.2 It is to prevent/minimise/protect excessively high current from entering the starter. (2)

3.3 Given: $I_L = 45$ A
$R_a = 0{,}370$
$V = 180$V

$EMF = V - I_a R_a$ ✓
$= 180\text{ V} - (45\text{ A} \times 0{,}65\ \Omega)$
$= 180\text{ V} - 29{,}25\text{ V}$✓
$= 150{,}75\text{ V}$✓
$= 0{,}15\ 075$ kV **OR** 0,151 kV✓Answer (4)

[10]

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QUESTION 4

Given: R = 300 mm = 0,3 m; N = 420 r/min = 7 r/s ;
Effective load = 0,425 kN.m =425 N.m; V = 220 V; I = 33 A

4.1 Input power [P] = IV
= 33A x 220V✓
= 7260 W✓
= 7,26 kW ⟶ Answer✓ (3)

4.2 Output power [P] = $\frac{2x\Pi NWr}{60}$
= $\frac{2\times3,142\times7\times425\times0,3}{1}$ ✓✓
= 5608,47 W✓
= 5,609 kW ⟶ Answer✓ (4)

4.3 Efficiency = $\frac{Output}{Input}\times100\%$
= $\frac{5,609\ kW}{7,26\ kW}\times100\%$ ✓
= 0,7 726 x 100%✓
= 77,26 % ⟶ Answer✓ (3)
[10]

QUESTION 5

5.1 Given: V = 220/60 Hz

5.1.1 X_L = 2 x 3,142 x 60 x 40 x 10^{-3}
= 15,082✓

$I_L = \frac{220}{15,082}$

= 14,587 A ⟶ Answer✓ (2)

5.1.2 $X_C = \frac{1}{2\pi fC}$
= 1 /2 x 3,142 x 60 x 130 x 10^{-6} ✓
= 20,401 A

$= \frac{220}{20,401}$

I_C = 10,783 A ⟶ Answer✓ (2)

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5.1.3 $I_R = \frac{V_t}{R} = \frac{220}{70}$ ✓

$= 3,143A$ ⟶ Answer✓ (1)

5.2 5.2.1 $I_t = \sqrt{I_R^2 + (I_L - I_C)^2} = \sqrt{3,14^2 + (14,587 - 10,783)^2}$ ✓

$= \sqrt{24,330}$ ✓

$= 4,933$ A ⟶ Answer✓ (3)

5.2.2 $Z = \frac{V_t}{I_R} = \frac{220}{4,933}$ ✓

$= 44,597\ \Omega$ ⟶ Answer✓ (2)

[10]

QUESTION 6

Given: Incandescent lamp = 80 W/100 V. Voltage supply = 240 V/60 Hz

6.1 Power = VI

$I = \frac{80}{100}$ ✓

$= 0,8$ A ⟶ Answer✓ (2)

6.2 $V = IR$

$R = \frac{V}{I}$

$= \frac{100}{0,8}$ ✓

$= 125\ \Omega$ ⟶ Answer✓ (2)

6.3 $Z = \frac{V}{I}$

$= \frac{240\ V}{0,8\ A}$ ✓

$= 300\ \Omega$ ⟶ Answer✓ (2)

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6.4 The inductance value of the circuit (L) = ?

$$Z = \sqrt{R^2 + X_L^2}$$

$$X_L = \sqrt{300^2 - 125^2}\ \checkmark$$

$$= 272{,}717\ \Omega \longrightarrow \checkmark$$

$$X_L = 2\pi fL$$

$$L = \frac{X_L}{2 \times 3{,}142 \times 60}\ \checkmark$$

$$= \frac{272{,}717}{2 \times 3{,}142 \times 60}\ \checkmark$$

= 0,723 H or 723mH ⟶ Answer✓ (4)
[10]

QUESTION 7

7.1 Resonance frequency $[F_r] = \frac{1}{2\Pi\sqrt{LC}}$

$$= \frac{1}{2 \times 3.142 \times \sqrt{0{,}02 \times 70 \times 10^{-6}}}\ \checkmark\checkmark$$

$$= \frac{1}{0.007435}\ \checkmark\checkmark$$

= 134,493 Hz ⟶ Answer✓✓ (6)

7.2
- The power factor decreases when KVA increases.✓
- Losses in the transmission lines increase (I^2R).✓
- Larger cables are needed to carry a larger current.✓
- Switches, switchgear, transformer and instruments must be capable of operation.✓ (Any 2 x 1) (2)

7.3 Capacitors✓
Synchronous machines✓ (2)
[10]

QUESTION 8

8.1 Given: N_1 = 350 windings
Input voltage = 210 V

8.1.1

$$N_2 = \frac{N_1 \times V_2}{V_1}$$

$$= \frac{350 \times 42}{210}\ \checkmark$$

= 70 windings ⟶ Answer✓ (2)

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8.1.2 $\frac{V_1}{V_2} = \frac{I_2}{I_1}$

$I_1 = \frac{42 \times 8}{210}$ ✓

$= 1,6\ A \longrightarrow$ Answer✓ (2)

8.1.3 Rating = $V_1 \times I_1$

$= 210 \times 1,6$✓

$= 336\ VA \longrightarrow$ Answer✓ (2)

8.2
- It improves the insulation qualities of the insulation. ✓
- It conducts the heat away from windings and core to the cooling surface.✓ (2)

8.3
- Hysteresis loss✓
- Eddy-current loss✓ (2)

[10]

QUESTION 9

9.1 9.1.1 **Deflecting torque** – causes a deflection of the pointer from its zero position.✓

9.1.2 **Controlling torque** – opposes the deflecting torque and increases with the deflection.✓

9.1.3 **Damping torque** – prevents oscillation of the moving system – enables its final position quickly.✓

(3 x 1) (3)

9.2 Given:- $I_m = 25\ mA; R_m = 50\ \Omega;\ I_t = 1\ A$

9.2.1 $V_m = I_m \times R_m$

$= 0,025\ A \times 50\ \Omega$

$= 1,25\ V \longrightarrow$ Answer✓ (1)

9.2.2 Current through shunt resistor:

$I_s = I_t - I_m$

$= 1 - 0,025$

$= 0,975\ A \longrightarrow$ Answer✓ (1)

9.2.3 Resistance of shunt:

$R_s = \frac{V_s}{I_s}$

$= \frac{1,25\ V}{0,975\ A}$ ✓

$= 1,282\ \Omega \longrightarrow$ Answer✓ (2)

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9.2.4 As a voltmeter:

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

$$= \frac{12V}{0{,}025}$$

$$= 480\ \Omega \longrightarrow \checkmark$$

$$R_{series} = R_t - R_m$$

$$= (480 - 50)\ \Omega \checkmark$$

$$= 430\ \Omega \longrightarrow \text{Answer} \checkmark$$

(3)
[10]

QUESTION 10

10.1
- Common emitter
- Common collector
- Common base

(3)

10.2 3 valence electrons (1)

10.3 It has the ability to display types of wave form that must be studied (2)

10.4 Capacitor (2)

10.5 **AN AND GATE WITH TWO INPUTS**

A	B	Output
0	0	0
0	1	0
1	1	1
1	0	0

✓ ✓

(2)
[10]

TOTAL: 100

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