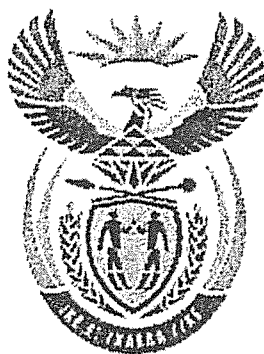


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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T480(E)(M25)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

ELECTRICAL TRADE THEORY N2

(11041872)

25 March 2013 (X-Paper)
09:00–12:00

This question paper consists of 8 pages and a 1-page formula sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
ELECTRICAL TRADE THEORY N2
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

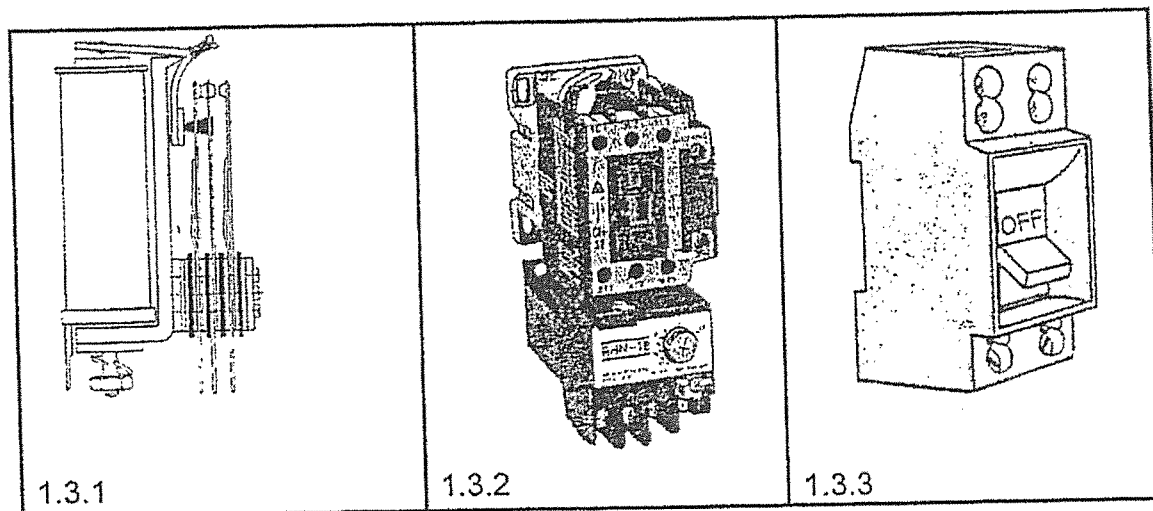
1. Answer ALL the questions.
 2. Read ALL the questions carefully.
 3. Number the answers according to the numbering system used in this question paper.
 4. Where applicable, answers must be in accordance with the SABS (SANS) Code of Practice SANS 10142-1:2003 for the Wiring of Premises.
 5. Sketches must be neat, labelled and large enough to show the required detail.
 6. Formulae used in Electrical Trade Theory N2 can be found at the end of the question paper.
 7. Answers must be given to two decimal places.
 8. Write neatly and legibly.
-

QUESTION 1: SWITCHGEAR, CONTACTORS AND RELAYS

1.1 State the purpose of a circuit breaker. (2)

1.2 Indicate where in an electrical circuit a disconnect switch must be connected. (1)

1.3 Identify the electrical components below.



(3)

1.4 An MCB of the domestic type operates faster when subjected to an overload current of 400% as compared to an overload current of 200%. Explain how this difference in operating speed is achieved in the following:

1.4.1 Thermal magnetic type MCB (3)

1.4.2 Magnetic type MCB (3)

[12]

QUESTION 2: CONDUCTORS AND CABLES

Choose an item from COLUMN B to complete each sentence in COLUMN A. Write only the letter (A–K) next to the question number (2.1–2.11) in the ANSWER BOOK.

COLUMN A	COLUMN B
2.1 Cables in the open (in free air) are ...	A expensive because trenches need to be dug.
2.2 Cables in ducts sometimes ...	B when the current leads or lags the voltage.
2.3 Buried-cable installations are ...	C the maximum difference between supply and outlet-point voltage.
2.4 An EMF of self-induction takes place ...	D the conductor and insulation factor.
2.5 Phase shift is ...	E volt-ampere.
2.6 True power is ...	F overheat due to poor heat dissipation.
2.7 Power factor is ...	G the ratio of true to apparent power.
2.8 Permissible volt drop is ...	H the maximum load current and the supply voltage.
2.9 Cable selection will be determined by ...	I the product of the voltage and in-phase component of the current.
2.10 The maximum short circuit fault current for a cable is directly proportional to ...	J when the current through the same coil causes flux to change around it.
2.11 The unit in which apparent power is measured is ...	K visible and often unsightly.

(11 × 1)

[11]

QUESTION 3: DC MOTORS AND STARTERS

3.1 Explain the purpose of the following components found in direct-current motors:

3.1.1 Field windings

3.1.2 Pole shoes

3.1.3 Brush gear

(3 × 1) (3)

3.2 Indicate how the field windings of the following DC motors are connected to the armature.

3.2.1 Shunt motor

3.2.2 Series motor

3.2.3 Short-shunt compound motor

(3 × 1) (3)

3.3 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.3.1–3.3.4) in the ANSWER BOOK.

3.3.1 The load of a DC series motor must be coupled to it by means of a clutch so that the motor can first pick up speed after it was started.

3.3.2 To reverse the direction of rotation of a DC series motor you need to reverse the connection to the supply.

3.3.3 A series motor has a very low starting torque.

3.3.4 Face-plate starters are used to increase the starting torque of a motor.

(4 × 1) (4)

3.4 Draw a neat, fully labelled graph that represents the load characteristics of a shunt connected DC motor.

(2)
[12]

QUESTION 4: AC MOTORS AND STARTERS

- 4.1 Explain the purpose of the following components found in alternating current motors:
- 4.1.1 The stator
 - 4.1.2 Slip rings
 - 4.1.3 Terminal box
- (3 × 1) (3)
- 4.2 With reference to induction motors explain the following:
- 4.2.1 How energy is transferred from the stator to the rotor.
 - 4.2.2 Why the resultant magnetic field rotates around the stator frame in three-phase induction motors.
 - 4.2.3 What determines the speed of rotation of the magnetic field.
- (3 × 1) (3)
- 4.3 Describe, with the aid of a neat labelled diagram, how an insulation resistance test to earth is carried out on the stator of a large induction motor. (5)
- 4.4 Draw a neat, fully labelled circuit diagram of a capacitor-start capacitor-run single-phase induction motor. Your sketch must clearly show the starting capacitor and the running capacitor. (4)
- [15]

QUESTION 5: EARTHING

- 5.1 Complete the following sentences/paragraph(s) by filling in the missing word(s). Write only the word(s) next to the question number (5.1.1–5.1.2) in the ANSWER BOOK.
- 5.1.1 The purpose of earthing is to guard every ... against the effect of static charges and ... (2)
 - 5.1.2 A floating earth point is where ... conducting parts are connected together, thus forming a common ... potential. (2)
- 5.2 Explain the following terms:
- 5.2.1 Protective conductor
 - 5.2.2 Bonding
- (2 × 2) (4)

- 5.3 Explain the function of systems earthing. (2)
- 5.4 State where and for what purpose earth mats are used. (2)
- [12]

QUESTION 6: PROTECTION

- 6.1 Complete the following sentences by writing only the missing word(s) next to the question number (6.1.1–6.1.4) in the ANSWER BOOK.
- 6.1.1 In a multiphase installation, the loads connected to each phase should, as far as is practical, be (1)
- 6.1.2 Varistors are non-linear voltage dependant (1)
- 6.1.3 The purpose of an earth leakage relay is to detect an ... and to automatically disconnect the installation or circuit from the (2)
- 6.1.4 Earth leakage protection must disconnect the supply when the imbalance between live and neutral is in the range of ... to (2)
- 6.2 Explain the following terms:
- 6.2.1 Surge arrestors
- 6.2.2 HRC fuses (2 × 2) (4)
- [10]

QUESTION 7: MEASURING INSTRUMENTS

- 7.1 State the function of the following measuring instruments:
- 7.1.1 Maximum demand meter
- 7.1.2 Frequency meter
- 7.1.3 Wattmeter (3 × 1) (3)
- 7.2 Show by means of a neat, fully labelled circuit diagram, how a kilowatt-hour meter is connected. (3)
- [6]

QUESTION 8: TRANSFORMERS

A three-phase transformer has a delta-connected primary and a star-connected secondary. The transformer is connected to an 11 000 V supply. The secondary phase voltage is 220 V.

Calculate the:

- | | | |
|-----|---|-------------|
| 8.1 | Primary phase voltage | (1) |
| 8.2 | Secondary line voltage | (2) |
| 8.3 | Primary phase current when the transformer draws a full load current of 120 A from the supply | (2) |
| 8.4 | Secondary phase current when it draws full load current | (4) |
| 8.5 | Full-load rating of the transformer in MVA | (3) |
| | | [12] |

QUESTION 9: ELECTRONICS

- | | | |
|-----|---|-------------|
| 9.1 | Explain how transistors amplify a varying input signal. | (4) |
| 9.2 | Draw a circuit diagram of the transistor circuit that operates like a switch. Indicate where the input, output and power supply is connected. | (3) |
| 9.3 | Name ONE application of a thyristor. | (1) |
| 9.4 | Explain the operating principle of a thyristor. | (2) |
| | | [10] |

TOTAL: 100

FORMULA SHEET

$$I_T = \frac{V}{Z}$$

$$I_{\text{ACTIVE/AKTIEWE}} = I_T \cos \theta$$

$$I_{\text{REACTIVE/REAKTIEWE}} = I_T \sin \theta$$

$$X_L = 2\pi fL$$

$$X_C = \frac{1}{2\pi fC}$$

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

$$\theta = \cos^{-1} \left[\frac{R}{Z} \right]$$

$$V_R = I_T R$$

$$V_{X_L} = I_T X_L$$

$$V_{X_C} = I_T X_C$$

$$V = \sqrt{V_R^2 + (V_{X_L} - V_{X_C})^2}$$

$$P = I^2 R$$

$$P = \sqrt{3} V_L I_L \cos \theta$$

$$S = VI$$

$$S = \sqrt{3} V_L I_L$$

DELTA

$$V_L = V_{\text{PHIF}}$$

$$I_L = \sqrt{3} I_{\text{PHIF}}$$

STAR/STER

$$V_L = \sqrt{3} V_{\text{PHIF}}$$

$$I_L = I_{\text{PHIF}}$$

CABLES/KABELS

$$I_{fc} = \frac{CIF \times A}{\sqrt{E}}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}$$

$$\omega = 2\pi f$$

$$N = \frac{f \cdot 60}{P}$$

$$s = \frac{n - n_r}{n}$$

$$I = \frac{V - E}{R_a}$$

Series motor/ Seriemoor

$$I_L = I_{se} = I_a$$

Long shunt / Langsjunt

$$I_{se} = I_a$$

$$I_L = I_a + I_{sh/sj}$$

Short shunt / Kortsjunt

$$I_L = I_{se}$$

$$I_L = I_a + I_{sh/sj}$$

Series Resistors / Serie weerstande

$$R_T = R_1 + R_2 + \dots R_n$$

Parallel Resistors / Paralelle weerstande

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots \frac{1}{R_n}$$



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MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

ELECTRICAL TRADE THEORY N2

25 MARCH 2014

This marking guideline consists of 8 pages.

INSTRUCTIONS AND INFORMATION:

NOTE: There is not only one answer or one method (approach) of answering the questions. This memorandum gives only one answer or one possible method (approach). Examiners must analyze the student's solution to determine if the question has been answered and must not adhere strictly to this memorandum contents only.

QUESTION 1: CONDUCTORS AND CABLES

- | | | | | |
|-----|---|-------|---------|-----|
| 1.1 | 1.1.1 | True | | |
| | 1.1.2 | True | | |
| | 1.1.3 | True | | |
| | 1.1.4 | False | | |
| | 1.1.5 | True | | |
| | | | (5 × 1) | (5) |
| 1.2 | $P = VI \cos \Phi$ ✓
$80\,000 = 220 \times I \times 0,82$ ✓
thus $I = 443,46 \text{ A}$ ✓ | | | (3) |
| 1.3 | The maximum load, the minimum power factor, the possible short-circuit fault current, exposed to the elements, the allowable voltage drop. ✓✓ (Any 2 × 1) | | | (2) |
| 1.4 | The maximum allowable volt drop between the point of supply and any output point, when the cable carries full load. ✓ (Statement must make sense.) | | | |

OR

It is the maximum voltage drop allowed in a circuit between the supply point and the socket outlet. It is regulated at 5% of the supply voltage. ✓

(1)
[11]**QUESTION 2: SWITCHGEAR, CONTACTORS AND RELAYS**

- | | | | | |
|-----|-------|--|---------|-----|
| 2.1 | 2.1.1 | Terminals are conducting parts where conductors can be attached. ✓ | | |
| | 2.1.2 | Insulated screw connectors are conducting parts where conductors can be attached with screws. They are surrounded with insulation and can be touched when the conductors are live. ✓ | | |
| | | | (2 × 1) | (2) |

2.2

COMPARISON	DISCONNECTORS	RELAYS	CONTACTORS
2.2.1 CONSTRUCTION	Switching device which is capable of opening contacts wide enough to isolate a circuit✓	Small electromagnetic switch with one or more sets of contacts✓	Large electromagnetic switch with one or more sets of contacts✓
2.2.2 USES	To isolate a circuit in order for repairs and maintenance to be carried out✓	Used in low-voltage circuits to control loads that draw a high current, e.g. head lamps of a car✓	Used in high-voltage circuits to control loads that draw a high current, e.g. large motors.✓

(3)

(3)

2.3

2.3.1

Operation on overload. When the current exceeds the design value, ✓ the bi-metal strip bends far enough to activate the trigger mechanism that operates the trip switch.✓

OR

Overload protection is achieved thermally.✓ The bimetal heats and bends to activate the trip switch. ✓

(2)

2.3.2

Operation on short circuit. A coil causes a magnetic field close to the iron armature ✓ which is immediately attracted without the aid of the bi-metal strip bending, and activates the trigger mechanism that operates the trip switch.✓

OR

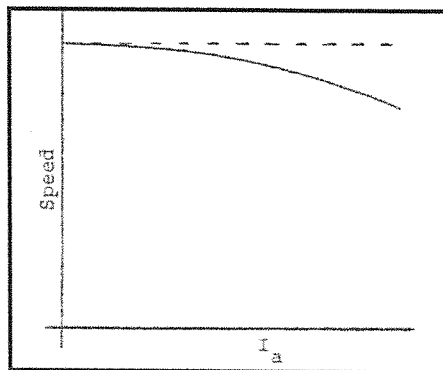
Short-circuit protection is achieved magnetically. ✓ The iron plate at the end of the bimetal strip becomes a strong magnet ✓ which attracts the armature to activate the trip switch.

(2)

[12]

QUESTION 3: DC MOTORS AND STARTERS

3.1

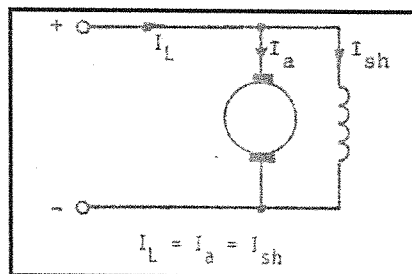


axes labelled ✓ correct curve ✓ (2 x 1) (2)

3.2 Relatively constant speed for a range of loads ✓ (1)

3.3 A low starting torque ✓ (1)

3.4



correctness ✓ current directions and supply voltage ✓ (2)

- 3.5 3.5.1
- At start-up all starting resistors are connected in series with the armature. ✓
 - As speed increases, the current decreases and the resistors can be removed one by one. ✓
 - Once running at full speed, the NVR keeps the switch arm in contact with the armature. (2)

3.5.2 If the supply voltage fails, the NVR cannot keep the switch arm in contact with the armature due to the electromagnetic field collapsing, ✓ and the spring returns the arm to the off position. ✓ (2)

3.5.3 On overload, the overload relay will deactivate the NVR, ✓ thus losing its magnetism and opening the circuit. ✓ (2)

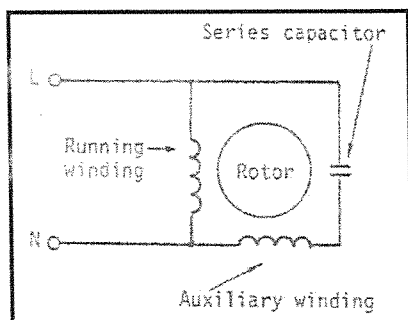
[12]

QUESTION 4: AC MOTORS AND STARTERS

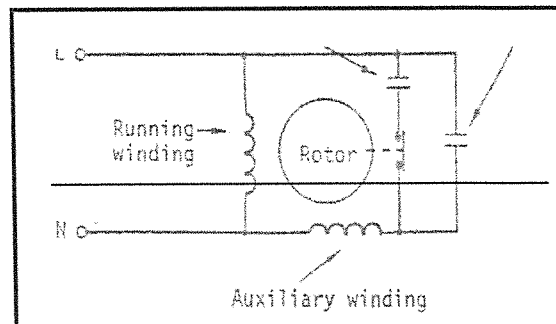
4.1 Wound rotor ✓ and squirrel cage ✓ (2)

4.2 4.2.2 ✓
4.2.4 ✓
4.2.1 ✓
4.2.3 ✓ (4)

4.3 4.3.1



OR



circuit correct ✓✓ any correct label ✓ (3)

4.3.2 Lawn mower ✓, washing machine ✓ (2)

4.4

- Autotransformer ✓
- Star-delta starting ✓
- Solid-state (thyristor) voltage controllers
- Rotor resistance starting ✓

(Any 3 x 1) (3)

4.5 Universal series motor ✓ (1)
[15]

QUESTION 5: EARTHING

5.1

- Earthing of all extraneous conductive parts ✓
- Double insulation of electrical equipment ✓
- Installation of earth leakage protection
- Bonding of all to a common earth to ensure electrical earth continuity
- Enclosing equipment that operates with high voltages (e.g. fencing)
- Electrically separating high voltage from the user (isolating transformer)

(Any 2 x 1) (2)

5.2 5.2.1 All non-current-carrying conductive parts of the portable appliance ✓

5.2.2 Double insulation as well as the earth leakage protection unit ✓
(2 x 1) (2)

- 5.3 The metallic frames and/or metallic enclosures must be bonded to earth.✓ (2)
- 5.4 5.4.1 An earth conductor runs above the power cables✓ and is connected to the steel frames (pylons) ✓ and a common earth.
(Any 2 × 1) (2)
- 5.4.2
- Tall metal earth poles to re-direct the lightning strike away from equipment✓
 - Earth rods and mats together with a bare wire grid laid in the ground
 - Overhead earth wires stretching across the substation✓
(Any 2 × 1) (2)
- 5.4.3
- The metal frame✓
 - The star point of the windings✓ (2)
- [12]

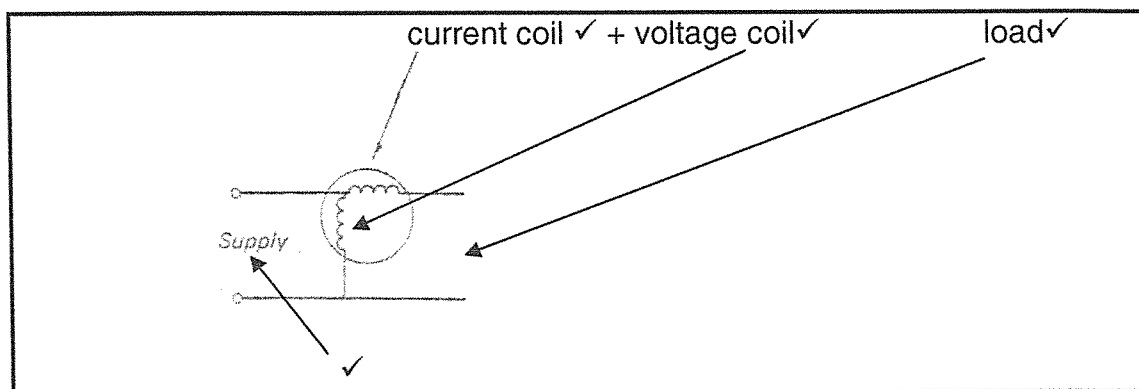
QUESTION 6: PROTECTION

- 6.1 As soon as the difference ✓ between the current in the live conductor and the neutral conductor is large enough (less than 30 mA)✓, the imbalance will trip the contacts✓ and disconnect live and neutral feeding the circuit.✓ (4)
- 6.2 If the current drawn by the load in all the phases is not similar in magnitude✓, the protection will be activated. ✓ (2)
- 6.3 This type of protection can be installed to protect 3-phase motors. ✓ (1)
- 6.4 A voltage surge far above the rated voltage ✓ will activate the protection. ✓ (2)
- 6.5 Surge arrestors that discharge high-voltage currents down to earth can be found in consumers' distribution boards. ✓ (1)
- [10]

QUESTION 7: MEASURING INSTRUMENTS

- 7.1 7.1.1 A frequency meter is connected to a single-phase system across the live and neutral conductors (in parallel). ✓
- 7.1.2 A voltmeter is also connected in this manner.✓
(2 × 1) (2)

7.2

(4)
[6]**QUESTION 8: TRANSFORMERS**

8.1 8.1.1 The turns ratio

$$N_{\text{prim}}/N_{\text{sec}} = V_{\text{prim}}/V_{\text{sec}} \checkmark$$

$$= 11\,000/220 \checkmark$$

$$= 50 : 1 \checkmark$$

(3)

8.1.2 $S = V_{\text{prim}} \times I_{\text{prim}} \text{ or } I_{\text{prim}} = S \div V_{\text{prim}} \checkmark$

$$= 100\,000 / 11\,000 \checkmark$$

$$= 9,09 \text{ A} \checkmark$$

(3)

8.1.3 $I_{\text{sec}} = S \div V_{\text{prim}} \checkmark$ OR $I_{\text{sec}} = \text{T.R.} \times I_{\text{prim}}$

$$= 100\,000/220 \checkmark$$

$$= 50 \times 9,09$$

$$= 454,54 \text{ A} \checkmark$$

$$= 454,54 \text{ A}$$

(3)

8.2 The voltage across each phase in the primary.

$$V_f = V_L \div \sqrt{3} \checkmark$$

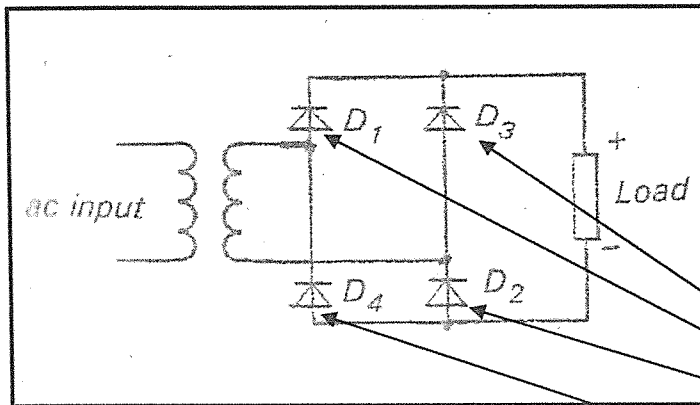
$$= 380 \div \sqrt{3} \checkmark$$

$$= 219,39 \text{ V} \checkmark$$

(3)
[12]

QUESTION 9: ELECTRONICS

9.1

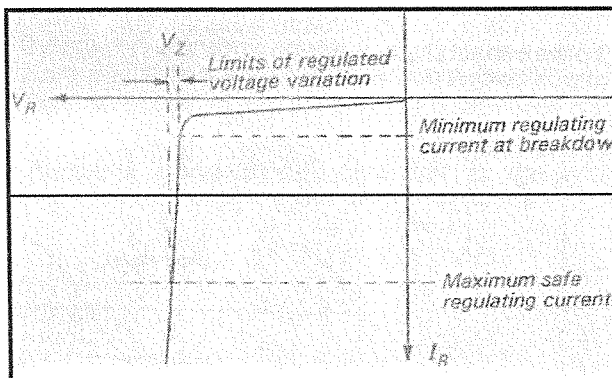


Symbol and correct connection needed to be awarded a mark for each diode

✓
✓
✓
✓

(4)

9.2

**OR**

Zener diodes are used for voltage regulation✓
 Zener diodes are used in reverse biased mode✓
 Zener diodes need series resistors for protection✓

(3)

9.3

- A thyristor requires a trigger pulse to start conducting and a thyristor only conducts current in one direction✓
- With a control circuit a thyristor can be triggered at accurate values to start conducting✓
- By controlling the firing angle at which a thyristor is triggered, load control can be achieved✓

(3)

[10]**TOTAL: 100**