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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

ELECTRICAL TRADE THEORY N3

(11041263)

12 November 2013 (X-Paper)
09:00–12:00

This question paper consists of 7 pages and 1 formula sheet.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTRICAL TRADE THEORY 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. 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. Answers must be given to TWO decimal places.
7. Write neatly and legibly.

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QUESTION 1: DOMESTIC APPLIANCES

1.1 A two element stove plate can provide three heat levels. Explain without making a sketch, how the elements must be connected to achieve this. (3)

1.2 Explain how an oven switch keeps the oven temperature constant. (6)

1.3 Name ONE electrical protection device that is used to protect against overload. (1)
[10]

QUESTION 2: PROTECTION

2.1 State THREE dangerous situations in a domestic installation that can lead to people being shocked by electricity. (3)

2.2 The following conductors/leads connect two components of the earthing system together so that earthing is achieved from the household appliance down to earth.

Name the TWO components that are connected by the following:

2.2.1 The earthing lead (2)

2.2.2 The earth-continuity conductor (2)

2.3 State why the earthing pin of a three-pin plug is longer than the other two pins. (1)

2.4 Give the purpose of earth-leakage protection. (2)
[10]

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QUESTION 3: ILLUMINATION

3.1 Use the fluorescent lamp circuit in FIGURE 3.1 below to answer the question.

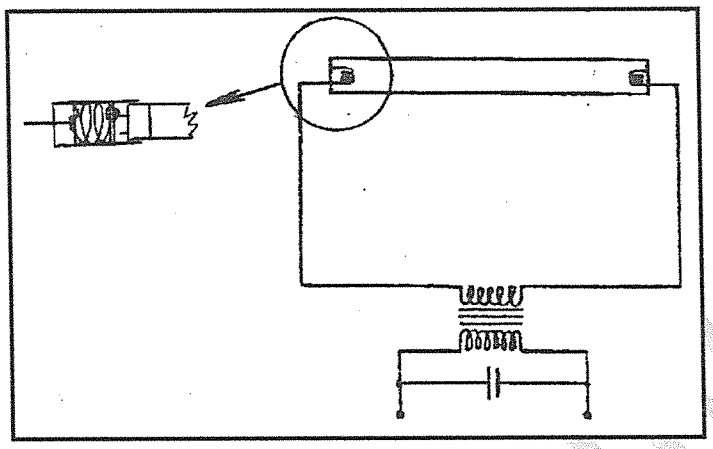

FIGURE 1: FLUORESCENT LAMP CIRCUIT

3.1.1 Identify the circuit in FIGURE 1. (1)

3.1.2 List TWO facts about the connection that is taking place in the encircled area. (2)

3.1.3 Describe how the lamp starts up. (2)

3.1.4 A workshop with single-phase supply uses two of these lamp circuits.

Illustrate with a circuit diagram how TWO lamps such as the one in FIGURE 1 should be connected to reduce the stroboscopic effect. (3)

3.2 Name the lamp type that has the lowest luminous efficiency. (1)

3.3 Name the lamp type that has the highest luminous efficiency. (1)
[10]

QUESTION 4: ALTERNATING CURRENT THEORY

4.1 The following data is given about a purely sinusoidal wave:

- The wave peaks are at +311,13 V and at -311,13 V.
- It completes a full cycle in 16,67 milliseconds.

Determine the wave's:

4.1.1 RMS value (1)

4.1.2 Average value (1)

4.1.3 Frequency (1)

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4.1.4 Mathematical equation (2)

4.1.5 Instantaneous value at 0,15 seconds (1)

4.1.6 Time it will take to reach 300 V for the first time (3)

4.2 State how a wave with a form factor of 1,3 and a crest factor of 1,6 will differ from a pure sine wave. (1)
[10]

QUESTION 5: SERIES RLC CIRCUITS

5.1 A series RLC circuit is supplied with a 50 Hz, 220 V supply. The resistor is 2 kΩ, the inductance is 628 Ω and the capacitance is 318 Ω.

Calculate the following:

5.1.1 Total impedance of the circuit

5.1.2 Current in the circuit

5.1.3 Voltage across the resistor

5.1.4 Voltage across the inductor

5.1.5 Voltage across the capacitor

5.1.6 The power factor

(6 × 1) (6)

5.2 Draw the phasor diagram of the circuit in QUESTION 5.1 above. (4)
[10]

QUESTION 6: THREE-PHASE AC SYSTEMS

6.1 Identify and explain what is wrong with the following statements:

6.1.1 Three-phase is better than single-phase because you get three times the power. (2)

6.1.2 Three phase power can only be supplied in industrial areas because houses use single-phase power. (2)

6.2 A three-phase delta connected motor is 90% efficient when running at full load. The motor's specifications are 380 V and 50 kW at a power factor of 0,866.

Calculate the following:

6.2.1 The power drawn from the supply if the motor is to deliver 50 kW (2)

6.2.2 The current through each motor winding when the motor delivers 50 kW (4)
[10]

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QUESTION 7: TRANSFORMERS

7.1 Explain the principle of operation of a transformer. (2)

7.2 Prove that the current ratio of a transformer will be the same as the inverse of its voltage ratio providing that the transformer is 100% efficient. (Assume the primary and secondary power factors to be equal.) (2)

7.3 A 6,35 kV/220 V single-phase transformer is rated at 100 kVA.

Neglecting losses, calculate the following:

7.3.1 Number of primary turns if there are 20 secondary turns (2)

7.3.2 Maximum permissible primary current (2)

7.3.3 Maximum power output if the power factor is 0,8 (2)
[10]

QUESTION 8: DIRECT-CURRENT MACHINES

8.1 Choose an item from COLUMN B that matches a description in COLUMN A. Write only the letter (A–H) next to the question number (8.1.1–8.1.6) in the ANSWER BOOK.

COLUMN A		COLUMN B	
8.1.1	The field coil of this DC motor has a large number of turns	A	separately excited
8.1.2	The field coil of this DC motor has few turns	B	compound
8.1.3	Two voltage sources supply this DC motor	C	differential-compound
8.1.4	This DC motor has two field coils on each pole shoe that produce a weaker magnetic field because the currents flow in opposite directions	D	series
8.1.5	This DC motor has two field coils on each pole shoe, but you are unsure of how they are connected	E	shunt
8.1.6	This DC motor has two field coils on each pole shoe and one of them is connected directly across the armature	F	cumulatively compounded
		G	long shunt
		H	short-shunt

(6 × 1) (6)

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8.2 Explain how the speed of a DC motor can be:

8.2.1 Increased (2)

8.2.2 Reduced (2)
[10]

QUESTION 9: AC MACHINES

9.1 Motor starters are designed to limit the starting current of a motor to a safe value. A three-phase wound-rotor motor-starter has starting resistors connected to the motor windings during starting.

Briefly describe, with or without the aid of simple diagrams, how this current limiting is achieved in the above-mentioned circuit. (4)

9.2 Answer the following questions on split-phase induction motors:

9.2.1 Draw a sketch to show how the running and starting coils are placed around the stator. (3)

9.2.2 Name the coil placed closer to the rotor. (1)

9.2.3 State how the phase angle between the starting and running winding currents can be increased. (1)

9.2.4 Name the component that is built into the motor to disconnect the starting winding once the motor has speeded up. (1)
[10]

QUESTION 10: MEASURING INSTRUMENTS AND ELECTRONICS

10.1 By using six diodes for rectification, a 3-phase AC supply can be used to give a DC output.

Sketch the circuit that will accomplish this. (4)

10.2 Make a sketch to show how a wattmeter is connected to a single phase load in order to measure energy use. (2)

10.3 Make a sketch to show how a voltmeter is connected to a high voltage AC supply in order to measure supply voltage safely. (2)

10.4 State the particles that atoms are made of as well as where they can be found within the atom. (2)
[10]

TOTAL: 100

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ELECTRICAL TRADE THEORY N3

FORMULA SHEET

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

$$I_{ACTIVE} = I_T \text{ Cos } \phi$$

$$I_{REACTIVE} = I_T \text{ Sin } \phi$$

$$X_L = 2\pi f L$$

$$X_C = \frac{1}{2\pi f C}$$

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

$$\phi = \text{Cos}^{-1}\left(\frac{R}{Z}\right)$$

$$V_R = I_T R$$

$$V_{XL} = I_T X_L$$

$$V_{XC} = I_T X_C$$

$$V = \sqrt{V_R^{\ 2} + (V_{XL} - V_{XC})^2}$$

$$P = I^2 R$$

$$S = VI$$

3-phase

$$P = \sqrt{3}\ V_L I_L \text{ Cos } \phi$$

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

DELTA

$$V_L = V_{PH\,/\,F}$$

$$I_L = \sqrt{3} I_{PH\,/\,F}$$

STAR

$$V_L = \sqrt{3} V_{PH\,/\,F}$$

$$I_L = I_{PH\,/\,F}$$

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

$$\omega = 2\pi f$$

$$N = \frac{f.60}{p}$$

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

The next five formulae are true for voltage.

$$i = I_m \text{ Sin } (\omega t)$$

$$I_{rms} = 0{,}707\ I_m$$

$$I_{ave} = 0{,}637\ I_m$$

$$I_{rms} = \sqrt{\frac{i_1^{\ 2} + i_2^{\ 2} + \ldots i_n^{\ 2}}{n}}$$

$$I_{ave} = \frac{i_1 + i_2 + .. i_n}{n}$$

$$\text{Form factor} = \frac{\text{RMS value}}{\text{AVE value}}$$

$$\text{Crest factor} = \frac{\text{MAX value}}{\text{RMS value}}$$

SERIES

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

PARALLEL

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

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MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER EXAMINATION

ELECTRICAL TRADE THEORY N3

12 NOVEMBER 2013

This marking guideline consists of 7 pages.

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QUESTION 1: DOMESTIC APPLIANCES

1.1 The two elements of a stove plate can either be connected in series✓ for low heat, parallel for high heat✓or by using only one of the elements✓for medium heat. (3)

1.2 When the temperature of an oven switch is set to the desired value, both top and bottom elements are switched on.✓ The liquid in the capillary tube expands with heat causing the bellows✓ to operate the micro-switches.✓ A few degrees before the required temperature the top element switches off ✓ A few degrees after the required temperature the bottom element switches off.✓ Now the bottom element keeps the oven temperature constant.✓
(Any 6 × 1) (6)

1.3 Fuse✓ or MCB. (1)
[10]

QUESTION 2: PROTECTION

2.1 Frayed insulation,✓ no earth-leakage protection,✓ electrical appliances soaked in water,✓ covers of switch- and plug-boxes missing
(Any 3 × 1) (Any other relevant answer) (3)

2.2 2.2.1 The earthing lead connects the earth bar in the DB✓ to the earth electrode.✓ (2)

2.2.2 The earth-continuity conductor connects the earthing terminal of an appliance or point of supply✓ to the earthing bar in the DB.✓ (2)

2.3 The earthing pin of a three-pin plug is longer than the other two pins so that it makes contact before and breaks contact after the live and neutral pins, for safety purposes.✓ (1)

2.4 The purpose of earth-leakage protection is to protect people and animals against electric shock✓ by disconnecting the supply when an earth fault occurs.✓ (2)
[10]

QUESTION 3: ILLUMINATION

3.1 3.1.1 Single instant-start lamp (no preheating).✓ (1)

3.1.2 Spring loaded connection.✓Only one pin needs to make contact.✓ (2)

3.1.3 Enough voltage across the lamp✓ to heat the tube for starting.✓ (2)

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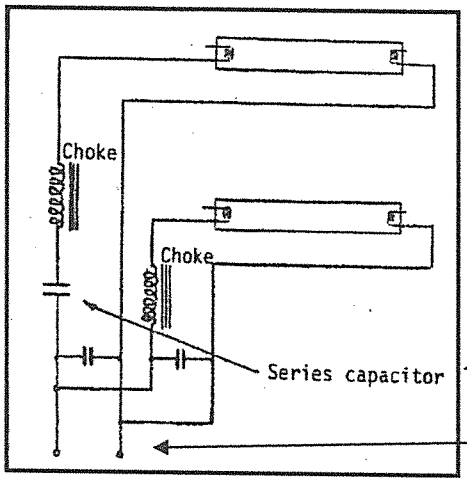
3.1.4



Correct wiring✓

✓

Single-phase supply✓ (3)

3.2 Incandescent/halogen lamps.✓ (1)

3.3 Sodium-vapour lamps or LED lamps.✓ (1)
[10]

QUESTION 4: ALTERNATING CURRENT THEORY

4.1 Given V_m = +311,13 V and -311,13 V. T = 0,01667 seconds.

4.1.1 RMS value = V_{rms} = 0,707. V_m = 0,707 x 311,13 = 220 V✓ (1)

4.1.2 average value = V_{ave} = 0,637. V_m = 0,637 x 311,13 = 198,19 V✓ (1)

4.1.3 frequency = 1/T = 1/0,01667 = 60 Hz (1)

4.1.4 mathematical equation v = V_m sin (2.π.f.t)✓ = 311,13 sin (376,99t)✓ (2)

4.1.5 instantaneous value v = 311,13 sin (376,99x0,15) = –0,05 V✓ (1)

4.1.6 Given e = 300 V

$300 = 311{,}13 \sin(376{,}99\,t)$

$376{,}99\,t = \sin^{-1}(300 \div 311{,}13)$✓

$= \sin^{-1}(0{,}96)$✓ = 1,3 rads

thus t = 1,3÷376,99 = 3,46 ✓milliseconds✓ (3)

4.2 It will be more peaked than a pure sine wave.✓The shape of the wave in question is not a pure sine wave. (1)
[10]

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QUESTION 5: SERIES RLC CIRCUITS

5.1 Given: f = 50 Hz , V_T = 220 V, R = 2 kΩ, X_L = 628 Ω and X_c = 318 Ω.

5.1.1 Total impedance of the circuit $Z^2 = R^2 + (X_L - X_c)^2$
$= 2000^2 + (628 - 318)^2$
Thus Z = 2023,88 Ω✓

5.1.2 Current in the circuit I = V/Z = 220/2023,88 = 108,7 mA✓

5.1.3 Voltage across the resistor = I.R = 0,1087 x 2000 = 217,4 V✓

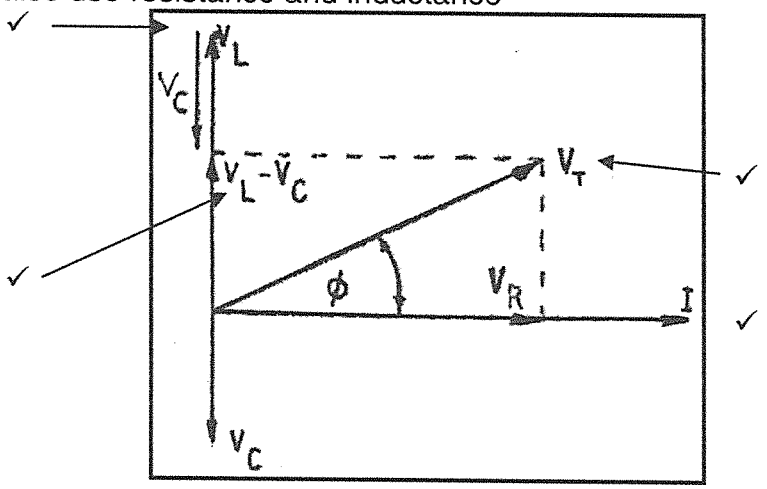
5.1.4 Voltage across the inductor = $I.X_L$ = 0,1087 x 628 = 68,26 V✓

5.1.5 Voltage across the capacitor = $I.X_c$ = 0,1087 x 318 = 34,57 V✓

5.1.6 The power factor = cos φ = R/Z = 2000/2023,88 = 0,99✓

(6 × 1) (6)

5.2 Can also use resistance and inductance



(4)
[10]

QUESTION 6: THREE-PHASE AC SYSTEMS

6.1 6.1.1 The power in a 3-phase system is $\sqrt{3}$ higher ✓than in a single phase system for the same frame sized motor / generator size / transformer✓ (2)

6.1.2 Single phase power are distributed in both industrial and residential areas ✓ as both line and phase values can be utilised in STAR connected / 4 wire systems✓. (2)

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6.2 Given: delta connected motor, η = 90% V = 380 V and P = 50 kW at a power factor of 0,866.

6.2.1 η = 90% = 0,9 = P_{out}/P_{in}✓ thus P_{in} = 50 000/0,9 = 55,56 kW✓ when only considering the efficiency and not the power factor of the motor as well (2)

6.2.2

$$P_{out} = \sqrt{3} \times V_L \times I_L \times Cos\theta \checkmark$$
$$50\,kW = \sqrt{3} \times 380 \times I_L \times 0.866$$
$$I_L = \frac{P_{IN}}{\sqrt{3} \times V_L \times Cos\theta} \checkmark$$
$$I_L = \frac{50000}{\sqrt{3} \times 380 \times 0.866} \checkmark$$
$$I_L = 87.721A \checkmark$$

(4)
[10]

QUESTION 7: TRANSFORMERS

7.1 Alternating current in the primary coil sets up a changing magnetic field in the iron core✓ which induces an emf in the secondary.✓
Alternatively: A transformer operates on the principal of mutual ✓induction✓ (2)

7.2 Voltage ratio = V_p/V_s
$P_{in}/P_{out} = V_p \times I_p\cos\varphi/V_s \times I_s\cos\varphi$✓
assume the primary and secondary power factors to be equal
the transformer is 100% efficient, so P_{in}/P_{out} = 1✓
thus (2)

$$1 = V_p \times I_p/V_s \times I_s$$
$$V_s \times I_s = V_p \times I_p$$
$$I_s/I_p = V_p/V_s$$

Current ratio of a transformer = $I_p/I_s = 1/(V_p/V_s)$

7.3 Given V_p = 6,35 kV , V_s = 220 V and S = 100 kVA. Neglecting losses:

7.3.1 N_s = 20
$N_p/N_s = V_p/V_s$
N_p = 20 x (6 350/220) ✓= 577 turns✓ (2)

7.3.2 S = $V_p.I_p$ thus 100 000 = 6 350 x I_p ✓
I_p = 15,75 A✓ (2)

7.3.4 P = V.I.cosφ = S x p.f = 100 kW x 0,8 = 80✓ kW✓ (2)
[10]

QUESTION 8: DC MACHINES

8.1 8.1.1 E✓

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8.1.2 D✓

8.1.3 A✓

8.1.4 C✓

8.1.5 B✓

8.1.6 H✓

(6 × 1) (6)

8.2 8.2.1 Increase the speed by reducing✓ the flux per pole or the field current. ✓ (2)

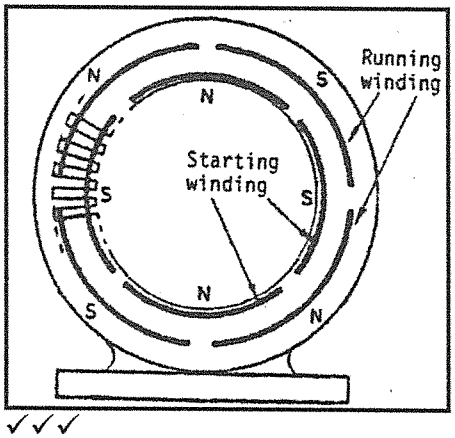
8.2.2 Decrease the speed by reducing✓ the voltage across the armature. ✓ (2)
[10]

QUESTION 9: AC MACHINES

9.1 A three-phase wound-rotor motor-starter has starting resistors connected to brushes, which run on slip rings connected to the rotor windings.✓ The starting resistors reduce current during the start-up sequence.
During start-up, the whole starting resistor is connected to the rotor coil.✓
When the motor has speeded up, the supply current is small enough to switch some resistance out of the circuit.✓ The switch-over should still draw enough current for the starting torque.✓ As the motor speeds up the external resistance is reduced by hand until the rotor is directly connected to the supply and the motor runs at full speed and torque.

(Any FOUR) (4)

9.2 9.2.1



✓✓✓

Sketch must show starting winding a few degrees away from running winding. (3)

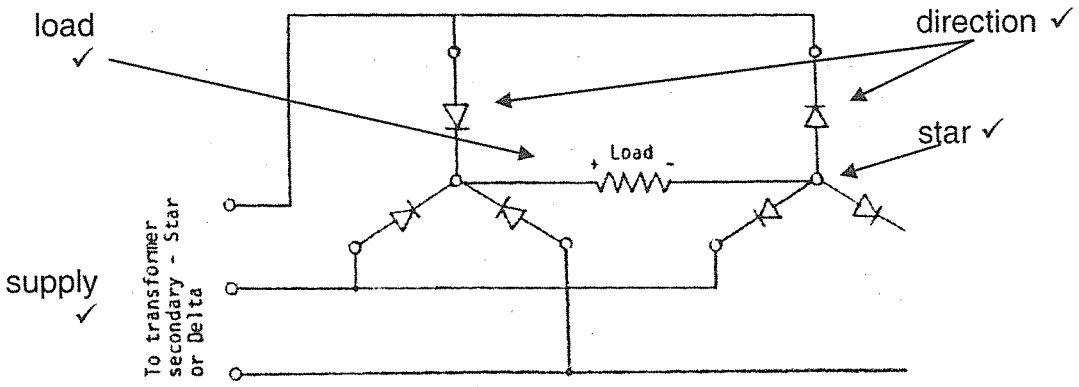
9.2.2 Starting windings are placed closer to the rotor.✓ (1)

9.2.3 By inserting a capacitor in series with the starting winding.✓ (1)

9.2.4 A centrifugal switch.✓ (1)
[10]

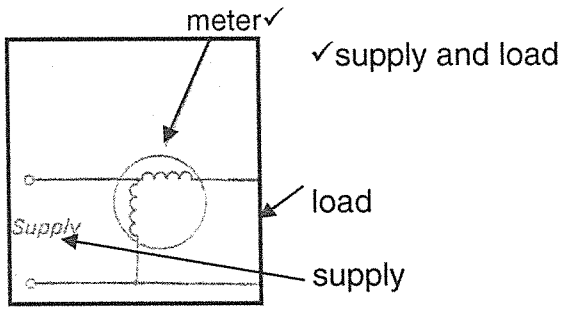
QUESTION 10: MEASURING INSTRUMENTS AND ELECTRONICS

10.1



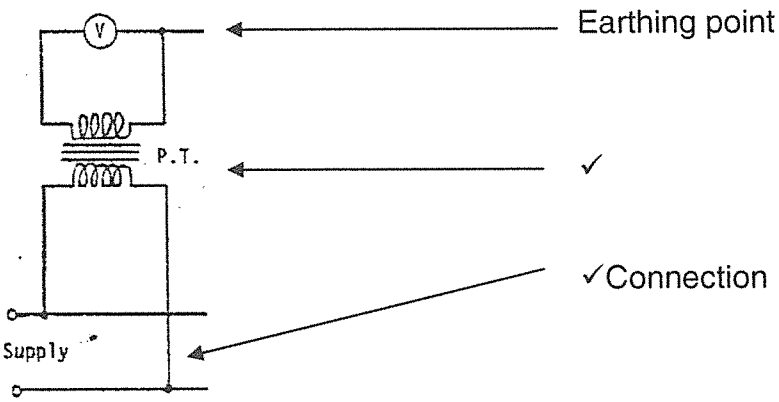
(4)

10.2



(2)

10.3



(2)

10.4 Atoms are made of protons, neutrons and electrons.✓ The protons and neutrons can be found close to the centre of the atom (core) and the electrons outside the core.✓ (2)
[10]

TOTAL: 100

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