basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

# NATIONAL SENIOR CERTIFICATE

## GRADE 12

## ELECTRICAL TECHNOLOGY

## NOVEMBER 2010

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 11 pages and 1 formula sheet.**

## INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.

2. Sketches and diagrams must be large, neat and fully labelled.

3. ALL calculations must be shown correctly rounded off to TWO decimal places.

4. Number the answers correctly according to the numbering system used in this question paper.

5. Non-programmable calculators may be used.

## QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 Coal is the primary source of energy in South Africa. State FOUR examples of renewable energy sources. (4)

1.2 List FOUR competencies that are required of a successful entrepreneur. (4)

1.3 Why is it important to wear surgical gloves when treating an open wound? Give TWO reasons. (2)
**[10]**

## QUESTION 2: TECHNOLOGICAL PROCESS

Mr Gumede and Mr Vermeulen are neighbours in adjacent flats. Each flat has a gate entrance. The two individual gates lead to the main gate outside. These two gates are currently non-self-locking. Recently they have been experiencing burglaries and criminals have gained access to their flats.

2.1 Identify the problem of the two neighbours in the above scenario in an electrical context. (2)

2.2 Write down the solution to the problem in QUESTION 2.1 in an electrical context. Name at least TWO additional devices that can be linked to the solution above. (5)

2.3 Draw a block diagram of the solution indicating the action that relates to the following:

- Input
- Process
- Output (3)

**[10]**

## QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Explain the negative impact HIV/Aids has on productivity in the electrical workshop. (3)

3.2 Name ONE safety precaution that must be taken when using a portable drilling machine. (1)

3.3 Explain why the precaution in QUESTION 3.2 must be taken. (2)

3.4 State ONE unsafe condition that may lead to an accident in an electrical technology workshop. (1)

3.5 Whose responsibility is it to maintain safety in an electrical technology workshop? Motivate the answer. (3)
**[10]**

## QUESTION 4: THREE-PHASE AC GENERATION

4.1 State the function of a kilowatt-hour meter. (1)

4.2 State ONE advantage that a three-phase system has over that of a single-phase system. (1)

4.3 How many degrees apart are the three coils placed in three-phase generation? (1)

4.4 Draw a voltage phasor diagram that represents a three-phase supply. (4)

4.5 A three-phase balanced load is connected in star across a 415 V/ 50 Hz supply. At full load the load consumes 6 kW when the power factor of the load is 0,85 lagging. Calculate the line current drawn by the load.

Given: $V_L$ = 415 V
f = 50 Hz
P = 6 kW
Cos θ = 0,85 (3)
**[10]**

## QUESTION 5: RLC CIRCUITS

5.1 Complete the following sentences by writing down the missing word:

5.1.1 The current in a capacitor ... the voltage across a capacitor by 90°. (1)

5.1.2 An inductor is made up of insulated copper wire which is wound around a core to form a ... (1)

5.2 If the frequency of the supply voltage connected across an RLC circuit is increased, state how it will affect the following:

5.2.1 The capacitive reactance of the capacitor (1)

5.2.2 The inductive reactance of the coil (1)

5.3 An AC circuit comprises a 12 Ω resistor, a 150 mH inductor and a 47 µF capacitor all connected in series across a 240 V/50 Hz AC supply. Answer the following questions:

Given: R = 12 Ω
L = 150 mH
C = 47 µF
F = 50 Hz

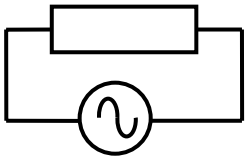
5.3.1 Draw a fully labelled circuit diagram. (4)

5.3.2 Calculate the frequency at which the circuit will resonate. (3)

5.3.3 Determine, by calculation, the inductive reactance of the circuit. (3)

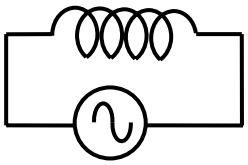
5.4 Study the electrical circuits in FIGURE 5.1 below. Draw, on the same set of axes, for each circuit, the graphical representation of the current and the voltage for that component.

5.4.1



(2)

5.4.2

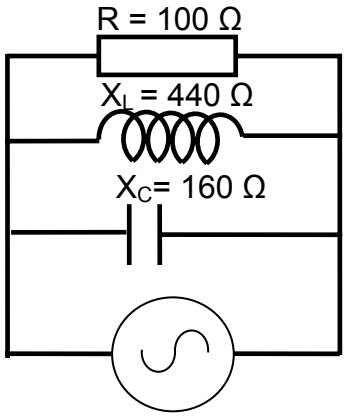


(2)

**FIGURE 5.1: AC CIRCUITS**

5.5 A 100 Ω resistor, an inductor with an inductive reactance of 440 Ω and a capacitor with a capacitive reactance of 160 Ω are all connected in parallel across a 240 V/50 Hz supply.

Given: R = 100 Ω
$X_L$ = 440 Ω
$X_C$ = 160 Ω
V = 240 V
F = 50 Hz




Calculate the following:

5.5.1 The current through the resistor (3)

5.5.2 The current flowing through the inductor (3)

5.5.3 The current change in the capacitor (3)

5.5.4 The total current flowing through the circuit (3)
**[30]**

## QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 The diagram in FIGURE 6.1 below shows the characteristic curve of an SCR.

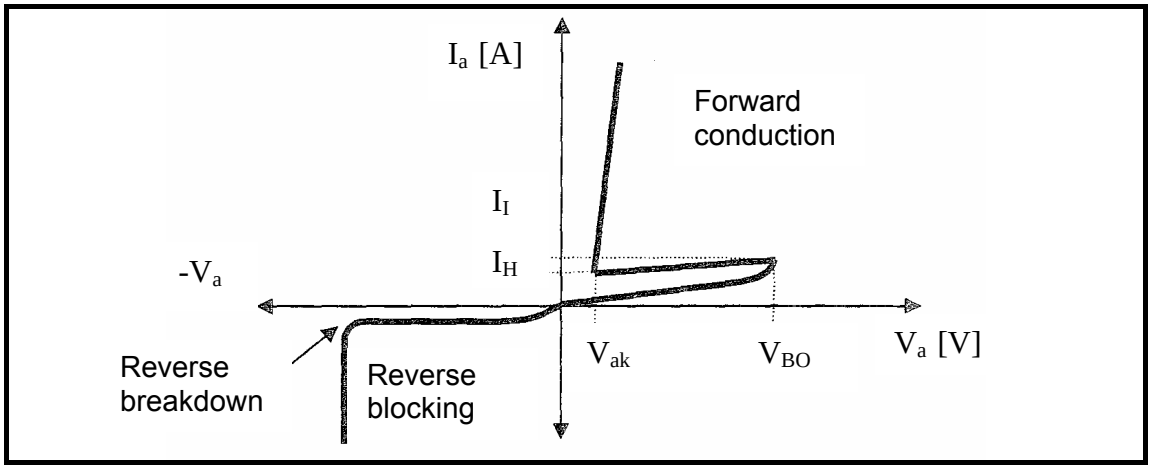



**FIGURE 6.1: CHARACTERISTIC CURVE OF AN SCR**

6.1.1 Draw a fully labelled symbol of an SCR. (3)

6.1.2 State how an SCR is switched on. (2)

6.1.3 State how an SCR is switched off. (2)

6.1.4 What happens to the SCR at the reverse breakdown voltage? (2)

6.1.5 State what occurs at $V_{BO.}$ (2)

6.2 Describe ONE disadvantage of an SCR in AC applications. (2)

6.3 The lamp dimming circuit in FIGURE 6.2 below is connected to a 240 V/50 Hz supply.

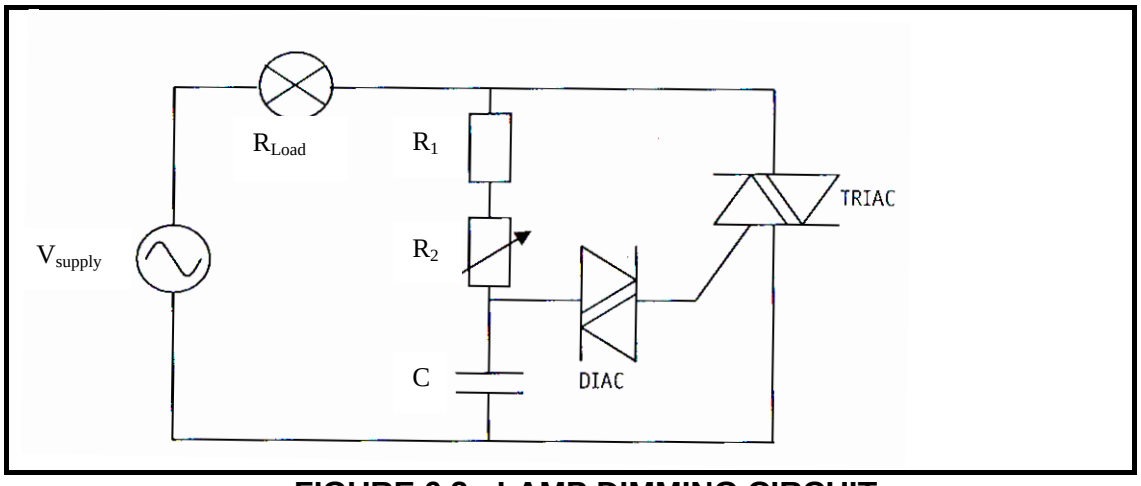



**FIGURE 6.2: LAMP DIMMING CIRCUIT**

6.3.1 What is the function of $R_1$? (2)

6.3.2 What is the function of $R_2$? (2)

6.3.3 Describe what would happen to the brightness of the lamp if the value of $R_2$ is increased. (4)

6.3.4 What is the function of the DIAC? (2)

6.4 Describe the factors that determine the physical size of a TRIAC. (2)
**[25]**

## QUESTION 7: AMPLIFIERS

7.1 State the function of an amplifier. (1)

7.2 With reference to the operational amplifier in FIGURE 7.1 below, answer the following questions.

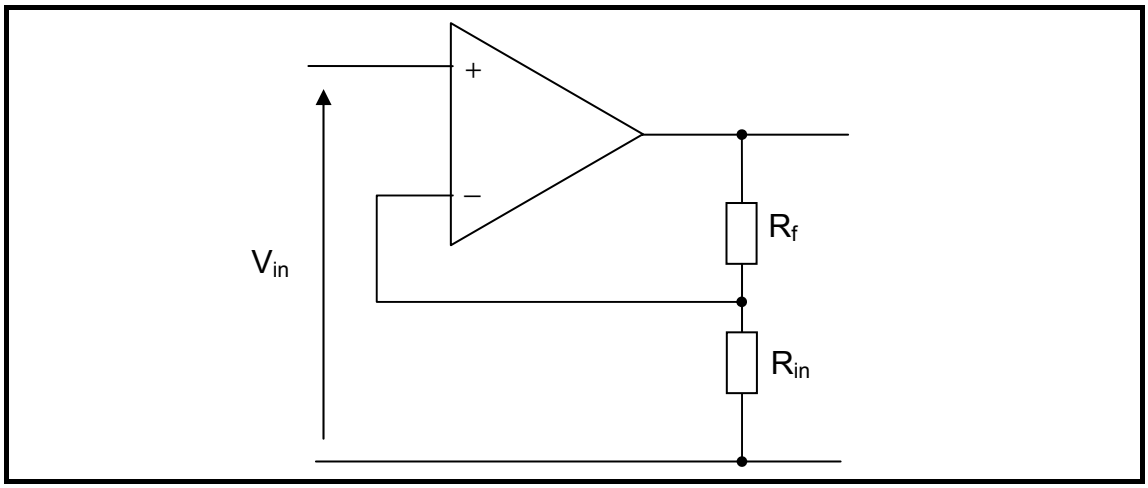



**FIGURE 7.1**

7.2.1 Name the circuit in FIGURE 7.1. (1)

7.2.2 Draw the output wave form if the input wave form is a sine wave. (2)

7.2.3 What will happen to the circuit if $R_f$ is very low (short circuit) and $R_{in}$ is made very high (infinite)? (4)

7.3 With reference to an operational amplifier, answer the following questions:

7.3.1 Name the ideal characteristics of an operational amplifier. (3)

7.3.2 What is meant by *open loop* gain? (3)

7.3.3 State TWO advantages of negative feedback. (2)

7.4 Operational amplifiers are commonly used in complex circuits (between stages) to link the stages. State, with a reason, the application (function) of the operational amplifier when utilised between stages. (2)

7.5 A comparator circuit compares two electrical signals. State, with a reason, the nature of the output if both signals have exactly the same value. (2)

7.6 Where would you use a non-inverting amplifier? Give ONE example to illustrate your answer. (2)

7.7 FIGURE 7.2 below is a circuit diagram of an operational amplifier.

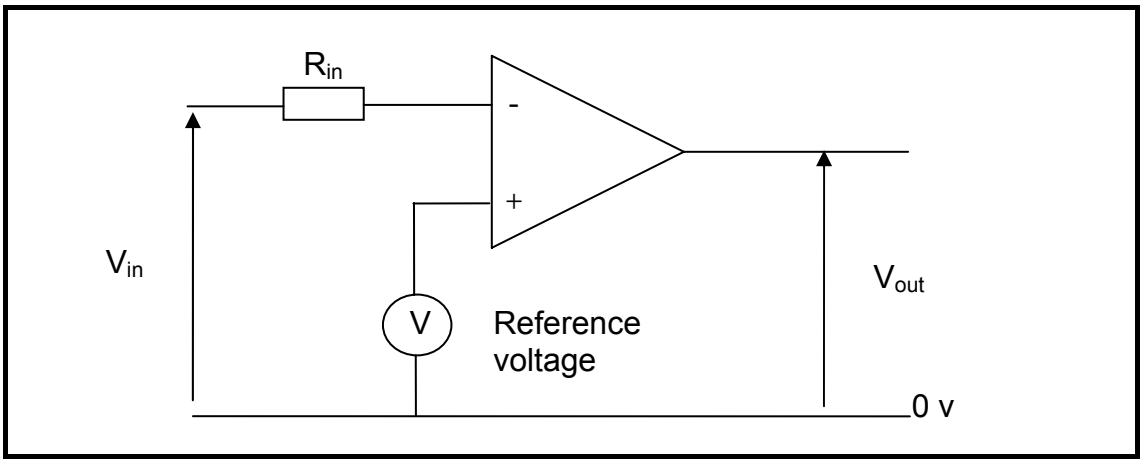



**FIGURE 7.2: OPERATIONAL AMPLIFIER CIRCUIT**

7.7.1 State in which mode the operational amplifier is connected. (1)

7.7.2 Draw the output wave for the circuit in FIGURE 7.2 if the input is a triangular wave. (2)

**[25]**

## QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Explain what will happen to the primary current of an ideal transformer if the load is doubled. (2)

8.2 Three-phase transformers may be connected in different transformer configurations. Draw a star-delta transformer configuration. The coil of each phase must be shown on your drawings. (2)

8.3 State why the core of a transformer is laminated using silicon steel which has a high internal resistance. (1)

8.4 What causes heat build-up in transformers? (1)

8.5 A 250 kVA, three-phase transformer with 400 turns on the primary is connected in delta-star. The supply voltage is 6 600 V. The full-load line current on the primary is 20 A, the secondary line voltage is 415 V and the power factor is 0,9.

Given: $S = 250$ kVA
$N_p = 400$
$V_{L(p)} = 6\,600$ V
$I_{L(s)} = 415$ V
$\cos \theta = 0,9$

Calculate:

8.5.1 The secondary phase voltage (3)

8.5.2 The turns ratio (3)

8.5.3 The secondary current of the transformer at full load (3)
**[15]**

## QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1 List THREE advantages of programmable logic over relay logic. (3)

9.2 With reference to an OR-gate, draw the following:

9.2.1 A circuit diagram made up of switches and a lamp (4)

9.2.2 The ladder diagram (3)

9.3 With reference to the ladder diagram in FIGURE 9.1 below, answer the following questions.

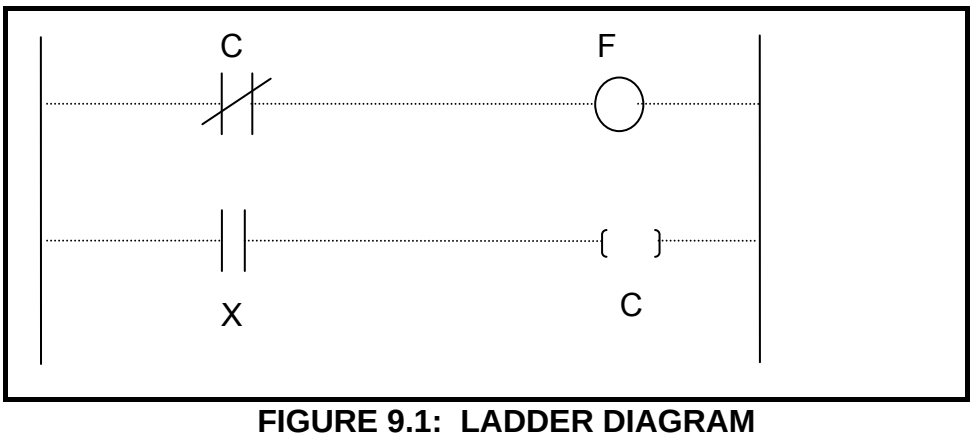



**FIGURE 9.1: LADDER DIAGRAM**

9.3.1 Draw the relay circuit of the ladder diagram in FIGURE 9.1. (5)

9.3.2 Name the logic function the circuit will perform. (1)

9.3.3 Write down the truth table for the circuit in FIGURE 9.1. (3)

9.4 The following operands are used in the programming of programmable logic controllers. Write down TWO examples of each.

9.4.1 Inputs (2)

9.4.2 Outputs (2)

9.4.3 Internal relays/flags or markers (2)

9.5 Explain the following terms with reference to programmable logic controllers:

9.5.1 Economical (1)

9.5.2 Reduced maintenance (2)

9.5.3 Ladder logic (1)

9.6 Draw the logic gate diagram that would represent the following Boolean expression:

$$(A.B+\overline{C})+(A.D)+C=F$$

(6)
**[35]**

**QUESTION 10: THREE-PHASE MOTORS AND CONTROL**

10.1 With reference to a star-delta starter, answer the following questions:

10.1.1 State the function of the starter. (1)

10.1.2 Describe how it achieves this function. (3)

10.2 State how the direction of rotation of a three-phase motor may be changed. (2)

10.3 A three-phase delta connected motor develops 8 kW at full load when the motor is connected across a 415 V/50 Hz supply. If the motor has a power factor of 0,85 and an efficiency of 100%, calculate:

Given: P = 8 kW
$V_L$ = 415 V
Cos θ = 0,85
f = 50 Hz

10.3.1 The current drawn by the motor at full load (3)

10.3.2 The apparent power of the motor (3)

10.4 Basic mechanical and electrical inspections should be carried out on three-phase motors before they are put into use.

10.4.1 State TWO electrical inspections. (2)

10.4.2 State TWO mechanical inspections. (2)

10.5 The circuit diagram shown in FIGURE 10.1 below represents the control circuit and power circuit of a direct-on-line starter.

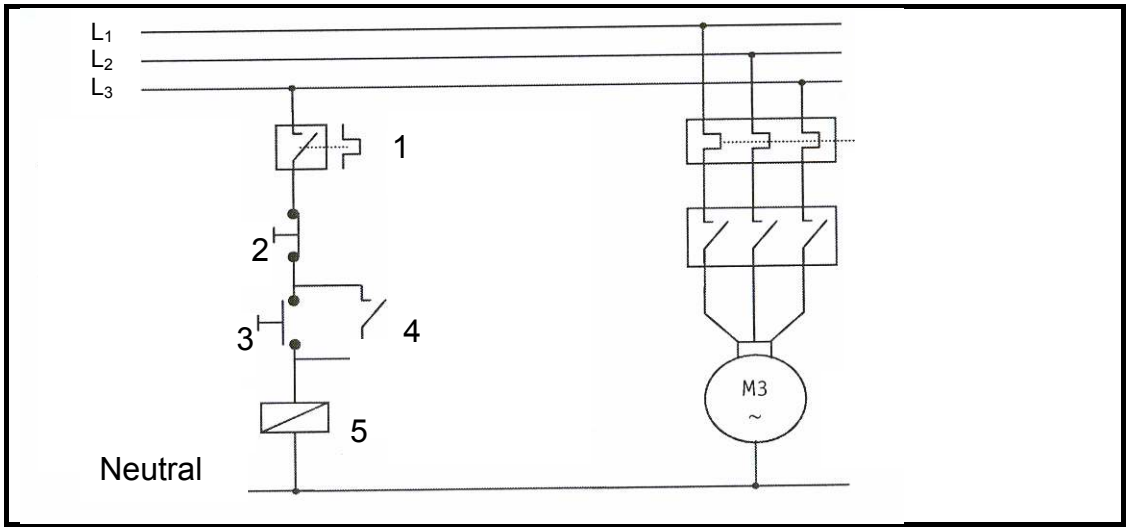



**FIGURE 10.1**

10.5.1 Name the parts marked 1 to 5. (5)

10.5.2 Describe the protection that the component labelled 4 offers to the motor. (3)

10.5.3 Describe the principle of operation of an overload unit in a direct-on-line starter. (4)

10.6 Name TWO losses that occur in three-phase electrical motors. (2)
**[30]**

**TOTAL: 200**

## FORMULA SHEET

$$X_L = 2\pi FL$$

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

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

$$I_T = \sqrt{I_R^2 + (I_C \cong I_L)^2}$$

$$V_T = \sqrt{V_R^2 + (V_C \cong V_L)^2}$$

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

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q = \frac{X_L}{R} = \frac{V_L}{V_R}$$

$$Cos\theta = \frac{I_R}{I_T}$$

$$Cos\theta = \frac{R}{Z}$$

$$P = VI\cos\theta$$
$$S = VI$$
$$Q = VI\sin\theta$$

} Single phase/ Enkelfase

$$V_R = IR$$
$$V_L = IX_L$$
$$V_C = IX_C$$

$$P = \sqrt{3}\, V_L I_L \cos\theta$$
$$S = \sqrt{3}\, V_L I_L$$
$$Q = \sqrt{3}\, V_L I_L \sin\theta$$

} Three phase/ Driefase

$$V_L = V_{Ph}$$
$$I_L = \sqrt{3} I_{Ph}$$

} Delta

$$V_L = \sqrt{3}\, V_{Ph}$$
$$I_L = I_{Ph}$$

} Star/Ster

$$f = \frac{1}{T}$$

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

$$\beta = \frac{I_c}{I_b}$$

$$I_b = I_e - I_c$$

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## GRADE 12

## ELECTRICAL TECHNOLOGY

## NOVEMBER 2010

## MEMORANDUM

**MARKS: 200**
**Approved Memorandum – 31 October 2010**

**This memorandum consists of 15 pages.**

## QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 Wind movement✓
Biomass (Dung, Moss etc)
Hydro✓
Nuclear
Solar✓
Wood
Wave movement✓

(Any relevant answer) (4)

1.2 Be a hard worker✓

Be a creative thinker✓

Be a visionary✓

Have financial management skills✓

Good communication skills; Personal drive and commitment; Good positive attitude and work ethic; Have the desire to succeed; Good marketing skills; Good time management skills; and be a leader.
(Only FOUR relevant competencies) (4)

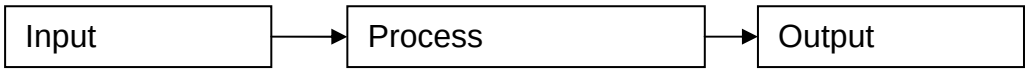
1.3 HIV, the virus that causes Aids, lives in human blood. Therefore, contact with an injured person with an open bleeding wound should be avoided, unless wearing approved surgical gloves. ✓ Bacterial Infection✓ To preotect yourself against infection. (2) **[10]**

## QUESTION 2: TECHNOLOGICAL PROCESS

2.1 The neighbours have a security problem. ✓ They are bothered by burglaries due to easy access through the gate entrances. They have no remote control over the entrances. ✓ (2)
Gates are not self locking
There is no warning system when the gates are open.

2.2 The solution is to install electronic locking systems✓✓✓, indication lamps✓, and an alarm system. ✓ The gates may now be controlled remotely and unauthorised access may be indicated by indication lamp and alarm. (5)
Burglar Proofing that closes automatically using electric motors or solenoids.
Motor Controlled Gates.

2.3




| Input | Process | Output |
|---|---|---|
| Pressing the remote switch ✓ | Operation of the internal circuitry ✓ | Opening of gate ✓ |

(3)
**[10]**

## QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 If HIV/Aids is not brought under control:

- it can affect productivity in that employees with skills✓
- may not function well, may take time off work, ✓
- may not work or even may die. ✓
- Colleagues may be unwilling to work with a person having HIV due to the stigma associated with HIV

Resulting in:

- slowing down of productivity
- costing more money

(Any THREE relevant answers) (3)

3.2 Ensure the following:

- Make sure that the drilling machine's cord is in a good condition.
- That there are no exposed conductors. (Not all portable drills have a cord.)
- Ensure that the drill bit is secured properly in the chuck.
- Ensure that the chuck is in a good condition.
- Personal Safety Issues

(Any other possible answers) ✓ (1)

3.3 An exposed conductor may lead to a short circuit between conductors, ✓ which could lead to electric shock or fire. ✓ (Any other relevant answers. This answer must however correlate with the answer given in 3.2.) (2)

3.4 Wet floors, wet work areas and bare conductors. ✓(Any other relevant answers) (1)

3.5 Safety is the responsibility of any person who enters or works in an electrical technology workshop. ✓ It is not only the responsibility of the teacher; each person has a responsibility to himself and others around him. ✓It only takes one person to ignore safety procedures to cause serious problems for all in the electrical technology workshop. ✓
(Any sound motivated response must be considered) (3)
(If mutiple parties are listed with no motivation a maximum of two out of three can be awarded.) **[10]**

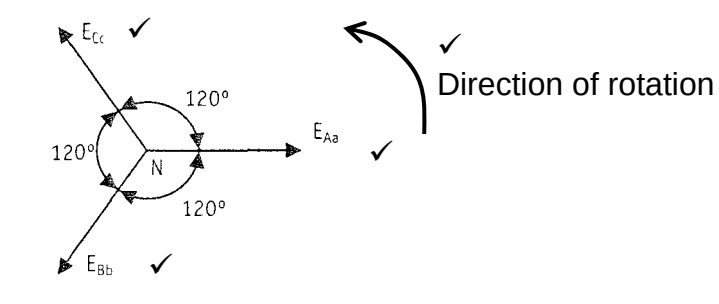
## QUESTION 4: THREE-PHASE AC GENERATION

4.1 The function of a kWh meter is to measure the amount of power ✓consumed by a consumer over a period of time (energy). (1)

4.2 Three-phase systems are more versatile, they can operate in both the star or delta mode.
Load distribution and phase balancing are possible. ✓(Any other relevant answers) (1)

4.3 120 degrees ✓ (1)

4.4




(4)

4.5 $V_L = 415\,V$
$F = 50\,Hz$
$P_{out} = 6\ kW$
$Pf = 0.85$

$$P = \sqrt{3}V_L I_L \cos\theta \quad ✓$$
$$I_L = \frac{P}{\sqrt{3}V_L \cos\theta}$$
$$= \frac{6x10^3}{\sqrt{3}x415x0.85} ✓$$
$$= 9.82\ A \quad ✓$$

(3)
**[10]**

## QUESTION 5: RLC CIRCUITS

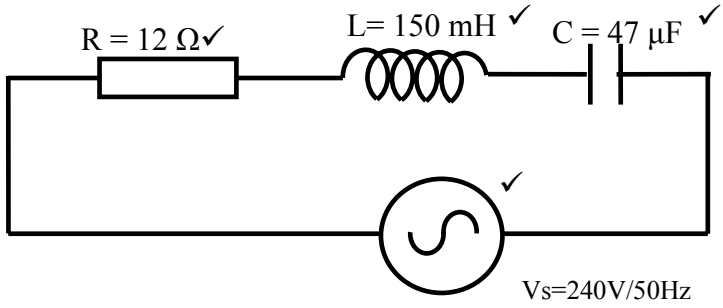
5.1 5.1.1 Leads (is ahead of) ✓ (1)

5.1.2 Coil✓ (1)

5.2 5.2.1 An increase in frequency will result in a decrease in capacitive reactance✓ (1)

5.2.2 An increase in frequency will result in an increase in inductive reactance✓ (1)

5.3 5.3.1



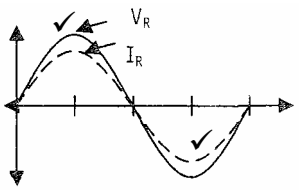

(4)

Non Labelled Diagram = Maksimum of 2 out of 4

5.3.2
$$F_r = \frac{1}{2\pi\sqrt{LC}} \quad ✓$$
$$= \frac{1}{2\pi\sqrt{0.15x47x10^{-6}}} ✓$$
$$= \underline{59.94\ Hz} \quad ✓$$
(3)

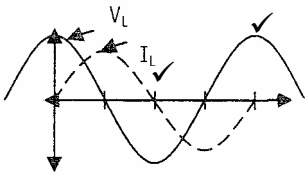
5.3.3
$$X_L = 2\pi FL \quad ✓$$
$$= 2x\pi x50x0.15 ✓$$
$$= \underline{47.12\ \Omega} \quad ✓$$
(3)

5.4 5.4.1




(2)

5.4.2




(2)

**FIGURE 5.1: AC CIRCUITS**
Phasor Diagrams accepted

5.5 5.5.1

$$I_R = \frac{V}{R} \quad \checkmark$$
$$= \frac{240}{100} \quad \checkmark$$
$$= \underline{\underline{2.4\ A}} \checkmark$$

(3)

5.5.2

$$I_L = \frac{V}{X_L} \quad \checkmark$$
$$= \frac{240}{440} \checkmark$$
$$= \underline{\underline{0.55\ A}} \checkmark$$

(3)

5.5.3

$$I_C = \frac{V}{Xc} \quad \checkmark$$
$$= \frac{240}{160} \checkmark$$
$$= \underline{\underline{1.5\ A}} \checkmark$$

(3)

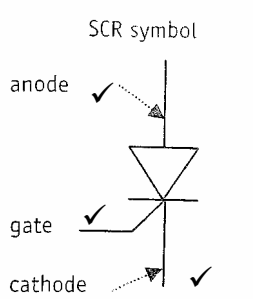
5.5.4

$$\therefore I_T = \sqrt{I_R^2 + (I_C - I_L)^2} \quad \checkmark$$
$$= \sqrt{2.4^2 + (1.5 - 0.55)^2} \quad \checkmark$$
$$= \underline{\underline{2.58\ A}} \quad \checkmark$$

(3)
**[30]**

## QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 6.1.1




If symbol is correct with no labelling = 1 Mark (3)

6.1.2 To switch on the SCR the anode must be positive in relation to the cathode voltage. ✓ Under this condition when a positive pulse is applied to the gate, the SCR will switch on. ✓
If the forward voltage applied to the SCR rises above Vbo. (2)

6.1.3 To switch off the SCR the supply voltage must be reduced to zero, ✓ or reversed. Alternatively the supply current must reduce to below the holding current threshold. ✓ (2)

6.1.4 At the reverse breakdown voltage the minimum charge carriers in reverse bias across the depletion layer will increase dramatically, causing the SCR to conduct. ✓ During this reverse current flow, a large amount of heat is generated and the SCR destroys itself. ✓ (2)

6.1.5 $V_{BO}$ is a specific voltage at which the SCR will switch on, ✓irrespective of whether there is a positive pulse on the gate or not. ✓ This is not the desired method of switching on the SCR. (2)

6.2 The SCR has an anode and a cathode. It is polarity sensitive and can only conduct in one direction✓✓ which is a limitation in AC conditions. (2)

6.3 6.3.1 $R_1$ limits the current ✓to protect the DIAC✓ when $R_2$ is set to a minimum, zero ohms. (2)

6.3.2 By adjusting $R_2$ the time constant is changed✓ (t=RC), changing the time it takes to charge up the capacitor (C) to the voltage ($V_{DIAC}$) that will trigger the DIAC causing it to conduct, thus changing the angle at which the TRIAC is fired, resulting in the adjustment of the brightness ✓of the lamp. (2)

6.3.3 If $R_2$ is increased the time constant of the trigger circuit is increased (t=RC). ✓ This will prolong✓ the time it takes for the capacitor to charge to the voltage that is equal to the break over voltage of the DIAC increasing the trigger angle (taking longer to trigger in each half-cycle) ✓ thus reducing the brightness of the lamp✓ as less time is allowed for current to flow through the lamp. (4)

6.3.4 The DIAC is used to trigger the TRIAC✓ into conduction with either polarity on the DIAC. ✓ The DIAC is a device that has the property that it has exactly the same trigger voltage value in either direction, thus triggering the TRIAC at exactly the same angle during every half-cycle. This prevents thermal runaway in the TRIAC and prevents flickering at lower voltages.
It prevents unwanted or stray voltages to falsely trigger the TRAIC (2)

Waveforms as an explanation is accpeted, provided it is correct.

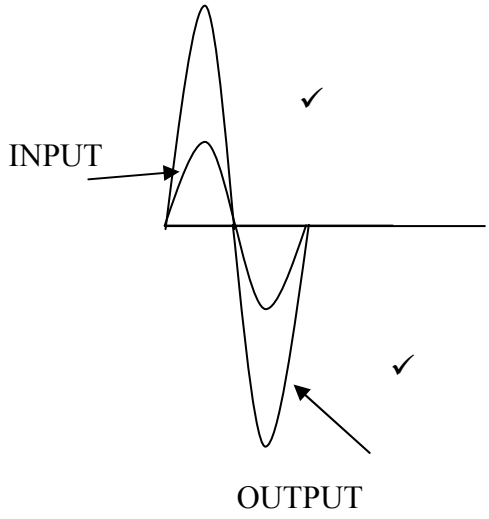
6.4 The current rating✓ expected to be controlled by the TRIAC as well as the duty cycle of the TRIAC✓. (2)
The operating voltage. **[25]**
Energy dissipated by the TRIAC.

## QUESTION 7: AMPLIFIERS

7.1 To amplify a small electrical input signal into a larger electrical output ✓ signal. (1)

7.2 7.2.1 The op-amp as a non-inverting amplifier✓ (1)

7.2.2




(2)

7.2.3 When $R_f$ becomes very low, the full output voltage is fed back into the inverting input✓, thus driving the output to saturation✓. The output will then follow the input similar to a Voltage follower✓. If $R_{in}$ is made infinitely high, the output impedance of the amplifier will rise accordingly, thus resembling a buffer amplifier✓. This could be proven mathematically by replacing the values of the resistors into the provided formula. (4)

7.3 7.3.1 Open-loop voltage gain is infinite✓
Input impedance is infinite✓
Output impedance is zero✓
Bandwidth is infinite
Unconditional stability
Differential inputs i.e. two inputs
Infinite common-mode rejection ratio
(any THREE) (3)

7.3.2 No feedback✓ is provided from the output✓ to the input✓ (3)

7.3.3 Unwanted part of the output signal is subtracted from the input signal✓
Errors are eliminated and not amplified✓
Bandwidth is increased
Noise and Distortion are limited
The gain is controlled (Any TWO)
If a learner made reference of using a differential amplifier in conjunction with negative feedback, this is correct. (2)

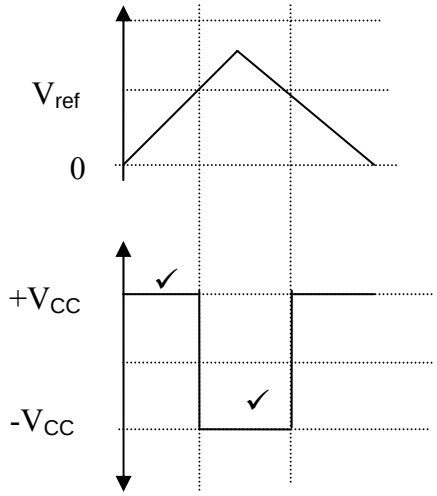
7.4 When an op-amp is utilised between stages it is used as a buffer amplifier✓ to adapt/match the impedance✓ between the stages. (2)

7.5 The output of the comparator will be zero. ✓ This is due to a comparator only amplifying the difference✓ between the input signals. (2)

7.6 Any application where a phase shift is not required✓, such as: audio amplifiers etc✓. (Alternative answer: The output wave must look exactly like the input wave, only larger.) (2)

7.7 7.7.1 Operational amplifier as an inverting voltage comparator. ✓ (1)

7.7.2

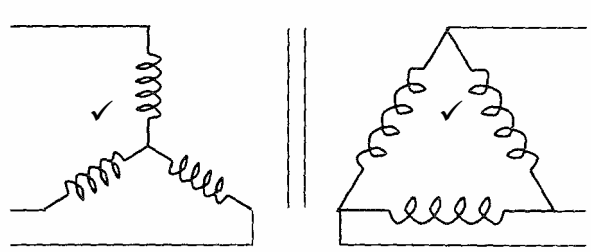



(2)
**[25]**

## QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 The primary phase current will also be doubled as it is directly proportional to the load. ✓✓ (2)

8.2




(2)

Star – Delta Transformer

If the learner used single phase transformers and connected it correctly, the answer is correct.

8.3 To reduce eddy currents. ✓ (Alternative answer: To reduce the area of the hysteresis loop, thus reducing the energy needed to overcome the residual magnetism.) (1)

8.4 Losses and current flow in transformers causes heat build-up. ✓ (1)
Overloading
Copper Losses
Iron Losses
Poor Cooling
Lack of Ventilation
Poor Connections / Hot connections
Excessive vibration due to poor mechanical construction

8.5 8.5.1 $V_{pP} = 6\,600\ V$

$$V_{pS} = \frac{V_{LS}}{\sqrt{3}} \quad ✓$$
$$= \frac{415}{\sqrt{3}} \quad ✓$$
$$= \underline{\underline{239.6\ V}} \quad ✓$$

(3)

8.5.2 $$T.R. = \frac{V_{pP}}{V_{pS}} \quad ✓$$
$$= \frac{6600}{239.6} \quad ✓$$
$$= 27.55:1 \quad ✓$$
$$= \underline{\underline{28:1}}$$

(3)

8.5.3 $$I_{LS} = \frac{S}{\sqrt{3}V_{LS}} \quad ✓$$
$$= \frac{250000}{\sqrt{3}x415} \quad ✓$$
$$= \underline{\underline{347.8\ A}} \quad ✓$$

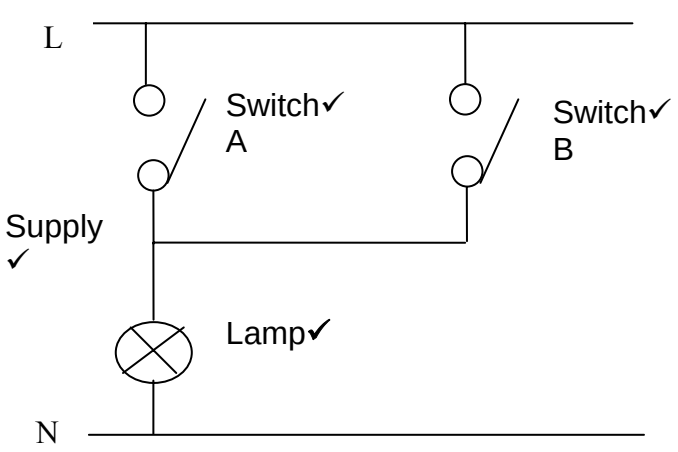
(3)
**[15]**

$$Is = \frac{Ip}{\sqrt{3}} \times \frac{Np}{Ns}$$
$$= \frac{20}{\sqrt{3}} \times 27.55$$
$$= \underline{\underline{318.12A}}$$
*alternatively*
$$Is = \frac{Ip}{\sqrt{3}} \times \frac{Np}{Ns}$$
$$= \frac{20}{\sqrt{3}} \times 28$$
$$= \underline{\underline{323.32A}}$$

## QUESTION 9: LOGIC CONCEPTS AND PLCs

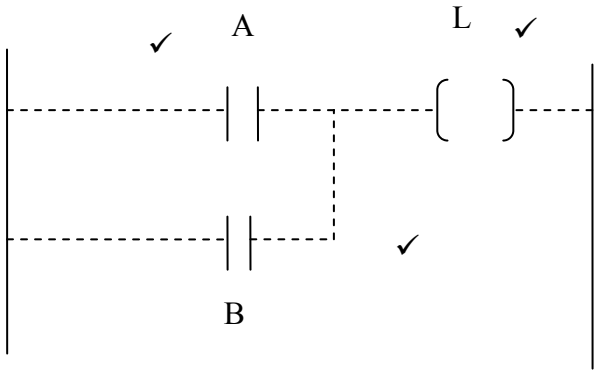
9.1 Economical, cheaper than relays ✓
Simplified design ✓
Quick delivery ✓
Compact and standardised
Improved reliability
Reduced maintenance (Any THREE) (3)

9.2 9.2.1



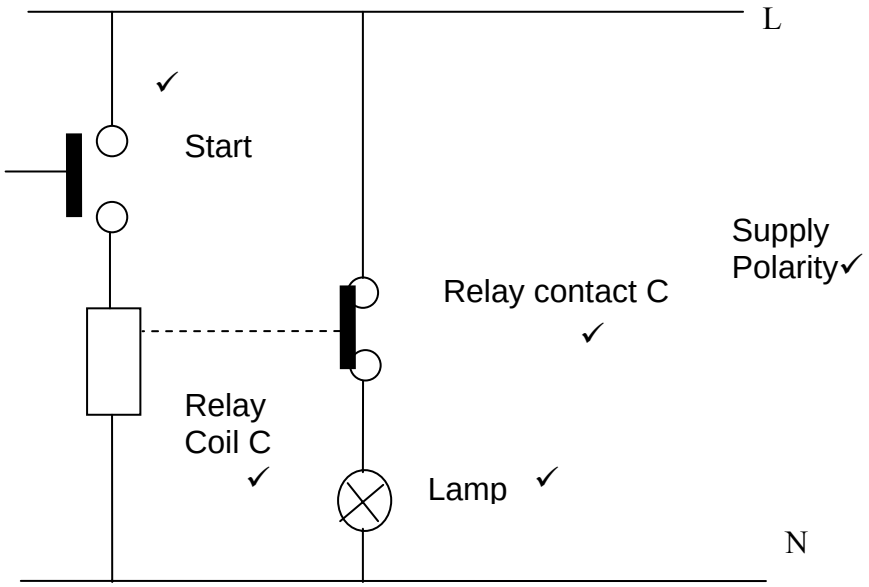

(4)

9.2.2




(3)

9.3 9.3.1




(5)

9.3.2 Inverter (NOT function) ✓ (1)

9.3.3

| X | F✓ |
|---|---|
| 0 | 1✓ |
| 1 | 0✓ |

(3)

9.4 9.4.1 Switches✓, pushbuttons ✓and contacts of various devices denoted by suffix [X] (Any TWO) (2)

9.4.2 Relay coils ✓and solenoids and valves✓ are denoted by suffix [Y] (Any TWO) (2)

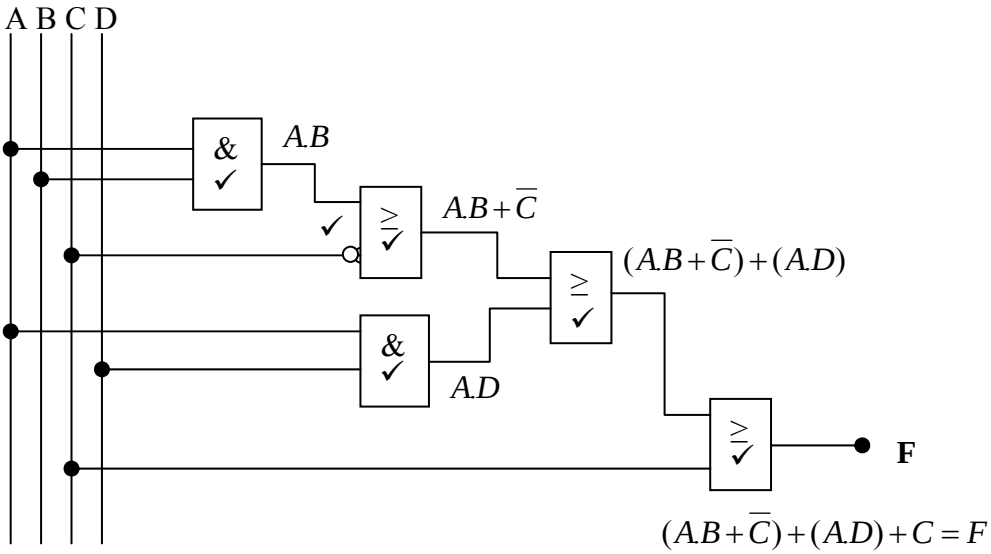
9.4.3 Internal relays/flags ✓also known as markers are used for internal ✓operations, memory and relay and are denoted by the suffix [M] (2)

9.5 9.5.1 For a control panel with more than ten relays, a programmable controller is cheaper. ✓ (1)

9.5.2 Fewer components are subject to wear✓✓ and units have built-in diagnostic functions. (2)

9.5.3 It is a series of instructions written in a language✓ that a PLC can understand. (Alternative answer: It is a programming language.) (1)

9.6



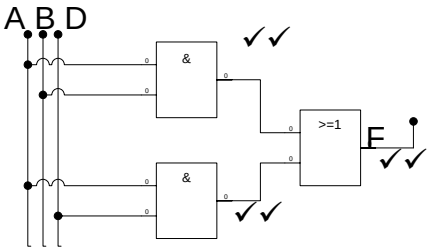

Or if The Learner simplified the expression

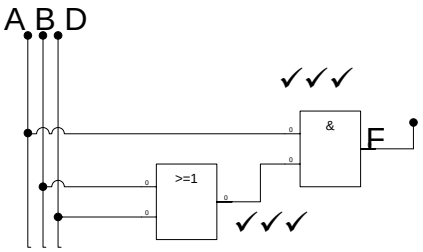
$(A.B+\overline{C})+(A.D)+C=F$

$A.B+\overline{C}+A.D+C=F$

$A.B+A.D=F\,(Alternative)$

$A(B+D)=F\,(Alternative)$




(6)
**[35]**

## QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 10.1.1 The function of a star-delta starter is to reduce the starting current ✓ of a motor at start as a motor draws 3 to 4 times full-load current at start. (1)

10.1.2 The motor is connected in star ✓at start, this reduces the voltage across the motor windings✓ which in turn reduces the current in the windings. ✓ Once the starting current has reduced, the motor windings are changed over to delta, restoring full-line voltage across the windings, therefore full current. (3)

10.2 Swap the connection✓ to any two phases. ✓ (2)

10.3 10.3.1

$$P_i = \sqrt{3}V_L I_L \cos\theta \ \checkmark$$

$$I_L = \frac{P_i}{\sqrt{3}V_L \cos\theta}$$

$$= \frac{8\,000}{\sqrt{3}\ x415\ x\,0.85} \checkmark$$

$$= \underline{13.09\ A} \checkmark$$

(3)

10.3.2

$$S = \frac{P}{\cos\theta} \checkmark$$

$$= \frac{8\,000}{0.85} \checkmark$$

$$= \underline{9.41\ kVA} \checkmark$$

(3)

10.4 10.4.1 Check to see that the frame of the motor is earthed. ✓
Check to see that all electrical connections are secure and insulated. ✓
(Any acceptable additional answers will be acceptable) (2)

10.4.2 Check to see if the rotor turns freely. ✓
Check to see if the motor is mounted securely. ✓
(Any acceptable additional answers will be acceptable) (2)

10.5 10.5.1 1 – Overload✓
2 – N/C stop✓
3 – N/O start✓
4 – N/O aux✓ (retaining circuit)
5 – coil✓ (5)

10.5.2 If the power is removed from the motor the contacts will open. ✓
When the power is restored the motor will not automatically ✓re-start protecting the motor and operator. ✓ (3)

10.5.3 The N/C overload contacts will open if the overload contactor is operated ✓due to an overload condition on the motor. ✓With the contacts now open the control circuit will open, ✓ de-energising the motors coil, switching the motor off. ✓ (4)

10.6 Iron losses. ✓
Copper losses. ✓ (2)
$I^2R$ Losses **[30]**
Mechanical Losses
Magnetic Losses / Stray Losses
Di-electric Losses due to poor / deteriorating insulation

**TOTAL: 200**