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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2013

MEMORANDUM

MARKS: 200

This memorandum consists of 15 pages.

INSTRUCTIONS TO MARKERS

1. All questions with multiple answers imply that any relevant, acceptable answer should be considered.
2. Calculations:
 - 2.1 All calculations must show the formula.
 - 2.2 All answers must show the correct unit.
 - 2.3 Alternative methods must be marked.
 - 2.4 Where an erroneous answer is to be carried over to the next step, the first answer will be marked incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values, using the incorrect answer from the first calculation. If correctly used, the learner should receive the full marks for subsequent calculations.
3. The memorandum is only a guide with model answers. Alternative interpretations must be considered, and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

- | | | | | |
|-----|-------|--|-----------|-----|
| 1.1 | 1.1.1 | Wind power ✓
Solar power ✓
Hydro power
Wave power
Geothermal Energy | (any two) | (2) |
| | 1.1.2 | Coal has a huge negative impact on the environment✓ and coal is also not a renewable source of energy, at some stage there will be no more coal to burn in SA. ✓
Coal pollution may also have a negative impact on the health of individuals / society | | (2) |
| 1.2 | 1.2.1 | Without electricity a person will not have the opportunity to make use of all the electrical and electronic devices✓ that are educational and allow for communication therefore retarding a person's progress in education and life. ✓ | | (2) |
| | 1.2.2 | The cost✓ of petrol increases which increase the cost of transporting coal to the power station✓
The cost of mining coal increases which increases the cost of generating electricity
Water resources are becoming scarce and therefore will become expensive increasing cost of generation of electricity
(This does not only limit the answer to Coal, could include any reference to generation of electricity)
Archaic energy systems and ineffective energy designs waste energy. | | (2) |
| | 1.2.3 | Without electricity people will have to rely on an alternative source of energy ✓ like wood and other inconvenient and polluting fuels such as coal, paraffin or candles. ✓ | | (2) |
- [10]**

QUESTION 2: TECHNOLOGICAL PROCESS

Consider all possible types of answers related to the answers OR related to the Technological Process as an interpretation thereof.

- | | | | |
|-----|-------|--|-----|
| 2.1 | 2.1.1 | The input receives the electrical instruction✓ and feeds into the CPU (central processing unit) ✓ | (2) |
| | 2.1.2 | The processing unit will receive✓ the input and interpret it and execute it and deliver it to the output ✓ | (2) |
| | 2.1.3 | The output receives the executed instructions✓ and delivers it to the external devices✓ | (2) |

2.1.4 The power supply supplies the processing unit✓ with the power to execute the instructions✓ (2)

2.2 To establish that the design specification has been met✓
To establish the correct operation of the artefact✓
(Any relevant answer) (2)
[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Horseplay in the workshop.✓
Working on a machine which does not have the correct guards or protective devices.✓
Working with live, open terminals.
Touching live conductors exposed in the workshop.
Using incorrect tools in the workshop.
Using correct tools incorrectly.
Not using safety equipment/uniform.
(Any two) (2)

3.2 Earth leakage protective devices.✓
Emergency stop button. ✓
Overload relay. ✓
Fuses
Circuit breakers
Stop Button
Emergency Disconnect Button
Isolator Switch
(Any three) (3)

3.3 Any fire extinguisher that uses a non-conductive material such as CO₂ type or powder type. ✓
Fire bucket with Sand
Type C Fire Extinguisher
ABC Dry Chemical (popular)
Carbon Dioxide (CO₂)
Halotron
Halotron 1211
High Performance Dry Chemical
Regular Dry Chemical (1)

3.4 Before connecting the meter make sure the power is switched off.✓
Set the meter to the highest current scale. ✓
Make sure that the meter is connected in series in the circuit.
Make sure the leads of the meter are plugged into the correct sockets of the meter.
Make sure correct scale is used for AC or DC.
After connecting the meter correctly proceed with the line test.
Mention of a clamp meter as ammeter is acceptable (Any two) (2)

- 3.5 The workshop must be well ventilated to prevent drowsiness ✓ which may lead to an accident and possible injuries. ✓
Some work processes may lead to fumes being released which, if not extracted, will cause health problems. (Any one)

(2)
[10]

QUESTION 4: THREE-PHASE AC GENERATION

- 4.1 For high power generation the three-phase system is more functional and efficient. ✓
For generators with the same size frame three-phase machines produce more power than single-phase machines.
Three-phase generators may be connected in parallel to obtain an increased supply.

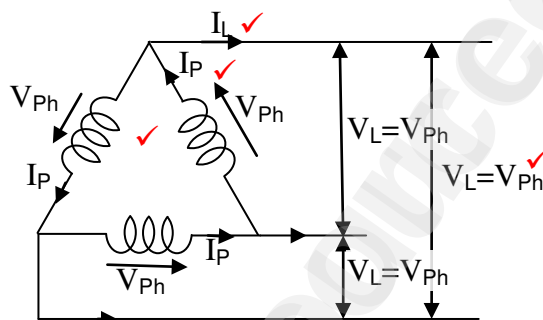
Three-phase systems can deliver both three-phase and single-phase power.

(Any one)

(1)

If candidate speaks of motor- no penalisation

4.2



(4)

Marks not allocated for Direction of arrows but for the labels.

4.3 4.3.1 $P = \sqrt{3} V_L I_L \cos \theta$

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

$$= \frac{60 \times 10^3}{\sqrt{3} \times 380 \times 0.85} \quad \checkmark$$

$$= 107.25 \text{ A} \quad \checkmark$$

(3)

- 4.3.2 If the power factor of the load was improved the current drawn by the load will be reduced ✓ while the load and the voltage across the load remains constant. ✓
The load and the voltage across the load will remain constant; therefore the current drawn by the load will decrease with an improved power factor.
The circuit Impedance changes.

(2)

[10]

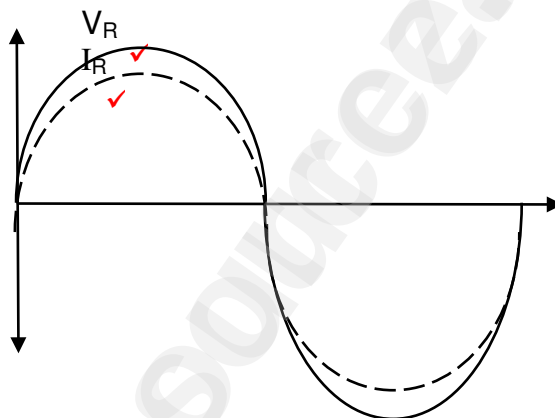
QUESTION 5: RLC CIRCUITS

- 5.1 The frequency of the supply ✓
 Capacitance of the capacitor ✓
 Size of the capacitor
 If physical characteristics as well as capacitance are mentioned – Only one mark as these refer to the same component /factor (2)

- 5.2 Inductive reactance is the opposition offered ✓ by the inductor to the flow of current in a coil when the coil is connected across an alternating-voltage supply ✓ and it is measured in ohms. (2)
 If mention is made of resistance – The learner will get 1 Mark Maximum

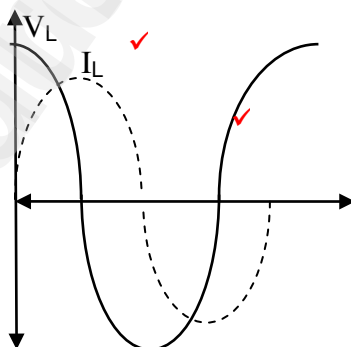
- 5.3 If the number of turns of the coil are increased the inductance of the coil will increase ✓ therefore the inductive reactance of the coil will increase. ✓ (2)

- 5.4 5.4.1



(Must show that V and I are in phase)

- 5.4.2



Must show that I lags V

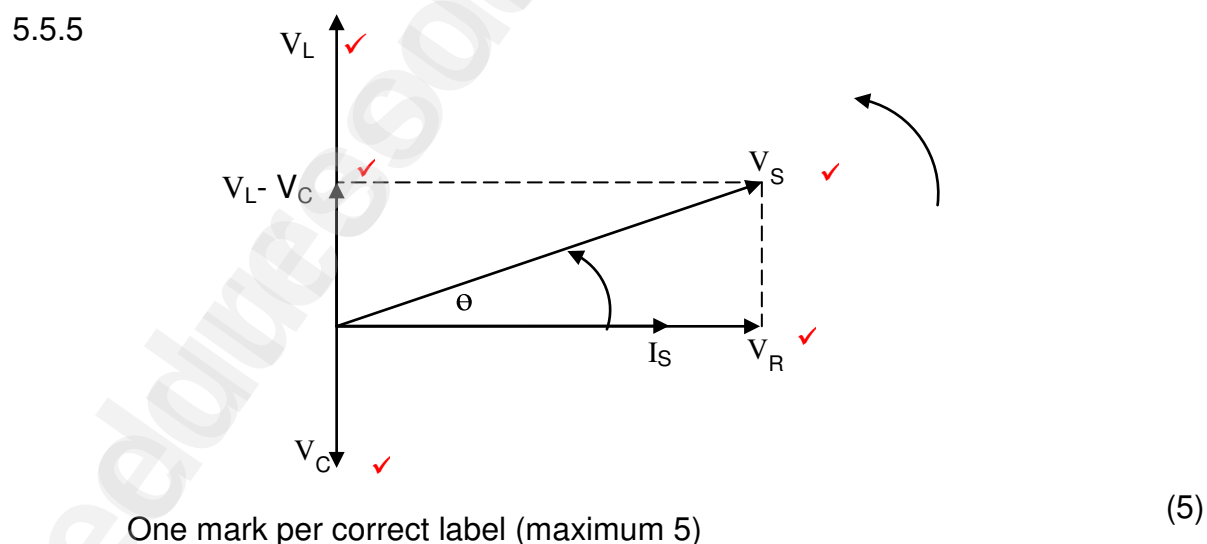
Labelling is important to show lag of the current with respect to the applied voltage.

5.5 5.5.1 $X_L = 2\pi fL$ ✓
 $= 2 \times \pi \times 50 \times 180 \times 10^{-3}$ ✓
 $= 56.55 \Omega$ ✓ (3)

5.5.2 $X_C = \frac{1}{2\pi fC}$ ✓
 $= \frac{1}{2\pi \times 50 \times 200 \times 10^{-6}}$ ✓
 $= 15.92 \Omega$ ✓ (3)

5.5.3 $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ✓
 $= \sqrt{10^2 + (56.55 - 15.92)^2}$ ✓
 $= 41.84 \Omega$ ✓ (3)

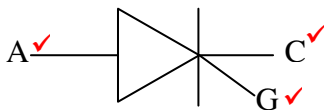
5.5.4 $I = \frac{V}{Z}$ ✓
 $= \frac{220}{41.84}$ ✓
 $= 5.26 \text{ A}$ ✓ (3)



5.6 $I_S = \sqrt{I_R^2 + (I_C - I_L)^2}$ ✓
 $= \sqrt{1^2 + (2 - 1.5)^2}$ ✓
 $= 1.12 \text{ A}$ ✓ (3)
[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1



(one mark for correct drawing without labels)

(3)

6.2

Speed control of electrical motors ✓
 Lamp dimming of incandescent lamps ✓
 Temperature control of furnaces
 Inverters

(Any two)

(2)

6.3

A voltage must be applied across the two main terminals of the SCR with the anode made positive ✓ and the cathode negative. ✓ It can now be triggered into conduction by a positive pulse to the gate. ✓

(3)

6.4

The physical size of an SCR is determined by the supply voltage ✓ it will be connected across and the maximum current ✓ that will flow through the device.

The higher the current, the larger the device should be.

External environmental heat factors

(2)

6.5

A voltage in any direction (of any polarity) ✓ must be applied across the DIAC ✓ this voltage must now be increased to the break-over voltage ✓ of the DIAC, about 30 V to 50 V. The DIAC will now switch on and allow current to flow through it.

(3)

6.6

6.6.1 To allow a specific gate voltage ✓ to the gate of the TRIAC to fire it into conduction ✓. OR to prevent transient signals to the gate of the TRIAC and therefore triggering the TRIAC.

(2)

6.6.2 The time it takes for the capacitor to fully charge depends upon the value of R_2 ✓ and the value of the capacitor. ✓ The time constant is calculated by $T=5RC$. Therefore if R_2 is increased the capacitor will take longer to charge ✓ to the required voltage to trigger the TRIAC into conduction. ✓ The current will therefore flow through the lamp for a shorter period reducing its brightness. ✓

(5)

6.7

6.7.1 When the TRIAC begins to conduct its internal resistance falls ✓ this will result in the voltage drop across the TRIAC dropping ✓ to a lower voltage (almost Zero). ✓
 (The reduction /fall /drop / lowering / decrease of internal resistance is the crux of the question – If no mention is made thereof – only award 2 marks maximum)

(3)

6.7.2 I_H is the holding current which is the minimum current ✓ that must flow through the TRIAC to maintain conduction. ✓
 If the current drops below I_H the TRIAC will stop conducting.

(2)

[25]

QUESTION 7: AMPLIFIERS

7.1 7.1.1 Positive feedback: the output signal ✓ is fed back into the input and added ✓ in phase ✓ to the input signal resulting an increased input signal therefore leading to an increased gain. (3)

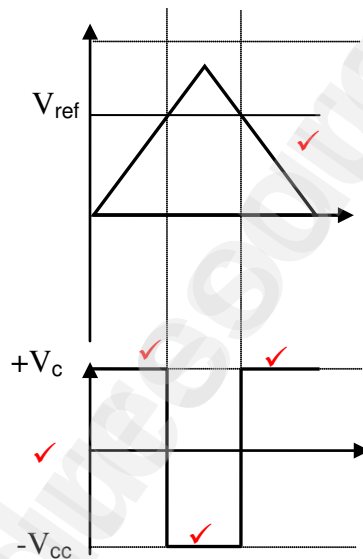
7.1.2 Leads to instability in circuits. ✓
Causes ring feed (sustained oscillation)
Renders the output therefore unpredictable (Any one) (1)

7.1.3 Design of oscillator circuits to overcome losses of natural oscillation ✓ (1)

7.2 1 - Inverting input ✓
2 - Non-inverting input ✓
3 - Output ✓ (3)

7.3 7.3.1 Inverting comparator op-amp ✓ (1)

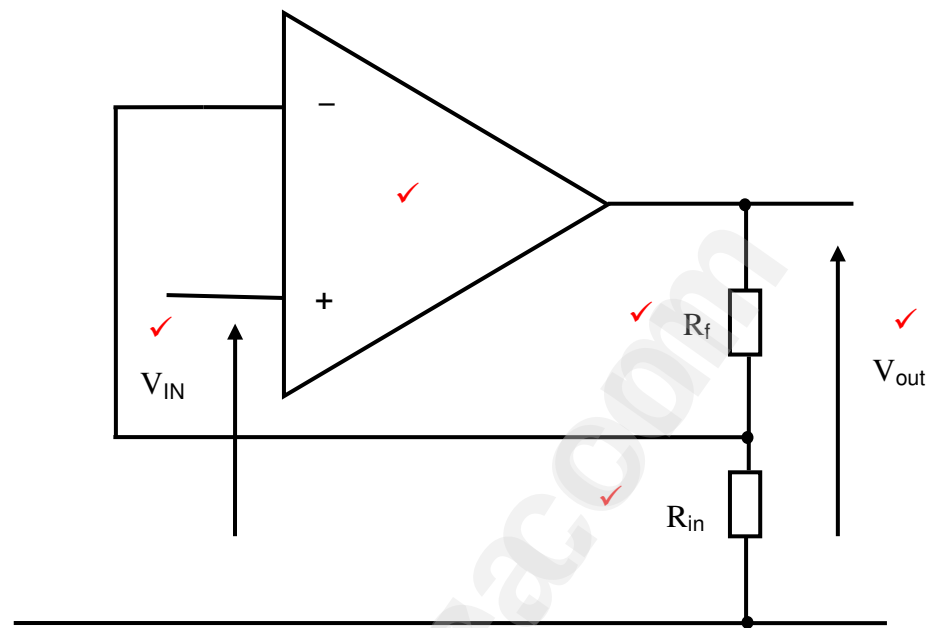
7.3.2



(5)

7.3.3 V_{ref} determines when the output voltage is switched ✓ due to a change in the input voltage ✓ above or below V_{ref} ✓. (3)

7.4



(5)

7.5 By making R_f small (zero or short-circuited) and R_{in} very large

(3)
[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 To step down the mains voltage in a domestic supply for use in a cellphone charger. ✓
Any practical application. (1)

8.2 An alternating voltage is connected to the primary winding of the transformer. ✓
This sets up an alternating current in the primary. ✓
This sets up a magnetic field that is linked to the secondary winding via a laminated iron core. ✓
The magnetic field expands outwards and collapses inwards cutting the secondary winding.
The relative movement between the magnetic field and the secondary winding results in an EMF being induced across the secondary winding. ✓
Lenz's law.
The process is due to mutual induction. ✓ (5)

8.3 8.3.1 The input power doubles (increase 100% -same amount) ✓

8.3.2 The current will also double (increase 100% -same amount) ✓

8.3.3 The voltage stays the same ✓

8.4 8.4.1

$$P_{OUT} = \sqrt{3} V_{L(S)} I_{L(S)} \cos \theta$$

$$I_{L(S)} = \frac{P_{OUT}}{\sqrt{3} V_{L(S)} \cos \theta} \quad \checkmark$$

$$= \frac{66 \times 10^3}{\sqrt{3} \times 380 \times 0.85} \quad \checkmark$$

$$= 117.97 \text{ A} \quad \checkmark \quad (3)$$

8.4.2

$$P_{OUT} = P_{IN}$$

$$P_{IN} = \sqrt{3} V_{L(P)} I_{L(P)} \cos \theta$$

$$I_{L(S)} = \frac{P_{IN}}{\sqrt{3} V_{L(P)} \cos \theta} \quad \checkmark$$

$$= \frac{66 \times 10^3}{\sqrt{3} \times 11000 \times 0.85} \quad \checkmark$$

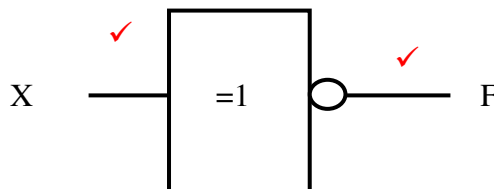
$$= 4.08 \text{ A} \quad \checkmark \quad (3)$$

Alternative method using Ratios and Phase Values is acceptable

[15]

QUESTION 9: LOGIC CONCEPTS AND PLCs

- 9.1 Sequencing of robots ✓
Control of machinery in factories ✓
Automation of machinery in assembly lines
(Any relevant answer) (2)
- 9.2 9.2.1 The program is written ✓ to memory from a device
(PC) ✓ OR The programme is stored here (2)
OR
(Function of the memory is to store the information ✓ it receives
during programming process ✓)
- 9.2.2 Execute ✓ the tasks (instructions program) ✓ that were written into (2)
memory.
OR
Process ✓ the information ✓
- 9.2.3 Connecting the input ✓ devices from the electrical circuits to the PLC. (2)
✓
OR
(The function of the input interface is to accept the input signal ✓ and
feed it into the PLC ✓)
- 9.3 Ladder logic (LL) ✓
Instruction list (IL) ✓
Logic block diagram (LBD) ✓ (3)
Flow Diagram
Function Blocks
Structured Text
- 9.4 9.4.1 NOT function ✓ (1)
- 9.4.2



Alternative symbols acceptable
Any two correct labels

(2)

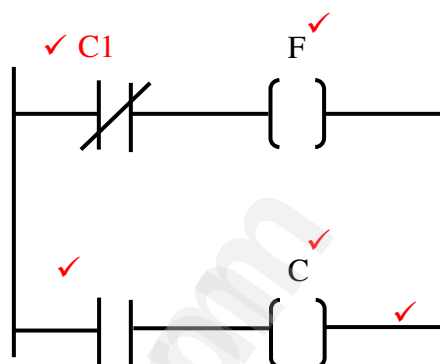
9.4.3

X	F
0	1 ✓
1	0 ✓

9.4.4

Start = I1
Relay Coil = C
Relay Contact = C1
Lamp = F

Can be interpreted either way
Different labelling techniques
Acceptable
Correct answer will receive full credit



(2)

(5)

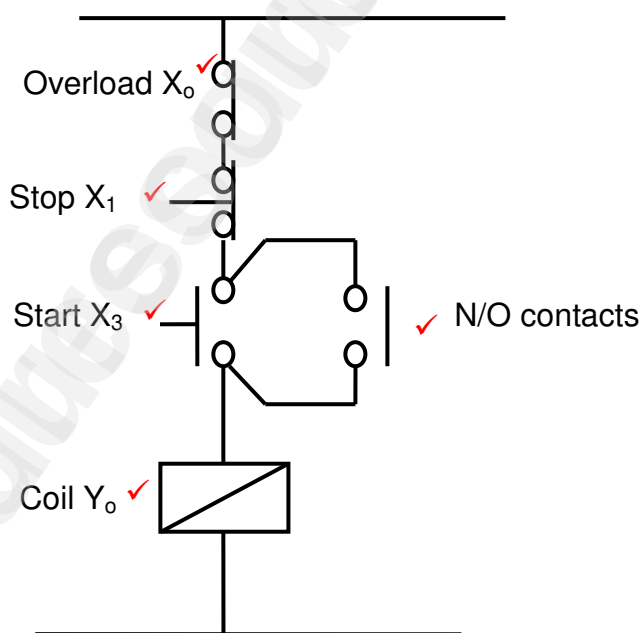
9.5

9.5.1

Direct online starter control circuit ✓
Holding Circuit

(1)

9.5.2



(6)

9.6

9.6.1

The design effort ✓ is simpler ✓ owing to fewer components and easy sequence planning.

(2)

9.6.2

Relay and timer ✓ problems are reduced. ✓
Fewer Moving Parts
Solid State

(2)

- 9.6.3 They are much more compact than a relay panel ✓. Mass production is possible by repeat of programs. ✓ (2)
(Compact – The device takes up less physical space – This has many advantages, reducing cost of manufacturing, using surface mount devices with automated manufacturing)
Standardised programming approaches and inter product compatability. Industry standards such as profibus etc.
- 9.7 Counter ✓
PLC (any other relevant answer) (1)
[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

- 10.1 Star connection ✓
Delta connection ✓ (2)
- 10.2 Insulation resistance between windings test. ✓
Insulation resistance to earth test. ✓
Short-circuit or open-circuit test. (3)
continuity test of the windings ✓
- 10.3 Is the cooling fan intact and turning freely but mounted securely on the motor shaft? ✓
Does the frame have any cracks or missing parts? ✓
Are the bearings noisy or feel rough when turning?
Is the motor mounted securely and are the bolts tightened properly?
End plates fastened properly? (Any two) (2)
- 10.4 By reversing/swapping the connections of any two of the supply lines to the stator. ✓ (1)
- 10.5 Large power range available ✓
Self-starting ✓
Higher starting torque
More efficient than single-phase motors
Physically smaller than single-phase motors for the same output (Any two) (2)
- 10.6 10.6.1 $P = \sqrt{3} V_L I_L \cos \theta$
 $I_L = \frac{P}{\sqrt{3} V_L \cos \theta}$ ✓
 $= \frac{17000}{\sqrt{3} \times 380 \times 0.8}$ ✓
 $= 32.29 \text{ A}$ ✓ (3)

$$\begin{aligned}
 10.6.2 \quad S &= \frac{P}{\cos \theta} \checkmark \\
 &= \frac{17000}{0.8} \checkmark \\
 &= 21.25 \text{ kVA} \checkmark
 \end{aligned}$$

OR

$$\begin{aligned}
 S &= \sqrt{3} \times V_L \times I_L \\
 &= \sqrt{3} \times 380 \times 32.29 \\
 &= 21.25 \text{ kVA}
 \end{aligned}$$

- 10.7 The casing of the motor is made from a conducting material, earthing it will activate protection under fault conditions $\checkmark$ preventing electric shock. $\checkmark$ (3)
- 10.8 Overload unit $\checkmark$
 No-volt coil $\checkmark$
 Emergency stop buttons $\checkmark$
 Circuit breakers
 Isolator switch
 MCB
 Fuse (3)
- (Any three)
- 10.9 Excessive current to the motor. $\checkmark$
 Motor not running on all three phases. $\checkmark$
 Motor used over long periods without switching and cooling off.
 Overloading the motor
 Insufficient ventilation (2)
 Over and under voltage condition
- (Any two)
- 10.10 Normally open contacts are contacts open in the de-energised state $\checkmark$ and closed in the energised state. $\checkmark$ (2)
- 10.11 Protect the fan from damage $\checkmark$
 Protect users from injuries $\checkmark$
 Force the air over the motor fins for cooling. (2)
 Take note that the Afrikaans version can be interpreted as an endplate!
- 10.12 The purpose of electrical switchgear is to safely distribute $\checkmark$ and control electrical energy and provide electrical protection $\checkmark$ as well protect the operator of the equipment. $\checkmark$ (3)

[30]**TOTAL: 200**