basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

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)

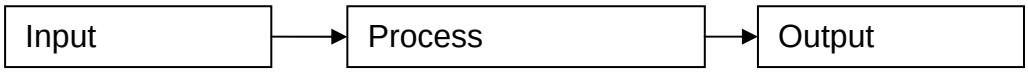
1.3 HIV, the virus that causes Aids, lives in human blood. Therefore, contact with an injured person with an open bleeding wound should be avoided, unless wearing approved surgical gloves. ✓ Bacterial Infection✓ To preotect yourself against infection. (2) **[10]**

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]**

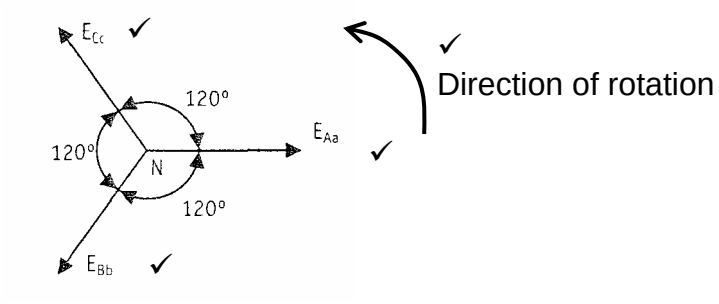
QUESTION 4: THREE-PHASE AC GENERATION

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

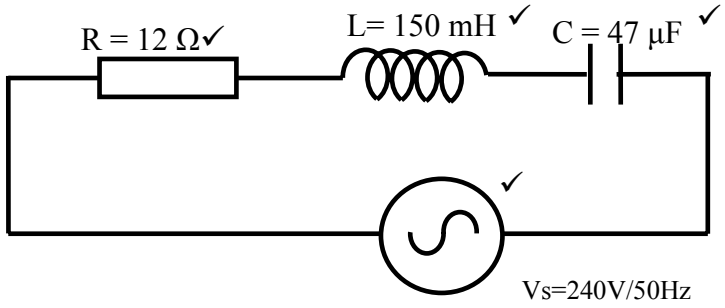
5.1 5.1.1 Leads (is ahead of) ✓ (1)

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

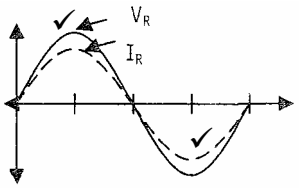
$$X_L = 2\pi FL \quad ✓$$

$$= 2x\pi x50x0.15 ✓$$

$$= \underline{47.12\ \Omega} \quad ✓$$

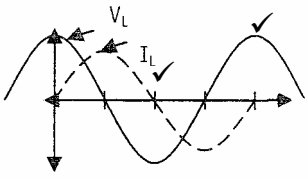
(3)

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)

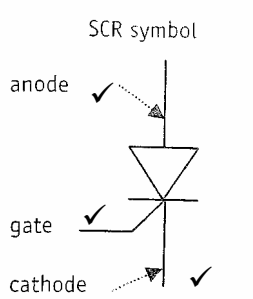
5.5.4

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

(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.

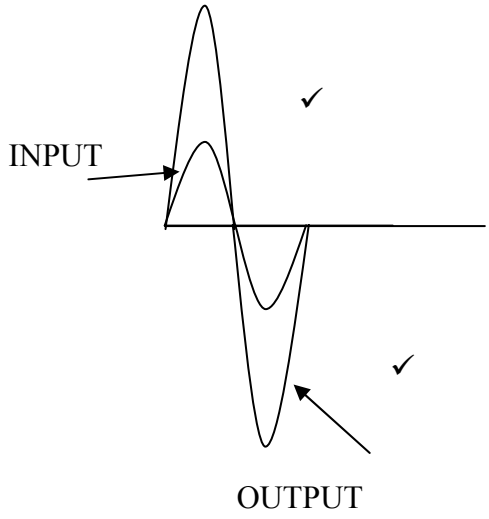
6.4 The current rating✓ expected to be controlled by the TRIAC as well as the duty cycle of the TRIAC✓. (2)
The operating voltage. **[25]**
Energy dissipated by the TRIAC.

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)

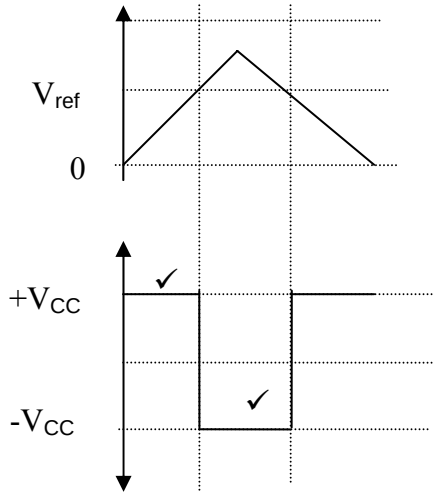
7.4 When an op-amp is utilised between stages it is used as a buffer amplifier✓ to adapt/match the impedance✓ between the stages. (2)

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

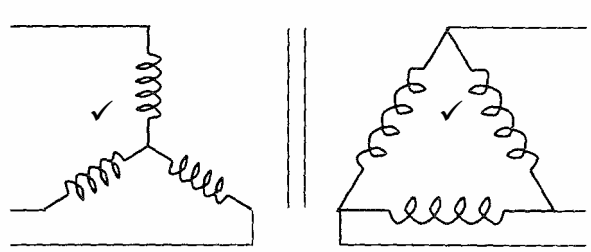


(2)
[25]

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)

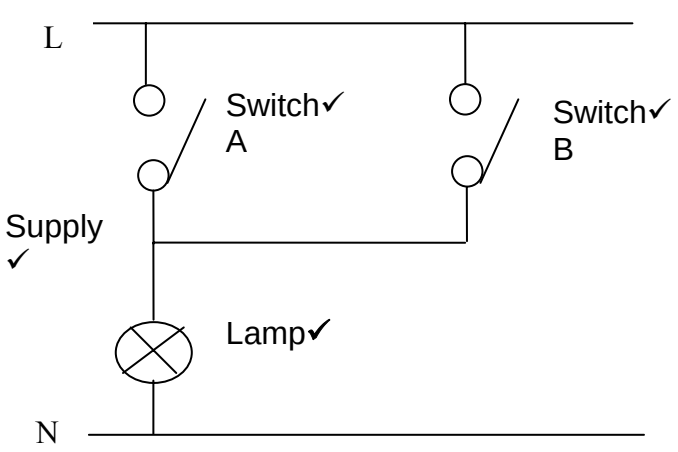
8.5.3 $$I_{LS} = \frac{S}{\sqrt{3}V_{LS}} \quad ✓$$
$$= \frac{250000}{\sqrt{3}x415} \quad ✓$$
$$= \underline{\underline{347.8\ A}} \quad ✓$$ (3)
[15]

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

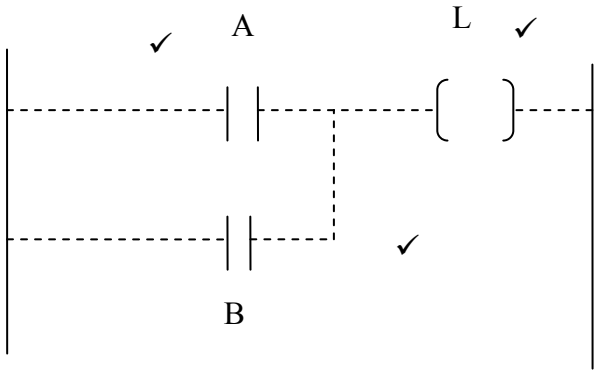
9.1 Economical, cheaper than relays ✓
Simplified design ✓
Quick delivery ✓
Compact and standardised
Improved reliability
Reduced maintenance (Any THREE) (3)

9.2 9.2.1



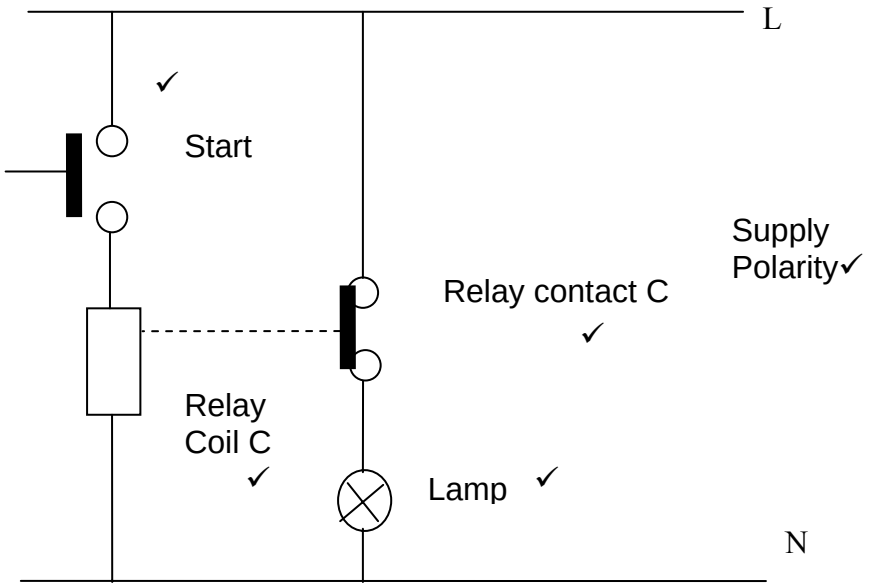
(4)

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)

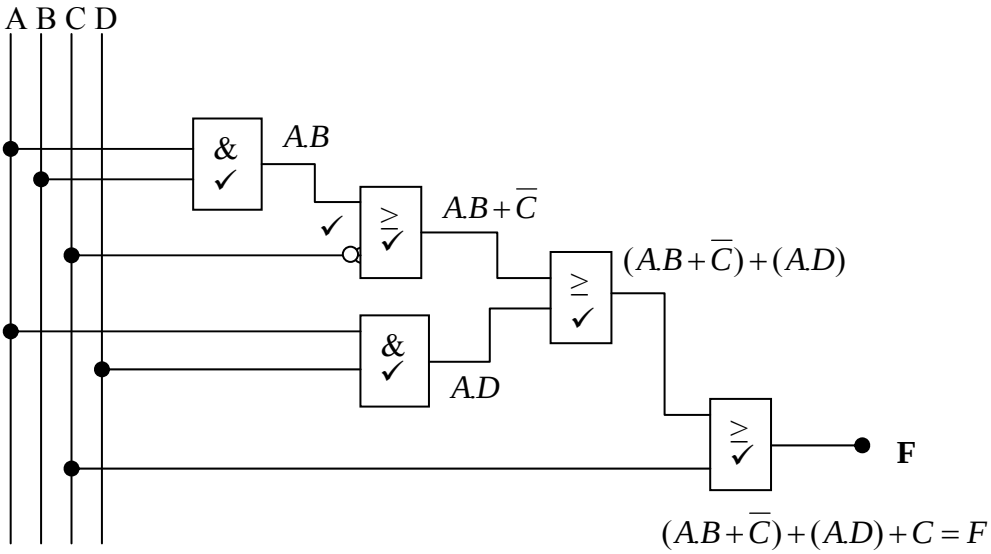
9.4.3 Internal relays/flags ✓also known as markers are used for internal ✓operations, memory and relay and are denoted by the suffix [M] (2)

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



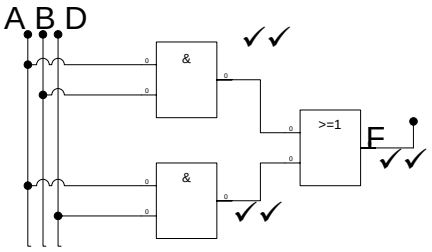
Or if The Learner simplified the expression

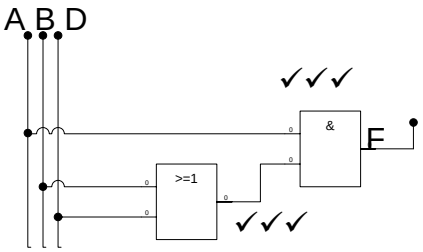
$(A.B+\overline{C})+(A.D)+C=F$

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

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

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





(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