basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

EXEMPLAR 2014

MEMORANDUM

MARKS: 200

This memorandum consists of 13 pages.

INSTRUCTIONS TO THE 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 formulae.

   2.2 Substitution of values must be done correctly.

   2.3 All answers MUST contain the correct unit to be considered.

   2.4 Alternative methods must be considered, provided that the same answer is obtained.

   2.5 Where an incorrect answer could be carried over to the next step, the first answer will be deemed 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 candidate should receive the full marks for subsequent calculations.

3. This 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: OCCUPATIONAL HEALTH AND SAFETY

1.1 Working on a live system with exposed conductors. ✓
Working with portable electric equipment that is not insulated correctly.
Using electrical machines without using the required safety equipment or clothing. (1)

1.2 Poor ventilation. ✓
Poor lighting (1)

1.3 First aid must be immediately given to any injured people. ✓
The situation must be immediately assessed and the person designated to deal with medical emergencies must be informed. (1)

1.4 If a workshop has no wheel-chair access, this will make it difficult ✓for people with physical disabilities to work in that workshop. This is an infringement of their right to ease of access. ✓ (2)

1.5 No person may enter or remain in a workplace under the influence of drugs as he may place himself and other persons✓ in danger while operating machinery.✓ It is unethical because it is an infringement of the right to work in a safe environment. (2)

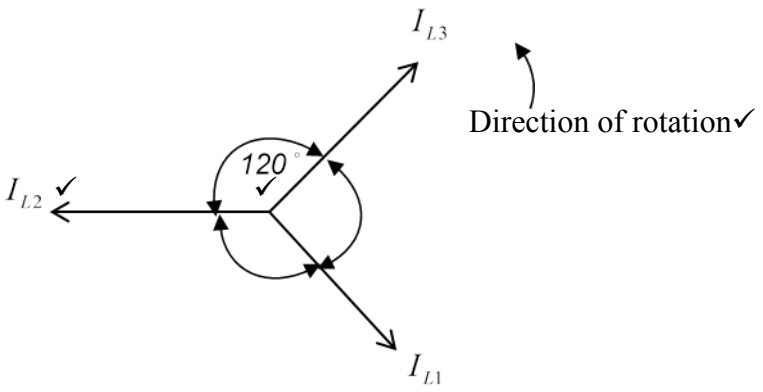
1.6 Risk analysis is a process that will inform workers ✓in the workshop about good housekeeping ✓ and safety practices ✓ improving the safety of all workers and equipment in the workshop. (3)
[10]

QUESTION 2: THREE-PHASE AC GENERATION 20

2.1 To measure the amount of power ✓ consumed by a consumer over a period of time ✓ (2)

2.2 For alternators of similar frame sizes, three-phase machines deliver a higher power than single-phase machines.✓
It is more versatile since, when connected in star, it can deliver both line and phase voltage.✓
Three-phase systems are easier to connect in parallel than single-phase systems. (2)

2.3



One mark for correct rotation direction
One mark for correct labelling of the phasor
One mark for mutual phase difference of 120° (3)

2.4 2.4.1

$$P = W_1 + W_2 \checkmark$$
$$= (4 + 17{,}5) \checkmark$$
$$= 21{,}5\,kW \checkmark$$

(3)

2.4.2

$$P = \sqrt{3} V_L I_L Cos\theta$$
$$I_L = \frac{P}{\sqrt{3} \times V_L \times Cos\theta}$$ ✓(One mark for the formula)
$$I_L = \frac{21500}{\sqrt{3}\ x\ 380\ x\ 0.8}$$ ✓
$$I_L = 40.83A$$ ✓

(3)

2.5 2.5.1

$$S = \sqrt{3}\ x\ V_L\ I_L$$
$$V_L = \frac{S}{\sqrt{3} x I_l} \checkmark$$
$$V_L = \frac{20\ x\ 1000}{\sqrt{3}\ x\ 25} \checkmark$$
$$= 461{,}9\ V \checkmark$$

(3)

2.5.2

$$V_L = \sqrt{3} \times V_{ph}$$
$$V_{ph} = \frac{V_L}{\sqrt{3}}$$ ✓
$$V_{ph} = \frac{461.9}{\sqrt{3}} \checkmark$$
$$= 266{,}7\,V \checkmark$$

OR

$$V_L = \sqrt{3} \times V_{ph} \checkmark$$
$$461.9 = \sqrt{3} \times V_{ph}$$
$$V_{ph} = \frac{461.9}{\sqrt{3}} \checkmark$$
$$= 266{,}7\,V \checkmark$$

(3)

2.6 Add a power factor correcting capacitor in parallel with the load. ✓
Make use of synchronous motors.
Make use of an AVR (Automatic Voltage Regulator) to assist in correcting the PF (Power Factor). (1)
[20]

QUESTION 3: THREE-PHASE TRANSFORMERS 20

3.1 Mutual induction✓
Electromagnetic induction between two coils. (1)

3.2 Constant overloading✓
Loose connections✓
Insufficient ventilation✓
Moisture in the oil (3)

3.3 Buchholtz relay✓ (1)

3.4 The breather allows the movement of air into and out of the reservoir tank. ✓ (1)

3.5 3.5.1 The resistance ✓ offered to the current ✓ flow in the windings. (2)

3.5.2 The quality of the iron which affects the hysteresis ✓ of the iron and eddy current ✓ flow in the iron. (2)

3.6 Calculate:

3.6.1 $V_{L(s)} = \sqrt{3}V_{ph}$

$V_{ph(s)} = \frac{V_{L(s)}}{\sqrt{3}}$ ✓

$= \frac{380}{\sqrt{3}}$ ✓

$= 219{,}39\ V$ ✓ (3)

3.6.2 $P = S\cos\theta$ ✓

$P = 200\,000 \times 0{,}85$ ✓

$P = 170\ kW$ (3)

3.6.3 $S = \sqrt{3}\, V_L\, I_L$

$$I_L = \frac{S}{\sqrt{3}\, V_L} \checkmark$$

$$= \frac{200\,000}{\sqrt{3}\, x\, 11000} \checkmark$$

$$= 10{,}5\ A \checkmark$$

(3)
[20]

QUESTION 4: THREE-PHASE MOTORS AND STARTERS

4.1 End plates✓
Stator✓
Rotor✓ (3)

4.2 It can only be used for relatively small induction motors whose starting currents do not require limitation. ✓
Very high starting current (typically 6 to 8 times the full load current of the motor).
Thermal stress on the motor, thereby reducing its life.
Unnecessary high starting torque, even when not required by the load, thereby increased mechanical stress on the mechanical systems such as rotor shaft, bearings, gearbox, coupling, chain drive, connected equipment, etc. leading to premature failure and plant down times. (1)

4.3 The number of poles✓
The frequency of the supply✓ (2)

4.4 Does the rotor turn freely or does something cause friction? ✓
Are the bearings squeaky or do they feel rough when the shaft is turned by hand? ✓
Is the motor mounted securely and are the bolts tightened properly? ✓
Is the cooling fan intact or do some of the fins appear chipped?
Are the endplates fastened properly?
Does the frame have any cracks? (3)

4.5 To start the motor safely ✓to protect both the motor and the operator✓ (2)

4.6 4.6.1
1- Overload unit ✓
2- N/C stop ✓
3- N/O start ✓
4- N/O main ✓
5- Neutral ✓ (5)

4.6.2 The function of the overload is to protect the motor under fault conditions✓ that result in the motor drawing in excess of the rated current ✓leading to possible damage of the motor. ✓ (3)

4.6.3 The motor is started in the star mode which reduces✓ the voltage across each phase✓ of the motor as in star $V_{PH} = \sqrt{3}\ V_L$. ✓ As the voltage across each phase is reduced, the current in each phase will also be reduced. ✓ (4)

4.6.4 The N/O start will be depressed. ✓
This will energise the contactor C_M and C_T .✓
The N/O_M will now close keeping both C_M and C_T energised. ✓
The N/C_T will remain closed as the timer is timing through. ✓
The N/C_Δ will still be closed as the delta contactor is not yet energised. ✓
This results in a complete circuit to the star coil energising the coil. ✓
This results in the motor starting in star. ✓
The timer will now time through opening the N/C_T contacts removing power from the star coil. ✓
The N/O_T will close after the timer has timed through and with the N/C_Y now closing because the star contactor is now de-energised. ✓
The delta path will be complete energising the delta contactor switching the motor into the delta mode. ✓ (10)

4.7
- When the motor is connected across an alternating supply, alternating currents will flow in the stator windings. ✓
- The alternating currents will set up a rotating magnetic field in and around the stator windings. ✓
- This rotating magnetic field will sweep across the rotor conductors of the squirrel cage rotor. ✓
- As the magnetic field sweeps over the rotor conductors the magnetic lines of flux cut the rotor conductors. ✓
- This induces an EMF across the rotor conductors due to Lenz's law. ✓
- This sets up currents in the rotor conducts which creates a rotating magnetic field in and around the rotor. ✓
- The two magnetic fields interact causing a force to be exerted between them resulting in the rotor to rotating. ✓ (7)

[40]

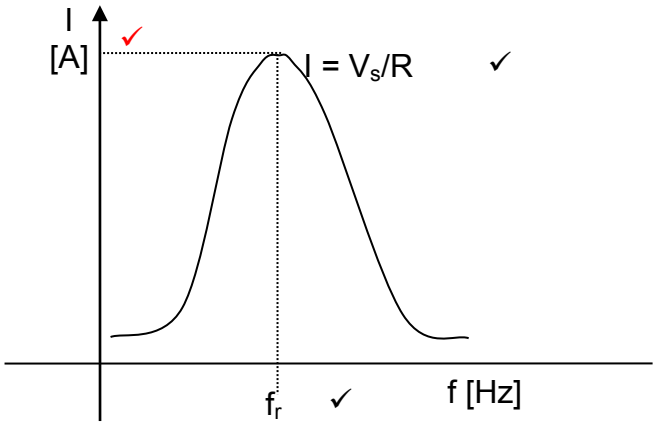
QUESTION 5: RLC

5.1 Impedance is the total opposition offered to the flow of current✓ by the resultant of the reactance and the resistance ✓of a circuit when the circuit is connected across an alternating voltage supply. ✓ (3)

5.2 When the frequency is increased, the inductive reactance will increase✓ thus increasing the impedance ✓of the circuit and reducing the current flowing through the circuit and hence the brightness of the lamp. ✓ (3)

5.3 The Q-factor is the voltage magnification ✓that occurs in a series RLC when the circuit is at resonant frequency. ✓ (2)

5.4



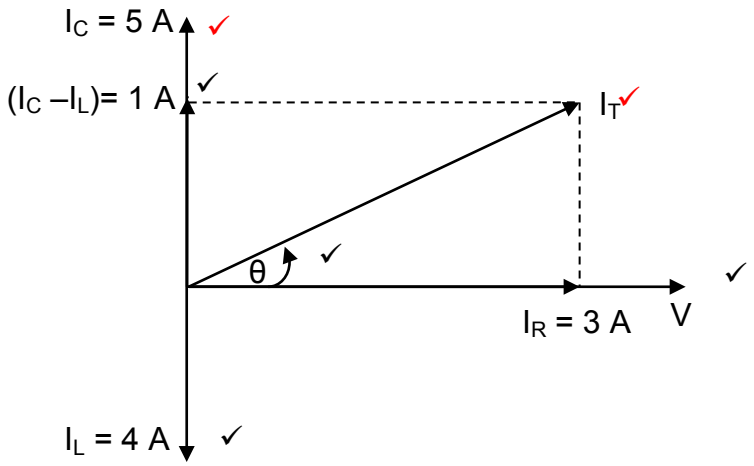
(3)

5.5 5.5.1

$$I_T = \sqrt{I_R^2 + (I_C - I_L)^2} \quad ✓$$
$$= \sqrt{3^2 + (5-4)^2} \quad ✓$$
$$= 3{,}16\ A \quad ✓$$

(3)

5.5.2

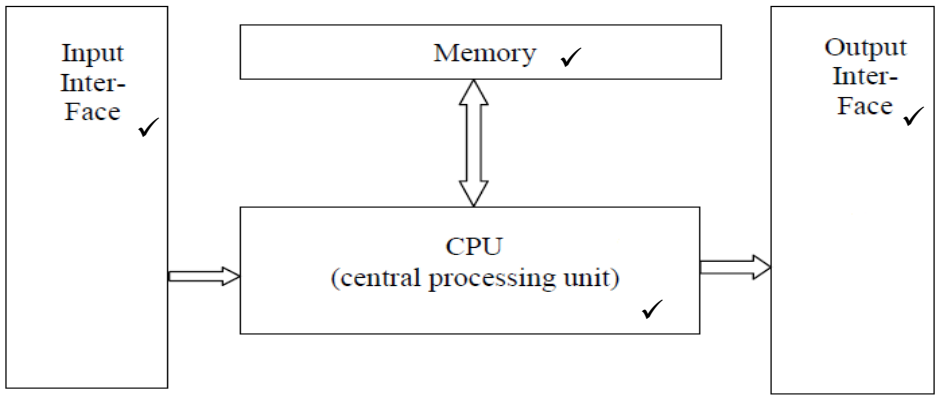


(6)
[20]

QUESTION 6: LOGIC

6.1 6.1.1 Programmable Logic Controller✓ (1)

6.1.2



(4)

6.1.3 It improved on hard-wired relay based systems.✓ (1)

6.1.4 Economical✓
Simplified design
Quick delivery
Compact and standardised
Improved reliability
Reduced maintenance (Any THREE) (3)

6.1.5 Relays or contactors✓ or
Thyristor control (solid state)
Any low current device (1)

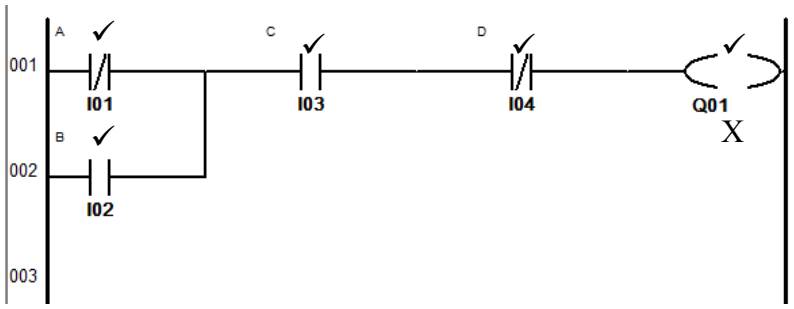
6.1.6 Ladder logic✓
Instruction list ✓and
Logic block diagram/Functional blocks (3)

6.2 6.2.1

✓✓✓✓✓

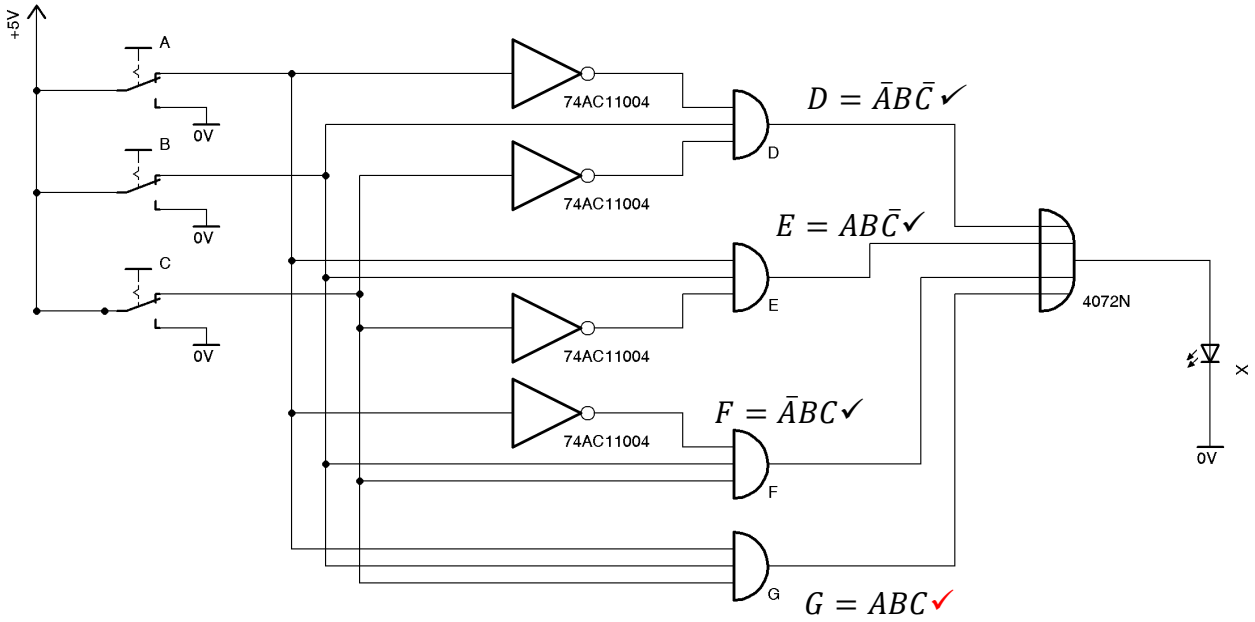
$X = (A + \bar{B}).\bar{C}D$ (5)

6.2.2



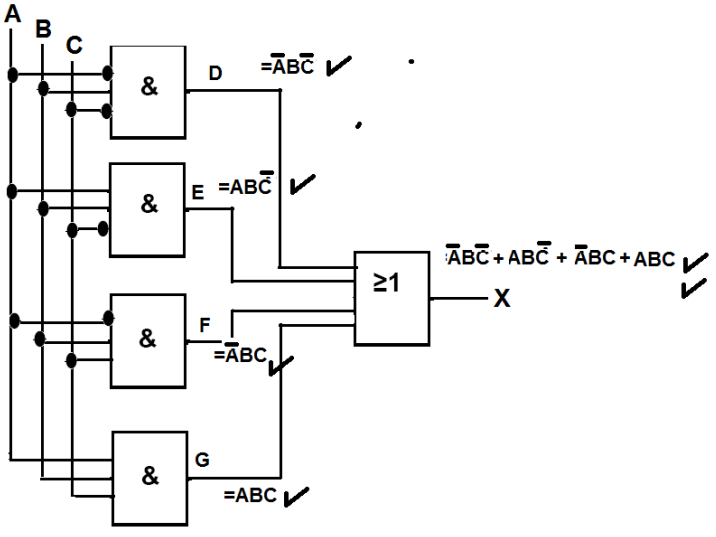
(5)

6.3



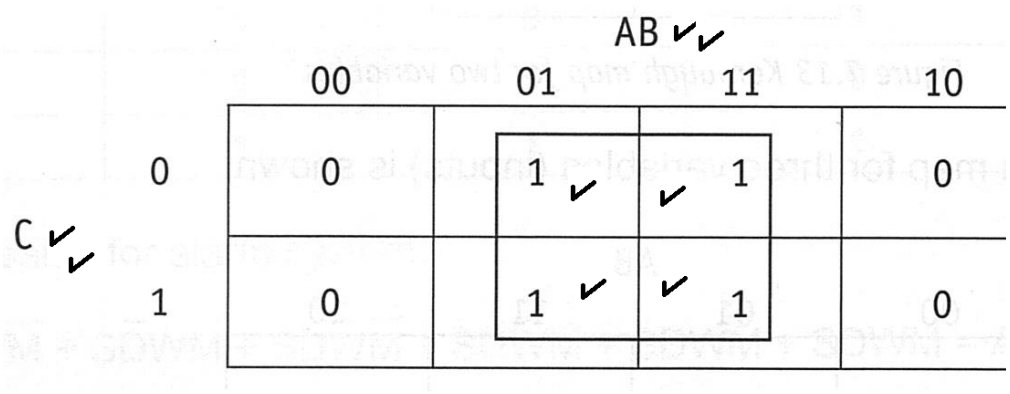
$X = \bar{A}B\bar{C} + AB\bar{C} + \bar{A}BC + ABC$ ✓✓

OR



(6)

6.4



(8)

6.5 A timer function is used to set and control ✓ the PLC program according to daily, weekly or yearly pre-set timing. ✓ The PLC will execute a task based on timing like switching the outside lights on automatically at dusk. ✓ (3)

[40]

QUESTION 7: AMPLIFIERS

7.1 Open-loop voltage gain A_V = infinite ✓
Input impedance Z_{in} . = infinite ✓
Output impedance Z_0 = zero
Bandwidth = infinite
Unconditional stability
Differential inputs, i.e. two inputs
Infinite common-mode rejection (Any TWO) (2)

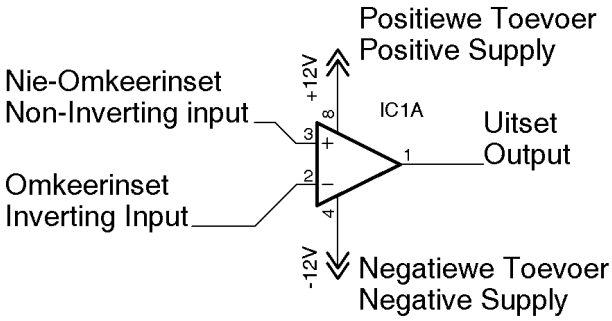
7.2 The dual DC supply supplies energy to the op amp to amplify an input signal. ✓ It allows the op amp to operate with a positive and negative supply (+Vcc and –Vcc). ✓ (4)

7.3 Feedback is obtained when the output signal ✓of an amplifier circuit is fed back to the input of the circuit. ✓ Negative feedback is achieved when the signal is fed back to the input, out of phase with the input signal✓, thus reducing the gain of the circuit. In effect the feedback signal is subtracted from the input signal. (3)

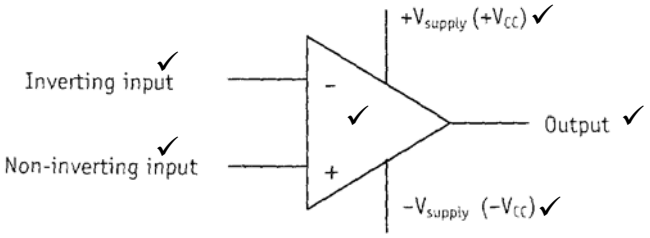
7.4 The bandwidth is increased. ✓
The level of noise (hiss) is decreased. ✓
The gain is decreased.
The deformation of the input signal is reduced. (2)

7.5 The bandwidth is the range of frequencies ✓ an amplifier can amplify without distorting ✓ the output signal or losing gain. (2)

7.6



OR



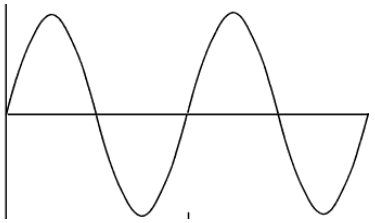
(6)

7.7 7.7.1 Non-inverting op-amp ✓ (1)

7.7.2

✓

OR



✓

(Must be in phase with input signal) (1)

7.7.3 The gain will also increase✓ (1)

7.7.4 The circuit in FIGURE 7.1 makes use of negative feedback.✓
By increasing the feedback resistor, the feedback signal fed back to the non-inverting input is reduced, thus reducing the negative feedback.✓
As the negative feedback is reduced, the gain of the circuit is increased.✓ (3)

7.8 7.8.1

$$A_V = -\frac{R_f}{R_{in}} \checkmark$$

$$= -\frac{10}{5} \checkmark$$

$$= -2 \checkmark$$

(3)

7.8.2

$$A_V = -\frac{V_{outf}}{V_{in}} \checkmark$$

$$\square\ V_{out} = -A_V V_{in}$$

$$= -2 \times 1 \checkmark$$

$$= -2V \checkmark$$

(3)

7.9 7.9.1 Summing amplifier✓ (1)

7.9.2 The inverting amplifier is often used as a mixer in audio circuits ✓ when more than one signal is applied to the input simultaneously. ✓ The output then becomes the sum of these input signals, from a microphone, an electric guitar or a keyboard. ✓ (3)

7.9.3

$$V_{out} = -(V_1 + V_2 + V_3) \checkmark$$

$$= -(2 + -1 + 3) \checkmark$$

$$= -4V \checkmark$$

(3)

7.10 7.10.1 R_1 and R_2 provide positive feedback to the non-inverting terminal ✓ causing the output to remain at its state✓ until the inverting terminal receives a pulse to change the state of the output✓ and they again provide feedback to remain in its state. (3)

7.10.2 The input capacitors firstly act as decouplers to decouple the DC from the input stage to the amplifier, ✓ only passing changes in input voltage. ✓
Incoming wave signals are therefore converted into short pulses. ✓ The capacitors are then used to trigger the op amp to change between its two saturation states. ✓ (4)

7.10.3 It has two stable states,✓ one positive✓ and one negative✓ saturation states i.e. High and Low/Set and Reset. (3)

[50]

TOTAL: 200