ET 6 - Electrician Theory Examination
Marking Schedule

Note: (1 mark) means that the preceding statement earns 1 mark.

This schedule sets out the expected answers to the examination questions. The marker can exercise their discretion and decide on the overall adequacy of any answer that is presented in the candidate's own words.

QUESTION 1

(Each part of question 1 is worth 1 mark)

(a)
- To ensure it has not frozen closed (½ mark if the term "frozen" is only used)

or
- To ensure trip mechanism operates

(b) Any TWO of:

- Thermal or bi-metal strips
- Magnetic
- Combined thermal/magnetic

(c) Low impedance causing large current flow, meter protection should operate. Meter inoperable or similar (½ mark only).

(d) Any TWO:

- Steam turbine
- Petrol motor
- Water turbine
- Diesel motor
- Gas turbine
- Wind turbine
- Francis turbine
- Kaplan turbine
- Pelton turbine

(e) Any TWO of:

- Low torque
- Cost effective
- Quiet operation
- Can be stalled

or similar

(f) The speed of rotation is increased.

(g) Change the connections to either the armature (or brush connections) or the field winding but not both.

(h) Connect a suitable discharge resistor or suitable voltmeter across the capacitor terminals or similar.

(i) ● To disconnect the supply if one phase is lost.
or
● To prevent damage to motor if one phase is lost.

(j) 120 degrees

(k) The difference between synchronous speed and rotor speed.

(l) Any TWO of:

- Ensure all stays are in place.
- Ensure it has a firm footing (or on a level surface).
- Do not work from top of ladder.
- Another person steadies the ladder when working near the top.

(m) Change the connections to either the start winding or the run winding but not both.

(n) The CT secondary must be short-circuited.

(o) Any ONE of:

- Reduction or elimination of neutral currents.
- Better utilisation efficiency of equipment.
- Reduction of volt-drop in the supply.

(p) Maximum voltage applied to the device in the reverse bias position.

(q) 400 V
230 V

(r) ● An internal centrifugal switch
or
● An external relay

disconnects the start winding.

(s) Any TWO of:

- Earth rod
- Buried conductors or earth mat
- Metallic reinforcing.

(t) Any ONE of:

- High starting current/reduce starting current
- Permit installation of a smaller cable
- Smaller transformer size
- Mechanical shock
- Reduce the effect of volt drop on the system.

QUESTION 2

(a) (i) $V_{ph} = V_L \div \sqrt{3} = 400 \div \sqrt{3}$ (½ mark)

$= 231V$ (½ mark)

$I_{fault} = V \div R = 231 \div 8$ (½ mark)

$= 28.88A$ (½ mark)

$I_{total} = I_{fault} + I_{load} = 28.88 + 20$ (½ mark)

$= 48.88A$ (½ mark)

(ii) The 32A fuses have a fusing factor (gG Utilisation Category) of 1.5
Fusing current = 1.5 x 32 = 48A (1 mark)

Total current is 48.88, which is more than the fusing current 48A (½ mark)

The fuses will blow (½ mark)

(b) (i) $I_{fault} = 230 \div (12 + 8)$ (½ mark)

$= 11.5A$ (½ mark)

$I_{total} = I_{fault} + I_{load} = 11.5 + 20$ (½ mark)

$= 31.5A$ (½ mark)

(ii) Total current is 31.5A, which is less than the fusing current 48A. The fuse will not blow.
Or
Total current is 31.5A, which is less than the rated current 32A. The fuse will not blow. (1 mark)

Vd across Earth conductor equals shock voltage

$Vd_E = I \times R = 11.5 \times 12$ (½ mark)

$= 138V$ (½ mark)

Electric shock hazard of 138V frame to earth exists

(1 mark)

Question 3

(a) Note that an advantage of one can be the disadvantage of the other and vice versa

Protection Device	Advantages	Disadvantages
(i) Miniature circuit breaker	Any TWO: * easy to reset * provides thermal and magnetic protection * current rating cannot be interfered with * multi-pole device, fault on one phase will disconnect all three	Any TWO: * not very fast operating speeds * must wait to reset for thermal * fixed fusing factor * nuisance tripping (in older models) * mechanical mechanism could fail
(ii) HRC fuse	Any TWO: * good discrimination * good back-up protection * fast operation * range of utilisation categories (fusing factor) * higher rupturing capacity	Any TWO: * not easy to see if it has operated * many different physical sizes available * difficult to discern rating, particularly if been in service for some time

(4 marks)

(b) Any TWO of:

- If the fuse blows again an arc may be established between the fuse terminals causing damage or injury
- Fuse wire does not have the same Utilisation category (fusing factor) as the HRC fuse
- Cannot safely interrupt short circuit currents of much higher values.
- Fuse wire may protrude past the holder which creates an exposure to shock.
- Suitable fixing for the fuse wire is <u>not</u> generally available.
- Fuse holder is not fire proof.
- Cannot provide "close" protection.
- Cannot ensure reliable operation within prescribed limits.
- Poor discrimination.
- Fusing characteristics not constant.
- Slower operation/acting.
- Deteriorates over time.

(2 marks)

(c) (i) Small overload: A small overload:

- causes a bi-metal to heat up and bend,

(1 mark)

- operating a trip mechanism that

(1 mark)

disconnects the circuit

(ii) Short circuit. A larger overload:

- causes a strong magnetic field

(1 mark)

- which attracts a trip mechanism

(1 mark)

that disconnects the circuit rapidly

QUESTION 4

(a) (i) Any ONE of:

- Ensures adequate earthing connections
- To test the impedance of the fault circuit
- Determine the level of prospective short-circuit current at the point of test.
- Determine whether the protection is correctly rated for the circuit (K rating)
- Determine if the protection will operate within the required time.

(1 mark)

(ii) Any ONE of:

- A single-phase plug from the tester is plugged into a socket outlet.
- Phase is connected to phase, neutral is connected to neutral and earth is connected to earth.
- Phase is connected to phase and earth is connected to earth.

(1 mark)

(b) (i) To prove the RCD operates within the specified current and time limits.

(1 mark)

(ii) Plug the RCD into a socket outlet and the RCD tester into the RCD being tested.

(1 mark)

(c) Both tests are carried out on live circuits

(1 mark)

(d) (i) Prove the meter works on a known source

(1 mark)

Test the circuit for isolation

(1 mark)

Prove the meter works on a known source

(1 mark)

(Total 3 marks)

(ii) Because it proves the meter works before and after testing for isolation

(1 mark)

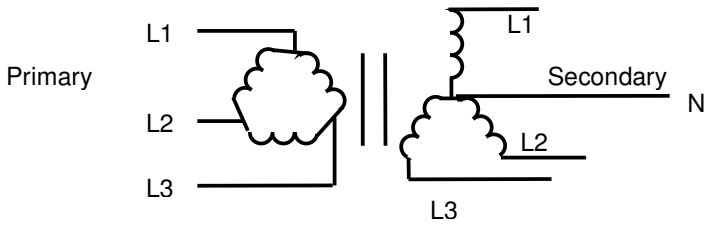
and that the circuit is isolated

(1 mark)

(Total 2 marks)

QUESTION 5

(a)



- Correct delta and lines (1 mark)
- Correct star and lines (1 mark)

(b) $N_s \div N_p = V_s \div V_p$

$V_s = N_s \times V_p \div N_p$ (½ mark)

$= 1 \times 11000 \div 47.8$ (½ mark)

$= 230.13V$ or $230V$ (1 mark)

(c) $V_1 = V_{ph} \times \sqrt{3}$ (½ mark)

$= 230 \times \sqrt{3}$ (½ mark)

$= 398.6V$ or $400V$ (1 mark)

(d) $VA = V_1 \times I_L \times \sqrt{3}$

$I_L = VA \div (V_1 \times \sqrt{3})$ (½ mark)

$= 15000 \div (11000 \times \sqrt{3})$ (½ mark)

$= 7.87A$ (1 mark)

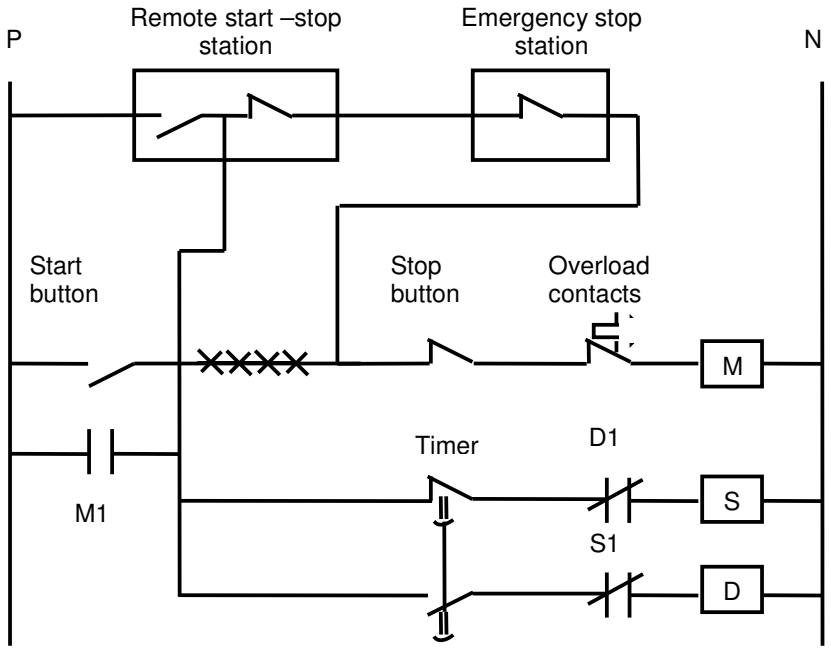
(e) $I_L = VA \div (V_1 \times \sqrt{3})$ (½ mark)

$= 15000 \div (398.6 \times \sqrt{3})$
or
$15000 \div (400 \times \sqrt{3})$ (½ mark)

$= 217.27A$ or $216A$ (1 mark)

QUESTION 6

(a)



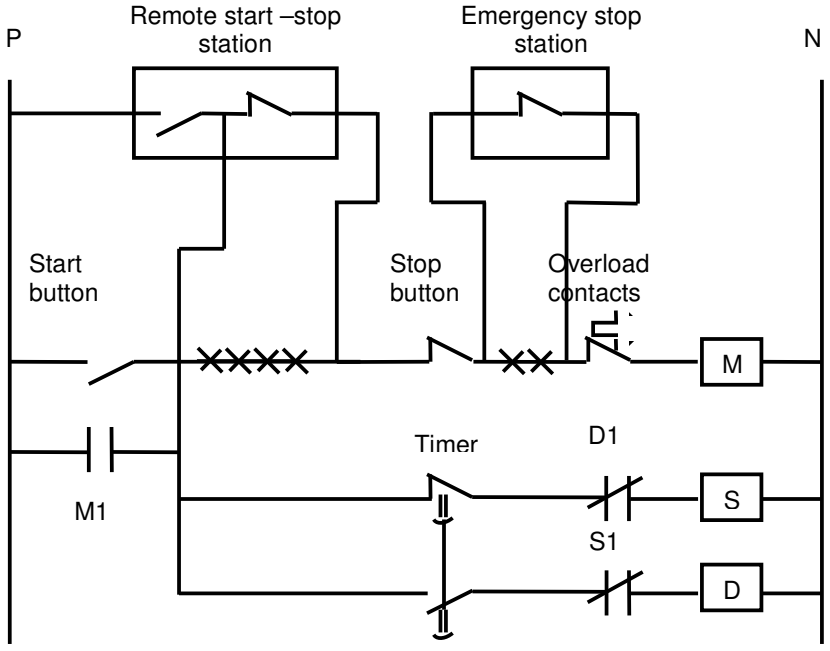
- ½ mark each for four correctly connected conductors
- 1 mark for a removing the correct conductor

Note: 1 Candidates receive no marks if the circuit shows a short circuit between P and N or is dangerous

2. Marks can be awarded for a circuit that does not work, but parts are correctly connected.

(3 marks)

Alternative solution



(b) (i) The input power:

Eff. = output/input

Input = output/eff. = 6/0.8

(½ mark)

= 7.5 kW

(½ mark)

(ii) The input kVA:

kVA = kW /PF = 7.5/0.75

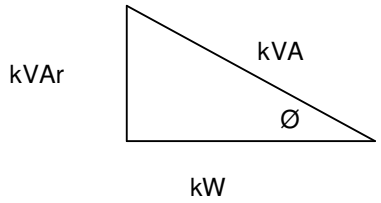
(½ mark)

= 10 kVA

(½ mark)

Alternative solution

Power factor = 0.75 = Cos Ø = 41^0.4'



Cos Ø = kW ÷ kVA

KVA = kW ÷ Cos Ø

= 7.5 kW ÷ 0.75

= 10 kVA

(iii) The input kVAr:

kVAr = $\sqrt{kVA^2 - kW^2}$

(½ mark)

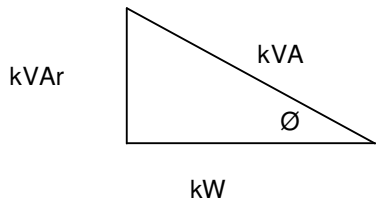
= $\sqrt{10^2 - 7.5^2}$

(½ mark)

= 6.6 kVAr

(1 mark)

Alternative solution



Tan Ø = kVAr ÷ kW

kVAr = Tan Ø x 7.5 kW

= 0.8816 x 7.5kW

= 6.612.kVAr

(iv) The phase angle:

$PF = \cos \Phi$

$\Phi = \cos^{-1} PF$

$\Phi = \cos^{-1} \times 0.75$

(½ mark)

$= 41.4°$

(½ mark)

(v) The line current:

$P = \sqrt{3}\, V_L\, I_L\, PF$

(½ mark)

$I_L = \dfrac{P}{\sqrt{3}\, V_L\, PF}$

(½ mark)

$I_L = \dfrac{7500}{\sqrt{3} \times 400 \times 0.75}$

(½ mark)

$I_L = 14.43\ A$

(½ mark)

QUESTION 7

(a) (i) 50 Hz

(1 mark)

(ii) N_s = f x 60 ÷ pp

(½ mark)

= 50 x 60 ÷ 2

(½ mark)

= 1500 rpm

(1 mark)

(iii) f = N_s x pp ÷ 60

(½ mark)

= 0.5 x 1500 x 2 ÷ 60

(½ mark)

= 2.5 Hz

(1 mark)

(iv) Pf = 400 x18 x √3 x 0.8

(½ mark)

= 9976 W

(½ mark)

Eff = output x 100 ÷ input

= 7500 ÷ 9976

(½ mark)

= 75%

(½ mark)

(b) I_{ph} = I_L ÷ √3 = 90 ÷ √3

(½ mark)

= 52 A

(½ mark)

Delta/star ratio

= D ÷ S = 400 ÷ 230 = I_{ph}

(½ mark)

= Delta I_{Ph} ÷ Delta/star ration

= 52 ÷ √3

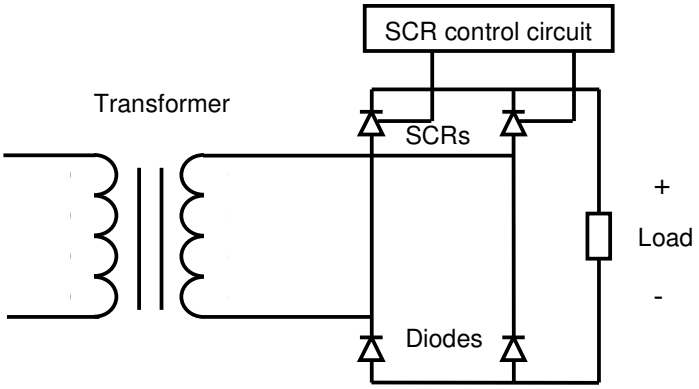
(½ mark)

= 30 A

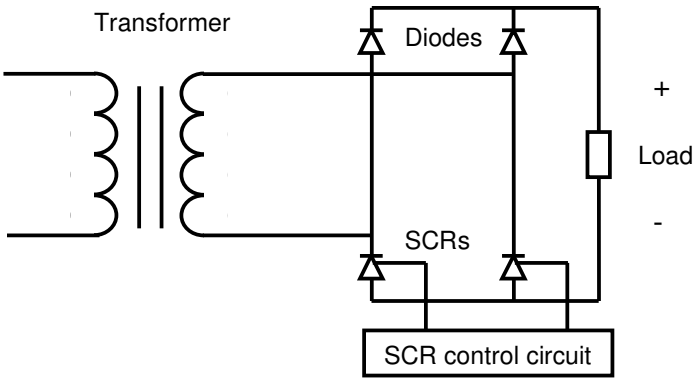
(1 mark)

QUESTION 8

(a) (i)

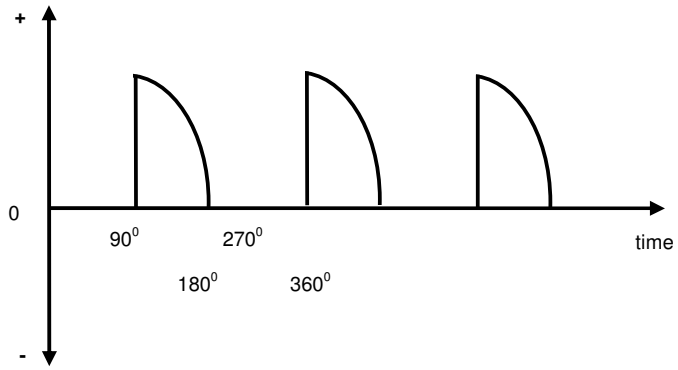


or



- Correctly connected transformer (1 mark)
- Correctly working bridge (2 marks)
- Load correctly connected (½ mark)
- Control circuit correctly connected (½ mark)

(ii)



- Correct shape, proportion and identical spacing

(2 marks)

or

- Correct shape and labelling

(2 marks)

(b) Any TWO:

- inductor
- capacitor
- resistor

(2 marks)

(c) Any TWO:

- current drops to zero
- current drops to less than holding current
- remove anode to cathode voltage.

(2 marks)

QUESTION 9

(a)
- Sufficient Light
- Not too bright (or glare)
- Uniform light (or glare)
- Correct colour

(2 marks)

(b) (i) Sodium Vapour

Application: Street lighting; security lighting etc.

(½ mark)

Reason: Any application where long lamp life and high efficacy are important and good colour rendition is not important.

(1½ marks)

(ii) Metal halide

Application: Sports grounds; factories; gymnasium, car parks

(½ mark)

Reason: Any application where long lamp life, high efficacy and good colour rendition are important.

(1½ marks)

(c) Any TWO of:

- Do not touch with naked finger
- Install in horizontal position only
- Do not cause excessive vibration

(2 marks)

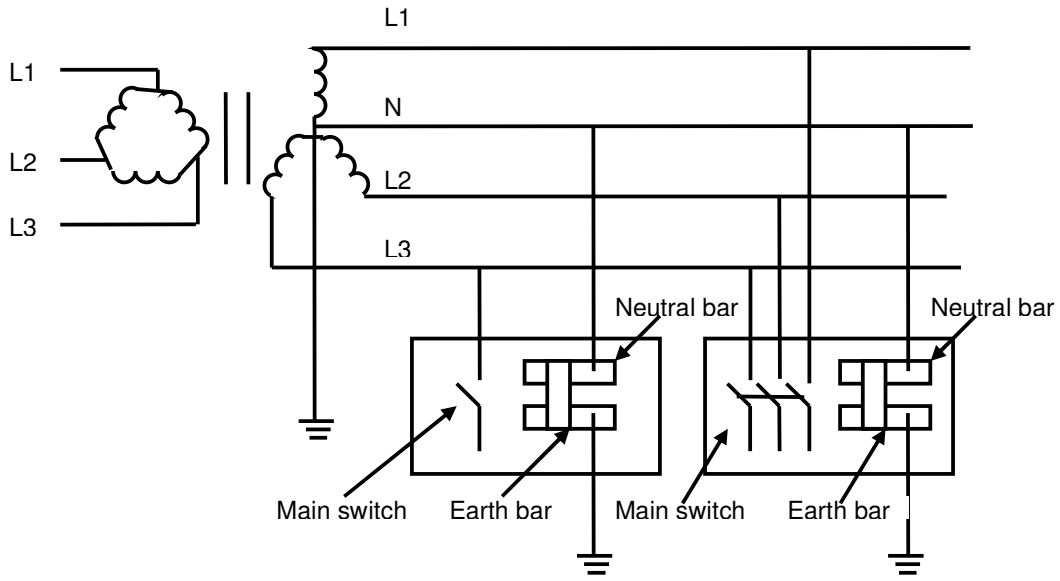
(d) Any ONE of:

- Flicker of the lamp can make rotating machinery appear stationary
- Due to stroboscopic effect

(2 marks)

QUESTION 10

(a)



Delta-star connected 11kV / 400V supply transformer including output lines

(1 mark)

Single-phase consumer including main switch and neutral and earth bar connections.

(1½ marks)

Three-phase consumer including main switch and neutral and earth bar connections.

(1½ marks)

All earthing arrangements.

(1 mark)
(Total 5 marks)

(b) Any THREE of:

- Low overall fault impedance.
- Limit of 230 V shock hazard to earth.
- Fewer conductors (no earth required for mains and distribution).
- Encourages high fault currents
- Two voltages
- Single, two and three-phase

(3 marks)

(c) • An MEN switchboard has an MEN link between the neutral and earth busbars

or

- A distribution switchboard does not have an MEN link between the neutral and earth busbars.

(1 mark)

(d) MEN switchboard

(1 mark)