ET 11 - Electrician Theory Examination
Marking Schedule

Notes:1. (1 mark) means that the preceding statement/answer earns 1 mark.

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

3. Symbols and terms - alternatives

Power	W or P
Voltage	V or E or U
Phase	Active

QUESTION 1

(Each part of question 1 is worth 1 mark)

(a) (i) Any ONE of:

- 220 kV
- 110 kV
- 66 kV
- 50 kV
- 33 kV

(½ mark)

(ii) Any ONE of:

- 33 kV
- 22 kV
- 11.kV
- 400 V
- 230 V

(½ mark)

(b) $\%\ \text{slip} = \frac{Ns - Nr}{Ns} \times \frac{100}{1}$

(c) Any ONE of:

- To sense the temperature rise in the motor windings.
- To operate the protection due to a temperature rise in the motor windings

(d) Any machinery where reverse operation may cause harm to people or damage to property, for example:

- Compressor
- Conveyor belt
- Circular saw
- Hoist

(e)
- To limit the current flowing through the electrode and tube.
- To produce a high voltage when the starter opens to start the tube glowing.

(f) 120°

(g) 3 kW

(h)
- To increase the leading phase displacement of start winding current.
- To increase starting torque

(i) Any ONE of:

- The neutral ensures a low impedance fault loop on an earth fault.
- The lower the resistance of the fault circuit, the higher the fault current and the more reliable the operation of protection equipment (fuses and circuit breakers).
- Limits the voltage to 230 V to earth.
- Mass of earth provides an alternative return path for the current if neutral is lost.
- Limit the potential to earth under fault conditions.

(j) Any ONE of:

- The lamp does not start.
- The lamp only glows at the ends.
- The lamp does not strike.

(k) Any ONE of:

- Slip ring motor
- Wound rotor induction motor

(l) It must be connected to the main earthing terminal in the main switchboard.

(m) Open.

(n)
- To produce a more even torque.
- To produce a quieter running motor.

(o) The ripple frequency is 300 Hz.

(p) Any ONE of:

- Fire hazard.
- Danger to persons.
- Explosion.

(q) Any ONE of:

- 50% of full load torque
- Half of the torque produced DOL.

(r) The copper ring (shading ring or shaded ring) or the rotor

(s) Any ONE of:

- To prevent dangerously high voltages being induced in the open-circuited secondary.
- To preserve the accuracy of the CTs.

(t)
- The ripple amplitude is less
- The ripple frequency is greater.

QUESTION 2

(a) (i) I_{fault} = 230 ÷ (11 + 5.7)

(½ mark)

= 13.77A

(½ mark)

I_{total} = I_{fault} + I_{load} = 13.77 + 40

(½ mark)

= 53.77A

(½ mark)

(ii) The 45A fuses have a fusing factor (gG Utilisation Category) of 1.5
Fusing current = 1.5 x 45 = 67.5 A

(½ mark)

Total current is 53.77A, which is less than the fusing current 67.5A

(½ mark)

The fuse will not operate within the minimum disconnection time.

(1 mark)

(iii) Vd across Earth conductor equals shock voltage

Vd_E = I x R = 13.77 x 5.7

(½ mark)

= 78.49V

(½ mark)

Electric shock hazard of 79.48V frame to earth exists

(1 mark)

(b)
- Earth resistance is very low.
- No potential difference can develop across the protective earthing conductor.
- Therefore the appliance frame is held at minimal voltage and no shock hazard exists.
- Ensure protection will operate.

(4 marks)

QUESTION 3

(a)
- When a fault occurs the protective device ("minor" device) nearest the fault operates.
- Before any other protective device ("major" device).

(2 marks)

(b) 60A The maximum current the fuse can continuously carry without overheating the fuse link and causing deterioration.

440V The maximum voltage the fuse can safely withstand across it, without flashover.

AC40. This indicates the maximum fault current the fuse can interrupt.

(3 marks)

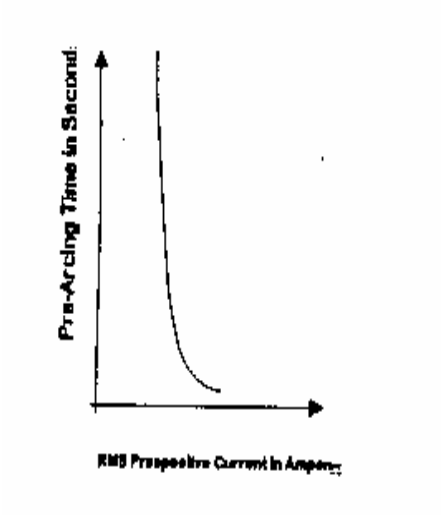
(c) When a protective device cannot withstand the prospective short circuit current, it must be backed-up by a device which can.

(2 marks)

(d) As current through a fuse or circuit breaker increases beyond its current rating, the time taken to operate decreases.

(2 marks)

(e)



(1 mark)

QUESTION 4

(a)
- Imbalance between the phase and neutral currents. (1 mark)
- A magnetic field is induced into the iron core. (1 mark)
- The induced magnetic field induces a current in the sensing coil (1 mark)
- The tripping coil is energised, isolating the circuit (1 mark)

(b) 30 milliamps (1 mark)

(c) Because the RCD limits the time a current can flow through a body. (2 marks)

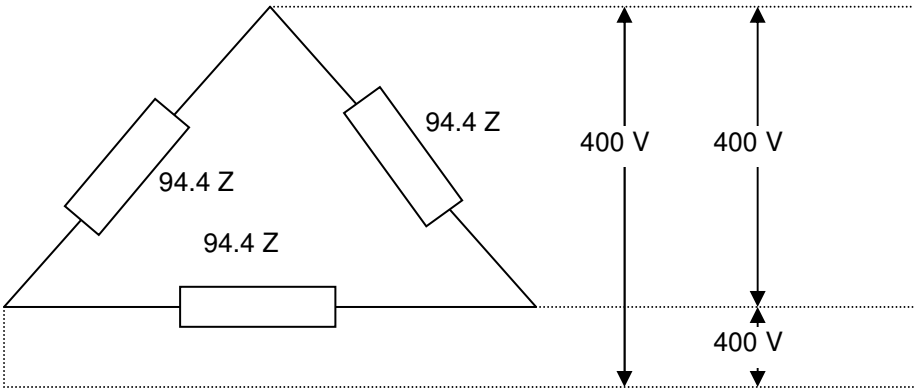
(d) The RCCB does not provide overcurrent or short-circuit protection. (1 mark)

(e)
- Yes
- The PRCD will not reliven when supply is restored.
  or
  The device must be reset before use.

(2 marks)

QUESTION 5

(a) (i)



- Delta configuration (1 mark)
- Correctly identified resistances (½ mark)
- Correctly identified voltages. (½ mark)

(ii) $I_P = \frac{V_L}{R}$ (½ mark)

$= \frac{400}{94.4}$ (½ mark)

$= 4.24$ Amps (1 mark)

(iii) $I_L = \frac{\sqrt{3} \times V_L}{R}$ (½ mark)

$= \frac{\sqrt{3} \times 400}{94.4}$ (½ mark)

$= 7.34$ Amps (1 mark)

(iv) $P = \sqrt{3} \times I_L \times V_L \times pf$ (½ mark)

$= \sqrt{3} \times 7.34 \times 400 \times 1$ (½ mark)

$= 5080$ W or 5.08 kW (1 mark)

(b) Then power consumption will drop one to one-third to 1.69 kW. (2 marks)

QUESTION 6

(a) (i) One third or 33.33%

(1 mark)

(ii)
- Overcurrent (or overload).
- No-voltage (or low-voltage)

(2 marks)

(iii) Any ONE of:

- To prevent the starter from switching motor windings to delta before run-up in star.
- To prevent a phase-to-phase short circuit.
- To prevent both star and delta contactors becoming energised at the same time.

(2 marks)

(b) (i) Because there is a higher starting torque per amp of line current.

(1 mark)

(ii)
- The lowest tapping (usually 65%)

(1 mark)

- To keep starting current to the minimum.

(1 mark)

(iii) There is not enough starting torque to drive the load, so the next higher tapping should be tried. This will increase starting voltage, current and torque.

(2 marks)

QUESTION 7

(a) (i) $\frac{N_s}{N_p} = \frac{V_s}{V_p}$

$V_s = \frac{N_s \times V_p}{N_p}$

(½ mark)

$= \frac{100 \times 11000}{4780}$

(½ mark)

= 230.13V or 230V

(1 mark)

(ii) $V_1 = V_{ph} \times \sqrt{3}$

(½ mark)

$= 230.13 \times \sqrt{3}$

(½ mark)

= 398.6V or 400V

(1 mark)

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

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

(½ mark)

$= \frac{250000}{(11000 \times \sqrt{3})}$

(½ mark)

= 13.12A

(1 mark)

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

(½ mark)

$= \frac{250000}{(398.6 \times \sqrt{3})}$

or

$\frac{250000}{(400 \times \sqrt{3})}$

(½ mark)

= 362.12 or 360.85A

(1 mark)

(b)
- When under load due to current flow there is an internal volt drop due to the impedance of the windings.
- Under no-load conditions no current flows, no volt drop.

(2 marks)

QUESTION 8

(a) (i) To shunt excess current away from the load.

(1 mark)

(ii) A Zener diode is designed to carry significant reverse current but a normal rectifier diode cannot.

(1 mark)

(iii) • The resistance <u>limits the current</u> through the Zener diode.

(1 mark)

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• To the <u>maximum value</u> capable of being handled by the diode <u>without damage.</u>

(2 marks)

• In the event of the <u>load becoming disconnected or open circuited</u>

(1 mark)

(b) Any TWO:

- Inductor
- Capacitor
- Resistor

(2 marks)

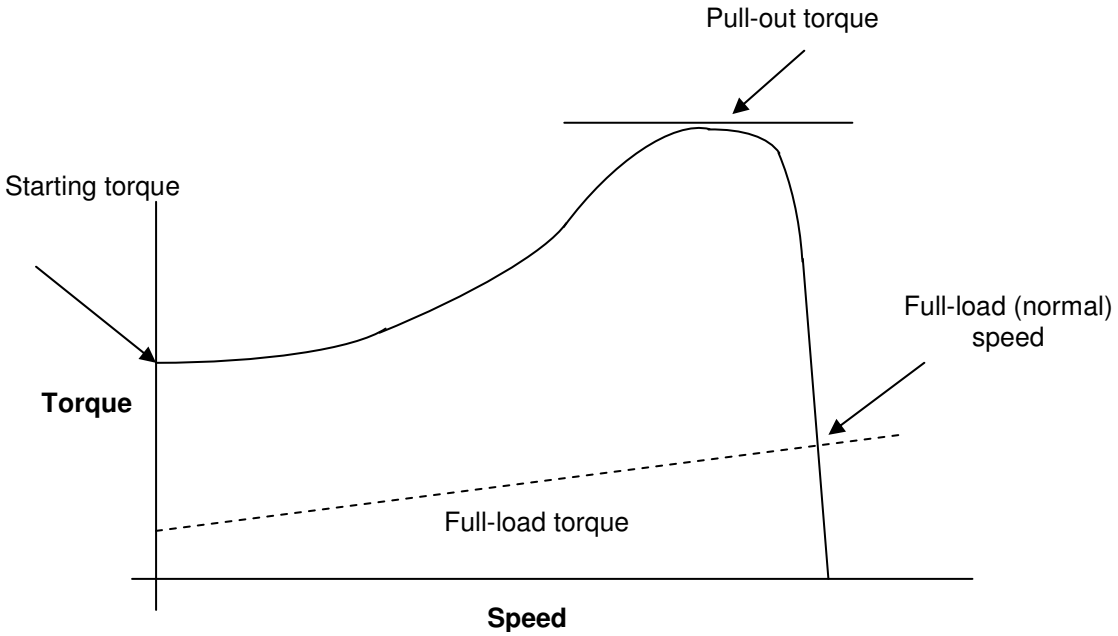
(c) Any TWO:

- Current drops to zero
- Current drops to less than holding current
- Remove anode to cathode voltage.
- Apply reverse polarity voltage across the SCR.

(2 marks)

QUESTION 9

(a)



- Correct axis (1 mark)
- Correctly shaped speed torque characteristic (1 mark)
- Starting torque correctly identified (½ mark)
- Pull-out torque correctly identified (½ mark)
- Full-load torque correctly identified (½ mark)
- Normal speed correctly identified (½ mark)

(b) (i) Starting torque
This is the torque developed when the motor is at stand-still
(1 mark)

(ii) Pull-out torque
This is the maximum torque developed without an abrupt drop in speed.
(1 mark)

(iii) Full toad torque
This is the torque required to produce rated power at full load speed.
(1 mark)

(iv) Full-load (normal speed)
This is the maximum speed developed by the motor under full load.

(c) The power factor is very low at starting, because the volts and amperes are not in phase, this produces poor starting torque.
(2 marks)

QUESTION 10

(a) kW = kVA x pf (½ mark)

= 12 x 0.7 (½ mark)

= 8400 watts (½ mark)

kW total = 9 kW + 15 kW + 8.4 kW (½ mark)

= 32.4 kW (1 mark)

(b) kVAr 1 = Tan θ x kW (½ mark)

= Tan 53.13 x 15 kW (½ mark)

= 20 kVAr (1 mark)

kVAr 2 = Tan θ x kW (½ mark)

= Tan 45.57 x 8.4 kW (½ mark)

= 8.57 kVAr (1 mark)

Total kVAr = 20 + 8.57 (½ mark)

= 28.57 kVAr (1 mark)

(c) kVA = $\sqrt{kW^2 + kVAr^2}$ (½ mark)

= $\sqrt{32.4^2 + 28.5^2}$ (½ mark)

= 43.20 kVA (1 mark)