ET 8 - 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.

Changes to original version shown in italics.

QUESTION 1

(Each part of question 1 is worth 1 mark)

(a) *Any ONE of:*

- This is the reactive volt amp that does not add to the power consumed but does add to the circuit current
- *VAr is the is the value of Q in the P&Q triangle* $kVAr = \sqrt{kVA^2 - kW^2}$

(b) 1500 rpm
or
Speed of rotating magnetic field

(c) 500 V d.c.

Note: Candidate must state in full to gain marks.

(d) (1) $I_L = I_{ph}$

(2) $I_L = \sqrt{3}\ I_{ph}$

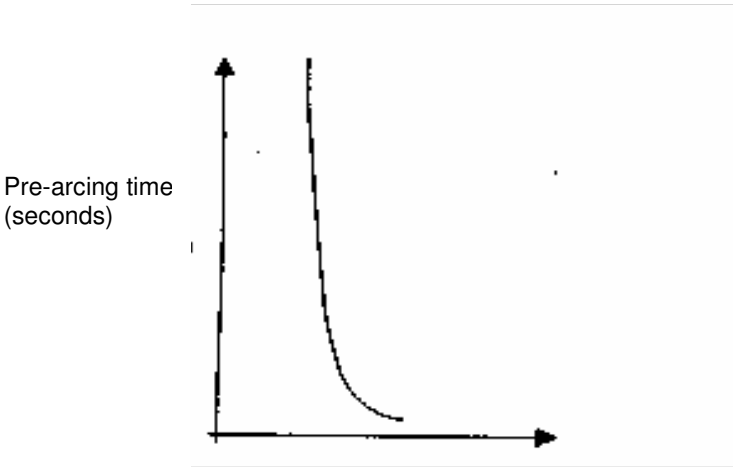
(e) 50% of full load torque

(f) One

(g) An HRC fuse

(h) (i) Sodium — Yellow / Orange *or Amber*
(ii) Mercury Vapour — White / Blue white *or Bright White*

(i)



(j) *Any ONE of:*

- Because the fuse [illegible] be capable of safely clearing that level of fault current without damage.
- *Ensure protection has enough rupturing capacity to clear fault.*
- *Makes sure protection can operate in 0.4 seconds in the case of a high fault.*

(k) $P = \sqrt{3} \times I_L \times V_L \times pf$

or

$P = \sqrt{3} \times I_L \times V_L$

or

$P = I^2 R$ for each phase and add together to get total power

or

$P = V \times I$ for each phase and add together to get total power

or

$P = \frac{V^2}{R}$ for each phase and add together to get total power

(l) Any ONE of:

- Damage to other cables cannot occur.
- Do not install final subcircuits in the same conduit as mains or submains.
- Lower voltage cables must have the same insulation rating as higher voltage cables *or lower voltage cables must not be installed with higher voltage cables if the lower voltage cables do not have the higher insulation rating*
- Installed cables may have to be de-rated (excessive heat).
- Induction from other cables.
- Production of harmonics.
- Interference with telecommunication systems
- *Adequate air-space for heat dissipation.*

(m) *Any ONE of:*

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

(n) Any ONE of:

- Capacity of the supply source
- Transformer impedance.
- Circuit impedance *or length of cable run or distance from the transformer to the switchboard*
- Protective device.

(o) The copper ring (shading ring *or shaded ring) or the rotor*

(p) A transducer is a device that changes energy from one form to another (e.g., a mechanical action into a electric signal).

(q) The order in which the three voltages in the phases reach their maximum positive values is called the phase sequence. A common order is Red Yellow and Blue.

(r) Any ONE of:

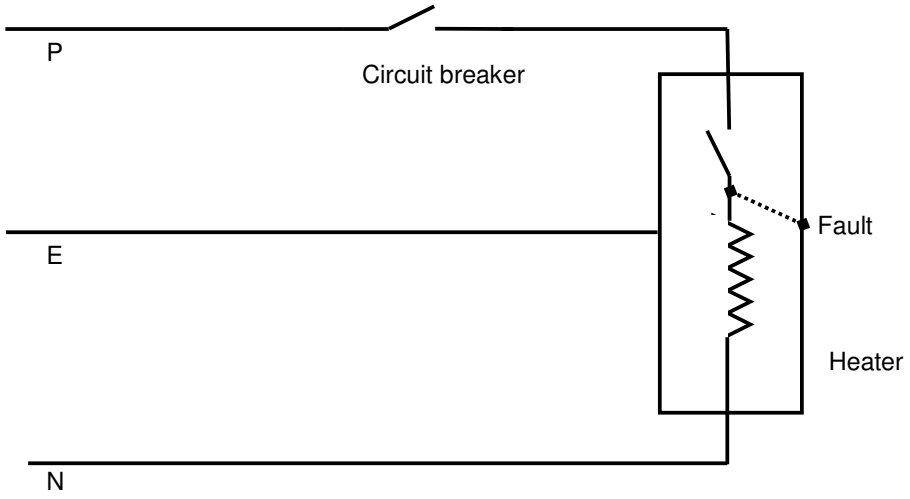
- Carrying out a testing or checking procedure with or without test instruments.
- Procedure to determine safety of system and compliance with regulations.
- *Testing is to check whether or not the work is electrically safe and there is not danger present to persons or damage to property.*

(s) 120 degrees

(t) Under fault conditions the earthing of the metal frame:
- Keeps the frame of appliance at earth potential.
- And ensures the operation of protective devices

QUESTION 2

(a)



Phase, neutral and earth correct

(½ mark)

Circuit-breaker in phase

(½ mark)

Heater switch in phase

(½ mark)

Fault in correct place

(½ mark)

Note: If circuit drawn correctly, but without circuit-breaker award 2 marks. Question does not require circuit breaker to be included.

(Total 2 marks)

(b) $I_{load} = \frac{W}{V} = \frac{2000}{230} = 8.7$ A

(½ mark)

$I_F = \frac{230}{100} = 2.3$ A

(½ mark)

$I_T = I_L + I_F = 8.7 + 2.3 = 11$ A

(1 mark)

(Total 2 marks)

(c) *Any THREE of:*

- Earth resistance is very low.
- No potential difference can develop across the protective earthing conductor.
- Therefore the appliance frame is held at 0 V and no shock hazard exists.
- *Ensure protection will operate.*

(3 marks)

(d) *Any THREE of:*

- If the protective earthing conductor resistance is high.
- The frame of the appliance will rise above earth.
- There will be a voltage difference between the frame of the appliance and earth presenting a shock hazard.
- *The protection may not operate*.

(3 marks)

QUESTION 3

(a) (i) Any ONE of:

- The ratio of the true power to apparent power.
- The ratio of resistance to impedance.
- *The factor by which the VA is multiplied to get the true power*

(1 mark)

(ii) Cos Φ
or
Cos φ
or
pf

(1 mark)

(b) (i) Total kW of load = V_P x I_P x pf

(½ mark)

= 230 x 215x 0.65

(½ mark)

= 32.142 kW

(1 mark)

kVAr = 32.142 x 0.549

(½ mark)

= 17.65 kVAr

(½ mark)

(ii) P = V I cosθ

I = $\frac{P}{V \cos\theta}$

(½ mark)

= $\frac{32142}{230 \times 0.9}$

(½ mark)

= 155.3 A

(1 mark)

(c) (i) Reduce the settings of the thermal overloads.

(1 mark)

(ii) Any ONE of:

- The connection of the capacitor reduces the current in the motor cable.
- The overloads need to be reset to recognise the lower current.

(2 marks)

QUESTION 4

(a) Multiple Earthed Neutral or MEN system

(1 mark)

(b) Any TWO of:

(1) The neutral is multiple earthed so that, if any "live" part of the supply system comes into contact with earth, current will flow back to the neutral by way of several parallel earth connections, and the net resistance of the fault circuit will be low.
(2) 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).
(3) Limits the voltage to 230 V to earth.
(4) Provides an alternative return path for the current if neutral is lost.

(2 marks)

(c) Any THREE of:

- When high fault currents flow there is increased mechanical forces exerted on equipment and cables,
- An increased risk of fire when high fault currents flow through a high-resistance connection.
- Shocks can occur in unexpected places.
- High risk of explosion due to equipment not being able to handle high fault currents.

(3 marks)

(d) (i) $MVA = \frac{250 \times 100}{1000 \times 5}$

(1 mark)

$= 5$ MVA

(1 mark)

or

$kVA = \frac{250 \times 100}{5}$

$= 5000$ kVA

GK

(ii) $I_{sc} = \frac{5000 \text{ kVA}}{\sqrt{3} \times 400\text{v}}$

(1 mark)

$= 7.22$ kA or 7217 Amps.

(1 mark)
GK

QUESTION 5

(a) (i) *Note: The power factor on the nameplate is 0.82, but it may not be able to be read clearly. The first digit could be a 6 or an 8. The second digit could be a 2 or an 8. Therefore, accept any calculation that uses 0.88 or 0.62 or 0.68.*

0.82 Input power = $\sqrt{3} \times V_L \times I_L \times pf$
= $\sqrt{3} \times 415 \times 8.52 \times 0.82$
(½ mark)
= 5021.68 watts
(½ mark)

Efficiency = $\frac{\text{Output} \times 100}{\text{Input} \times 1}$
(½ mark)
= $\frac{4000 \times 100}{5021.68 \times 1}$
(½ mark)
= 79.6%
(1 mark)

0.88 Input power = $\sqrt{3} \times V_L \times I_L \times pf$
= $\sqrt{3} \times 415 \times 8.52 \times 0.88$
(½ mark)
= 5389.12 watts
(½ mark)

Efficiency = $\frac{\text{Output} \times 100}{\text{Input} \times 1}$
(½ mark)
= $\frac{4000 \times 100}{5389.12 \times 1}$
(½ mark)
= 74.2%
(1 mark)

0.62 Input power = $\sqrt{3} \times V_L \times I_L \times pf$
= $\sqrt{3} \times 415 \times 8.52 \times 0.62$
(½ mark)
= 3796.88 watts
(½ mark)

Efficiency = $\frac{\text{Output} \times 100}{\text{Input} \times 1}$
(½ mark)
= $\frac{4000 \times 100}{3796.88 \times 1}$
(½ mark)
= 105.3%
(1 mark)

0.68 *Input power* = $\sqrt{3} \times V_L \times I_L \times pf$

= $\sqrt{3} \times 415 \times 8.52 \times 0.68$

(½ mark)

= *4164.32 watts*

(½ mark)

Efficiency = $\frac{\text{Output} \times 100}{\text{Input} \times 1}$

(½ mark)

= $\frac{4000 \times 100}{4164.32 \times 1}$

(½ mark)

= *96%*

(1 mark)

(ii) %Slip = $\frac{(Ns - Nr) \times 100}{Ns \times 1}$

= $\frac{(1500 - 1440) \times 100}{1500 \times 1}$

(½ mark)

= 4%

(½ mark)

or

Slip speed = Ns – Nr

= 1500 – 1440

= 60 rpm

(b) Any ONE of:

- A means of classifying the degree of protection from *solid objects* and *liquids* afforded to electrical equipment.
- Grades of protection from the environment.

(2 marks)

(c) (i) Thermal overloads

Any TWO of:

- Are designed to have an inbuilt delay
- This allows for a current surge at the closing of supply to a motor yet protects the motor against sustained overload.
- *Phase imbalance of single-phasing*

(2 marks)

(ii) HRC fuses

- The HRC fuses are capable of safely interrupting far higher levels of PSSC than the thermal overload in a fault situation

(1 mark)

- The HRC fuses operate much faster than the thermal overload under short circuit conditions, and they will disconnect the circuit before any damage occurs.

(1 mark)

QUESTION 6

(a) (i) 0V

(1 mark)

(ii) 230 V

(1 mark)

(b) *(i) The MCB affords:*

- *Magnetic (short-circuit) and thermal (overload) protection to the circuit.*

(2 marks)

- *Magnetic (short-circuit) protection to the light fittings.*

(1 mark)

(ii) The HRC fuse affords magnetic (short-circuit) and thermal (overload) protection to the fitting in which it is installed.

(2 marks)

(iii)
- An overload in a fitting will operate the protection just for that fitting.
- A short-circuit in a fitting will usually operate the fuse for the fitting before the MCB

(2 marks)

(c) Any ONE of:
- the main circuit breaker would operate disconnecting all the lights in the circuit.
- the wiring and components in the light fittings may have a much lower current rating.
- *The MCB may not trip and cause a shock hazard due to a faulty fitting.*

(1 mark)

QUESTION 7

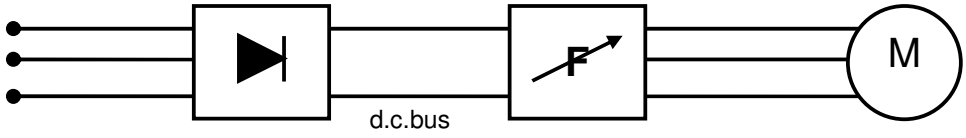
(a) A variable speed controller varies frequency and voltage to vary the speed.

(1 mark)

The electronic soft start varies voltage on starting to limit starting current.

(1 mark)

(b) (i)

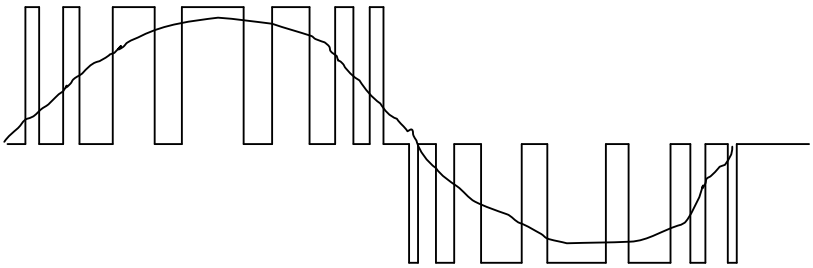


Rectifier Inverter 3 phase motor

(2 marks)

(ii) Any THREE of:

- The a.c. supply is rectified to d.c.
- An inverter is used with special electronic switching circuit to provide a variable frequency and voltage a.c. supply.
- The induction motor with its high reactance tries to smooth out the square wave into a sine wave.
- Pulse Width Modulation (PWM switching) is used to create a 3Ø wave form
-



Note: A candidate who (correctly) answers this question with the last 2 bullet points (the diagram being a representation of the 4th bullet point) and one of bullet points 1 to 3 gains 3 marks.

(3 marks)

(c) Any THREE of:

- More efficient - less power loss.
- Smoother starting - less wear and tear on the motor.
- Easier to adjust for overcurrent and other parameters.
- Power factor very high because of d.c. bus
- Visual feed-back through display panels.
- Physical size smaller than auto-transformer.
- More economical to maintain – less equipment involved.
- *Reduces mechanical shock to equipment*
- *More even current flow*

- *More even torque*
- *Torque is very constant at start*
- *Cheaper in the larger sizes*
- *Built in protection and monitoring*

(3 marks)

QUESTION 8

(a)
- 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.
- Therefore, no-load voltage is higher than the full load voltage.

(3 marks)

(b) The secondary of the C.T. must be shorted out, before the instrument is removed.

(1 mark)

(c) (i) Primary phase voltage

$$= \frac{66}{\sqrt{3}}$$

(½ mark)

$$= 38.105 \text{ kV}$$

(½ mark)

(ii) Secondary line voltage

$$= \frac{38.105}{3.46}$$

(½ mark)

$$= 11 \text{ kV}$$

(½ mark)

(iii) Full load secondary current

$$MVA = \frac{I_L \times V_L \times \sqrt{3}}{10^6}$$

$$I_{Lsec} = \frac{MVA \times 10^6}{V_L \times \sqrt{3}}$$

(1 mark)

$$= \frac{2 \times 10^6}{11000 \times \sqrt{3}}$$

(1 mark)

104.85 Amps

(1 mark)

(iv) Current in each secondary winding

$$= \frac{104.85}{\sqrt{3}}$$

(½ mark)

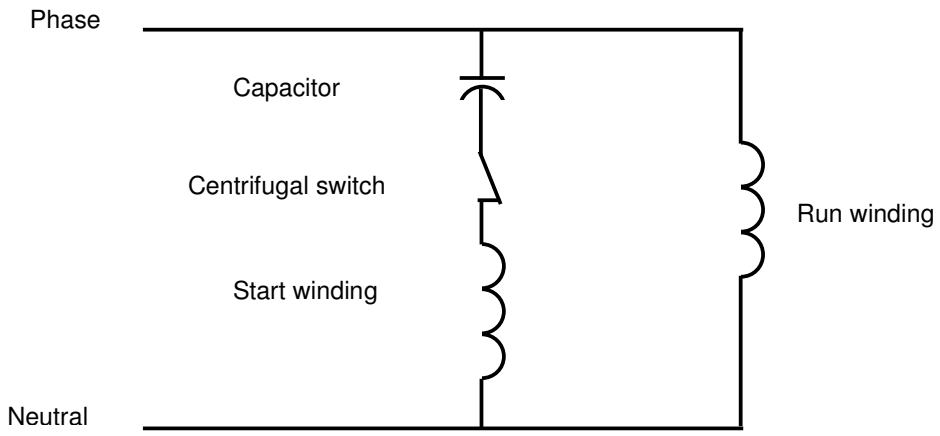
$$= 60.53 \text{ Amps}$$

(½ mark)

Note: For (iii) and (iv), if a candidate gets the wrong answer for (ii), but correctly uses that figure for (iii) and (iv), then award marks for the method used, that is 2 marks for (iii) and a half mark for (iv).

QUESTION 9

(a) (i)



(2 marks)

(ii) Any ONE of:

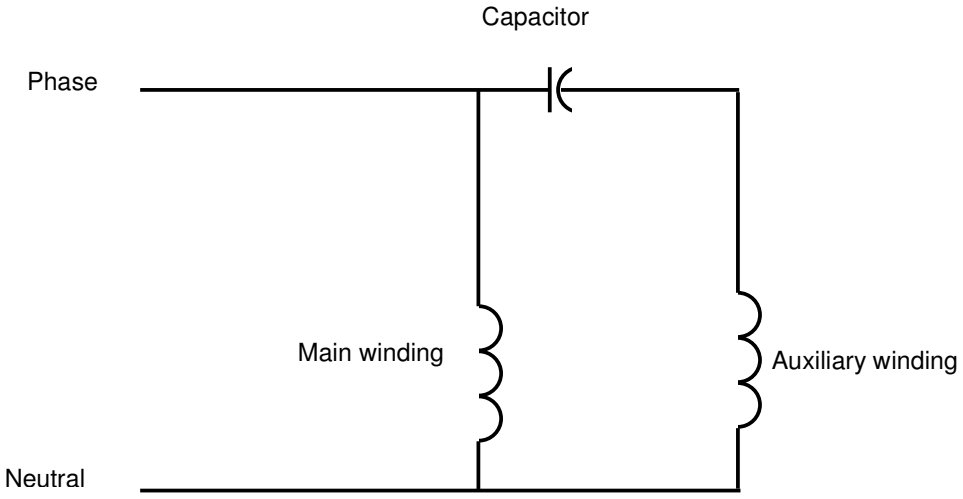
- It has a higher starting torque.
- *The phase angle can be made to approach 90^0, therefore the higher the torque*

(1 mark)

(iii) Reverse the supply of the start or run winding but not both.

(1 mark)

(b) (i)



(1 mark)

(ii) Any ONE of:

- It is quieter running.
- They are cheaper as both windings are identical
- *More constant torque due to in-circuit capacitor*

(1 mark)

(iii) Connect the capacitor in series with the other winding

(1 mark)

(c) Any ONE of:

- Cheaper, because there is no capacitor, or
- Smaller in size, because there is no capacitor(s) strapped to them

(1 mark)

(d) Swap the whole motor around

(1 mark)

QUESTION 10

(a)
- Some of the tungsten filament evaporates.

(1 mark)
- And combines with the halogen close to the bulb wall to form a halide.

(1 mark)
- The halide circulates through convection back to near the filament.

(1 mark)
- The tungsten disassociates from the halide.

(1 mark)
- And reattached to the filament

(1 mark)

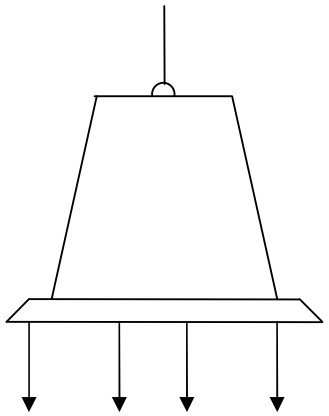
Note award 1 mark if candidate states that the lamp works on the principle of the halogen cycle.

(b)
- The lamp must not be handled with the naked hand.

(1 mark)
- The lamp must be horizontally mounted.

(1 mark)

(c) (i) Direct lighting diagram



(1 mark)

(ii) Direct lighting description
All light from the fitting is thrown directly onto the surface being illuminated.

(1 mark)

(d) The number of candelas emitted by a light source.
or
The power of a light source to emit light in a given direction.

(1 mark)