

ET 5 - Electrician Theory Examination

Marking Schedule

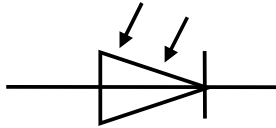
Note: (1 mark) means that the preceding statement earns 1 mark.

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

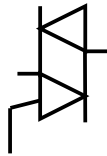
(Each part of question 1 is worth 1 mark)

(a)

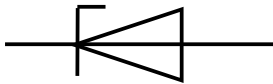


- (b) (1) Current (load)
(2) Length of run, voltage drop, or similar
- (c) Because an auto-transformer can fail or can be incorrectly connected in such a way as to have the primary voltage across the secondary.
- (d) To ensure all equipment, including leads etc, are protected.
- (e) 4:1
- (f) Connect a suitable discharge resistor or suitable voltmeter across the capacitor terminals or similar.
- (g) Any TWO:
- * reduce starting current
 - * Reduce voltage surges
 - * Limit mechanical shock
- (h) Efficiency increases
- (i) Delta-star
- (j) *
- * Arc eye
 - * Burns
- (k) Any TWO:
- * Diesel motor
 - * Water turbine
 - * Petrol motor
 - * Gas turbine
 - * Steam turbine
 - * Wind turbine
- Or similar – no marks if just, say “gas” or “petrol” is written

- (l) (1) CO₂
(2) Dry powder, or similar
- (m) (1) To keep frame of appliance at earth potential.
(2) To ensure the operation of protective devices
- (n) Maximum voltage applied to the device in the reverse bias position.
- (o) They have a balanced rotating magnetic field (not a pulsating one).
Statement in brackets not necessary to achieve full marks)
- (p) (i) Triac



- (ii) Zener diode



- (q) Any machinery where reverse operation may cause harm to people or damage to property .e.g. Compressor or Conveyor belt
- (r) Tap-changers (½ mark for changing windings)

or

Change in terminal voltage is achieved through the volt drop caused by the changing current through the transformer's internal impedance.

- (s) In Star
- (t) The CT secondary must be shorted.

QUESTION 2

- (a)
- Polarity
 - Earth Continuity
 - Visual
 - Insulation Resistance.

Also accept:

- Earth Loop Impedance
- or
- RCD Test

(2 marks)

(b) Earth Continuity

- Test between the earth contact on the plug and the switchboard earth bar
- Meter: Low ohmmeter
- Maximum reading: 0.5Ω

(3 marks)

Insulation Resistance

- Test between all conductors
- Meter: Insulation resistance tester 500V d.c.
- Minimum reading $1M\Omega$
 $20M\Omega$ (1/2 mark)

(3 marks)

Polarity

Check visually and with instruments that all phase conductors are switched and that all conductors go to the right terminals

(1 mark)

Visual check

- No access to live parts without the use of a tool
- Covers are all on
- Connections are tight
- Correct colour code

Any other reasonable answers

(1 mark)

Also accept:

Earth Loop Impedance

- Test between furthest point on the active conductor and the corresponding point on the protective earthing conductor
- Meter: Earth Loop Impedance Tester
- Circuit impedance compared to the corresponding impedance in the stated tables

or

RCD Test

- Plug the RCD tester into the into a socket outlet and test.
- RCD should operate within 300 mS at the maximum residual current of 30 mA.

Mark allocation: Apply the mark of the test/check above, that this test/check is used in substitution to reach a total of 8 marks

Question 3

(a) Current in earth continuity conductor = $\frac{230}{14} = 16.43 \text{ A}$ (1 mark)

Total current in the line = $16.43 + 27 = 43.43 \text{ A}$ (1 mark)

(Total 2 marks)

(b) Fusing factor of motor-rated fuse is 2 (accept any factor in the range 1.75 – 2.5) so fusing current is $32 \times 2 = 64 \text{ A}$ (accept 56 – 80).

This is greater than the 43.43 A line current. The circuit protection will not operate.

(3 marks)

(c) Current in earth continuity conductor = $\frac{230}{24} = 9.58 \text{ A}$ (1 mark)

Vd across earth continuity conductor = $9.58 \times 10 = 95.8 \text{ V}$ (1 mark)

Shock hazard of 95.8 V (2 marks)

between the frame of the appliance and “earth” (1 mark)

(Total 5 marks)

Question 4

(a)

Protection Device	Advantages	Disadvantages
(i) Miniature circuit breaker	Any TWO: <ul style="list-style-type: none"> * easy to reset * provides thermal and magnetic protection * Current rating cannot be interfered with * Cost – don't have to buy new one if it trips 	Any TWO: <ul style="list-style-type: none"> * not very fast operating speeds * must wait to reset for thermal * fixed fusing factor * Nuisance tripping (in older models) * Replacement cost
(ii) HRC fuse	Any TWO: <ul style="list-style-type: none"> * good discrimination * good back-up protection * fast operation * range of utilisation categories (fusing factor) * higher rupturing capacity * Lower initial cost 	Any TWO: <ul style="list-style-type: none"> * 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

Candidates can use the advantage of one and the disadvantage of the other or vice versa

(4 marks)

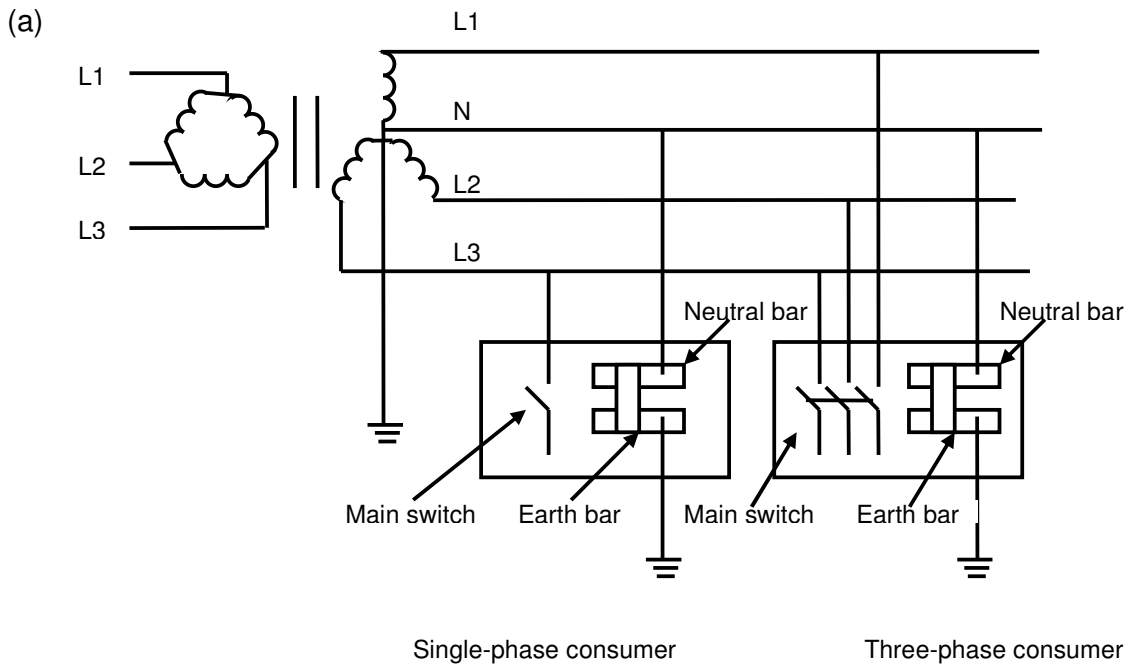
- (b) (i) Small overload: A small overload:
 - * causes a bi-metal to heat up and bend,
 - * operating a trip mechanism that
 - * disconnects the circuit

(3 marks)

- (c) (ii) Short circuit. A larger overload:
 - * causes a strong magnetic field
 - * which attracts a trip mechanism
 - * that disconnects the circuit rapidly

(3 marks)

QUESTION 5



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 TWO:

- Low overall fault impedance.
- Limit of 230 V shock hazard to earth.
- Fewer conductors (no earth required for mains and distribution).

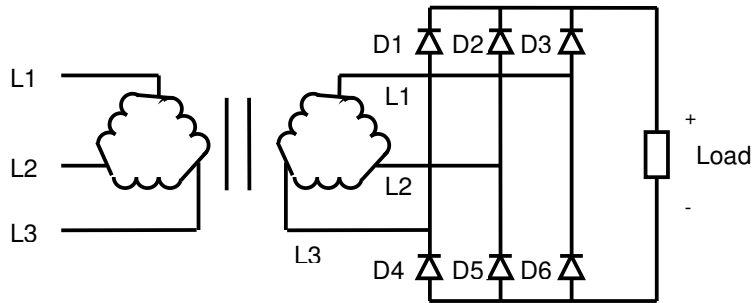
(2 marks)

(c) Everything electrical must be installed, used, etc, so as not to cause harm to people or damage to property.

(3 marks)

Question 6

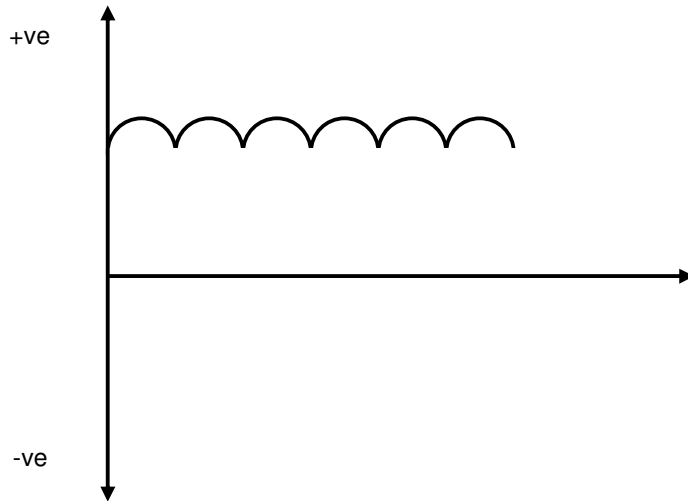
(a)



- * Correct delta/delta transformer (1 mark)
- * Diodes all point to positive terminal (1 mark)
- * Secondary transformer correctly connected (1 mark)
- * Polarity of load is correct (1 mark)

(Total 4 marks)

(b)



(2 marks)

(c) Any TWO of:

- * Capacitor
 - * Inductor
 - * Resistor
- (1 mark)

- (d) (i) Faulty starter (1 mark)
- (ii) Faulty tube or ballast (1 mark)
- (iii) End of tube life (1 mark)

Question 7

$$(a) \quad (i) \quad I = \frac{W}{V} = \frac{12000}{230} = 52.17 \text{ A}$$

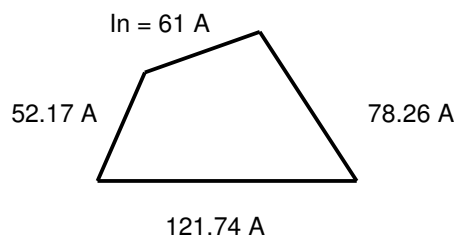
$$I = \frac{W}{V} = \frac{18000}{230} = 78.26 \text{ A}$$

$$I = \frac{W}{V} = \frac{28000}{230} = 121.74 \text{ A}$$

($\frac{1}{2}$ mark for formula and $\frac{1}{2}$ mark for each correct answer)

(Total 2 marks)

(ii)



($\frac{1}{2}$ mark for correct component and correct scale and $\frac{1}{2}$ mark for correct answer)

Candidate can answer this question by using calculations. Accept any answer in the range 58 – 63. Space allocated for drawing in paper too small.

(3 marks)

$$(iii) \quad P_T = P_1 + P_2 + P_3$$

($\frac{1}{2}$ mark)

$$= 12 + 18 + 28$$

($\frac{1}{2}$ mark)

$$= 58 \text{ kW}$$

(1 mark)

(Total 2 marks)

(b) The phase voltages would fluctuate about 230V depending on individual phase loads.

(2 marks)

(c) Any ONE of:

- To maximise the use of all capital equipment (transformers, cables etc).
- To maintain unity power factor
- Lower neutral current and maximise use of electrical equipment

(1 mark)

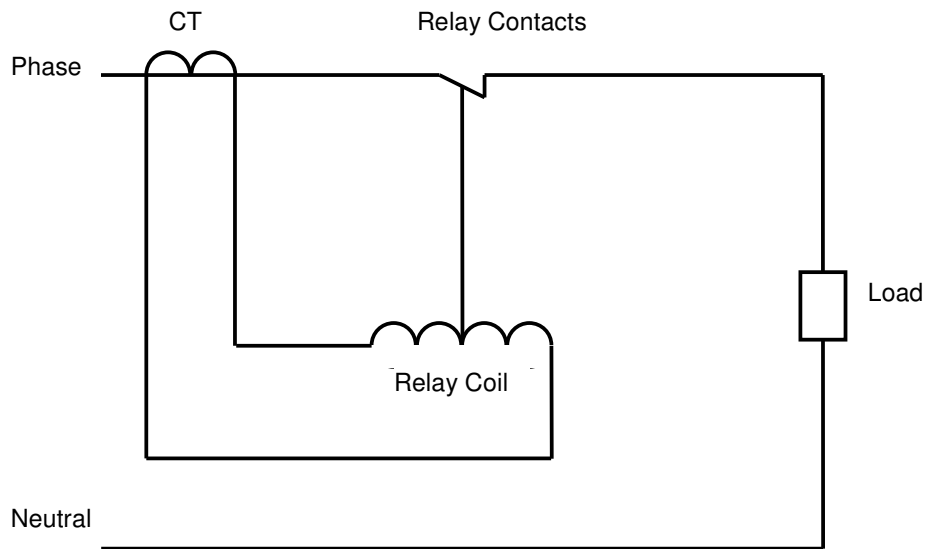
QUESTION 8

- (a) (i) A small mechanical overload for a long time.
Causes the motor to slow causing excess current flow, which may burn the windings out if the protection does not operate (1 mark)
- (ii) A mechanical overload that exceeds the motor's pullout torque.
Causes the motor to stop, which causes very high current flow, which, may burn the windings out if the protection doesn't operate quickly enough (1 mark)
- (iii) Under voltage
Causes the motor to slow which in turn creates excess current flow, which may burn the windings out if the protection doesn't operate quickly enough (1 mark)
- (iv) If one motor winding open circuits.
The motor will stall and the line current will increase which if the protection doesn't operate fast enough will burn out the windings. (1 mark)
- (b) (i) Thermal (1 mark)
- (ii) Magnetic (1 mark)
- (c) If the rotor speed decreases (1/2 mark)
and the sync speed remains constant (1/2 mark)
the stator rotating magnetic field is cutting the rotor bars more often. (1/2 mark)
- This causes an increase in rotor emf and current. (1/2 mark)
- The increased rotor current produces an increased rotor magnetic field. (1/2 mark)
- By Lenzes Law this increased magnetic field (1/2 mark)
- Aids the stator magnetic field or reduces the stator back emf (1/2 mark)
- and more current flows in the stator (1/2 mark)

Award a half mark for an answer "the rotor torque on a 3 phase induction motor would increase if the speed dropped" given in isolation.

Question 9

(a)



½ mark for each correct component, 1 mark for correct circuit
Loss of ½ mark if relay contacts shown open and loss of further 1 mark for incorrect circuit

(3 marks)

(b) If open circuited, high voltages may be present causing hazard of electric shock and possible damage to the CT windings.

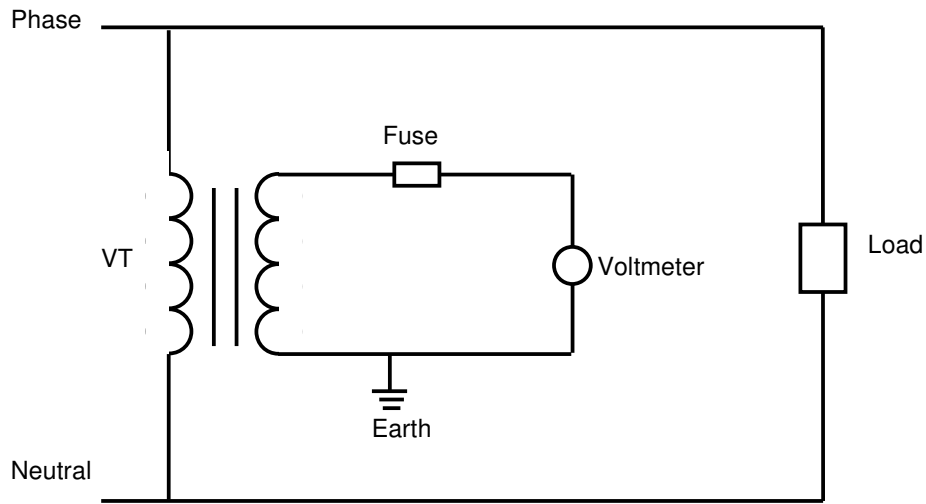
(1 mark for high voltages; ½ mark each for electric shock and damage)

(2 marks)

(c) (1) 1 A
(2) 5 A

(1 mark)

(d)



($\frac{1}{2}$ marks for each correct component, $1\frac{1}{2}$ marks for correct circuit)

(3 marks)

(e) 110 V (63.5 V)

(1 mark)

Question 10

- (a) Candidates receive no marks if the circuit shows a short circuit between P and N or if the armature short-circuited.

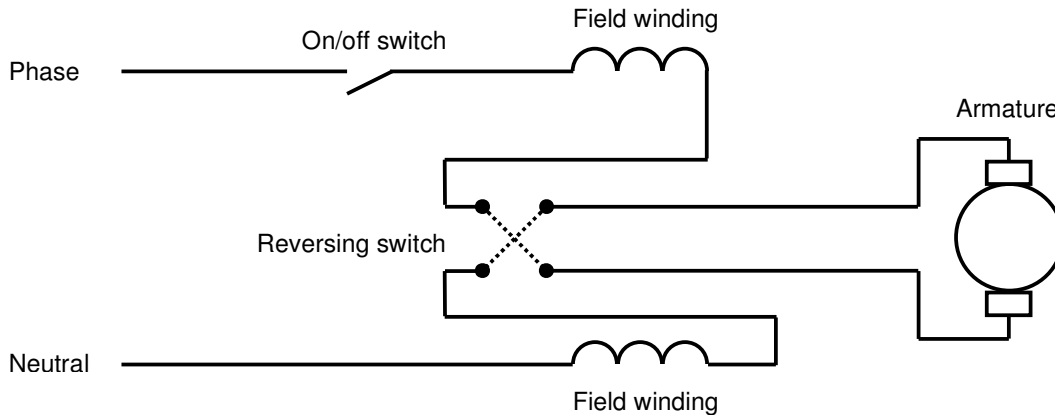


Figure 1

($\frac{1}{2}$ marks for each correct conductor, $1\frac{1}{2}$ marks for correct operation)

(5 marks)

- (b) Any FOUR of:

- High power-to-weight ratio.
- Maximum torque at zero speed.
- Can be easily speed controlled.
- High speeds available.
- Smaller size
- Lower cost
- Ease of maintenance

(2 marks)

- (c)
- 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 (as per marking schedule)
(1 mark)
 - The HRC fuses therefore are necessary to protect the entire downstream circuit of – conductors / contactors / overload unit / junction boxes / isolators / motor
(1 mark)

(Total 3 marks)