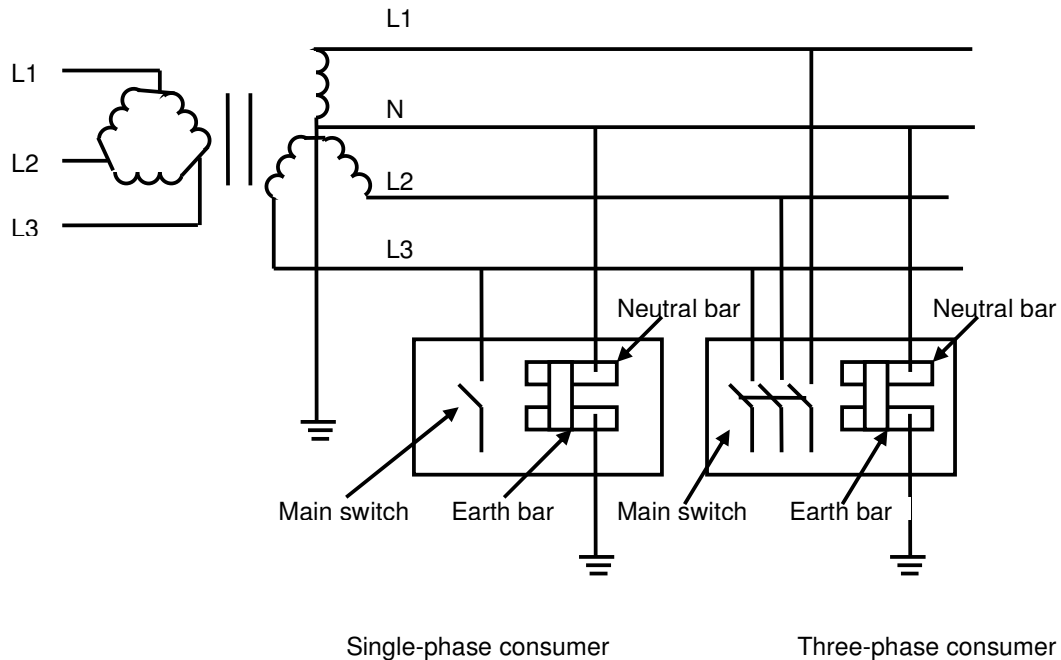


- (e) (i) 1 M Ω minimum (1 mark)
- (ii) 1 Ω maximum (1 mark)
- (f) Connect a suitable discharge resistor or suitable voltmeter across the capacitor terminals or similar. (2 marks)
- (g) (i) $I = \frac{V}{R}$
 $= \frac{240}{24}$ (1/2 mark)
 $= 10A$ (1 mark)
- (ii) More (1/2 mark)
- (h) Change the connections to either the start winding or the run winding. (2 marks)
- (i) • Current (load)
 • Length of run, or similar (2 marks)
- (j) As current through the protective device increases the time taken to operate decreases.

Note: A drawn representation of the characteristic is acceptable. (2 marks)

QUESTION 2

(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 TWO 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.

Note: Award a ½ mark for the answer "0 voltage between neutral and earth"
(2 marks)

(c) Any TWO of:

- An MEN switchboard has an MEN link between the neutral and earth busbars
Or
A distribution switchboard has no MEN link between the neutral and earth bars
- An MEN switch board is connected to earth via an earth electrode
Or
A distribution switchboard is connected to earth via an MEN switchboard
- An MEN switchboard can be the closest switchboard to the point of supply
Or
A distribution switchboard cannot be the closest switchboard to the point of supply

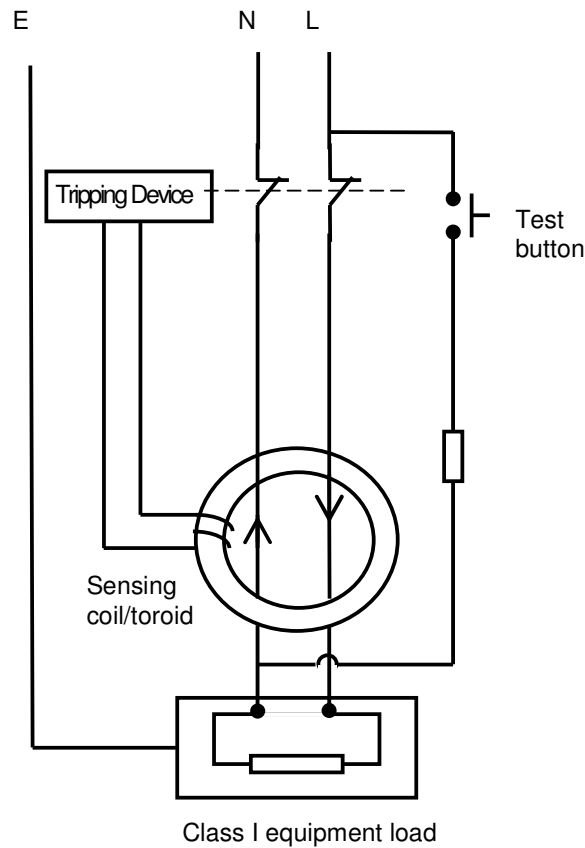
(2 marks)

(d) MEN switchboard

(1 mark)

QUESTION 3

(a)



- Correctly connected test circuit and resistance (1 mark)
 - Correctly connected sensing coil/toroid (1 mark)
 - Correctly connected phase, neutral and earth. (1 mark)
 - Correctly connected tripping circuit (1 mark)
- (b)
- Neutral current out of balance with the phase current. (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, opening the RCD contacts (1 mark)

(c) PRCD **P**ortable **R**esidual **C**urrent **D**evice.

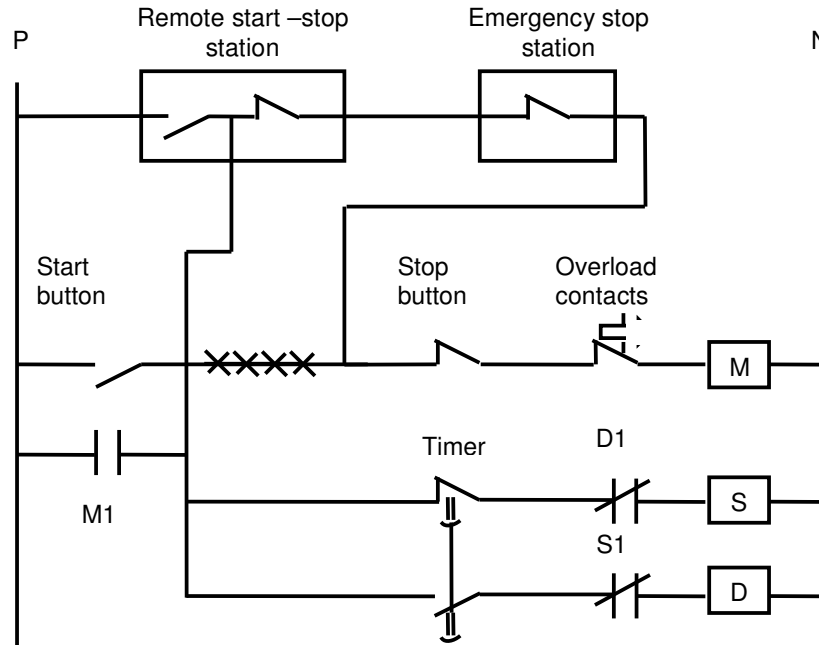
(1 mark)

RCBO **R**esidual Current-Operated **C**ircuit **B**reaker with **O**vercurrent
Protection

(1 mark)

QUESTION 4

(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)

(b) (i) Eff. = $\frac{\text{output}}{\text{input}}$
 Input = $\frac{\text{output}}{\text{eff.}}$
 = $\frac{8}{0.84}$
 = 9.5 kW

(½ mark)

(½ mark)

(1 mark)

(ii) kVA = $\frac{\text{kW}}{\text{Pf}}$
 = $\frac{9.5}{0.81}$
 = 11.7 kVA

(½ mark)

(½ mark)

(1 mark)

$$\begin{aligned} \text{(iii) } P &= \sqrt{3} V_L I_L \text{ PF} \\ I_L &= \frac{P}{\sqrt{3} V_L \text{ PF}} \end{aligned}$$

(½ mark)

$$I_L = \frac{9500}{\sqrt{3} \times 400 \times 0.84}$$

(½ mark)

$$I_L = 16.3\text{A}$$

(1 mark)

(c) Any ONE of:

- Reduce starting current
- Permits the installation of a smaller cable
- Smaller transformer size can be used
- Reduce mechanical shock
- Reduce the effect of volt drop on the system.

(1 mark)

QUESTION 5

(a) The description has to cover:

1. An insulation resistance test showing:
 - the use of an insulation resistance tester (½ mark)
 - a 500V d.c. test voltage (½ mark)
 - testing between phase and earth and neutral and earth (½ mark)
 - an expected test result of 10,000 ohms or 0.01 Mohms (1 mark)
 - the test result being a minimum value (½ mark)

2. A protective earthing conductor test showing:
 - the use of a meter that can accurately read values of 1 ohm or less (½ mark)
 - a testing between the PEC conductor of the flexible cord and the case of the cylinder (½ mark)
 - an expected test result of 1 ohm (½ mark)
 - the test result being a maximum value (½ mark)

(b) The procedure has to cover:

- Identifying the correct fuse on the switchboard. (1 mark)
- Attaching a Danger tag to the circuit. (1 mark)

- Removing the isolator cover and testing for voltage at the supply side of the isolator using the prove-test-prove method. (2 marks)

QUESTION 6

- (a)
 - Overload caused by too many appliances in use.
 - A faulty appliance
 - A faulty circuit. (3 marks)

- (b) (i) Overload caused by too many appliances in use.

Action taken to establish that this is the cause

- Total up the rating of appliances (1 mark)

Remedial action taken or recommended

- Use fewer appliances. (1 mark)

- (ii) A faulty appliance.

Action taken to establish that this is the cause

- Carry out an insulation resistance test of each appliance in turn to establish which is faulty. (1 mark)

Remedial action taken or recommended

- Repair the faulty appliance. (1 mark)

- (iii) A faulty circuit.

Action taken to establish that this is the cause

- Disconnect circuit at switchboard. (1 mark)

- Carry out an insulation resistance test of the circuit to establish fault. (1 mark)

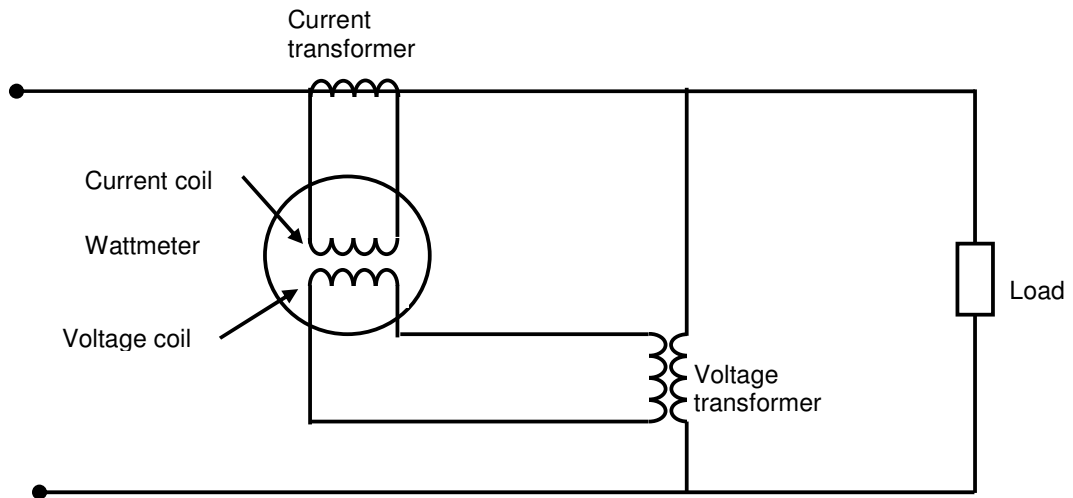
Remedial action taken or recommended

- Repair or replace the faulty circuit component. (1 mark)

Note: Re-setting the MCB for a third (or more) time before any testing is taken to establish the cause of the fault is considered hazardous.

QUESTION 7

(a)



- Correctly connected current transformer (1 mark)
- Correctly connected voltage transformer (1 mark)
- Correctly connected load (1 mark)
- Correctly connected wattmeter (2 marks)

(b) (i) $V_{SPH} = \frac{6600}{27.5}$ (1/2 mark)
 $= 240 \text{ V}$ (1 mark)

(ii) $V_{SL} = 240 \times \sqrt{3}$ (1/2 mark)
 $= 416 \text{ V}$ (1 mark)

(iii) $I_P = \frac{kVA \times 1000}{\sqrt{3} \times V_L}$ (1/2 mark)
 $= \frac{150000}{\sqrt{3} \times 6600}$ (1/2 mark)
 $= 13.1 \text{ A}$ (1 mark)

QUESTION 8

(a) Current in earth continuity conductor = $\frac{230}{14} = 16.4 \text{ A}$ (1 mark)

Total current in the line = $16.4 + 27 = 43.4 \text{ A}$ (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 43.4 A line current. The circuit protection will not operate.

(3 marks)

(c) Current in earth continuity conductor = $\frac{230}{24} = 9.6 \text{ A}$ (1 mark)

Vd across earth continuity conductor = $9.6 \times 10 = 96 \text{ V}$ (1 mark)

Shock hazard of 96 V (2 marks)

between the frame of the appliance and "earth" (1 mark)

(Total 5 marks)

QUESTION 9

(a) Any THREE of:

- Smoother starting - less wear and tear on the motor.
- Easier to adjust for overcurrent and other parameters.
- 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)

(b) Any TWO 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)

(c) (i) Any ONE of:

- Because there is a higher starting torque per amp of line current.
- There is a closer match between the tapping and load at start.
- Smoother start up.

(1 mark)

(ii) Any ONE of:

- To keep starting current to a minimum.
- To ensure there is less voltage drop on the system

(2 marks)

(iii) The next higher tapping should be tried. This will increase starting voltage, current and torque.

(2 marks)