SAFETY | COMPETENCY | COMPLIANCE

Candidate Code No.	
For Board Use Only	
Result	Result
Date	Date
Int	Int

ELECTRICIAN'S THEORY EXAMINATION

18 June 2016

QUESTION AND ANSWER BOOKLET

Time Allowed: Three hours

INSTRUCTIONS – READ CAREFULLY

You have 10 minutes to read this paper but do not start writing until you are told to do so by the supervisor.

Write your Candidate Code Number in the box provided above. Your name must NOT appear anywhere on this paper.

Answer all questions.

The pass mark for this examination is 60 marks.

Use a pen for written answers. **Do not** use a pencil or a red pen.

Drawing instruments and pencils may be used when diagrams are required. Marks are allocated on the basis of correctness.

Do not use correcting fluid or correcting tape.

For calculation questions all workings, including formulae, must be shown to gain full marks.

Non-programmable calculators may be used.

Warning – You could get 0 marks for any question, or part of a question, if you show anything hazardous or dangerous in your answer.

Candidates are not permitted to use any Act, Regulation, Standard, Code of Practice, Handbook or other reference text in this examination.

PLEASE HAND THIS PAPER TO THE SUPERVISOR BEFORE LEAVING THE ROOM.

(turn over)

Question 1

(a) (i) State the test voltage used for carrying out an insulation resistance test on three-phase, 400V, electrical equipment incorporating MIMS elements.

(1 mark)

_____

(ii) State the minimum permitted test result for the insulation resistance test on the electrical equipment.

(1 mark)

_____

(b) (i) State what is meant by the term **pull-out torque** as it applies to an a.c. induction motor.

(1 mark)

_____

_____

(ii) State what occurs to an a.c. induction motor if the **load torque** exceeds the **pull-out torque**.

(1 mark)

_____

_____

(turn over)

Question 1 continued

(c) A single-phase induction motor is being installed in a circular saw bench.

State **ONE** reason why a capacitor-start motor is used rather than a split-phase motor.

(2 marks)

_____

_____

_____

(d) An electrical installation has a prospective short-circuit current rating of 3.7 kA when measured at the switchboard. There are rewireable fuses on the switchboard.

State **ONE** reason why the rewireable fuses need to be replaced.

(2 marks)

_____

_____

_____

(e) Measurements from a single-phase light industrial electrical installation show the following:

- 235V
- 70A
- 15.2 kW

Calculate the power factor of the circuit.

(2 marks)

(turn over)

Question 1 continued

(f) A single-phase induction motor is being installed in a ventilation fan for a ducted air conditioning system.

State **ONE** reason why a capacitor-start capacitor-run motor is used rather than a split-phase motor.

(2 marks)

_____

_____

_____

(g) (i) Define the term **current rating** as it applies to HRC fuses.

(1 mark)

_____

_____

(ii) Define the term **breaking (or rupturing) capacity** as it applies to HRC fuses.

(1 mark)

_____

_____

(h) State the **TWO** main functions of a ballast (choke) in a fluorescent light fitting.

(2 marks)

(1) _____

_____

(2) _____

_____

(turn over)

Question 1 continued

(i) (i) State **ONE** precaution that could be taken when using an insulation resistance tester, set on the 500V d.c. range, to carry out an insulation resistance test on electrical equipment containing semi-conductor devices.

(1 mark)

_____

_____

(ii) State **ONE** reason why you would take the precaution stated in (i)(i).

(1 mark)

_____

_____

(j) Define the term **direct light distribution** as it applies to a light fitting.

(2 marks)

_____

_____

_____

(turn over)

Question 2

(a) (i) Describe the method by which a rotating magnetic field effect is created in a single-phase **split-phase** induction motor.

(3 marks)

_____

_____

_____

_____

_____

_____

(ii) Explain why a single-phase **capacitor-start** induction motor has a higher starting torque when compared to a single-phase **split-phase** induction motor?

(3 marks)

_____

_____

_____

_____

_____

_____

(b) If an external starting relay is to be used for a single-phase, split-phase induction motor, which winding will it switch?

(1 mark)

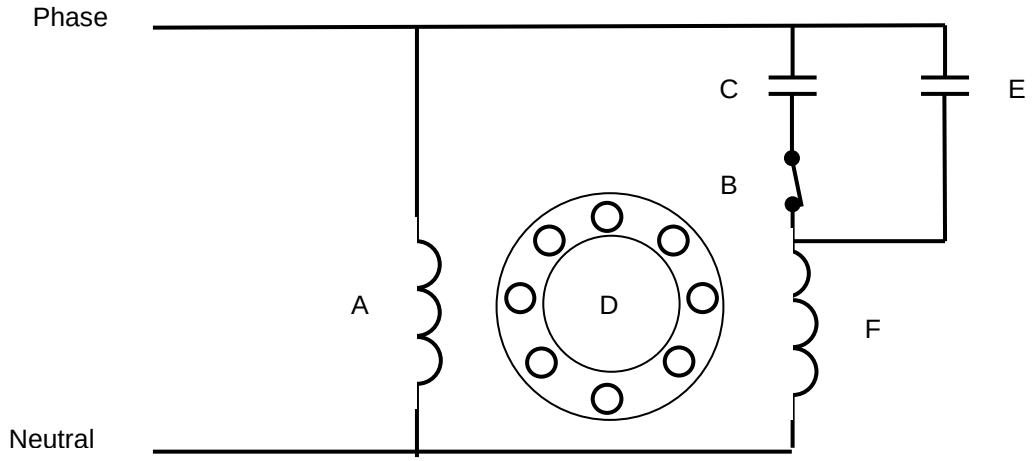
_____

(turn over)

Question 2 continued

(c) Identify each of the components labelled A to F in the diagram of a single-phase induction motor

(3 marks)



A _____

B _____

C _____

D _____

E _____

F _____

(turn over)

Question 3

(a) A 25 kW balanced load has a power factor of 0.75. The load is supplied directly from the secondary side of a delta/star transformer. The voltage on the transformer secondary is 415V.

Calculate the load current drawn by the load.

(2 marks)

(b) The delta/star transformer in (a) has a turns ratio of 47.8/1 and a voltage on the secondary side of 415V.

(i) Use the load current from (a) to calculate the **primary phase current** of the transformer.

(2 marks)

(ii) Calculate the **primary line current** of the transformer.

(2 marks)

(turn over)

Question 3 continued

(c) State the reason why transformers are rated in kVA.

(2 mark)

_____

_____

_____

_____

(d) Explain the reason why a 500 kVA transformer at Scott Base, Antarctica can be operated more heavily loaded than an identical 500 kVA transformer installed in Wellington.

(2 marks)

_____

_____

_____

_____

(turn over)

Question 4

(a) A three-phase, 10 kW pump motor needs repairing. The motor has been isolated and cables disconnected. The motor cables are still connected to the DOL starter.

State **TWO** precautions which must be taken to ensure the safety of persons and property while the work site is left unattended.

(2 marks)

(1) _____

_____

_____

(2) _____

_____

_____

(b) Describe how **isolating** three-phase electrical equipment is different from **switching off** that three-phase electrical equipment.

(3 marks)

_____

_____

_____

_____

_____

_____

_____

_____

turn over)

Question 4 continued

(c) Describe **THREE** methods of preventing the reconnection of the electricity supply to an isolated fixed-wired, three-phase machine that is being worked on.

(3 marks)

(1) _____

_____

_____

(2) _____

_____

_____

(3) _____

_____

_____

(d) Describe the circumstances where a **danger tag** is used.

(1 mark)

_____

_____

_____

(e) A voltage test using the prove-test prove method is being carried out on the supply side of a three-phase main switch to see if a switchboard is isolated.

What tests need to be made to clearly establish that isolation has taken place.

(1 mark)

_____

_____

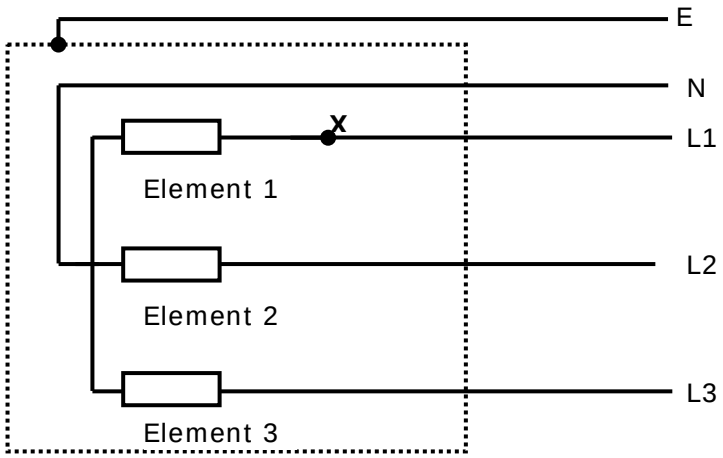
_____

(turn over)

Question 5

Introduction

The figure below represents a three-phase, star-connected 400V, 18 kW commercial oven. The oven is protected by 32A HRC fuses with a fusing factor (gG Utilisation Category) of 1.5.



An earth fault of negligible impedance has developed between L1 and the oven frame while the oven is operating. The fault occurred at point X.

The total earth fault-loop impedance is 3.96Ω. Of this impedance, the protective earthing conductor resistance is 3.75Ω due to a high resistance termination.

Use the information in the introduction to this question to answer parts 5(a), 5(b) and 5(c).

(turn over)

Question 5 continued

(a) (i) Calculate the line current of L1 **before** the fault occurs.

(2 marks)

(ii) Calculate the current that will flow in fault X.

(1½ marks)

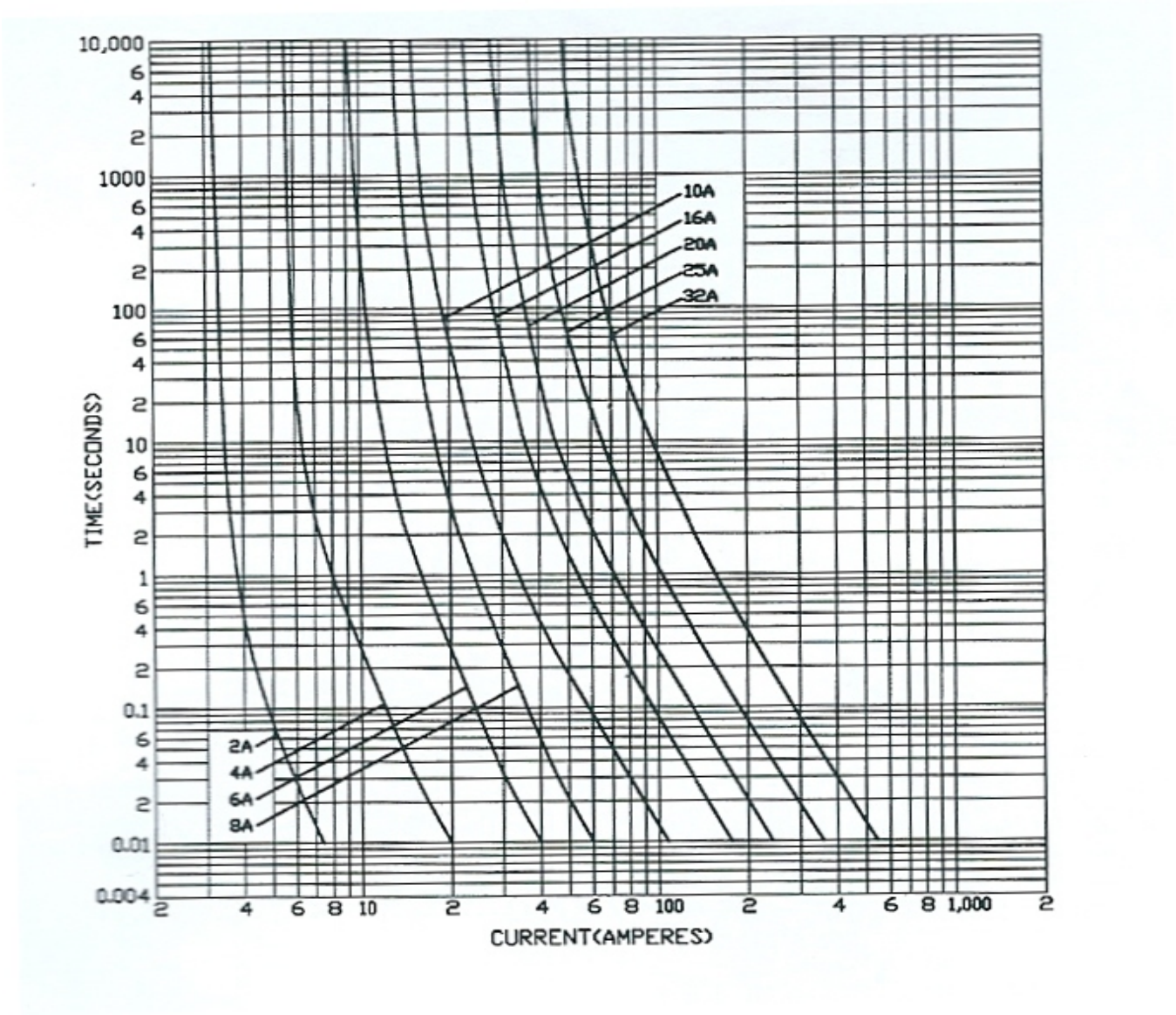
(iii) Calculate the total current that will flow in L1 when the fault occurs.

(1½ marks)

(turn over)

Question 5 continued

(b) The following is an inverse-time graph for HRC fuses



(i) Refer to inverse time graph and determine how long it will take for the 32A HRC fuse to operate with the fault current calculated in (a)(iii) flowing.

(½ mark)

_____

(ii) Refer to inverse time graph and determine the minimum fault current that needs to flow before the 32A HRC fuse will operate in 0.4s.

(½ mark)

_____

(turn over)

Question 5 continued

(iii) Calculate the minimum earth fault loop impedance required if the 32A HRC fuse is to operate within 4 s.

(2 marks)

(c) Calculate the voltage that will develop on the frame of the oven as a result of the fault on L1.

(2 marks)

(turn over)

Question 6

A single-phase, 230V electrical installation has two sets of inductive loads.

(a) Inductive Load 1

This incorporates motors and transformers.

V	P (W)	Line current I_L	VA	p.f.	Effective Z - Ω	VAr
230		20		0.75		3042.614

Calculate the value P (W).

(2 marks)

(b) Inductive Load 2

This incorporates motors and lighting.

V	P (W)	Line current I_L	VA	p.f.	Effective Z - Ω	VAr
230			2500	0.92		979.796

Calculate the value P (W.)

(2 marks)

(turn over)

Question 6 continued

(c) Calculate the total kVA of the installation.

(4 marks)

(d) Calculate the pf of the installation.

(2 marks)

(turn over)

Question 7

(a) Draw and label the **power circuit** for an automatic star/delta starter for a three-phase induction motor with the following components:

- The three-phase supply to the starter
- The main contactor
- Overloads that protect the motor in star and in delta
- The 6 terminal motor terminal block
- The star contactor
- The delta contactor

(5 marks)

(turn over)

Question 7 continued

(b) A three-phase induction motor is controlled by a star/delta starter. Each winding has a value of **8Ω**. Testing needs to be carried out to confirm this value.

The control circuit of the star/delta starter is livened but the **power circuit remains isolated.**

(i) The control circuit closes the **main and star** contactors so the motor windings are connected in **star**.

An ohmmeter is used to the test the windings.

Complete the following table by entering the expected results from the ohmmeter.

(1 mark)

$L_1 - L_2$	$L_1 - L_3$	$L_2 - L_3$
Ω	Ω	Ω

(ii) The control circuit closes the **main and delta** contactors so the motor windings are connected in **delta**.

An ohmmeter is used to the test the windings.

Complete the following table by entering the expected results from the ohmmeter.

(3 marks)

$L_1 - L_2$	$L_1 - L_3$	$L_2 - L_3$
Ω	Ω	Ω

(turn over)

Question 7 continued

(c) An ohmmeter test of the windings of a three-phase induction motor produces the following results.

In Star

$L_1 - L_2$	$L_1 - L_3$	$L_2 - L_3$
Open circuit	16Ω	Open circuit

In Delta

$L_1 - L_2$	$L_1 - L_3$	$L_2 - L_3$
8Ω	16Ω	8Ω

State the fault that has occurred on the motor.

(1 mark)

_____

_____

(turn over)

Question 8

Introduction

A three-phase, 400V workshop has been completely rewired. The work included all final subcircuits including a fixed wired, single-phase 2 kW water heater with a MIMS element. There was no change to the mains, main earthing system or switchboard.

Use the information in the introduction to this question to answer parts 8(a) and 8(b).

(a) An insulation resistance test is required to be carried on the new work and the **installation has been isolated**.

(i) For the insulation resistance test state:

- The type of instrument used.
- The test voltage – if applicable

(1 mark)

_____

_____

(ii) The water heater has been disconnected before testing of the electrical installation commences.

State the **THREE** other actions that need to be taken before insulation resistance testing can commence.

(3 marks)

(1) _____

(2) _____

(3) _____

(turn over)

Question 8 continued

(iii) Describe how to carry out the insulation resistance test on the shop.

Include the permitted minimum value of any test results.

(2 marks)

_____

_____

_____

_____

_____

_____

(iv) Describe how to carry out the insulation resistance test on the water heater.

Include the permitted minimum value of any test results.

(2 marks)

_____

_____

_____

_____

_____

_____

(turn over)

Question 8 continued

(b) The required testing has been completed and the installation has been relivened. An earth-fault loop impedance test has been carried out on the main switchboard

(i) What other earth fault loop impedance test needs to be carried out?

(1 mark)

_____

_____

_____

(ii) State **ONE** reason why the earth fault loop impedance test stated in (b)(i) is carried out.

(1 mark)

_____

_____

_____

(turn over)

Question 9

(a) The diagram on the following page shows a three-phase MEN switchboard and a three-phase distribution switchboard in a three-phase electrical installation

The main supply comes into the MEN switchboard. The three-phase distribution switchboard is supplied from the MEN switchboard and is protected by an RCBO.

On the diagram draw the conductors that show:

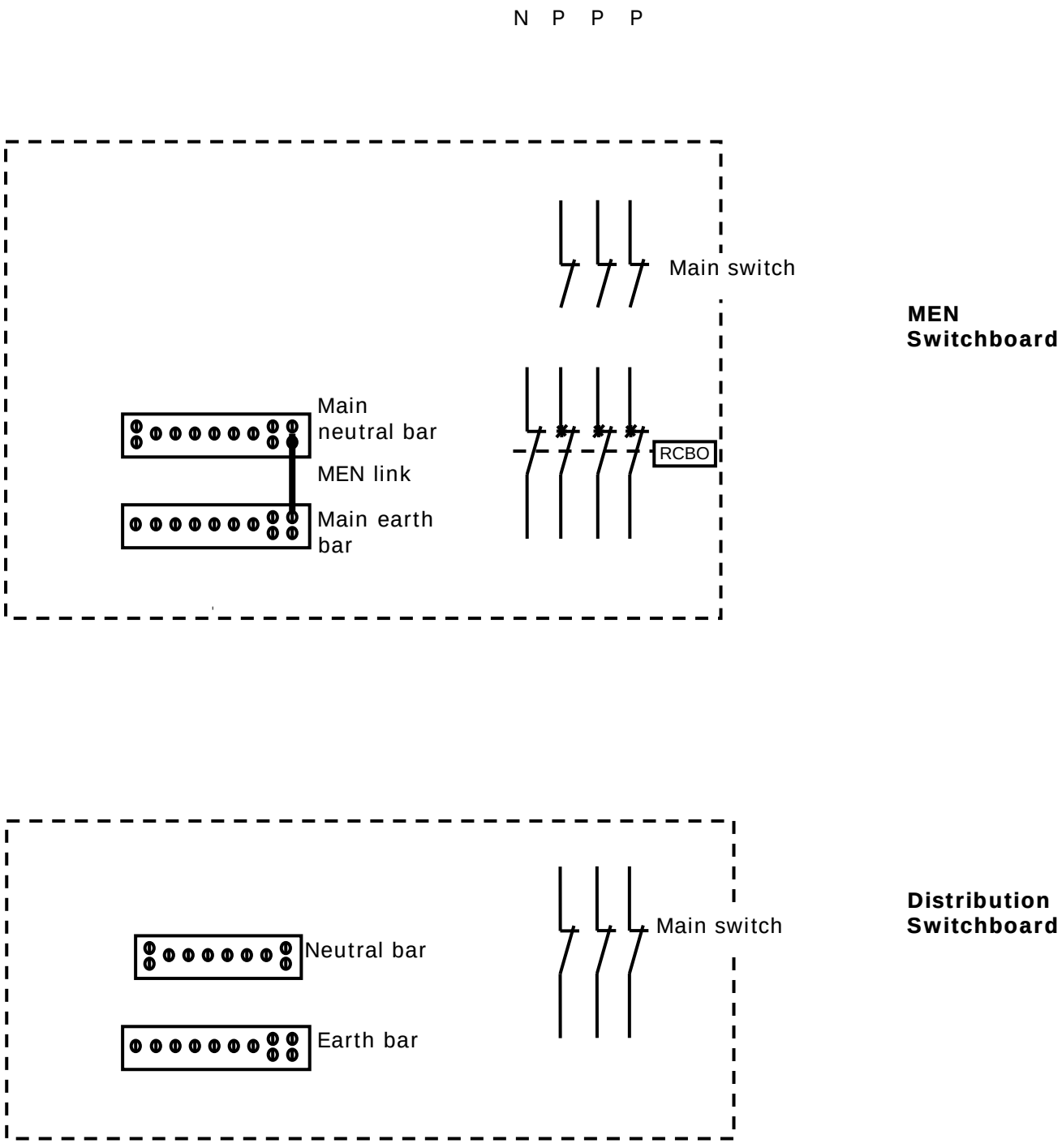
- The supply to the MEN switchboard.
- The wiring for the MEN switchboard that includes the necessary neutral and earthing arrangements that ensures the installation is safe.
- The wiring arrangement between the MEN switchboard and the distribution switchboard.
- The wiring for the distribution switchboard that includes the necessary neutral and earthing arrangements that ensures the installation is safe.

The metering and other final subcircuits, MCBs, RCDs on both switchboards **do not** need to be drawn.

(5 marks)

(turn over)

Question 9 continued



(turn over)

Question 9 continued

(b) State the reason why there is no MEN link in the distribution switchboard in the diagram in (a).

(2 marks)

_____

_____

_____

_____

(c) An electrical installation has been livened but the **MEN link was not installed** in the main MEN switchboard.

State what occurs when the electrical installation operates normally.

(1 mark)

_____

_____

(d) An electrical installation has been livened but the **MEN link was not installed** in the main MEN switchboard.

State **TWO** situations that could occur if an earth fault occurs in the electrical installation

(2 marks)

(1) _____

_____

_____

(2) _____

_____

_____

For Candidate's Use

In the box, write the number of **EXTRA** sheets you have used. Write **NIL** if you have not used any

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Questions Answered	**Marks**	
1		
2		
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7		
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TOTAL		