



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

ELECTRICIAN'S THEORY EXAMINATION

19 November 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 based on 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.

A formulae sheet has been included for your use.

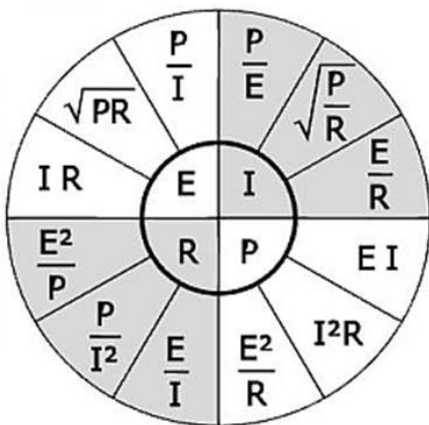
PLEASE HAND THIS PAPER TO THE SUPERVISOR BEFORE LEAVING THE ROOM.

(turn over)

Formulae Summary for EWRB Examinations

This is not a comprehensive list of formulae. It is a generic guideline that may be of use in the examination. The specific examination may require the use of formulae that are not listed.

$V = IZ$ $I = \frac{V}{Z}$	$X_C = \frac{1}{2\pi fC}$ $X_L = 2\pi \times fL$	$P = VI \cos \theta$ $P = I^2 R$ $P_{\text{delta}} = 3P_{\text{star}}$
<p><i>Star :</i></p> $I_L = I_{ph}$ $V_p = \frac{V_L}{\sqrt{3}}$	$Z^2 = R^2 + (X_L - X_C)^2$ $Z = R \pm jX$	$pf = \cos \phi = \frac{P}{S}$ $P = \sqrt{3} \times V_L \times I_L \times \cos \theta$ $P = 3V_{ph} I_{ph} \cos \phi$
<p><i>Delta :</i></p> $V_L = V_{ph}$ $I_p = \frac{I_l}{\sqrt{3}}$	$Q = \frac{V^2}{X_C}$ $Q = VI \sin \theta$ $Q_C = P(\tan \phi_1 - \tan \phi_2)$	$S = \sqrt{P^2 + Q^2} \quad S = \sqrt{3} \times V_L I_L$ $S = VI$
$\%Z = \frac{S_{\text{rating}}}{S_{\text{fault}}} \times 100$	$\% \eta = \frac{nS \cos \phi}{nS \cos \phi + n^2 P_{Cu} + P_{Fe}} \times 100$	$\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$
$P_{out} = \frac{2 \times \pi \times T \times N}{60}$	$N_s = \frac{60f}{p}$	$\% Slip = \frac{N_s - N_r}{N_s} \times 100$
$\eta = \frac{P_{out}}{P_{in}} \times 100\%$	$\omega = \frac{2\pi N}{60}$	<p><i>Insulation Resistance</i></p> $R_2 = \frac{l_1 R_1}{l_2}$
$\tan \phi = \frac{opp}{adj}$	$\sin \phi = \frac{opp}{hyp}$	$\cos \phi = \frac{adj}{hyp}$
<p><i>Series :</i> $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$</p> <p><i>Parallel :</i> $C_T = C_1 + C_2$</p>	$Q = CV$ $R = \frac{\rho l}{A}$	$\% \text{ Regulation} = \frac{V_{nl} - V_{fl}}{V_{nl}} \times 100$



Question 1

- (a) (i) What characteristic is described by the term as current through the protective device increases, the time taken to operate decreases?

(1 mark)

- (ii) What test would be carried out to determine if the rupturing capacity of an HRC fuse is compatible with the prospective short circuit current of an electrical installation.

(1 mark)

- (b) Three-phase, fixed-wired electrical equipment has been operating normally and has been isolated from an adjacent isolating switch.

Two phases were found to be live when voltage testing was carried out at the equipment terminals.

State what fault has occurred.

(2 marks)

(turn over)

Question 1 continued

- (c) A three-phase, 400V commercial oven has 3 MIMS elements connected in **star**. Each element is rated at 6 kW.

Calculate the phase current drawn by the oven.

(2 marks)

- (d) State **ONE** reason why the resistance of the protective earthing conductor of a flexible cord for a Class I electrical appliance is set at a maximum of 1 Ω .

(2 marks)

- (e) State **ONE** reason why an earth fault-loop impedance test is carried out on the socket outlet furthest from the main switchboard in a low voltage electrical installation.

(2 marks)

(turn over)

Question 1 continued

- (f) State **ONE** reason why having a protective earthing conductor resistance of less than 1Ω in a Class I electrical appliance effectively prevents electric shock hazards under fault conditions.

(2 marks)

- (g) A 12 V d.c. supply with an internal resistance of 0.2Ω is installed to supply 9V lights for an emergency lighting circuit. All lights are connected in parallel across the supply.

Each light in the circuit draws 1.5A at the rated voltage of 9V.

Calculate the maximum number of lights that can be used in the emergency lighting circuit.

(2 marks)

(turn over)

Question 1 continued

- (h) (i) Define the term **cut off characteristic** as it applies to an HRC fuse. (1 mark)

- (ii) Define the term **total clearing time** as it applies to an HRC fuse. (1 mark)

- (i) A three-phase induction motor is controlled by a star/delta starter that incorporates thermal overloads.

State **ONE** reason why HRC fuses are installed at the origin of the final subcircuit supplying the induction motor.

(2 marks)

- (j) State **ONE** hazard that could occur when disposing of low-pressure or high-pressure sodium-vapour lamps.

(2 marks)

(turn over)

Question 2

Introduction

A new factory has been constructed that incorporates some imported machinery that operates at a voltage other than standard low voltage. A dedicated supply is required for this machinery.

A 300 kVA, three-phase, delta-star transformer will be used. The characteristics of the transformer are:

- A turns ratio of 137.5 to 1
- A primary voltage of 33 kV

Use the information in the introduction to this question to answer parts 2(a), 2(b), 2(c), 2(d) and 2(e).

(a) Calculate the secondary phase voltage.

(2 marks)

(b) Calculate the secondary line voltage.

(2 marks)

(turn over)

Question 2 continued

(c) Calculate the **primary line** current.

(2 marks)

(d) Calculate the **maximum secondary line current** the transformer can deliver under full load conditions.

(2 marks)

(e) When the load on a transformer changes from no-load to full-load a voltage drop occurs at the secondary terminals.

(i) Is this voltage drop normal?

(1 mark)

(ii) State a reason to support your answer in (e)(i).

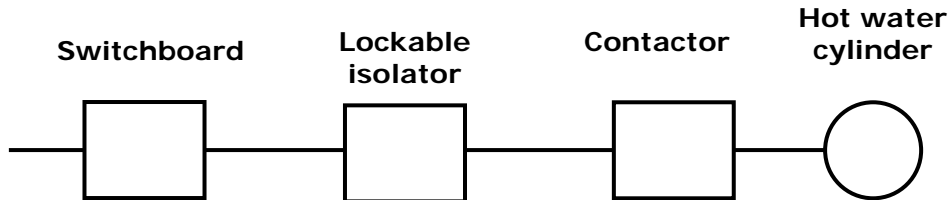
(1 mark)

(turn over)

Question 3

Introduction

This is a block diagram of a three-phase circuit to a three-phase **star-connected** hot water cylinder in a factory.



HRC fuses protect the final subcircuit to the three-phase hot water cylinder.

The existing hot water cylinder is to be removed. The new cylinder will be installed once building alterations have been completed.

Use the information in the introduction to this question to answer parts 3(a), 3(b), 3(c) and 3(e).

(a) Describe how to isolate the existing hot water cylinder.

(3 marks)

Question 3 continued

- (b) Building alterations have been completed. A new correctly-rated flexible cable has been connected to the new hot water cylinder.

State **TWO** instrument tests that must be carried out on the new flexible cable and hot water cylinder to ensure that they are safe to connect to the electricity supply.

(1 mark)

(1) _____

(2) _____

- (c) The electrician connecting the new cylinder to the contactor has found there is no lock or danger tag on the isolator.

State the action that the electrician, connecting the cylinder to the contactor, must take to ensure that it is safe to connect.

(1 mark)

- (d) The new hot water cylinder has been connected to the contactor.

Describe how to test whether the hot water cylinder is effectively connected to the MEN earthing system. State the test instrument used.

(3 marks)

(turn over)

Question 3 continued

(e) The elements in the existing hot water cylinder were rated at 1500 W each.

The elements in the new hot water cylinder are rated at 6000 W each.

State **TWO** factors relating to the existing final subcircuit that need to be considered because of the increase in load.

(2 marks)

(1) _____

(2) _____

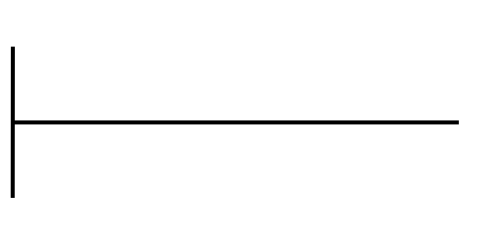
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Question 4

(a) Show the output waveform and the ripple frequency of the stated single-phase rectifiers supplied at 230 V, 50 Hz:

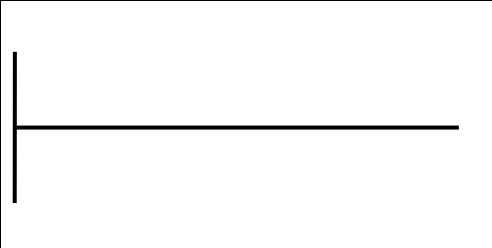
(i) Single-phase half-wave rectifier

(1½ marks)

Output waveform	
Ripple frequency	


(ii) Centre-tapped full-wave rectifier

(1½ marks)

Output waveform	
Ripple frequency	

(iii) Single-phase full-wave bridge rectifier

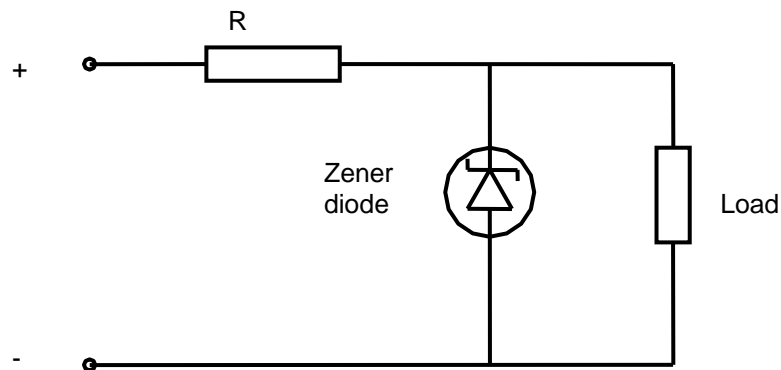
(1½ marks)

Output waveform	
Ripple frequency	

(turn over)

Question 4 continued

(b) This figure shows a load supplied by a rectified d.c. supply.



(i) State the purpose of the Zener diode?

(1 mark)

(ii) What main advantage does a Zener diode have when compared to a normal rectifier diode?

(1 mark)

(iii) State the main purpose of the resistance R?

(2 marks)

(turn over)

Question 4 continued

- (c) State **ONE** reason why rectified three-phase a.c. is easier to smooth with filters, than rectified single-phase a.c.?

(1 mark)

- (d) State **ONE** component that may be used as part of a circuit to filter a rectifier output.

(½ mark)

(turn over)

Question 5

Introduction

A three-phase 400V small commercial factory has the following loads:

- Lighting and heating 9 kW unity power factor
- Motors 15 kW 0.6 p.f. lagging
- Welding set 12 kVA 0.7 p.f. lagging

The KVAr of the installation is 28.6 kVAr.

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

- (a) Calculate the **total kW** of the installation.

(3½ marks)

- (b) Calculate the **kVA** of the entire electrical installation.

(2 marks)

(turn over)

Question 5 continued

(c) Calculate the power factor (p.f.) of the entire electrical installation.
(2 marks)

(d) Calculate the line current drawn by the installation.
(2½ marks)

(turn over)

Question 6

- (a) In an electrical installation the **rupturing capacity** of an MCB on the switchboard is **under-rated** for the fault level of the installation.

State **TWO** situations that could occur if a short-circuit fault occurs on the final subcircuit the MCB protects.

(2 marks)

(1) _____

(2) _____

- (b) An earth fault loop impedance test at the main switchboard of an electrical installation shows that prospective short-circuit current level is 3 kA.

- (i) State **ONE** reason why the rewirable fuses on the main switchboard need to be replaced.

(1 mark)

- (ii) State **TWO** types of protective devices that can be used to replace the rewirable fuses.

(1 mark)

(turn over)

Question 6 continued

- (c) An HRC fuse has terms 63A - 440V - AC40 marked on it.

Define each of these terms.

(3 marks)

63A

440V

AC40

- (d) An electrical installation comprises an MEN main switchboard and three distribution boards.

State how correct discrimination occurs between protective devices if a fault occurs on a final subcircuit supplied from a distribution board.

(2 marks)

(turn over)

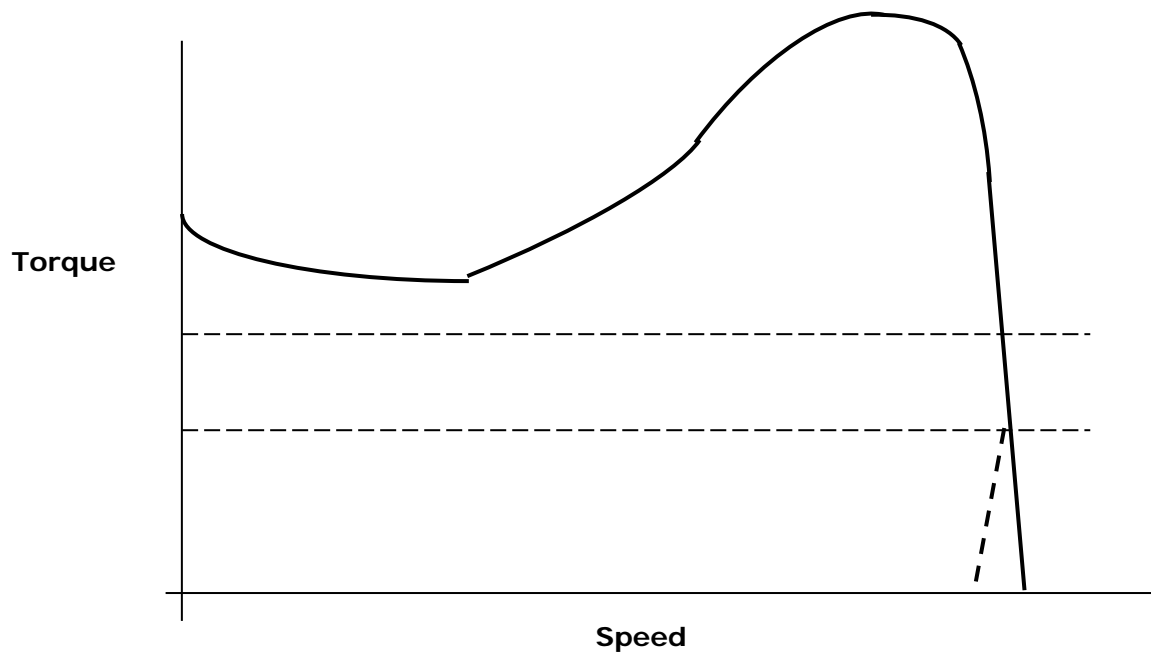
Question 6 continued

- (e) State **ONE** reason why an HRC fuse would be installed up-stream of the MCBs on a switchboard in an existing single-phase commercial installation. (1 mark)

(turn over)

Question 7

- (a) This figure is a speed/torque characteristic graph of a squirrel cage induction motor.



On the graph show the location of:

- The starting torque
- The maximum or pull-out torque.
- Full-load torque
- Running torque
- Rotor speed – N_R
- Synchronous speed N_S .

(3 marks)

(turn over)

Question 7 continued

- (b) (i) Draw and label a circuit diagram of a 400V control circuit of a three-phase DOL motor starter.

(4 marks)

- (ii) On the diagram drawn in (b)(i) include a remote stop-start station that is connected into the control circuit using a three-core cable.

(3 marks)

(turn over)

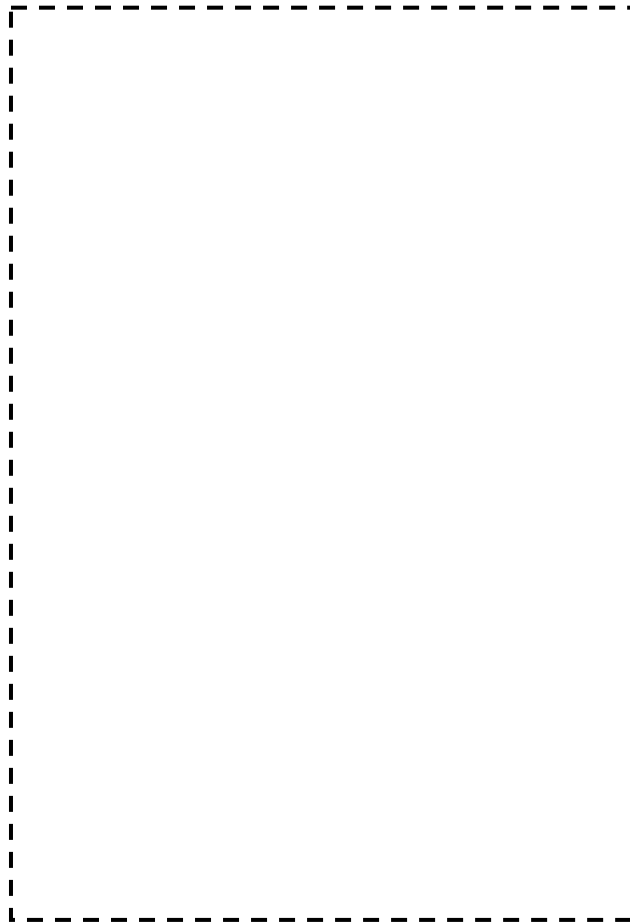
Question 8

- (a) Draw and label a circuit diagram of a 230V RCD used for personal protection. Include the Class I equipment as the load.

The RCD must include all the components necessary to allow the RCD to be deemed **electrically safe**.

(4 marks)

Single-phase RCD



Class I equipment



(turn over)

Question 8 continued

- (b) (i) State the **maximum permitted** rated residual current of an RCD installed for personal protection of children in a kindergarten. (½ mark)

- (ii) State the **maximum permitted** rated residual current of an RCD installed for the protection of property. (½ mark)

- (c) Figure A depicts a symbol that may be found on an RCD.

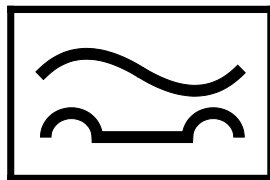


Figure A

- (i) State the type of RCD identified by Figure A. (½ mark)

- (ii) State the **TWO** operating characteristics of the RCD identified by Figure A. (2 marks)

(1) _____

(2) _____

(turn over)

Question 8 continued

- (d) State the reason why Type **AC** RCDs are prohibited from being used in New Zealand.

(½ mark)

- (e) (i) The phase and neutral on the supply side of a single-phase RCD have been transposed.

Would the RCD operate if it detected an earth leakage fault on the circuit it protects? State a reason to support your answer.

(1 mark)

- (ii) Would an RCD operate if there was a short between neutral and earth on the final subcircuit it protects? State a reason to support your answer.

(1 mark)

(turn over)

Question 9

Introduction

A nameplate of a three-phase, 4-pole, induction motor has the following information:

Frequency	60 Hz
Line voltage	400V
Line current	
kW	10
Efficiency	81.5%
Slip	4%

The line current lags the voltage by a phase angle of 35°

Use the information in the introduction to this question answer parts 9(a), 9(b), 9(c) and 9(d)

(a) Calculate the **power factor** of the motor. (1 mark)

(b) Calculate the **input power** of the motor. (2 mark)

(c) Calculate the **line current** of the motor. (2 marks)

(turn over)

Question 9 continued

(d) (i) Calculate the slip speed of the motor

(3 marks)

(ii) Calculate the rotor speed of the motor

(2 marks)

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	
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2		
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