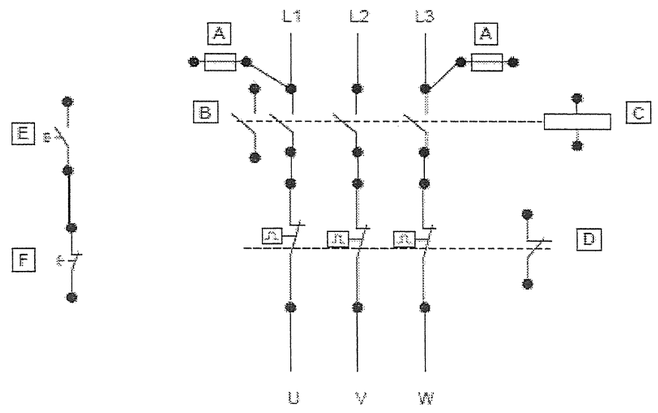
WRITE ALL YOUR WORK ON THE ANSWER BOOK PROVIDED. EVERY ANSWER SHOULD INCLUDE ALL WORKINGS, NECESSARY DIAGRAMS AND FORMULAE.

START EACH ANSWER ON A FRESH PAGE.

Answer any **FIVE** Questions

1. (a) The figure below represents the components of a direct-on-line (DOL) starter with a 400V control circuit and a remote stop/start station:
   - L1, L2, and L3 represent the three-phases connected to the main contacts.
   - U, V and W represent the three conductors from the thermal overloads to the motor
   - A are the control circuit fuses
   - B is the hold-in contact
   - C is the 400V coil
   - D is the auxiliary overload contact
   - E is the start button
   - F is the stop button

   Copy the figure on the answer booklet and complete a working 400V control circuit. **(8 marks)**



(b) A 400V, three-phase, induction motor is protected by thermal overloads and HRC fuses.
   i. Explain why the thermal overloads are installed to protect the motor. **(2 marks)**
   ii. Explain why the HRC fuses are installed to protect the motor circuit. **(2 marks)**

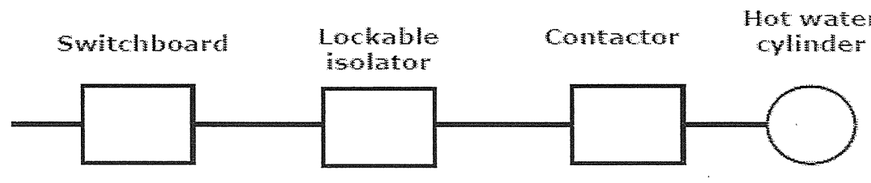
(c) A three-phase 400V, 3kW induction motor in an industrial machine is controlled by a star-delta starter. The motor was removed from the machine for cleaning and checking. Subsequently the motor was returned, and checks and tests need to be carried out to ensure the motor is safe to reconnect. The cable supplying the motor is still connected to the motor.

   i. Describe how to test the motor and attached cables to identify the motor windings. Identify the type of instrument to be used, and state the expected test results. **(3 marks)**

   ii. Two tests using test instruments need to be carried out on the motor and attached cables to ensure it is safe to connect to the electricity supply.
      (a) State the first test that needs to be carried out. **(1 mark)**
      (b) For each of the two tests state:
         1. The type of test instrument used.
         2. The test voltage, if applicable
         3. How the test is carried out.
         4. A test result value that will permit the motor to be returned to service. **(4 marks)**

2. (a) Explain why mechanical interlocks are incorporated in a star/delta starter. **(3 marks)**
   (b) State the reason why a capacitor would be connected in series with the start winding in a single-phase a.c. split-phase induction motor. **(3 marks)**
   (c) For what reason would you connect a resistor across a circuit after the electricity supply to that circuit has been isolated? **(2 marks)**
   (d) State the main consideration when selecting a protective device for a switchboard. **(2 marks)**
   (e) In relation to HRC fuses define the term cut-off characteristic as it applies to HRC fuses. **(2 marks)**

   (f) The block diagram below shows a three-phase star-connected hot water cylinder in a factory. HRC fuses protect the final sub-circuit 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.



   i. Describe how to isolate the existing hot water cylinder. **(4 marks)**
   ii. 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. **(4 marks)**

3. A water pump is run by a 15 kW, 3 phase, 415 Volts, 50 Hz motor. Both the pump and the motor are submerged in water.

   (a) What are the features of such a motor to be able to run under water? **(4 marks)**
   (b) Name four types of protection which are required for the motor. **(2 marks)**
   (c) Describe in detail one of the above-mentioned protection devices. **(4 marks)**
   (d) The motor starter is situated above ground. Draw a diagram showing how the cable between the starter and the motor is installed. **(4 marks)**
   (e) Describe with the aid of a diagram one type of starter suitable for this motor. **(6 marks)**

4. (a) List the advantages and disadvantages of:

i. Paper insulated, lead sheathed and armoured Cables
ii. Thermosetting insulated Cables.
iii. PVC\SWA\PVC Cables. **(6 marks)**

(b) Answer briefly:

i. Why are heavy section single core cables for use in 3 phase a.c. systems usually unarmoured? **(3 marks)**
ii. How are such cables protected to prevent them being damaged when installed underground? **(3 marks)**
iii. What do you understand by single-point bonding as applicable to single-core cables with non-magnetic armour? **(3 marks)**
iv. What precautions should be taken when installing single-core cables with non-magnetic armour bonded at one point only? **(3 marks)**
v. From a current rating point of view is solid bonding to be preferred to single-point bonding? Give reasons for your answer. **(2 marks)**

5. (a) Draw circuit diagrams to show how the power may be measured in a balanced / unbalanced load using a minimum of instruments for the following circuits.

i. Three-phase three wire load
ii. Three-phase four wire load

For each of the above cases show how the power is obtained. **(10 marks)**

(b) Draw a neat and well labelled circuit diagram to show how a wattmeter, voltmeter and an ammeter may be connected to a three-phase three wire balanced load to measure:

i. The power factor
ii. The reactive voltamperes

Explain how the above are obtained from the instruments readings **(10 marks)**

6. (a) Explain with the aid of diagrams the method of reversing the direction of rotation of each of the following types of motor:

i. Three-phase induction motor **(2 marks)**
ii. Single-phase capacitor start motor **(2 marks)**
iii. DC shunt motor **(2 marks)**
iv. Universal motor **(2 marks)**

(b) Briefly describe what type of motor enclosure is required for the following condition:

i. Possibility of falling liquids **(2 marks)**
ii. Poor ventilation in the working area **(2 marks)**
iii. Sited externally **(2 marks)**
iv. Flammable gases present **(2 marks)**

(c) Name any **four** factors that may be considered when ordering an electric motor? **(4 marks)**

END OF PAPER

EXAMINATION: AUTHORISATION B

Paper II (Electrical Installation Technology)

Time Allowed: 3 Hrs

July 2018