SPARKS

Electrical supply systems:

(Covering Outcome 2 of Unit 304 'Understand the principles of internal and external earthing arrangements for electrical installations for buildings, structures and the environment' (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91)

BS7671:2008 +A3:2015 (Answers – references to On-Site Guide)

You may find it helpful to have a copy of BS7671:2008 +A3:2015 On-Site Guide.

Question 1:

TN-C-S, TN-S and TT are all types of?

Earthing arrangement (2.1)

Question 2:

State the typical cross-sectional-areas for: (a) The earthing conductor and (b) the main protective bonding conductors installed in an installation having a single-phase supply and a 100A maximum service cut-out fuse.

(a) 16mm^2 and (b) 10mm^2 (Fig: 2.1(i), (ii) and (iii))

Question 3:

The Distributor's cut-out, Energy meter and isolator switch *(if provided),* are the property of which person/s?

Distributors cut-out - property of the distributor (2.2.1) Energy meter - property of the meter owner or energy supplier (2.2.2) Isolator switch - property of the distributor (2.2.4)

Question 4:

A small portable generator with an output ranging from 0.2kVA to 10kVA single-phase is likely to have a 'floating earth', what does this mean?

A floating earth means that there is no earth connection between the chassis of the portable generator and the earth connection on the socket-outlet of the unit. The earth socket-tube of the socket-outlet is connected to the frame of the generator only. (See figure 2.4.1 On-Site Guide).

Question 5:

Where a portable generator supplies electrical equipment with exposed conductive parts an earth electrode should be installed. What is the function of the electrode?

To provide a reference for the generator to the general mass of earth; the electrode does not form part of the earthing arrangement. (2.4.3 On-Site Guide)

Revision for AC circuit components:

(Covering Unit 309 Outcome 7 'Understand how different electrical properties can effect electrical circuits, systems and equipment' (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 or EAL equivalent)

Task 1: Complete the following to provide a revision summary.

If two conductive plates are arranged parallel to each other and separated by a layer of insulation, and a voltage applied between the plates, an electric charge will be created.

The description above refers to which type of electrical component?

A capacitor

The electric charge can be determined from the following formula. Complete the key.

Q = I t
Where **Q** = charge in Coulombs, **I** = current in Amperes and **t** = time in seconds

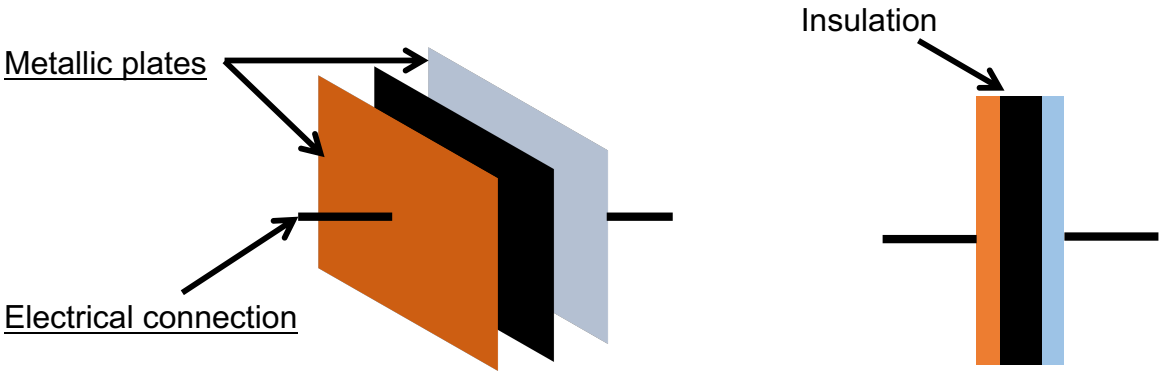
The amount of charge that can be stored is determined by three factors, these are?

(i) The area of the metallic plates

(ii) The thickness of the insulation, (dielectric), between the plates

(iii)The material used for the insulation, (dielectric).

Complete the labels for the following diagram.



The illustration shows the basic construction of a: Capacitor

The name given to the insulation is the: Dielectric

The capacitance, (symbol C) of a capacitor is measured in: Farads (symbol F)

When a voltage is applied to a capacitor a current will flow. The current will reduce in value as the capacitor reaches full charge. At full charge the current will be zero.

If a charged capacitor is connected into a circuit, the stored charge will be released. The discharge current will depend on the circuit properties generally however current will start high and then decrease to zero as the capacitor fully discharges.

If a capacitor is connected to an alternating current (AC), circuit it will charge and discharge for as long as the supply is connected.

The opposition to current flow in a capacitor in an AC circuit is called?

Capacitive reactance (symbol $\mathbf{X_C}$) measured in: (unit: **Ohms** symbol: **Ω**)

The capacitive reactance of a capacitor connected in an AC circuit depends on two factors, these are?

(i) The **Frequency** of the a.c. supply (unit: Hertz, symbol: Hz)

(ii) The **Capacitance** of the capacitor (unit: Farads, symbol: F)

If a capacitor is rated in μF (micro-farads), state the formula to find capacitive reactance and make a key stating the name and unit symbol for each **relevant** part of the formula:

Formula:

$$Xc = \frac{1}{2 \pi f C}$$

Key:

Xc = Capacitive reactance in Ω
f = frequency in Hz
C = capacitance in Farads
π = 3.142

Task 2: Practice questions:

1) Calculate the capacitive reactance of a capacitor rated at 125μF when it is connected into an a.c. circuit operating at 50Hz.

$$X_C = \frac{1}{2 \times \pi \times 50 \times 125 \times 10^{-6}}$$

$$= 25.5\ \Omega$$

$X_C = 25.5\Omega$

2) A capacitor has 230V applied across it and a current of 1.5A flows through it when connected to a 50Hz a.c. supply. Determine the value, (or rating), of the capacitor in μF.

$$X_C = \frac{U_o}{I} \qquad X_C = \frac{1}{2\ \pi\ f\ C}$$

$$X_C = \frac{230}{1.5} \qquad C = \frac{1}{2\ \pi\ f\ X\ c}$$

$X_C = 153.333\ \Omega$

$$C = \frac{1}{2\pi \times 50 \times 153.333}$$

$$C = 20.76\ \mu F$$

Capacitors:

(Covering Unit 309 Outcome 7 'Understand how different electrical properties can effect electrical circuits, systems and equipment' (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 or EAL equivalent)

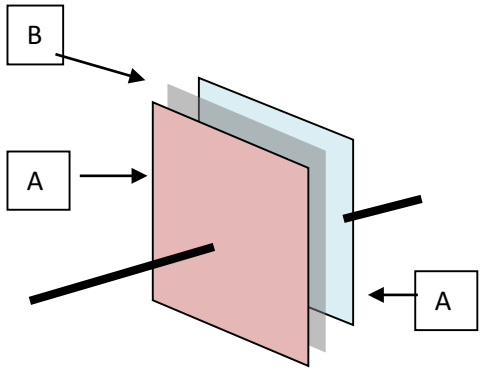
Question 1:

Complete the following statement:

A capacitor consists of at least two **metallic plates (A)**, separated by an insulator called a **dielectric (B).** When a voltage is applied to the plates an electric **charge** can be stored.

Question 2:

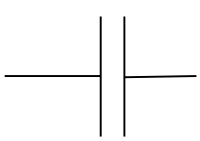
By using the letter codes in question 1, complete the labels on the diagram:



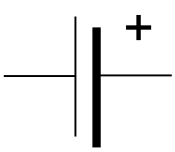
Question 3:

Identify the correct names for each of the capacitor symbols shown below.

Symbols:

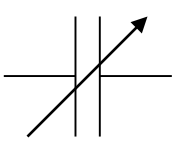


General

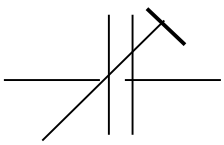


Electrolytic

Or Polarised



Variable



Pre-set adjustment

The following table illustrates some types of dielectric used in capacitor manufacture, the maximum electrical stress voltage (MV) the insulator can withstand and typical applications of the capacitors.

Material	Max. Electrical Stress Voltage (MV)	Application
Air	2	Variable capacitors.
Mica	100	High frequency capacitors
Paper	5	General purpose capacitors
Polythene	40	Higher quality than paper – general purpose uses
Insulating Oil	50	Industrial capacitors used for power factor correction.

Capacitor Facts:

Question 4:

Complete the missing words in the following statements.

Unit of capacitance:

The Unit of Capacitance is the **farad, symbol F**

The farad shows how much electric **charge** can be stored in a capacitor per volt applied across the capacitor terminals.

Quantity of stored charge:

The quantity of electricity stored can be expressed as:

$$Q = CV$$

Q = charge measured in **coulombs**

C = capacitance of the capacitor in farads

V = the p.d. across the plates measured in volts

Dimensions:

The capacitance of a capacitor relies on the physical dimensions of the capacitor:

a) Capacitance is ***directly proportional*** to the physical **area** of the plates and

b) Capacitance is ***inversely proportional*** to the **distance between** the plates, i.e. the thickness of the dielectric.

Electric field:

When a capacitor is charged, an electric field will exist between the plates.

The electric field can be increased by **increasing** the applied voltage.

If the applied voltage exceeds the dielectric stress voltage limit, (called the 'electric field strength'), the dielectric will **break-down** resulting in a **short - circuit** between the plates; the capacitor will be destroyed and cannot be repaired.

Electric field strength can be found by the potential difference (p.d), across the plates (V), being divided by the distance, (d) between the plates:

$$E = \frac{V}{d}$$

E is expressed in volts per metre.

Energy stored in a capacitor:

The energy stored in a capacitor depends on its capacitance and the square of the potential difference, (p.d), across it.

Energy *(W)* = ½ CV² measured in Joules.

Question 5:

Find the energy stored in a 100μF capacitor that has a p.d. of 200V across it.

Use 10^{-6} because capacitor is in μF

Energy *(W)* = ½ CV²

$W = 0.5 \times 100 \times 10^{-6} \times 200^2$

Connection arrangements:

Capacitors can be connected in series, parallel or a combination of series and parallel.

Question 6:

Complete the following summary for the total capacitance of a capacitor.

i. Capacitance will be **increased** with a greater area of the plates
ii. Capacitance will be **decreased** if the thickness of the dielectric is increased

Question 7:

Complete the following statements for combinations of capacitors.

i. Capacitance will be increased if capacitors are connected in **parallel** with each other.
ii. Capacitance will be decreased if capacitors are connected in **series** with each other.

Question 8:

Identify two formulae that can be used to determine the total capacitance of a group of capacitors connected in (a) series, and (b) parallel.

(a) $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ **etc…**

note: total capacitance decreases – complete opposite to resistance

(b) $C_T = C_1 + C_2 + C_3$ **etc…**

note: total capacitance increases - complete opposite to resistance

Question 9:

Two capacitors 12μF and 8μF are connected in series across a 10V dc supply. Calculate the total capacitance of this circuit.

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$

$\frac{1}{C_T} = \frac{1}{12} + \frac{1}{8} = 0.083 + 0.125$

$\frac{1}{C_T} = 0.208$

So $C_T = \frac{1}{0.208} = 4.8\mu F$

Note: In this example there is no need to change μF to farads. **Or…**

$C_T = \frac{C_1 C_2}{C_1 + C_2}$

$= \frac{(12)(8)}{12 + 8}$

$= \frac{96}{20}$

$= 4_1 8\mu F$

Note: This method only works with 2.

Question 10:

Determine the electric charge on each of the two capacitors in question 1 above.

$Q = C\ V$

$Q = 4.8 \times 10$

$Q = 48\mu C$

Warning:

All capacitors have the ability to retain stored charge; it is therefore dangerous to touch the terminals of a capacitor without first ensuring that it is discharged.

Discharging can be carried out in a number of ways:

a) By the use of a high ohm discharge resistor permanently connected across the capacitor terminals.

b) By shorting - out the terminals using a substantial piece of well insulated wire (not preferred.)

NOTE: It is imperative that safety glasses be worn whilst discharging a capacitor as hot metallic particles could be repelled from the arc should the device be fully charged.

Revision for AC circuit components:

(Covering Unit 309 Outcome 7 'Understand how different electrical properties can effect electrical circuits, systems and equipment' (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 or EAL equivalent)

Task 1: Complete the following to provide a revision summary.

When a coil of wire, such as a motor winding, transformer winding, inductor or choke (ballast), is connected to an alternating current supply, opposition to current flow is caused by **two conditions**, these are?

i) Resistance and (ii) Inductance

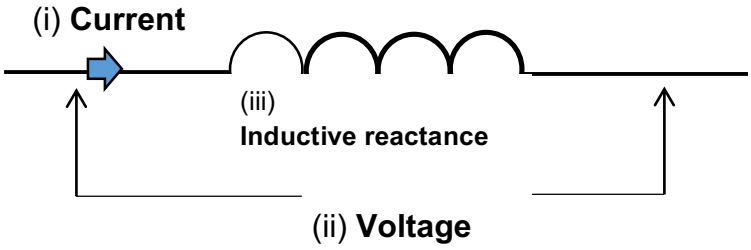
The combined effect of these two conditions is called?

Inductive reactance (symbol $\mathbf{X_L}$) measured in: (unit: **Ohms** symbol: **Ω**)

The inductive reactance of a coil depends on two factors, these are?

(i) The **Frequency** of the a.c. supply (unit: Hertz, symbol: Hz)
(ii) The **Inductance** of the coil (unit: henry, symbol: H)

Label the following diagram using correct terms at (i), (ii) and (iii)



State the formula for inductive reactance and make a key stating the name and unit symbol for each **relevant** part of the formula:

Formula:

$$\mathbf{X_L = 2\ \pi\ f\ L}$$

Key:

X_L = Inductive reactance in Ω
f = frequency in Hz
L = inductance in henrys
π = 3.142

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Task 2: Practice questions:

1) Calculate the inductive reactance of a coil of 0.26H when it is connected into an a.c. circuit operating at 50Hz.

$X_L = 2 \pi f L$

$X_L = 2 \times \pi \times f \times L$

$X_L = 2 \times \pi \times 50 \times 0.26$

$X_L = 81.681\Omega$

2) A coil has 200V measured across it and a current of 1.85A flowing through it when connected to a 50Hz a.c. supply. Determine the value, (or rating), of the inductor, in henrys.

$X_L = \frac{U_o}{I}$

$X_L = \frac{200}{1.85}$

$X_L = 108.108\ \Omega$

$X_L = 2 \pi f L$

$L = \frac{X_L}{2 \pi f}$

$L = \frac{108.108}{2 \times \pi \times 50}$

$L = 0.344$ H

3) Determine the current flowing through a coil of 0.65H when connected to a 230V 60Hz a.c. supply.

$X_L = 2 \pi f L$

$X_L = 2 \times \pi \times 60 \times 0.65$

$X_L = 245\ \Omega$

$I = \frac{U_o}{X_L}$

$I = \frac{230}{245}$

$I = 0.94$ A

4) Calculate the voltage across an inductor of 0.25H when the current flowing through it is 2.65A at 48Hz.

$X_L = 2 \pi f L$

$X_L = 2 \times 3.142 \times 48 \times 0.25$

$X_L = 75.4\ \Omega$

$U_o = I \times X_L$

$U = 2.65 \times 75.4$

$U = 199.8$ V (200)

Initial verification of electrical installations: Answers

(Covering Unit 307 'Understand principles, practices and legislation for the inspection, testing commissioning and certification of electro-technical systems and equipment in buildings, structures and the environment' (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 and the EAL equivalent)

Task 1: complete the following questions regarding the principles, practices and legislation for the initial verification of electrical installations.

Reference (GN) is for the IET Guidance Note 3 document

1) State two occasions when initial verification can be carried out.

Answer: during construction and on completion of the installation (page15 GN3)

2) Identify two aspects of BS7671 that initial verification will confirm.

Answer: design and construction (page15 GN3)

3) When an inspector carries out an initial verification explain why inspection and testing can only be '*so far as is reasonably practicable"*?

Answer: It would not be possible for an inspector to confirm the correct size cable has been installed throughout its length due to the cable being buried or enclosed within the fabric of the building. However he/she may confirm the correct cable size at a distribution board. (page15 GN3)

4) Identify the three BS7671 generic requirements for items to be verified during the initial verification procedure.

Answer:

Equipment is correct type and complies with applicable British Standards, or equivalent

The fixed installation is correctly selected and erected

The fixed installation is not visibly damaged

(page15 GN3)

5) State the correct title of the statutory document that concerns inspection and test records, and identify the length of time records must be kept.

Answer: The Electricity at Work Regulations 1989, and in particular Regulation 4(2). The Memorandum of guidance on the Electricity at Work Regulations (HSR25) recommends records be kept for the lifetime of the installation. (page16 GN3)

6) Briefly explain the meaning of the term 'Relevant criteria' in respect to the initial verification process.

Answer: The designer may have made specific requirements for a given installation; as such the inspector will need to ask for these requirements or, if relevant, forward a copy of the test results to the designer for verification. (page16 GN3)

7) State who is responsible for comparing and verifying inspection and test results with relevant criteria for an installation.

Answer: The person responsible for inspecting and testing the installation. (page16 GN3)

8) State the correct titles of three certificates that apply to a new installation or additions to an existing installation.

Answer:

Electrical Installation Certificate – multiple-signature

Electrical Installation Certificate – single-signature

Minor Electrical Installation Works Certificate

(page16 GN3)

9) List three items of required information regarding the assessment of general characteristics for an installation.

Answer:

- *Maximum demand*
- *Number and type of live conductors*
- *Type of earthing*
- *Nominal voltage*
- *Supply frequency*
- *Prospective short-circuit current*
- *Earth fault loop impedance (Ze)*
- *Type and rating of overcurrent protective devices*
  See page 17 of GN3

10) The Health and Safety at Work… Act 1974 requires relevant information to be available for what purpose?

Answer: safe use / inspection & testing / maintenance (page17 GN3)

Electrical Instrument readings: Answers

In the following exercise match each unit with its measured unit

No.	Unit		Measured Unit
1	Current 2×10^{3}	**A**	**36mA**
2	Voltage 132×10^{3}	**B**	**45000Ω**
3	Resistance 150×10^{6}	**C**	**6kW**
4	Current 36×10^{-3}	**D**	**150MΩ**
5	Resistance 45×10^{3}	**E**	**20MW**

6	Power 60×10^2	**F**	**132kV**
7	Power 20×10^6	**G**	**2kA**
8	Voltage 400×10^6	**H**	**400MV**

Solutions:

1	**G**	**5**	**B**
2	**F**	**6**	**C**
3	**D**	**7**	**E**
4	**A**	**8**	**H**

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Cable Selection: Revision multiple-choice questions

(Covering Outcome 6 of Unit 305, 'Understand the practices and procedures for installing wiring systems, associated equipment and enclosures', (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 or EAL equivalent)

No.	Question.	Answer
1	The term **Ib** is used to identify which one of the following?	
a	Current rating of the circuit protective device	
b	Rating factor for ambient temperature	
c	Current rating of the cable	
d	Design current of the circuit	**X**

No.	Question.	Answer
2	If a BS3036 semi-enclosed fuse is to be used to protect a cable the correct symbol and rating factor is?	
a	Cf 0.725	**X**
b	Cr 0.735	
c	Cf 0.500	
d	Cr 0.250	

No.	Question.	Answer
3	Identify the correct symbol and rating factor for a cable installed in contact with thermal insulation for 400mm of its length	
a	Ci 0.88	

b	Cf 0.78	
c	Cs 0.63	
d	Ci 0.51	**X**

No.	**Question.**	**Answer**
4	The recommended maximum voltage drop allowance for a lighting circuit is:	
a	1%	
b	2%	
c	3%	**X**
d	5%	

No.	**Question.**	**Answer**
5	An extra-low nominal voltage is?	
a	25V	**X**
b	200V	
c	230V	
d	250V	

No.	**Question.**	**Answer**
6	In cable selection, when applying a rating factor for ‘groups’ which of the following statements is correct?	

a	Factors apply to the number of cores in the cable	
b	Factors apply to the number of circuits existing	
c	Factors apply to the number of circuits in total	**X**
d	Factors apply to the cores in a multi-core cable	

No.	**Question.**	**Answer**
7	The current rating of a single-core 16mm², 70ºC thermoplastic insulated, non-armoured cable, clipped direct to a surface and supplying a three-phase load is?	
a	87A	
b	79A	**X**
c	68A	
d	61A	

No.	**Question.**	**Answer**
8	The mV/A/m rating for a 10mm² multi-core armoured 70ºC thermoplastic insulated cable supplying a single – phase load is?	
a	4.4	**X**
b	3.8	
c	2.8	
d	2.4	

No.	**Question.**	**Answer**
9	The current and mV/A/m rating for a 2.5mm² 70ºC thermoplastic insulated cable installed to Method 101 is?	

a	27A and 18mV/A/m	
b	21A and 18mV/A/m	
c	17A and 18mV/A/m	**X**
d	13A and 29mV/A/m	

No.	**Question.**	**Answer**
10	The reference method to be used to determine current-carrying capacity of non-sheathed cables enclosed in conduit on a masonry wall, is?	
a	Reference Method A	
b	Reference Method B	**X**
c	Reference Method C	
d	Reference Method D	

Periodic Inspection and Testing of electrical installations:

(Covering Unit 307 'Understand principles, practices and legislation for the inspection, testing commissioning and certification of electro-technical systems and equipment in buildings, structures and the environment' (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 and the EAL equivalent)

Practice Multiple-choice questions:

No.	Question.	Answer
1	Which one of the following is concerned principally with Part 6 of BS7671?	
a	Electricity at Work Regulations 1989	
b	Building Regulations	
c	Electricity, Safety, Quality and Continuity Regulations	
d	IET Guidance Note 3	**X**

No.	Question.	Answer
2	To enable an electrically skilled person to construct an installation and to commission it, which document is required?	
a	IET BS7671:2008	
b	Electricity at Work Regulations 1989	
c	The Specification	**X**
d	Part P of the Building Regulations	

No.	Question.	Answer
3	Precise details regarding electrical equipment to be installed must be obtained from?	
a	The equipment manufacturer	**X**
b	The client	
c	Main contractor	
d	Electricity supplier	

No.	Question.	Answer
4	Electrical test instruments should conform to which of the following British Standards?	
a	HS (G) 141	
b	HSE Guidance	
c	EAWR 1989	
d	BS EN 61557	**X**

No.	Question.	Answer

5	Electrical shock hazards may arise from parts of an electrical installation, especially?	
a	Resistive loads	
b	Electric heating systems	
c	Voltages on earthed metalwork	
d	Capacitive loads	**X**

2

No.	**Question.**	**Answer**
6	The responsibilities of an inspector are each of the following except?	
a	No danger occurs to persons, livestock and property during testing	
b	Comparing the test results with design criteria	
c	Consider the condition of the installation and advise accordingly	
d	Issue prohibition notices	**X**

No.	**Question.**	**Answer**
7	The requirement for inspecting and testing the electrical installation for a house of multiple occupancy, is that it must be inspected and tested at least?	
a	Annually	
b	Every two years	
c	Every five years	**X**
d	Every ten years	

No.	**Question.**	**Answer**
8	When inspecting an installation for the first time the purpose is to verify each of the following except?	
a	No part of the installation is damaged	
b	Test results comply with previously obtained data	**X**
c	Parts of the fixed installation are correctly selected and erected	
d	Installed electrical equipment is of the correct type	

No.	**Question.**	**Answer**
9	Records concerning the condition of the electrical installation of domestic or non-domestic premises may be required by each of the following except?	
a	The person carrying out the inspection and testing	

b	The owner of the premises	
c	The occupant of the premises	
d	The main building contractor	**X**

No.	Question.	Answer
10	A re-inspection & next test date for an existing installation is decided by?	
a	The client	
b	Electrical designer	
c	Electrical contractor	
d	The person carrying out the inspection and testing	**X**

No.	Question.	Answer
11	Completion of the electrical design, construction and inspection when carried out by different persons requires the issue of?	
a	A Minor Works Certificate	
b	Electrical Installation Certificate	**X**
c	Schedule of test results	
d	NICEIC membership	

No.	Question.	Answer
12	Inspection can be undertaken?	
a	Throughout different stages of construction	**X**
b	On completion of the installation	
c	On completion of the construction	
d	If required during commissioning of the installation	

No.	Question.	Answer
13	The first three tests to be carried out on a typical domestic 32A socket circuit is likely to be?	
a	Continuity of protective conductor / continuity of ring final conductors / insulation resistance	**X**
b	Continuity of protective conductor / polarity / insulation resistance	
c	Continuity of protective conductor / insulation resistance / polarity	

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d	Insulation resistance / polarity / continuity of protective conductors	

No.	Question.	Answer
14	A Thermographic survey on electrical equipment is usually carried out on?	
a	Switch-gear in domestic premises before completion	
b	Switch-gear in commercial and industrial premises during use	**X**
c	Any switch-gear during mechanical maintenance procedures	
d	Electrical cable routes in all premises	

No.	Question.	Answer
15	A radial circuit 50m in length is wired with a cable having 4.61mΩ/m, (mΩ per metre), at 20°C the expected cable resistance when carrying out a Method 2 continuity test is likely to be?	
a	2305Ω	
b	2.305Ω	
c	0.460Ω	
d	0.2305Ω	**X**

Electrical Machines: (Covering Outcome 8 'Understand the operating principles and applications of DC machines and AC motors of Unit 309 NVQ Level 3 Diploma 2357 – 13 and EAL equivalent)

Power Transfer

Power Transfer concerns the process of converting electrical energy into mechanical energy.

Question 1:

Give ONE example of a device that demonstrates electrical to mechanical power transfer.

Answer:
The electric motor

Power transfer can also work in the opposite direction, i.e. a conversion from mechanical energy to electrical energy.

Question 2:

Give ONE example that converts mechanical to electrical energy.

Answer:
The electrical generator

Losses:

In the process of transferring energy some losses will occur.

Question 3:

Identify ONE example that will contribute to a mechanical loss in a machine and ONE example of how this loss is minimised in practice.

Answer:

Friction – between fixed and rotating parts

Friction can be minimised with the use of good quality bearings and lubrication

In electrical machines, apart from mechanical losses there are other losses.

Question 4:

State TWO losses, other than mechanical losses, that can occur in an electric motor.

Answer:

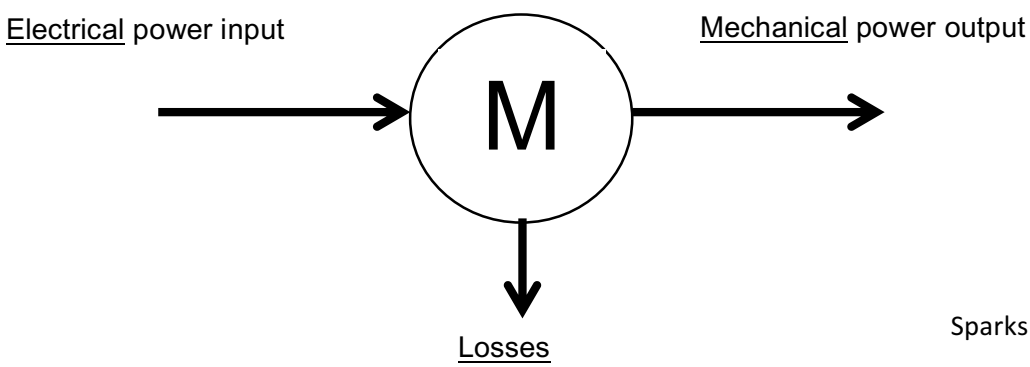
- **Copper losses** - known as the $\mathbf{I^2R}$ loss due to current in the copper windings
- **Iron losses** – these are due to **Eddy Currents** inducted in the metal frame of the machine, and **Hysteresis loss** caused by continually reversing magnetic fields within the machine structure

Efficiency: (Symbol η Greek letter 'Eta')

The efficiency of an electric motor is the ratio of mechanical power output to the electrical power input.

Question 5:

Complete the labels on the diagram below



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Formula:

To calculate the efficiency of a machine such as an electric motor one of two formulae can be applied:

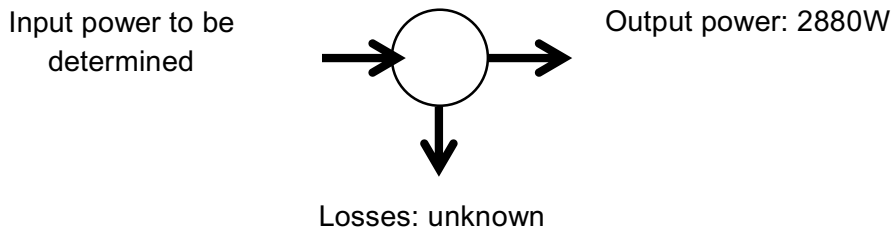
i. **Efficiency η (%) = $\frac{\text{Output power}}{\text{Input power}}$ x 100** (Expressed as a percentage)

or

ii. **Efficiency η (p.u) = $\frac{\text{Output power}}{\text{Input power}}$** (Expressed as a 'per-unit' value)

Example:
Calculate the efficiency as a per – unit value, and as a percentage, for a 230V single-phase electric motor drawing 15A with a full power output of 2880W.

Solution:
Advice: It is always advisable to show the arrangement in a simple drawing first.



Input power can be found from basic principles, i.e. P = U x I

P = 230 x 15 = **3450Watts**

Efficiency η = $\frac{\text{Output power}}{\text{Input power}}$ so Efficiency η = $\frac{2880}{3450}$ therefore η (per unit) = **0.84**

Expressed as a (%) Efficiency η = 0.84 x 100 = **84%** *(So there are 16% losses)*

Question 6:

Calculate the current taken by a 2kW, 230V electric motor operating at full load with a power factor of 0.6 and an efficiency of 70%



Advice:

First step: calculate the input power to the motor by rearranging the formula:

$$\text{Efficiency } \eta = \frac{\text{Output power}}{\text{Input power}} \times 100$$

So $$\text{Input power} = \frac{\text{Output power}}{\eta} \times 100$$

$$\text{Input power} = \frac{2000}{70} \times 100 = \textbf{2857W or 2.857kW}$$

Second step: calculate input current from rearranging the formula:

$$\text{Power factor pf} = \frac{\text{Watts (W)}}{\text{Volts x Amps}}$$

Note1: the Watts in the formula will be the input power of the motor.

$$\text{Current (A)} = \frac{W}{V \times pf}$$

$$= \frac{2857}{230 \times 0.6} = \textbf{20.7A}$$

Note 2: Both mechanical power output and electrical power input share the same Unit, i.e. Watts. This makes power transfer calculations straightforward.

Principles and practices for testing electro-technical systems:
(Covering Unit 307 'Understand principles, practices and legislation for the inspection, testing commissioning and certification of electro-technical systems and equipment in buildings, structures and the environment' (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 and the EAL equivalent)

Test instruments:

Complete the following questions regarding electrical test instruments and test sequence:

1) List the electrical test instruments which give the following units.

a) MΩ
b) kA
c) mS

a) Insulation resistance ohmmeter
b) Prospective short circuit current tester
c) RCD tester

2) State **THREE** safety checks to be carried out on an earth fault loop impedance tester and leads before use.

- *Test probes should have finger guards*
- *Test probe metal tips should not exceed 4mm but preferably 2mm*
- *Test leads should be fused*

3) State the circuit classification for each of the following insulation test instrument voltages:

a) 250 V dc
b) 500 V dc
c) 1000 V dc

a) SELV circuit and PELV

b) Low voltage circuit (up to and including 500V exception to SELV and PELV)

c) Low voltage circuit (above 500V)

4) A reading of 10Ω is obtained when carrying out a resistance measurement on a 10mm^2, 150m long main protective bonding conductor on a mains water supply service:

i. Suggest **one** possible reason for this reading
ii. Suggest a solution based on the reason given in (i)

iii. Calculate the expected reading based on the information given and the resistance per metre of copper cable being 1.83μΩ / m (micro ohms per metre)

i. Reading could be due to a loose termination. Alternative answers could be – a poorly fitted bonding clamp. Clamp fitted to a dirty or corroded pipe. Instrument not calibrated correctly. Test leads damaged or badly connected.

ii. Loose terminal should be identified and tightened. Alternative answers:- re-fit bonding clamp after cleaning pipe and clamp. Check test instrument batteries have good charge and calibration is correct. Carefully check condition of test leads and any damage will require new leads to be fitted.

iii. R = Cable resistance per m x length of cable
R = 1.83 x 150
R = 274.5 μΩ or 0.000274Ω

Note: in practice low reading resistance test instruments do not indicate measurements this small.

5) List in the correct sequence, the first **THREE** tests that should be performed during an initial verification on a new lighting installation.

Continuity of protective conductors including main and supplementary bonding

Insulation resistance

polarity

6) The test for the continuity of a cpc in a radial circuit feeding one socket-outlet uses a temporary link and a low reading ohmmeter. State:

a) where the temporary link is connected
b) where the low reading ohmmeter is connected
c) what the meter reading actually represents

a) between line and circuit protective (earth) conductor at the consumers control unit (good practice to disconnect both)
b) between line and earth at the socket – outlet
c) the value measured is (R_1 + R_2) for the circuit

7) List **THREE** precautions to be taken before conducting an insulation resistance test on power circuits located in a large commercial installation.

i) Obtain all relevant information regarding the circuit/s to be tested

ii) Obtain permission to isolate the circuit from the supply

iii) Obtain permission to disconnect electrical equipment that may be damaged by test voltages when circuits are tested

8) A periodic inspection and test is to be carried out on a commercial office lighting installation. Identify the precautions to be taken regarding this type of inspection and test.

i) Establish if there are standby power supplies that can be activated when the mains supply to the lighting circuits is isolated.
ii) Identify the type of luminaire – it may have electronic control – gear that can be damaged by high test voltages
iii) Check whether luminaires have power - factor correction capacitors installed as they may remain charged when the supply is isolated.

9) State the main reason for conducting a periodic inspection and testing on an electrical installation.

BS7671: 2008 +A3 2015; Regulation 621.1 …Periodic inspection and testing of every electrical installation shall be carried out …in order to determine, so far as is reasonably practicable, whether the installation is in a satisfactory condition for continued service…

Electro-Technical Science Revision Quiz:
(Covering Unit 309 (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 or EAL equivalent)

True or False:
For each question decide if the answer or statement is true or false. You may need to refer to your notes, text books or, where necessary, complete a calculation to see if the answer is correct or not.

1) Electric current flows when a potential - difference is connected across a completed circuit?

TRUE	✓
FALSE	

2) Conventional electric current flows from the negative to the positive terminal in a circuit supplied by a battery?

Conventional current flows from positive to negative and Electron current flows from negative to positive
Conventional current so called because it was assumed that this was the direction current flowed round a circuit until atomic theory was understood.

TRUE	
FALSE	✓

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3) The unit measurement for potential-difference is Amperes?

TRUE	
FALSE	✓

The unit of potential-difference (pd) is the Volt.
The Ampere is the measurement of current flow

4) Energy is measured in Joules and represents the *'ability to do work'*?

TRUE	✓
FALSE	

5) The *'rate of doing work'* is measured in Watts and can be found from the formula:-
P = V x I or P = U x I

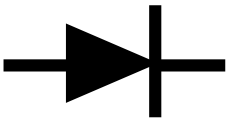
TRUE	✓
FALSE	

6) The resistance of a conductor decreases with increasing length and increases with decreasing cross-sectional-area?

The resistance of a conductor increases with increased length and does increase with decreasing cross-sectional-area, so half the statement is true, but overall the statement is false.

TRUE	
FALSE	✓

7) The symbol represents a semi-conductor diode?



TRUE	✓
FALSE	

8) The right-hand 'grip' rule is used when trying to determine the direction of current flow in a coil?

There are a number of 'right-hand' rules: The right-hand 'grip' rule concerns straight conductors; the thumb of the right-hand points in the direction current is flowing in the conductor and the fingers indicate the direction the magnetic field is revolving about the conductor. The right-hand 'grasp' rule applies to a coil of wire, where the thumb points to the end of the coil that is 'North' when the fingers point in the direction the coils are wound.

TRUE	
FALSE	✓

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9) The force exerted on a current- carrying conductor when it is lying at right-angles in a magnetic field can be found by applying Flemings' RIGHT-HAND rule?

The conductor is carrying current and so will produce a magnetic field around itself. This field will be opposed by the magnetic-field the conductor is lying in and the conductor will be rejected; this is the motor principle represented by the 'left-hand rule'. The right-hand rule applies to the generator principle

TRUE	
FALSE	✓

10) The 'incandescent' lamp works on the principle of an electric current flowing through a filament?

TRUE	✓
FALSE	

Now check your answers.

WORDSEARCH – Special locations

Try to find the following words that are all Special Locations.

(Answers can be left to right, right to left, up or down)

Bath	Medical	Booth
Shower	Solar	Fairground
Sauna	Mobile	Vehicle
Demolition	Transportable	Maintenance
Agricultural	Exhibitions	Marina
Restricted	Caravan	Gangway

A	B	C	O	N	T	A	C	N	O	I	T	A	T	O	R	F	M	T	H
S	N	O	I	T	I	B	I	H	X	E	M	I	W	S	E	I	O	U	P
E	E	S	T	E	I	D	T	E	D	L	A	C	I	D	E	M	A	L	L
S	K	E	L	E	C	T	R	O	D	E	C	A	L	O	L	E	X	K	F
U	E	A	M	A	I	N	T	C	O	N	O	R	E	W	C	F	H	U	K
C	E	R	T	G	F	I	C	A	T	O	F	A	A	E	I	A	I	E	U
H	A	T	M	R	E	R	C	N	P	I	A	V	E	R	H	T	A	B	N
O	M	O	B	I	L	E	T	O	Y	T	U	A	F	O	E	R	I	O	T
C	O	I	L	C	E	W	L	A	B	I	G	N	A	R	V	A	T	O	A
K	A	N	C	U	C	O	A	S	O	L	A	R	E	B	O	N	P	T	Y
G	L	G	T	L	A	H	U	K	L	O	N	U	V	L	O	S	O	H	N
N	E	A	R	T	N	S	S	A	L	M	G	I	O	N	G	P	C	N	J
I	C	U	R	U	A	T	I	N	O	E	W	A	R	G	C	O	A	S	N
A	F	A	I	R	G	R	O	U	N	D	A	T	P	L	T	R	Y	W	J
N	E	T	U	A	H	E	A	A	P	R	Y	I	W	O	L	T	H	I	I
I	Y	P	R	L	T	E	S	S	I	V	E	A	R	K	E	A	W	T	O
R	E	S	T	R	I	C	T	E	D	T	R	P	A	F	A	B	L	T	Q
A	E	O	H	N	I	U	D	A	R	P	L	F	A	M	A	L	T	H	N
M	A	I	N	T	E	N	A	N	C	E	C	S	I	D	I	E	G	Y	X
P	S	F	T	E	S	V	E	Q	S	E	B	V	J	U	Y	K	L	E	S

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End of Year Revision: Electrical Science & Principles

(Covering Unit 309: 'Understanding the electrical principles associated with the design, building, installation, and maintenance of electrical equipment and systems' (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 or EAL equivalent)

Attempt the following Multiple Choice questions

No.	Question.	Answer
1	Three resistors of 10Ω, 25Ω and 53Ω are connected in parallel with each other. The total resistance will be?	
a	Higher than 53Ω	
b	Higher than 25Ω	
c	Total of 88Ω	
d	Lower than 10Ω	**X**

No.	Question.	Answer
2	Three resistors are connected to a parallel circuit. Two of the resistors are rated at 107Ω alongside a 35Ω resistor. Calculate the total resistance of the circuit.	
a	3.05Ω	
b	13.5Ω	
c	21.16Ω	**X**
d	142Ω	

No.	Question.	Answer
3	The total resistance of a series circuit is 150Ω. If the circuit consists of five resistors, and one resistor is 10Ω, what is the value of the remaining four?	
a	140Ω	**X**
b	112Ω	
c	100Ω	
d	9Ω	

No.	Question.	Answer
4	When current passes through a conductor in one direction	
a	Heat is generated	
b	An alternating magnetic field is produced in the conductor	
c	Electrons flow from positive to negative	
d	A magnetic field is set up around the conductor	**X**

No.	Question.	Answer
5	When current in a conductor is shown by the symbol ⊕ the current is	
a	Alternating	
b	Flowing away from the viewer	X
c	Flowing towards the viewer	
d	Positive	

No.	Question.	Answer
6	If current is flowing as shown in the symbol of question 5 above, the magnetic field produced will be?	
a	Moving clockwise around the conductor	X
b	Moving anti-clockwise around the conductor	
c	Passing over the length of conductor	
d	Alternating across the conductor	

No.	Question.	Answer
7	Magnetic flux density is measured in?	
a	Webers	
b	Joules	
c	Farads	
d	Teslas	X

No.	Question.	Answer

8	Force acting on a current carrying conductor lying at 90° to a magnetic field is measured in?	
a	Joules	
b	Newtons	**X**
c	Watts	
d	Webers	

No.	**Question.**	**Answer**
9	A conductor 100m long and carrying 5A is lying at 90º to magnetic field of 1.5T, what is the force on the conductor?	
a	750N	**X**
b	115N	
c	107.5N	
d	100N	

No.	**Question.**	**Answer**
10	Calculate the induced voltage in a 500m long conductor when it is passing through a flux density of 3T at a rate of 3m/s	
a	500V	
b	4.5kV	**X**
c	450V	
d	55.5V	
No.	**Question.**	**Answer**
11	What is the resistance of 1000m of 1.5mm² copper cable is if the conductor resistivity is given as 17.2μΩ/m?	

a	0.85 Ω	
b	0.95 Ω	
c	10.00 Ω	
d	11.47 Ω	**X**

No.	**Question.**	**Answer**
12	The proton has what type of electrical charge?	
a	Negative	
b	Positive	**X**
c	None	
d	Equal positive and negative	

No.	**Question.**	**Answer**
13	What is the assumed current demand for an electric heating element rated at 12kW when connected to a 230V supply?	
a	0.52A	
b	2.42A	
c	5.22A	
d	52.2A	**X**

No.	**Question.**	**Answer**

14	If a distribution circuit cable is supplied at end A with 230v, and resistive loads are taken from it at points B and C, if the overall voltage drop from A to C is 2.6%, the voltage at C will be?	
a	220V	
b	224.02V	**X**
c	226V	
d	598V	

No.	Question.	Answer
15	If an electric motor has a rated output of 20kW and an efficiency of 78%, the electrical input to the motor will be?	
a	15.60kW	
b	21.00kW	
c	24.00kW	
d	25.64kW	**X**

No.	Question.	Answer
16	An auto-transformer operates on the principle of?	
a	Self-induction	**X**
b	Mutual induction	

c	Impedance	
d	resistance	

No.	**Question.**	**Answer**
17	A transformer has a rating of 6000VA, if the output voltage is 110V what is the total current that can be delivered?	
a	0.2A	
b	32A	
c	50A	
d	54.6A	**X**

No.	**Question.**	**Answer**
18	A step – down transformer has a primary voltage of 230V and a secondary voltage of 50V The turns ratio for this transformer is	
a	9.6 : 1	
b	6.9 : 1	
c	4.6 : 1	**X**
d	4.2 : 1	

No.	**Question.**	**Answer**
19	The line voltage of a star connected transformer is 440V. What is the phase voltage?	

a	230V	
b	254V	**X**
c	400V	
d	420V	

No.	**Question.**	**Answer**
20	If the measuring range of a voltmeter is to be extended which one of the following is used?	
a	Multiplier	**X**
b	Shunt resistor	
c	Diode	
d	Diode shunt	

Practice multiple-choice questions:

(Covering Unit 309 Outcome 8, 'Understand the operating principles of dc and ac motors' (Level 3 NVQ Diploma in Installing Electro-Technical Systems and Equipment 2357-13 / 91 or EAL equivalent)

No 1	In a 3-phase electric motor, speed is determined by knowing the frequency of the supply and?	**Answer**
a	Voltage	
b	Current	
c	Power rating	
d	Number of pairs of poles	**X**

No 2	The speed of a 3-phase electric motor is 1000 r.p.m, this refers to the?	**Answer**
a	Speed of the stator	
b	Speed of the rotor	**X**
c	Synchronous speed	
d	Point where the motor reaches full power	

No 3	The difference between synchronous and asynchronous speed of an induction motor is usually expressed as?	**Answer**
a	Wasted energy	
b	A power loss	
c	A per-unit value	

d	A percentage	**X**

No 4	A 3-phase induction motor has a synchronous speed of 750 rpm and a shaft speed of 715 rpm, what is the slip?	**Answer**
a	95.3%	
b	9.53%	
c	4.67%	**X**
d	2.45%	

No 5	A six pole AC induction motor is connected to a three-phase supply of 50Hz. The synchronous speed of the stator flux is	**Answer**
a	750rpm	
b	1000rpm	**X**
c	1500rpm	
d	3000rpm	

No 6	The starting current of an electric motor is higher than the running current because there is?	**Answer**
a	No back-emf on start-up	**X**
b	A high load to move	

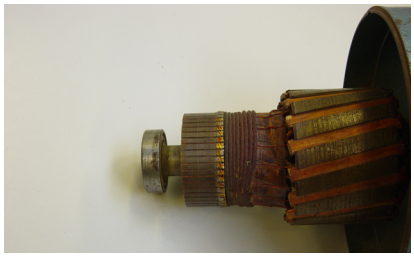
c	Full power on start-up	
d	Usually a starting device used	

No 7	Single - phase induction motors are likely to be fitted with which one of the following devices?	**Answer**
a	Voltage relay	
b	Star-delta starter	
c	Induction relay	
d	Centrifugal switch	**X**

No 8	A 3kW single-phase electric motor will generally be fitted with?	**Answer**
a	Start and run windings	**X**
b	Starting resistance	
c	Variable resistance	
d	Run windings	

No 9	Which of the following statements is true for single-phase capacitor start, induction run electric motors?	**Answer**
a	The capacitor remains in circuit all the time the motor runs	
b	The start winding and capacitor are connected in parallel	

c	The run winding and the capacitor are connected in series	
d	The start winding and capacitor are connected in series	**X**

No 10	The component shown in the figure below is usually found in which type of AC motor? 	**Answer**
a	Cage induction	
b	Dual cage induction	
c	Universal	**X**
d	Synchronous	