



(c) From AS/NZS 3000:2000: 2.9.6

Provided that the switchboard is installed in an area which is accessible only to authorized persons and the means of access to such areas is provided with facilities for locking.

Or

From AS/NZS 3000:2007: 2.9.3.1

Provided that the switchboard is installed in an area which is accessible only to authorized persons and the means of access to such areas is provided with facilities for locking.

(2 marks)

(d) The current carrying capacity of the neutral shall not be less than that of the largest associated active conductor.

AS/NZS 3000:2000: 3.5.2(b)(i)(A)

AS/NZS 3000:2000: 3.5.2(b)(ii)

(2 marks)

(e) (i) Any ONE of:

- 0.5m
- Not permitted

Note: The structure of the question clearly leads candidates to the conclusion that a PVC sheathed cable can be buried direct under a Category A system with no further protection and that there is a minimum depth for such an arrangement. However, the Standard does not permit such an arrangement. Therefore, in the context of the question, either answer was deemed acceptable.

(ii) 0.3m

AS/NZS 3000:2000: Table 3.7

AS/NZS 3000:2007: Table 3.6

(2 marks)

(f) 

- Install a loop in the cable immediately before the termination
- The size of the loop shall be determined by the cable size and severity of the vibration.

AS/NZS 3000:2000: 3.9.8.3.2

AS/NZS 3000:2007: 3.9.7.3(b)

(2 marks)

(g) From AS/NZS 3000:2000: 5.8.2.2

Any ONE of:

- - Where the piping is installed within the building containing the electrical installation. 5.8.2.2
- Where the piping is metallically continuous from inside the building to the point of contact with the ground. 5.8.2.2
- Metallic piping that are unavoidably in contact with the exposed conductive parts of wiring enclosures, cable components or other electrical equipment 5.8.2.3

Or

From AS/NZS 3000:2007

Any ONE of:

- - Conductive water piping that is installed and accessible within the building containing the electrical installation. 5.6.2.2
  - Conductive water piping that is continuously conductive from inside the building to the point of contact with the ground. 5.6.2.2
  - Metallic piping that are unavoidably in contact with the exposed conductive parts of wiring enclosures, cable components or other electrical equipment 5.6.2.3
- (2 marks)

(h) • Any TWO of:

- Must have a minimum IP rating of IPX4.  
AS/NZS 3000:2000: 7.1.4.1(b)  
AS/NZS 3000:2007: 6.2.4.1(b)
- Shall not be installed within 0.3 m of the floor.  
AS/NZS 3000:2000: 7.1.4.2  
AS/NZS 3000:2007: 6.2.4.2
- Must have automatic switching and be incorporated in a shaver supply unit complying with AS/NZS 3194  
AS/NZS 3000:2000: 7.1.4.2(b)(i)  
AS/NZS 3000:2007: 6.2.4.2(b)(i),(ii)

Or

- Must be protected by a RCD with a maximum rated residual current of 30 mA and enclosed in a cupboard provided that the enclosure is maintained during the normal operation of the connected equipment.  
AS/NZS 3000:2000: 7.1.4.2(b)(ii),(iii)  
AS/NZS 3000:2007: 6.2.4.2(b)(iii),(iv)  
(2 marks)

(i) From AS/NZS 3000:2000: 7.7.9

Shall be installed in all active conductors

Or

From AS/NZS 3000:2007: 7.5.9.1

Shall be installed in all the unearthed conductors

(2 marks)

(j) Fault kVA =  $\frac{350}{0.06}$

(½ mark)

= 5833 kVA

(½ mark)

$I_{sc}$  =  $\frac{5833}{\sqrt{3} \times 400}$

(½ mark)

= 8.42 kA

(½ mark)

## Question 2

(a) From AS/NZS 3000:2000

Any TWO of:

- The breaking capacity shall be not less than the prospective short-circuit current at the point of installation. 2.4.4.3(a)
- All currents caused by a short circuit occurring at any point of a circuit shall be interrupted before the temperature of the conductors reaches the admissible limit. 2.4.4.3(b)
- Protective devices shall be provided to interrupt any short-circuit current flowing in the conductors before such a current can cause danger due to thermal and mechanical effects produced in conductors and connections. 2.4.4.1
- Shall be capable of breaking any overcurrent up to and including the prospective short-circuit current at the point where the device is installed. 2.4.2

Or

From AS/NZS 3000:2007: 2.5.4.5

- The breaking capacity shall be not less than the prospective short-circuit current at the point where the devices are installed.
- All currents caused by a short circuit occurring at any point of a circuit shall be interrupted before the temperature of the conductors reaches the permissible limit.

(2 marks)

(b) Any TWO of:

From AS/NZS 3000:2000: 2.4.3.4

- Where effective protection for a conductor is afforded by a protective device located on the supply side of its origin or the point of reduction in current-carrying capacity.
- Where short-circuit protection for a conductor is provided in accordance with Clause 2.4.4, there are no branch circuits or socket-outlets; and electrical equipment supplied by a conductor is not capable of causing overload currents.
- Installations for telecommunication, control, signalling, and the like.
- A conductor within a switchboard or busway that supplies one or more circuits that are individually protected against overload where —
  - (i) short-circuit protection of the conductor is provided in accordance with Clause 2.4.4; and
  - (ii) overload protection of the conductor is provided when the sum of the current ratings of the circuit protective devices is not more than the current-carrying capacity of the conductor.

Or

From AS/NZS 3000:2007: 2.5.3.4

- Where unexpected opening of the circuit could cause a danger greater than overload.
- Provided that the conductor is not situated in a location presenting a fire risk or a risk of explosion.
- Provided that the conductor is not situated where requirements for special installations and locations specify different conditions and the conductor is located on the load side of a change in current-carrying capacity that is effectively protected against overload by a protective device placed on the supply side of the origin of the conductor.
- Provided that the conductor is not situated where requirements for special installations and locations specify different conditions and the conductor supplies electrical equipment that is not capable of causing an overload current and the conductor has no branch circuits or socket outlets connected between the origin of the conductor and the electrical equipment.
- Provided that the conductor is not situated where requirements for special installations and locations specify different conditions and the conductor is provided for installations for telecommunication, control, signalling, and the like

(2 marks)

(c) Any TWO of:-

From AS/NZS 3000:2000: 2.4.2

- Circuit-breakers incorporating short-circuit and overload releases.
- Circuit-breaker fuse combinations.
- Enclosed fuse links.

Or

From AS/NZS 3000:2007: 2.5.2

- Circuit-breakers incorporating short-circuit and overload releases.
- Fuse combination units (CFS units).
- Fuses having enclosed fuse links (HRC fuses).
- Circuit-breakers in conjunction with fuses.

(2 marks)

(d) Any TWO of:

From AS/NZS 3000:2000: 2.3.2

- Enclosed fuse-links complying with the appropriate Standard(s) in the AS 2005 series.
- Miniature overcurrent circuit-breakers complying with AS 3111 or AS/NZS 4898.
- Moulded-case circuit-breakers complying with AS 3947.2.
- Residual current devices complying with AS 3190, AS/NZS 3175 or AS/NZS 61009.1.
- Any other device having characteristics similar to any of the devices listed above that it is not of the automatically reclosing type.

Or

From AS/NZS 3000:2007: 2.4.3

- Enclosed fuse-links complying with the appropriate Standard(s) in the AS 60269 series.
- Miniature overcurrent circuit-breakers complying with AS/NZS 60898 or AS 3111
- Moulded-case circuit-breakers complying with AS 60947.2.
- Residual current devices complying with AS 3190, AS/NZS 61008.1 or AS/NZS 61009.1.
- Other devices with no automatic reclose function, having characteristics similar to any of the devices listed above.

(1 mark)

(e) The gM fuse links:

- Have a higher fusing factor.
- So they will not operate under motor starting currents.

(1 mark)

(1 mark)  
GK

### Question 3

- (a) (i) Section 6 of AS/NZS 3000  
ER 37 (3)  
(1 mark)
- (ii) Section 3 of NZS 3019  
ER 41(3)  
(1 mark)
- (b) (i) All of the work  
(½ mark)  
ER 39(1)
- (ii) 1 day after the completion of the work.  
ER 39(5)  
(½ mark)
- (iii) The mains, main switchboard and main earthing system  
ER 41  
(1½ marks)
- (iv) The electrical inspector  
ER 40  
(½ mark)
- (c) (i) • All of the work  
Or  
• - The new sub-main to the outbuilding.  
- The new distribution board in the outbuilding.  
- The final subcircuits.  
ER 39(1)  
(1½ marks)
- (ii) Within 20 working days after the completion of the certificate  
ER 40(2)  
(½ mark)

- (iii) No work requires inspection  
ER 41  
(½ mark)
- (iv) The electrician  
ER 39  
(½ mark)
- (d) (i) All of the work  
ER 39(1)  
(½ mark)
- (ii) The mains and main switchboard  
ER 41  
(1 mark)
- (e) Any ONE of:
- Earth fault loop impedance test
  - RCD testing
  - Polarity test
  - Phase rotation test
- (½ mark)  
GK

#### Question 4

(a) 6 mm<sup>2</sup> is the minimum size cable. (1 mark)

(b) (i)  $I_{(FL)} = \frac{P}{V}$  (1/2 mark)

$= \frac{8000}{230}$  (1/2 mark)

$= 34.78 \text{ amps}$  (1 mark)

From table 9, the minimum size cable is 4 mm<sup>2</sup>. The cable is rated for 39A. (1/2 mark)

The correction factor from table 27(1) is 0.94. (1/2 mark)

The cable rating would be 39 x 0.94 = 36.66A. (1 mark)

A 4 mm<sup>2</sup> cable is the minimum size cable that will satisfy the load requirements

(ii) The maximum voltage drop permitted = 230 x 2.5% = 5.75V (1/2 mark)

From table 42, a 4 mm<sup>2</sup> cable, with an operating temperature of 75 °C has a 9.71 mV/A.m (1/2 mark)

From table 42, to convert to single-phase 9.71 x 1.155 = 11.215 (1/2 mark)

Voltage drop =  $\frac{V/A.m \times \text{amps} \times \text{metres}}{1000}$  (1/2 mark)

$= \frac{11.215 \times 34.78 \times 20}{1000}$  (1/2 mark)

$= 7.8V$  (1/2 mark)

From table 42, a 6 mm<sup>2</sup> cable, with an operating temperature of 75 °C, has a 6.49 mV/A.m

From table 42, to convert to single-phase  $6.49 \times 1.155 = 7.496$  (½ mark)

$$\text{Voltage drop} = \frac{\text{V/A.m} \times \text{amps} \times \text{metres}}{1000}$$

$$= \frac{7.496 \times 34.78 \times 20}{1000}$$

$$= 5.21\text{V}$$

(½ mark)

(1 mark)

A 6 mm<sup>2</sup> is the minimum size cable that will satisfy the voltage drop requirements

## Question 5

- (a) (i) An active (phase) to frame fault on the appliance. (1 mark)  
GK
- (ii) They show the earth fault loops for the fault at "A" on the Class I electrical appliance. (2 marks)  
GK
- (iii) It is considered to be the earth fault loop with the lowest impedance. (1 mark)  
GK
- (b) The instrument is connected between the furthest point on the active (phase) conductor and the corresponding point on the associated protective earthing conductor, e.g. at a socket-outlet.  
AS/NZS 3000: 2000: B4.6(b)  
AS/NZS 3000: 2007: B4.6(b)

Or

Plug the tester into the socket outlet futherest from the supply and if the RCD trips the test is satisfactory.

GK and AS/NZS 3000: 2000: 6.3.4.2.1: Note 2  
GK and AS/NZS 3000: 2007: 8.3.10(b)

- (c) (i) The installation does not comply because AS/NZS 3000: 2000: Table B5.1 (or AS/NZS 3000: 2007: Table B.1) permits:
- maximum circuit length of 68m. (1 mark)
  - For that size cable with that protection. (1 mark)
- AS/NZS 3000: 2000: Table B5.1  
AS/NZS 3000: 2007: Table B1
- (ii) Any ONE of:
- Install a 16A, type B, MCB
  - Install a 20A, type B, MCB
  - Install a 20A HRC fuse
  - Install a 16A, type C, MCB

AS/NZS 3000: 2000: Table B5.1  
AS/NZS 3000: 2007: Table B1  
(1 mark)

(d) 4 mm<sup>2</sup> copper (Cu)

AS/NZS 3000:2000: 5.5.1.2(c)  
AS/NZS 3000:2007: 5.3.3.2  
(1 mark)

## Question 6

(a) It must be located electrically closest to the point of supply.

ER 52(4)  
(1 mark)

(b) (i) From AS/NZS 3000:2007: 2.9.8.3

- By a permanent sign at a main entrance to the electrical installation
- By a permanent sign at the fire indicator panel.

Or

From AS/NZS 3000:2007; 2.9.2.4

- Shall be legibly and permanently indicated by a conspicuous notice.
- At each entry to the building that may be used by emergency services personnel.

(2 marks)

(ii) Any ONE of:

From AS/NZS 3000:2000

- In a domestic residence. 2.9.8.2(b)
- Within 1.2 m of the ground, floor or platform where it does not meet the requirements of Clause 2.9.6. 2.9.8.4(a)
- In storage cupboards in an area not set aside for the purpose. 2.9.8.4(c)
- Within or above any zone classified in accordance with Clause 7.2.2 for a swimming pool or spa pool. 2.9.8.4(e)
- Within a sauna. 2.9.8.4(e)
- Within a fire-isolated stairway, passageway or ramp. 2.9.8.4(f)
- Within a cupboard containing a fire-hose reel. 2.9.8.4(g)
- In the vicinity of an automatic fire sprinkler system where it is not suitably protected from the effects of the operation of the sprinkler system. 2.9.8.4(h)

Or

From AS/NZS 3000:2007

- In any tenancy or single electrical installation, either domestic or non-domestic  
2.9.2.3(b)
- Within 1.2 m of the ground, floor or platform where it does not meet the requirements of Clause 2.9.6.  
**2.9.2.5(a)**
- In a cupboard or similar enclosure in an area not set aside for the purpose.  
2.9.2.5(c)
- Within or above any zone classified in accordance with Clause 7.2.2 for a swimming pool or spa pool.  
2.9.2.5(e)
- Within a sauna.  
2.9.2.5(e)
- Within a fire-isolated stairway, passageway or ramp.  
2.9.2.5(h)
- Within a cupboard containing a fire-hose reel.  
2.9.2.5(i)
- In the vicinity of an automatic fire sprinkler system where it is not suitably protected from the effects of the operation of the sprinkler system.  
2.9.2.5(j)  
(1 mark)

(iii) From AS/NZS 3000:2000: 2.9.6

Provided that the switchboard is installed in an area which is accessible only to authorized persons and the means of access to such areas is provided with facilities for locking.

Or

From AS/NZS 3000:2007: 2.9.3.1

Any ONE of:

- The live parts are arranged so that basic protection is provided by barriers in accordance with the provisions of Clause 1.5.4.4.
- Provided that the switchboard is installed in an area which is accessible only to authorized persons and the means of access to such areas is provided with facilities for locking.  
(2 marks)

(c) Any FOUR from:

From AS/NZS 3000:2000: 2.9.8.4

- Shall not be installed above open water containers or fixed or stationary cooking appliances
- Shall not be installed within the space contained by vertical planes 3 m from the centre of a shower rose and extending from the floor to the ceiling.
- Shall not be installed within or above any zone classified for a swimming pool or spa pool.
- Shall not be installed within a sauna.
- Shall not be installed within a fire-isolated stairway, passageway or ramp.
- Shall not be installed within a cupboard containing a fire-hose reel.

Or

AS/NZS 3000:2007: 2.9.2.5

- Shall not be installed above open water containers or fixed or stationary cooking appliances
- Shall not be installed within or above any zone classified for a bath or shower.
- Shall not be installed within or above any zone classified for a swimming pool or spa pool.
- Shall not be installed within a sauna.
- Shall not be installed within a fire-isolated stairway, passageway or ramp.
- Shall not be installed within a cupboard containing a fire-hose reel.
- Shall not be installed in a refrigeration room.

(4 marks)

## Question 7

- (a) (i)
  - Must have seven strands
  - Minimum size of 6 mm<sup>2</sup>

AS/NZS 3000:2000: 3.12.2.2  
AS/NZS 3000:2007 3.12.2.2  
(1 mark)

- (ii) Yes. The maximum span for this type of cable is 60m

AS/NZS 3000:2000: Table 3.9  
AS/NZS 3000:2007: Table 3.9  
(1½ marks)

- (iii) Any ONE of:

- No. Joints shall not be made in neutral screened cables under tension.

AS/NZS 3000:2000: 3.12.7.3  
AS/NZS 3000:2007 3.7.2.9.2

- Yes. If supported by a catenary

AS/NZS 3000:2000: 3.13.1  
AS/NZS 3000:2007 3.13.1  
(1½ marks)

- (iv) (1) 4.5 metres

AS/NZS 3000:2000: Table 3.8

Or

4.6 metres

AS/NZS 3000:2007: Table 3.8

- (2) 3 metres

AS/NZS 3000:2000: Table 3.8  
AS/NZS 3000:2007: Table 3.8  
(1 mark)

(b) (i) From AS/NZS 3000:2000 3.11.3.4

Any ONE of:

- Orange marker tape
- The wiring enclosure is light orange in colour
- Light-orange coloured polymeric cable strip

Or

From AS/NZS 3000:2007 3.11.4.5

- Orange marker tape at 50% of the trench depth

(1 mark)

(ii) From AS/NZS 3000:2000 3.11.3.5

- Marker signs where cable enters or leaves a building

Or

From AS/NZS 3000:2007 3.11.4.6

Any ONE of:

- Permanent cable marker signs shall be provided to indicate the point where cable enters or leaves a structure.
- Recorded on a plan, and the plan located at the switchboard from where the cable originates.

(1 mark)

(iii) 0.5 m

AS/NZS 3000:2000: Table 3.7

AS/NZS 3000:2007: Table 3.6

(1 mark)

(iv) Shall be laid on a bed of not less than 50 mm of sand or friable soil free of sharp stone and covered by not less than 50 mm of the same material.

AS/NZS 3000:2000: 3.11.3.2

AS/NZS 3000:2007: 3.11.4.2

(2 marks)

## Question 8

(a) (i) (A) Any TWO of:

- Use of test equipment which causes the device to operate under residual alternating current and residual pulsating direct current conditions; or
- Operation of the integral test device provided that manufacturer's compliance documentation and equipment markings confirm that the RCD is intended to operate under residual alternating current and residual pulsating direct current conditions.
- A suitable test could be performed using a test plug with a resistor between the active and earth pins.

AS/NZS 3000:2000:6.3.3.6.1

AS/NZS 3000:2007:8.3.10.2

(4 marks)

(B) To verify that the RCD operates to disconnect the designated circuit.

AS/NZS 3000:2000:6.3.3.6.1

AS/NZS 3000:2007:8.3.10.2

(4 marks)

(ii) From AS/NZS 3000:2000: 6.3.4.2.1 or B4.2

- To verify that the protective device will operate to disconnect an earth-fault current within the time and touch voltage requirements of Clause 1.7.4.3.

Or

Any ONE of:

From AS/NZS 3000:2007

- To verify the complete earth fault loop, including the integrity of the MEN connection and the upstream neutral (PEN) conductors  
8.3.9.1
- To verify that the protective device will operate to disconnect an earth-fault current within the time and touch voltage requirements of Clause 5.7.  
8.3.9.1
- The circuit protective device must interrupt the resulting fault current sufficiently quickly to prevent the touch voltage persisting long enough to be dangerous.

B4.2

(2 marks)

(b) Yes, it can be certificated because:

(1 mark)

- The minimum test of 1 Mohm for the installation or parts of the installation may be obtained with appliances disconnected.

(1 mark)

- Sheathed heating elements may have an insulation resistance test of at least 10 000 ohms.

(1 mark)

AS/NZS 3000:2000: 6.3.3.3.2

AS/NZS 3000:2007: 8.6.3.2

## Question 9

### Solution 1

Equipment	Load Group	Calculation	Load (KW)	
10 x 40W Fluorescent fittings	A	$10 \times 40 = 0.6$	0.4	(1 mark)
35 x 75W, fluorescent lights	A	$35 \times 75 = 2.63$	2.63	(1 mark)
18 x 1ph, 10A Socket outlets	B	$1 + (17 \times 0.75) = 13.75$	13.75	(1 mark)
10 x 1 ph, 15A socket outlets	B	$3.45 + (9 \times 0.75 \times 3.45) = 26.74$	26.74	(1 mark)
2 x 3ph, 9 kW Motors	D	$1 \times 9 = 9$ $1 \times 9 \times 0.75 = 6.75$	15.75	(1 mark)
2 x 5 kW Chiller motors	D	$10 \times 0.5 = 5$	5	(1 mark)
1 x 15 kW pottery kiln	C	$1 \times 15 = 15$	15	(1 mark)
3 x 4kW instantaneous water heaters	C	$3 \times 4 \times 0.75 = 9$	9	(1 mark)
Total			88.27	(2 marks)

Note: The pottery kiln is not specifically catered for in Table C2. While the most likely load group is "C", it could also be taken as being in load group G or K. As load group K is by assessment (and there is nothing particularly unique about the kiln), it is assessed as full load current.

Therefore, if either of load group G or K is used for the kiln, the only change is to the instantaneous water heater calculation, which would be:

$$4 + (2 \times 4 \times 0.75) = 10 \text{ kW}$$

The new total would be 89.47 kW

Solution 2

Equipment	Load Group	Calculation	Load (KW)	
10 x 40W Fluorescent fittings	A	$10 \times 40 = 0.4$	0.4	(1 mark)
35 x 75W, fluorescent lights	A	$35 \times 75 = 2.63$	2.63	(1 mark)
18 x 1ph, 10A Socket outlets	B	$1 + (5 \times 0.75) = 4.75/ \text{phase}$ $4.75 \times 3 = 14.25$	14.25	(1 mark)
10 x 1 ph, 15A socket outlets	B	$3.45 + (2 \times 0.75 \times 3.45) = 8.625$ $3.45 + (2 \times 0.75 \times 3.45) = 8.625$ $3.45 + (3 \times 0.75 \times 3.45) = 11.213$	28.46	(1 mark)
2 x 3ph, 9 kW Motors	D	$1 \times 9 = 9$ $1 \times 9 \times 0.75 = 6.75$	15.75	(1 mark)
2 x 5 kW Chiller motors	D	$10 \times 0.5 = 5$	5	(1 mark)
1 x 15 kW pottery kiln	C	$1 \times 15 = 15$	15	(1 mark)
3 x 4kW instantaneous water heaters	C	$3 \times 4 \times 0.75 = 9$	9	(1 mark)
Total			90.49	(2 marks)

Note: The pottery kiln is not specifically catered for in Table C2. While the most likely load group is "C", it could also be taken as being in load group G or K. As load group K is by assessment (and there is nothing particularly unique about the kiln), it is assessed as full load current.

Therefore, if either of load group G or K is used for the kiln, the only change is to the instantaneous water heater calculation, which would be:

$$4 + (2 \times 4 \times 0.75) = 10 \text{ kW}$$

The new total would **be 91.49 kW**