

**1 Electric Power and Energy Consumption****Example 1**

$$1 \text{ kW} \rightarrow 1000 \text{ J/s}$$

$$1 \text{ kWh} \rightarrow \text{Using } 1 \text{ kW for an hour}$$

$$\begin{aligned} 1 \text{ kWh} &= 1000 \text{ W} \times 60 \times 60 \text{ s} \\ &= 3\,600\,000 \text{ J} \end{aligned}$$

**Example 2**

$$\text{Electrical energy } E = P \times t$$

$$E \text{ (in kWh)} = P \text{ (in kW)} \times t \text{ (h)}$$

$$t = E / P$$

$$t = 0.36 \text{ kWh} / (60/1000) \text{ W} = 6 \text{ h}$$

**Example 3**

$$\text{Electrical energy } E = P \times t = 2.50 \text{ kW} \times 6 \text{ h} \times 7 = 105 \text{ kWh}$$

$$\text{Cost} = 105 \text{ kWh} \times 30.0 \text{ cents/kWh} = \$31.50$$

**Exercises 1**

$$1 \quad (a) \quad P = VI = 12 \text{ V} \times 1.5 \text{ A} = 18 \text{ W}$$

$$(b) \quad P = V^2/R = (8.0 \text{ V})^2/10 \, \Omega = 6.4 \text{ W}$$

$$(c) \quad P = I^2 R = (2 \text{ A})^2 (15 \, \Omega) = 60 \text{ W}$$

$$(d) \quad P = I^2 R = (3.0 \text{ V}/35.0 \, \Omega)^2 (5 \, \Omega) = 0.0367 = \underline{0.037 \text{ W (2sf)}} \text{ [resistor]}$$

$$P = I^2 R = (3.0 \text{ V}/35.0 \, \Omega)^2 (30 \, \Omega) = 0.22 \text{ W (2sf)} \quad \text{[lamp]}$$

$$P = V^2/R = (3.0 \text{ V})^2/35 \, \Omega = 0.26 \text{ W (2sf)} \quad \text{[Total power in circuit]}$$

*Try working Q1 with the 3 different versions of power formula. They should all give you the same answer. If you do not get the same answer, some of your understandings of the quantities are not correct.*

- 2 (a) The lamp will operate at normal brightness and convert 100 J of electrical energy to light and thermal energy every second when the p.d. across the lamp is 240 V.

(b) (i)  $E = P t = 100 \text{ W} \times 2 \times 60 \times 60 \text{ s} = 720 \text{ kJ}$

(ii) Resistance of lamp  $= V^2 / P = (240 \text{ V})^2 / 100 \text{ W} = 576 \Omega$

Therefore,  
the power when p.d. is 110 V  
 $= V^2 / R$   
 $= (110 \text{ V})^2 / 576 \Omega = 21.0 \text{ W}$

$E = P t = 21.0 \text{ W} \times 2 \times 60 \times 60 \text{ s} = 151 \text{ kJ}$

3 (ai)  $P = V^2 / R = (12.0 \text{ V})^2 / 12.0 \Omega = 12 \text{ W}$

(a ii)  $V = 12.0 \text{ V} / 18.0 \Omega \times 12.0 \Omega = 8.0 \text{ V};$   
So,  
 $P = V^2 / R = (8.0 \text{ V})^2 / 12.0 \Omega = 5.3 \text{ W}$

(bi)  $P = V^2 / R = (12.0 \text{ V})^2 / 6.0 \Omega = 24 \text{ W}$

(b ii)  $V = 12.0 \text{ V} - 8.0 \text{ V} = 4.0 \text{ V}$   
So,  
 $P = V^2 / R = (4.0 \text{ V})^2 / 6.0 \Omega = 2.7 \text{ W}$

(ci)  $P = 12 \text{ W} + 24 \text{ W} = 36 \text{ W}$

(cii)  $P = 5.3 \text{ W} + 2.7 \text{ W} = 8.0 \text{ W}$

- (d) Circuit 2, as the resistors will only convert a total of 8.0 J of electrical energy into thermal energy in one second.

- (e) The  $6 \Omega$  resistor in circuit 1 as it has the largest power of 24 W. That means it converts 24 J of electrical energy into thermal, energy in 1 second.

[Recall: use  $P = V^2 / R$  to compare power consumed by resistors in parallel circuit.]

4 (ai)  $I = P / V = 60 \text{ W} / 110 \text{ V} = 0.55 \text{ A}$

(a ii)  $I = P / V = 60 \text{ W} / 240 \text{ V} = 0.25 \text{ A}$

(bi)  $R = V^2 / P = (110 \text{ V})^2 / 60 \text{ W} = 200 \Omega$

(b ii)  $R = V^2 / P = (240 \text{ V})^2 / 60 \text{ W} = 960 \Omega$

- (ci)  $I = V / R = 240 \text{ V} / 200 \Omega = 1.2 \text{ A}$   
Since the current through it is now 1.2 A instead of 0.25 A, the lamp will be very bright and might blow.

- (cii)  $I = V / R = 110 \text{ V} / 960 \Omega = 0.11 \text{ A}.$   
Since the current through it is now 0.11 A instead of 0.55 A, the lamp will be very dim and might not light up.

### 3 Safe Use of Electricity in the Home

#### Exercises 3

1. earth pin

live pin

neutral pin

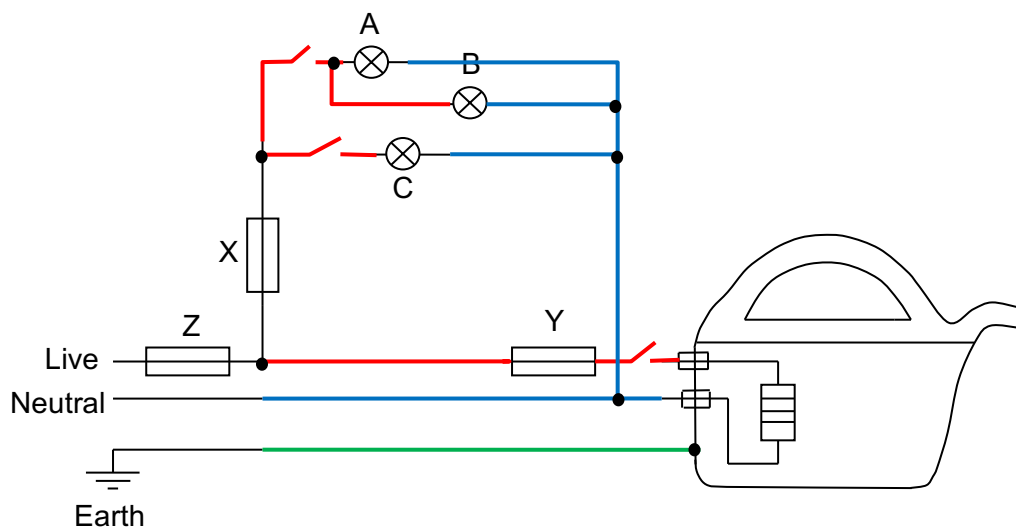
2. Using  $I = P / V$

total current drawn from socket  
 = current in electric kettle and current in oven  
 =  $2000 \text{ W} / 220 \text{ V} + 2500 \text{ W} / 220 \text{ V}$   
 =  $9.091 \text{ A} + 11.36 \text{ A}$   
 =  $20.45 \text{ A}$   
 =  $20 \text{ A}$

The individual 3-pin plug fuse rating is usually  $13 \text{ A}$ , so current will still flow in both appliances.

However, the overall current drawn from the socket is  $20 \text{ A}$  which may cause excessive heating in the cables of the socket and result in a fire.

3 (a)



**Note:**

- Fuse is on live wire before the switch so that the switch will be at low potential when the fuse melts.
- Earth wire should be connected to the metal casing of the kettle.
- Lamps A and B should be connected in parallel, each with  $240 \text{ V}$  applied across it (its rating for normal brightness).

(b)  $P = VI \rightarrow I = P / V$ :  $I_X = 0.75 \text{ A}$  (2 sf)  $I_Y = 3.125 \text{ A} \approx 3.1 \text{ A}$  (2 sf)  
 $I_Z = I_X + I_Y = 3.88 \text{ A} \approx 3.9 \text{ A}$  (1 d.p.)

(c) The current flowing through fuse Y is  $10 \text{ A}$  which exceeds its fuse rating of  $5 \text{ A}$ , fuse Y will melt and break, and the kettle will be cut off from the mains.

The current flowing through fuse X is unchanged at 0.75 A. Hence, fuse X remains undamaged and the 3 lamps will continue to operate at normal brightness.

The current flowing through fuse Z has increased to 10.75A but it is still lower than its fuse rating of 15 A. Hence fuse Z remains undamaged.

- (d) Switches and fuses must be on the live wire so that they can effectively isolate the kettle and the lamps from the high voltage mains when the switches are off and the fuses are damaged.

- (e) electrical energy  $E = P \times t$   $= (750/1000) \text{ W} \times (15/60) \text{ s} \times 14 = 2.625 \text{ kWh}$   
(P in kW, t in hours)

Cost of electricity =  $E \times \text{unit cost}$   $= 2.625 \times 0.35 = 0.919$   
 $\approx \$0.92$  (rounded off to the nearest cent)