Practical Electricity - ANSWERS

1 Electric Power and Energy Consumption

Example 1

1 kW → 1000 J / s

1 kWh → Using 1 kW for an hour

1 kWh = 1000 W × 60 × 60 s
= 3 600 000 J

Example 2

Electrical energy $E = P \times t$

E (in kWh) = P (in kW) × t (h)

$t = E$ / P

t = 0.36 kWh / (60/1000)W = 6 h

Example 3

Electrical energy $E = P \times t$ = 2.50 kW × 6 h × 7 = 105 kW h

Cost = 105 kWh × 30.0 cents/kWh = $31.50

Exercises 1

1 (a) $P = VI$ = 12 V × 1.5 A = 18 W

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

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

(d) $P = I^2R$ = $(3.0\text{ V}/35.0\ \Omega)^2$ (5 Ω) = 0.0367 = 0.037 W (2sf) [resistor]
$P = I^2R$ = $(3.0\text{ V}/35.0\ \Omega)^2$ (30 Ω) = 0.22 W (2sf) [lamp]
$P = V^2/R$ = $(3.0\text{ V})^2$/35 Ω = 0.26 W (2sf) [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 W × 2 × 60 × 60 s = 720 kJ

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

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

$E = P\,t$ = 21.0 W × 2 × 60 × 60 s = 151 kJ

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

(aii) V = 12.0 V/18.0 Ω × 12.0 Ω = 8.0 V;
So,
$P = V^2 / R$ = $(8.0\text{ V})^2$ / 12.0 Ω = 5.3 W

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

(bii) V = 12.0 V – 8.0 V = 4.0 V
So,
$P = V^2 / R$ = $(4.0\text{ V})^2$ / 6.0 Ω = 2.7 W

(ci) P = 12 W + 24 W = 36 W

(cii) P = 5.3 W + 2.7 W = 8.0 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 Ω 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 W / 110 V = 0.55 A

(aii) $I = P / V$ = 60 W / 240 V = 0.25 A

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

(bii) $R = V^2 / P$ = $(240\text{ V})^2$ / 60 W = 960 Ω

(ci) $I = V / R$ = 240 V/ 200 Ω = 1.2 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 V/ 960 Ω = 0.11 A.
Since the current through it is now 0.11A 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

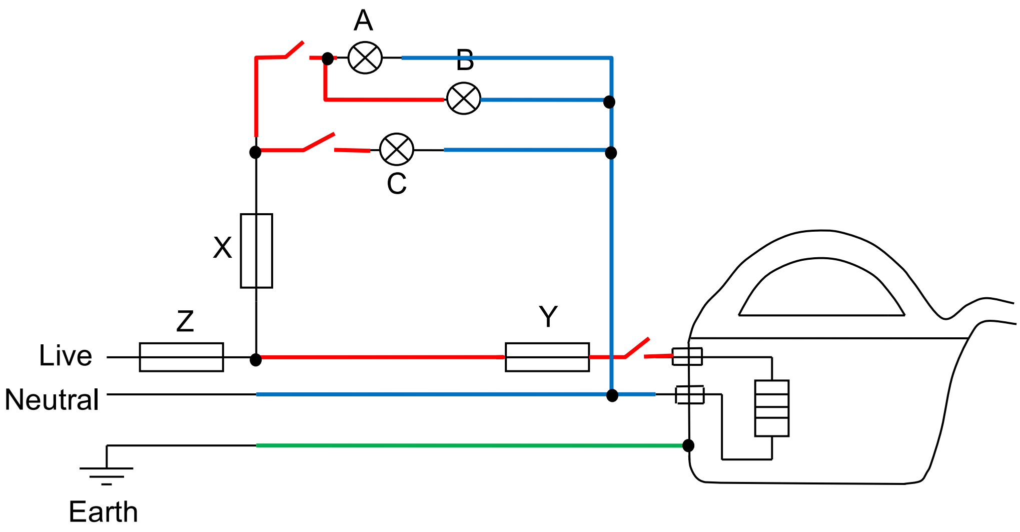
2. Using $I = P / V$

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

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

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

3 (a)



Note:

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

(b) $P = VI \rightarrow I = P / V$: I_X = 0.75 A (2 sf) I_Y = 3.125 A≈ 3.1 A (2 sf)

$I_Z = I_X + I_Y$ = 3.88 A ≈ 3.9 A (1 d.p.)

(c) The current flowing through fuse Y is 10 A which <u>exceeds its fuse rating of 5 A</u>, fuse Y will <u>melt and break</u>, and the kettle will be cut off from the mains.

The current flowing through fuse X is <u>unchanged</u> 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 <u>increased to 10.75A</u> but it is still lower than its fuse rating of 15 A. Hence fuse Z remains <u>undamaged</u>.

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

(e) electricial energy $E = P \times t$ = (750/1000) W × (15/60) s × 14 = 2.625 kWh

(P in kW, t in hours)

Cost of electricity = E × unit cost = 2.625 × 0.35 = 0.919

≈ \$0.92 (rounded off to the <u>nearest cent</u>)