The current I (in A) in a conductor depends on time as $I = 2t^2 - 3t + 7$, where t is in s. What quantity of charge moves across a section through the conductor during the interval t = 2 s to t = 4 s

Given $I = 3t^2 - 3t + 7$

$$\therefore \quad q = \int_2^4 I\,dt \qquad \text{See eq 27.2}$$

$$\therefore \quad q = \int_2^4 (2t^2 - 3t + 7)\,dt$$

$$\therefore \quad q = \left| \frac{2}{3}t^3 - \frac{3}{2}t^2 + 7t \right|_2^4$$

$$\therefore \quad q = \left(\frac{2}{3}(4)^3 - \frac{3}{2}(4)^2 + 7\times 4\right) - \left(\frac{2}{3}(2)^3 - \frac{3}{2}(2)^2 + 7\times 2\right)$$

$$q = (42.66 - 24 + 28) - (5.33 - 6 + 14)$$

$$= 46.66 - 13.33$$

$$q = \boxed{33.33 \text{ C}}$$

RESISTANCE AND OHM'S LAW.

What diameter copper wire has a resistance per unit length of $3.28 \times 10^{-3}\ \Omega/m$ at $20^\circ C$

Given

$$\frac{R}{l} = 3.28 \times 10^{-3}\ \Omega/m$$

$$d = ?$$

$\therefore$

$$R = \frac{\rho_r l}{A} \qquad \text{eq } 27.10$$

$$\therefore \frac{R}{l} = \frac{\rho_r}{A}$$

ρ_r = is the resistivity

$\rho_r = 1.7 \times 10^{-8}$ for copper

$$3.28 \times 10^{-3} = \frac{1.7 \times 10^{-8}}{A}$$

$$\therefore A = 5.18 \times 10^{-6} = \pi r^2$$

$$\therefore r^2 = \frac{5.18 \times 10^{-6}}{3.14} = 1.65 \times 10^{-6}$$

$$r = 1.28 \times 10^{-3}$$

$$\therefore \boxed{d = 2.56 \times 10^{-3}\ m}$$

$$\therefore d = 2r = 2 \times 1.28 \times 10^{-3}$$

$$= 2.56 \times 10^{-3}\ m$$

The RESISTIVITY OF DIFFERENT CONDUCTORS.

A 500-W heating coil designed to operate from 110 V is made of nichrome wire 0.5 mm in diameter. (a) Assuming that the resistivity of the nichrome remains constant at its 20°C value, find the length of the wire used. (b) Now consider the variation of the resistivity with temperature. What power will the coil of part (a) actually deliver when it is heated to 1200°C?

$$P = IV = \frac{V^2}{R} \qquad I = V/R$$

$$R = V^2/P = \frac{(110)^2}{500} = 24.2\,\Omega$$

(a) $$R = \frac{\rho l}{A}, \qquad l = \frac{RA}{\rho}$$

$$\therefore\ l = \frac{(24.2)(\pi r^2)}{1.5\times10^{-6}} = \frac{24.2\times3.14\times(2.5\times10^{-4})^2}{1.5\times10^{-6}}$$

$$l = \boxed{3.17\ m}$$

(b) $$R = R_0\{1+\alpha\Delta T\}$$

$$= 24.2\{1+0.4\times10^{-3}\times1180\}$$

$$R = 35.6\ \Omega$$

$1200°C - 20°C = 1180°C$

$$\therefore\ P = \frac{V^2}{R} = \frac{(110)^2}{35.6}$$

$$= \boxed{340\ W}$$

1200°C minus room temp = the actual temp.

Suppose that you want to install a heating coil that will convert electric energy to heat at a rate of 300 W for a current of 1.5 A (a) Determine the resistance of the coil (b) the resistivity of the coil wire is $10^{-6}\ \Omega.m$, and its diameter is 0.3 mm. Determine its length.

(a) Given $P = 300\ W$

$I = 1.5\ A$

$\therefore \quad R = \frac{P}{I^2} = \frac{300}{(1.5)^2} \qquad P = I^2R$

$R = \boxed{133.3\ \Omega}$

(b) $\rho = 10^{-6}\ \Omega.m \quad , \quad A = \pi r^2 = 3.14(1.5\times10^{-4})^2 = 7.1\times10^{-8}$

$R = 133.3$

$l = ? \qquad \left(R = \frac{\rho l}{A}\right)$

$\therefore \quad l = \frac{RA}{\rho} = \frac{133.3 \times 7.1\times10^{-8}}{10^{-6}} = \boxed{9.42\ m}$

ELECTRICAL ENERGY AND POWER. 102 $\frac{27}{4}$

An electric heater with a resistance of 20Ω requires 100 V across its terminals. A built-in switching circuit repetitively turns the heater on for 1 s and off for 4 s.
(a) How much energy is produced by the heater in 1 h? (b) What is the average power delivered by the heater over a period of one cycle?

Given $R = 20\ \Omega$, $V = 100\ V$

First $P = IV = \frac{V^2}{R} = (100)^2/R = 500\ W.$

in 1h (a) $U_{1hr} = \frac{500 \times 3600\ s}{5}$

$U_{1hr} = 36 \times 10^4\ J$ OR $= \underline{360\ kJ}$

5 s

(b) $\bar{P} = \frac{\Delta U}{\Delta t} = \frac{500 \times 1\ s}{5} = \underline{100\ W}$

ENERGY CONSERVATION IN HOUSEHOLD CIRCUITS 102 $\frac{27}{5}$

The heating element of a coffee maker operates at 120 V and carries a current of 2 A. Assuming that all of the heat generated is absorbed by the water, how long does it take to heat 0.5 kg of water from room temperature (23°C) to the boiling point.

Given $V = 120$ V

$I = 2$ A

$\therefore \quad P = IV = 240$ W.

Now $\Delta U = mc\Delta T$ and $\Delta T = 100 - 23 = 77°C$

$\therefore \quad \Delta U = 0.5 \times 4186 \times 77$ $\quad c = 4186$ J/kg·°C ← specific heat of water

$\Delta U = \boxed{161 \text{ kJ}}$

$$\therefore \quad t = \frac{\Delta U}{P} = \frac{161 \times 10^3}{240} = \boxed{672 \text{ s}}$$

OR $\boxed{11.2}$ Min

ENERGY CONSERVATION IN HOUSEHOLD CIRCUITS 102 27

5B

An electric heater operating at full power draws a current of 8 A from a 110-V circuit

(a) What is the resistance of the heater?

(b) Assuming the resistance R remains constant, at what What Voltage and Current would the heater dissipate 750 W.

Given $V = 110\ V$, $I = 8\ A$, $P = 750\ W$.

Sol: (a)

$$V = IR \Rightarrow R = \frac{V}{I} = \frac{110}{8} = \boxed{13.75\Omega}$$

(b)

$$P = IV = I^2R$$

$$\Rightarrow 750 = I^2(13.75)$$

$$\Rightarrow I^2 = \frac{750}{13.75}$$

$$I = \boxed{7.38A}$$

for voltage

$$P = IV \Rightarrow V = \frac{P}{I}$$

$$\Rightarrow V = \frac{750}{7.38} = \boxed{101.6\ V}$$