SOLUTION CHAPTER 27

1E. The current in the electron beam producing a picture on a typical video display terminal is 200 μA. How many electrons strike the screen each second?

27-1 $q = n|e| \Rightarrow n = \frac{q}{|e|} = \frac{it}{|e|} = \frac{(200 \times 10^{-6} A)(1 S)}{1.6 \times 10^{-19} C}$

$$= 1.25 \times 10^{15}$$

12P. A steady beam of alpha particles ($q = +2e$) traveling with constant kinetic energy 20 MeV carries a current of 0.25 μA. (a) If the beam is directed perpendicular to a plane surface, how many alpha particles strike the surface in 3.0 s? (b) At any instant, how many alpha particles are there in a given 20 cm length of the beam? (c) Through what potential difference was it necessary to accelerate each alpha particle from rest to bring it to an

mass of Alpha particle = 4 (mass of proton)

27-12

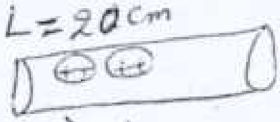
$\frac{m}{2} v^2 = 20\ \text{MeV}$ K.E. = 20 MeV, $I = 0.25 \times 10^{-6}$ A

$v = \sqrt{\frac{2KE}{m_A}}$ $q = +2e$,

m_A = mass of Alpha-particle → (++)

(a) $n = \frac{\Delta q}{2e} = \frac{i \Delta t}{2e}$

$= \frac{(.25 \times 10^{-6})(3)}{2(1.6 \times 10^{-19})} = \underline{2.3 \times 10^{12}}$



$t' = L/v$

(b) $n' = \frac{i t'}{2e} = \frac{i L}{2 e v}$

$= \frac{(0.25 \times 10^{-6})(20 \times 10^{-2})}{2(1.6 \times 10^{-19}) \sqrt{\frac{2 \times 20 \times 10^{6} \times 1.6 \times 10^{-19}}{4(1.67 \times 10^{-27})}}}$

(1.67 × 10^-27 = mass of proton)

$= \underline{5.05 \times 10^{3}}$

(c) use the conservation law $(K.E. + P.E.)_i = (K.E. + P.E.)_f$

$(K.E. + P.E.)_i = (K.E. + P.E.)_f$

K.E.$_i$ = 0, P.E.$_i$ = $2qV$, P.E.$_f$ = 0

$20\ \text{MeV} = 20 \times 10^{6} \times 1.6 \times 10^{-19}$ J

$V = \frac{20 \times 10^{6} \times 1.6 \times 10^{-19}}{2(1.6 \times 10^{-19})} = \underline{10^{7}\ \text{Volts}}$

27E. A wire with a resistance of 6.0 Ω is drawn out through a die so that its new length is three times its original length. Find the resistance of the longer wire, assuming that the resistivity and density of the material are unchanged.

27-27 $R = 6.0\,\Omega$, $\ell' = 3\ell$ $(V = V')$

$(\ell A = \ell' A')$

$$R = \frac{\rho \ell}{A} = \frac{\rho \ell^2}{A\ell} = \frac{\rho \ell^2}{V}$$

the new resistance $R' = \frac{\rho \ell'}{A'} = \frac{\rho \ell'^2}{V'}$

$$R' = \frac{\rho (3\ell)^2}{V} = 9\frac{\rho \ell^2}{V} = 9R = 9(6)$$

$$= 54\,\Omega$$

53P. A cylindrical resistor of radius 5.0 mm and length 2.0 cm is made of material that has a resistivity of $3.5 \times 10^{-5}\ \Omega \cdot m$. What are (a) the current density and (b) the potential difference when the energy dissipation rate in the resistor is 1.0 W?

27-53

$r = 5\ mm = 5 \times 10^{-3}\ m$

$\ell = 2\ cm = 2 \times 10^{-2}\ m$

$\rho = 3.5 \times 10^{-5}\ \Omega$

$P = 1.0\ W$

$P = i^2 R \Rightarrow i = \sqrt{\frac{P}{R}}$,

$R = \frac{\rho \ell}{A}$

(a) $J = \frac{i}{A} = \frac{1}{A}\sqrt{\frac{P}{\rho \ell / A}} = \sqrt{\frac{P}{\rho \ell A}}$, $A = \pi r^2 = \pi (5 \times 10^{-3})^2$

$= \sqrt{\frac{1\ W}{\pi (5 \times 10^{-3})^2 (3.5 \times 10^{-5})(2 \times 10^{-2})}} = 1.3 \times 10^{5}\ A/m^2$

(b) $P = i^2 R = J V A \Rightarrow V = \frac{P}{JA}$

$V = \frac{1\ W}{\pi (5 \times 10^{-3})^2 (1.3 \times 10^{5})} = 9.4 \times 10^{-2}\ V$

55P. A 100 W lightbulb is plugged into a standard 120 V outlet. (a) How much does it cost per month to leave the light turned on continuously? Assume electrical energy costs 6¢/kW·h. (b) What is the resistance of the bulb? (c) What is the current in the bulb? (d) Is the resistance different when the bulb is turned off?

27-55 $P = 100\ W = 100\ \frac{\text{Joules}}{s}$, $V = 120\ V$

(a) $\text{Cost} = (100\ W)\left(\frac{24h}{d}\right)\left(\frac{31d}{\text{month}}\right)\left(6\ \frac{\text{Cents}}{KW \cdot h}\right) = 446\ \text{Cents}$

(b) $R = \frac{V^2}{P} = \frac{(120)^2}{100} = 144\ \Omega$

(c) $i = \frac{P}{V} = \frac{100W}{120\ \text{Volts}} = 0.833A$

(d) No