Problem 6.1:

Chemistry thoughts:

$$A_r^{\circ}(Al) = 26.982$$

*Multiply by $1\,\text{Dalton} = 1.66\times10^{-27}\,kg$

$$(26.982)\left(1.66\times10^{-27}\,\frac{kg}{atom}\right) = 4.479E-26\,\frac{kg}{atom}$$

$$n = \frac{(\#\,atoms)(carriers/atom)}{Volume}$$

problem states 1 carrier/atom

$$n = \left(\frac{1}{4.479E-26}\,\frac{atoms}{kg}\right)\left(\frac{2700\,kg}{1\,m^3}\right)$$

$$\boxed{n = 6.02\times10^{28}\,\frac{charges}{m^3}}$$

charge density

Area of wire: $A = \pi r^2 = 2.08E-6\,m^2$

$$V_{drift} = \frac{I}{nqA} = \frac{3}{(6.02E28)(1.6E-19)(2.08E-6)}$$

$$\boxed{= 1.49\times10^{-4}\,\frac{m}{s}}$$

change to copper

$$A_r^\circ(Cu) = 63.546 \qquad \rho_{cu} = 8960 \frac{kg}{m^3}$$

$$63.546\,(1.66E{-}27) = 1.05E{-}25 \frac{kg}{atom}$$

$$n = \left(\frac{1 \quad atoms}{1.05E{-}25 \ \cancel{kg}}\right)\left(\frac{8960 \ \cancel{kg}}{m^3}\right) = 8.53E28 \frac{atoms}{m^3}$$

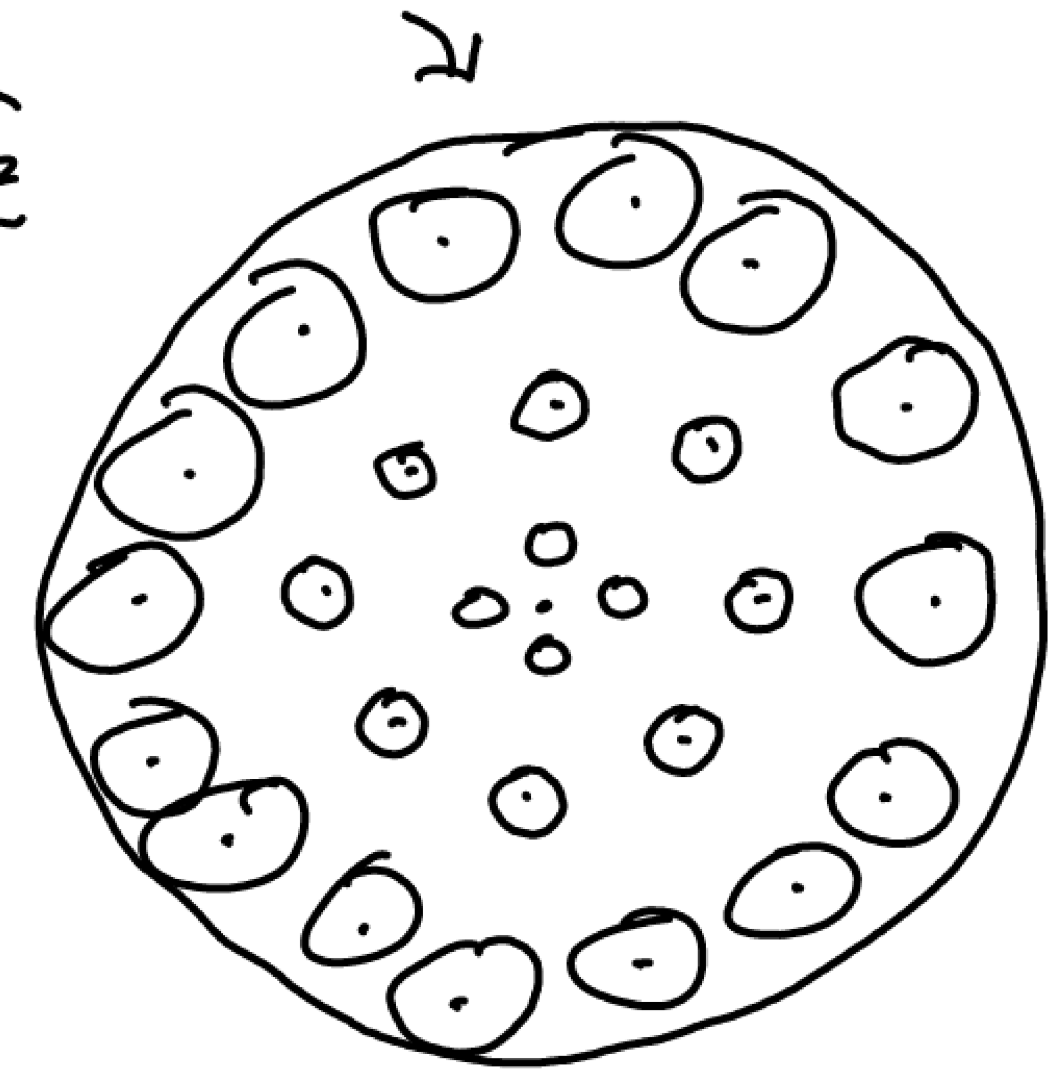
$$V_{drift} = \frac{I}{nqA} = \frac{3}{(8.53E28)(1.6E{-}19)(2.08E{-}6)}$$

$$\boxed{= 1.05 \times 10^{-4} \ m/s}$$

* Almost the same as Aluminium

Current Density : 2D cross section of current $\vec{I}$

$\vec{I} \Rightarrow \vec{J}(r) = cr^2\,\hat{z}$

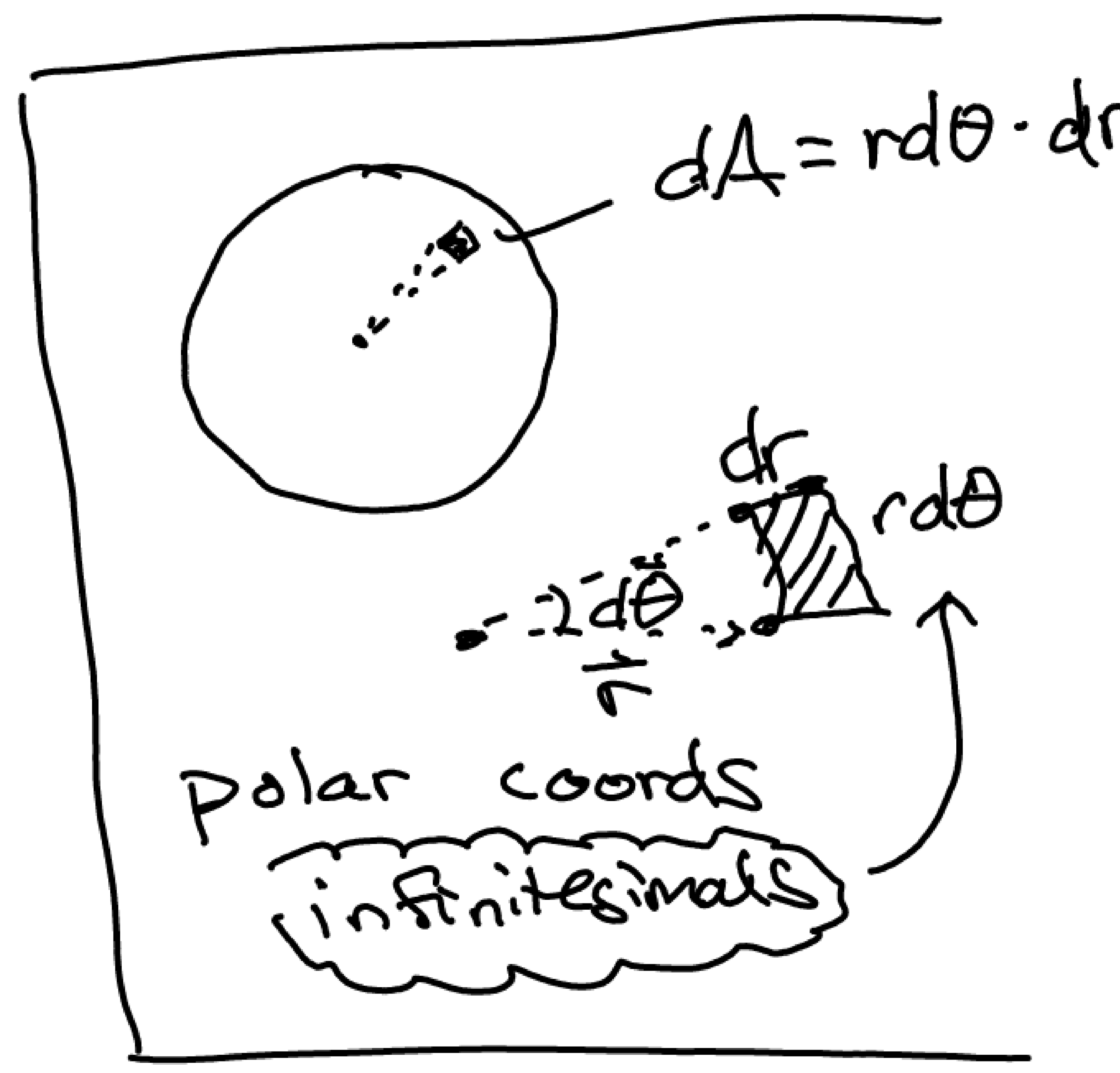


$\odot$ large I

$\circ$ small I

current increases as r increases

Integrate in 2D



$$I = \iint J\,dA$$

$$I = \int_0^{2\pi}\int_0^{\tilde{r}} cr^2\, r\,dr\,d\theta$$

$$= 2\pi c\int_0^{\tilde{r}} r^3\,dr = \frac{2\pi c r^4}{4}\Big|_0^{\tilde{r}} = \boxed{\frac{\pi c r^4}{2}}$$

Now evaluate:

$$I_R = \frac{\pi c R^4}{2} = 636\,\mu A$$

total current

$$I_{R/2} = \frac{\pi c (R/2)^4}{2} = \frac{\pi c R^4}{32}$$

$$\boxed{= 39.8\,\mu A}$$

$R = 3E{-}3\,[m]$

$C = 5E6\,[A/m^4]$

problem 6.3:

$$V = IR \qquad R = \frac{V}{I} = \boxed{6.75\,\Omega}$$

6.4:

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

$\rho = 1.68\,E-8\ \Omega\cdot m$

$l = 1\,km = 1000\,m$

$A = \pi r^2 = 5.35\,E5\ m^2$

$$= (1.68\,E-8)\frac{1000}{5.35\,E5}$$

$$\boxed{= 0.314\ \Omega}$$

6.5:

$$R = \rho \frac{l}{A} \Rightarrow \rho = \frac{RA}{l}$$

$$\boxed{= 2.44 \times 10^{-8}}$$

Gold!

$$R = R_o\left[1 + \alpha(T - T_o)\right]$$

$$= 77.7\left[1 + (3.4E-3)(150 - 20)\right]$$

$$\boxed{= 112\ \Omega}$$

$\alpha_{gold} = 0.0034\ K^{-1}$

see § 9.3 in textbook

problem 6.6

$\Delta V = IR$

$I = \frac{\Delta V}{R} = \frac{1.5}{2200}$

$I = 6.8E\text{-}4A = \boxed{0.68mA}$

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problem 6.7:

14 gauge: dia = 1.63 mm

Nichrome: $\rho = 100E\text{-}8\ \Omega\cdot m$

$V = 110V$

Power = 300 Watts

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

$\Downarrow$

$R = \frac{V^2}{P} = \frac{110^2}{300} = \underline{40.3\,\Omega}$

First find Resistance then design the wire

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

$l = \frac{AR}{\rho} = \frac{(\pi r_{14}^2)R}{\rho}$

$l = \frac{(\pi)(\frac{1.63E-3}{2})^2(40.3)}{100E-8} = \boxed{84 \text{ meters}}$

problem 6.8:

cost is: $0.10 \frac{\$}{kWh}$

Note "Kilowatt hour" kWh is an Energy (Joules)

energy used by consuming one "kWh"

$1 kWh = 1000 \text{ Watts} \cdot 1 \text{ hour}$

$= \left(1000 \frac{J}{\cancel{s}}\right) \cdot (1 \cancel{hour}) \cdot \frac{3600 \cancel{sec}}{1 \cancel{hour}}$

$= 3.6 \text{ Mega Joules} = \boxed{3.6E6 J}$

First find total "on" time (in hours)

$t = (4 hr)(365.25) = 1461 \ hr/year$

Cost is then simply a unit conversion:

$$\frac{\$}{year} = (100 \cancel{W})\left(0.1 \frac{\$}{\cancel{kW \cdot hr}}\right)\left(\frac{1 \cancel{kW}}{1000 \cancel{W}}\right)\left(1461 \frac{hr}{yr}\right)$$

$\boxed{= \$14.61 \text{ per year}}$ for 100 Watt

$\boxed{= \$2.34 \text{ per year}}$ for 16 Watt

Problem 6.9:

Unit conversion for Area

$$A = 0.52\ mm^2 \left(\frac{1\ m}{1000 mm}\right)^2$$

$$= 5.2E-7\ m^2$$

$$R = \rho \frac{l}{A} = (1.68E-8) \frac{(1000)(2\pi \cdot 2E-3)}{(5.2E-7)}$$

$$\boxed{= 0.406\,\Omega}$$