58. (a) The magnitude of the toroidal field is given by $B_0 = \mu_0 n i_p$, where n is the number of turns per unit length of toroid and i_p is the current required to produce the field (in the absence of the ferromagnetic material). We use the average radius ($r_{\text{avg}} = 5.5$cm) to calculate n:

$$n = \frac{N}{2\pi r_{\text{avg}}} = \frac{400\,\text{turns}}{2\pi(5.5\times10^{-2}\,\text{m})} = 1.16\times10^{3}\,\text{turns/m} \ .$$

Thus,

$$i_p = \frac{B_0}{\mu_0 n} = \frac{0.20\times10^{-3}\,\text{T}}{(4\pi\times10^{-7}\,\text{T}\cdot\text{m/A})(1.16\times10^{3}/\text{m})} = 0.14 \text{ A} \ .$$

(b) If Φ is the magnetic flux through the secondary coil, then the magnitude of the emf induced in that coil is $\mathcal{E} = N(d\Phi/dt)$ and the current in the secondary is $i_s = \mathcal{E}/R$, where R is the resistance of the coil. Thus

$$i_s = \left(\frac{N}{R}\right)\frac{d\Phi}{dt} \ .$$

The charge that passes through the secondary when the primary current is turned on is

$$q = \int i_s\,dt = \frac{N}{R}\int\frac{d\Phi}{dt}\,dt = \frac{N}{R}\int_0^{\Phi} d\Phi = \frac{N\Phi}{R} \ .$$

The magnetic field through the secondary coil has magnitude $B = B_0 + B_M = 801B_0$, where B_M is the field of the magnetic dipoles in the magnetic material. The total field is perpendicular to the plane of the secondary coil, so the magnetic flux is $\Phi = AB$, where A is the area of the Rowland ring (the field is inside the ring, not in the region between the ring and coil). If r is the radius of the ring's cross section, then $A = \pi r^2$. Thus

$$\Phi = 801\pi r^2 B_0 \ .$$

The radius r is $(6.0\,\text{cm} - 5.0\,\text{cm})/2 = 0.50\,\text{cm}$ and

$$\Phi = 801\pi(0.50\times10^{-2}\,\text{m})^2(0.20\times10^{-3}\,\text{T}) = 1.26\times10^{-5}\,\text{Wb} \ .$$

Consequently,

$$q = \frac{50(1.26\times10^{-5}\,\text{Wb})}{8.0\,\Omega} = 7.9\times10^{-5} \text{ C} \ .$$