13.1 a) $\chi_m = -\mu_0 \frac{q^2 Z r^2}{4 m_e V}$

(q: e^- charge; Z: atomic #; r^2: electron radius; V: volume of atom; m_e: e^- mass; μ_0: permeability of free space)

Calculate for carbon:

$\mu_0 = 1.26 \times 10^{-6} \frac{m \cdot kg}{s^2 A^2}$

$q = 1.60 \times 10^{-19} C$

$Z = 6$

$r = 70 \times 10^{-12} m$

$m_e = 9.11 \times 10^{-31} kg$

$V = 1.44 \times 10^{-30} m^3$

$\chi_{m,\,carbon} = -1.81 \times 10^{-4}$

b) $F = -V \mu_0 \chi_m H \frac{dH}{dz}$

Assume $V = (5cm)^3 = 1.25 \times 10^{-4} m^3$

$\frac{dH}{dz} = \frac{H}{.05m}$

$F_g = mg = .02kg \cdot 9.8 m/s^2 = .196 kg \cdot m/s^2$

$F = -1.25 \times 10^{-4} \cdot 1.26 \times 10^{-6} \cdot (-1.81 \times 10^{-4}) \cdot \frac{H^2}{.05} = .196$

$\hookrightarrow H = 5.86 \times 10^5 A/r$

$B = \mu_0 (1 + \chi_m) H = .74 T$

13.2 ?

13.3 $\Delta E = \frac{1}{2} V \mu_0 \chi_m H^2$

$E = \frac{1}{2} \int \vec{B} \cdot \vec{H} \, dV$

a) The permanent magnet generates a magnetic field $\vec{B}$ which then causes the domains in the iron to reorient and become attracted.

b) A magnet is a dipole with a magnetic moment that experiences a torque to align itself with an external magnetic field.

13.4 2.

13.5