19. The energy of a magnetic dipole in an external magnetic field $\vec{B}$ is $U = -\vec{\mu} \cdot \vec{B} = -\mu_z B$, where $\vec{\mu}$ is the magnetic dipole moment and μ_z is its component along the field. The energy required to change the moment direction from parallel to antiparallel is $\Delta E = \Delta U = 2\mu_z B$. Since the z component of the spin magnetic moment of an electron is the Bohr magneton μ_B, $\Delta E = 2\mu_B B = 2(9.274 \times 10^{-24}\,\text{J/T})(0.200\,\text{T}) = 3.71 \times 10^{-24}\,\text{J}$. The photon wavelength is

$$\lambda = \frac{c}{f} = \frac{hc}{\Delta E} = \frac{(6.63 \times 10^{-34}\,\text{J·s})(3.00 \times 10^{8}\,\text{m/s})}{3.71 \times 10^{-24}\,\text{J}} = 5.36 \times 10^{-2}\ \text{m} .$$