Thermal freezeout

1. Suppose we applied our estimates for thermal freezeout of WIMPs to the case of electron-positron annihilation into photons. Given that the cross section is $\sigma v \approx \pi\alpha^2/m_e^2$, where m_e is the electron mass and α is the fine structure constant, what final relic density would you expect for electrons and positrons, compared to that for dark matter? An order of magnitude estimate is sufficient. Is this in agreement with observations (assuming the universe today has a number of electrons equal to the number of protons)? If not, why is this not a problem?

2. Write down an approximate relationship between the annihilation cross section, the Planck mass and the temperature at matter-radiation equality, if the thermal freezeout of a n-body annihilation process (with $n > 2$) gives rise to the relic abundance of dark matter. You may ignore O(1) factors and changes in the number of effective degrees of freedom in the radiation bath, and assume that freezeout occurs at a temperature of roughly $T \sim m_\chi$.