

Iron has 26 protons and 30 neutrons.

- Estimate the weight of one N_A number of iron atoms in grams
- Write down the electronic structure of iron. Indicate the spins of the valence electrons in iron.
- What is the total orbital angular momentum of an electron in the last filled orbital.
- Now consider one mole of vaporized Na atoms at a temperature of 1000K.
 - The splitting between the first excited state and the ground state is 590 nm. Considering only the ground and first excited states what is number of atoms in these two states.
 - At what temperature would the number of atoms in the excited state be 10% of the number of atoms in the ground state.

Consider a cold gas of 100,000 Rubidium atoms confined to a cubical region of $1 \text{ mm} \times 1 \text{ mm} \times \text{mm}$. Rb has 27 protons and 48 neutrons.

- Is this atom a fermion or boson.
- Estimate the temperature at which quantum mechanics plays a significant role in the dynamics of this gas.
- For just two of these atoms in a one dimensional box of size L , write down the wave function and energies of the lowest two states, $\psi_{ab}(x_1, x_2)$. Assume that the atoms are spineless.
- Now consider the same gas at a higher temperature of $T=300 \text{ K}$ and now in 3D. Draw a graph of the distribution of molecular speeds.
- On your graph indicate (roughly) the top 30% fastest atoms
- Determine the average speed of the atoms.
- Determine the probability that an atom will be faster than the most probable speed. (You can leave your final answer as an unevaluated, but dimensionless integral.)

Consider metallic Cu, which has electronic structure $[\text{Ar}]4s^1 3d^{10}$. has $Z = 29$ protons and $N = 35$ neutrons. It has a density of $\rho = 8.96 \text{g/cm}^3$. We will treat the valence electrons of *Cu* as a gas of electrons at zero temperature.

- Determine the number of valence electrons per unit volume.
- Estimate the typical wavelength and energy of an electron in Copper.
- Determine the kinetic energy of the last filled electronic state (the fermi energy). Obtain a numerical number for copper.
- What is the relationship between momentum p , the wave number k , and the wavelength λ
- Determine the fermi momentum.
- Determine the mean energy and mean momentum of an electron in a *Cu*.
- Explain why the mean momentum should be less than the fermi momentum.