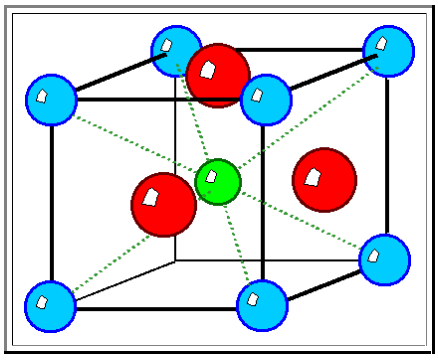
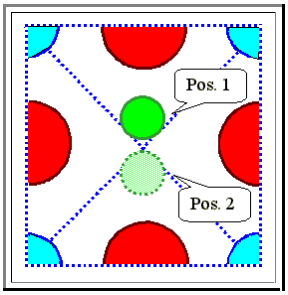
3.6.2 Ferro Electricity

- The name, obviously, has nothing to do with "*Ferro*" (= Iron), but associates the analogy to ferro magnetism. It means that in some special materials, the electrical dipoles are not *randomly* distributed, but interact in such a way as to align themselves even *without* an external field.
  - We thus expect *spontaneous polarization* and a *very large* dielectric constant (**DK**).
  - This should be very useful - e.g. for making capacitors - but as in the case of ferro *magnetism*, there are not too many materials showing this behavior.
- The best known material used for many application is **$BaTiO_3$** (**Barium titanate**).
  - It has a simple lattice as far as materials with three different atoms can have a simple lattice at all. The doubly charged **Ba^{2+}** atoms sits on the corners of a cube, the **O^{2-}** ions on the face centers, and the **Ti^{4+}** ion in the center of the cube.
  - We have **8 Ba^{2+}** ions belonging to **1/8** to the elementary cell, **6 O^{2-}** ions belonging to **1/2** to the elementary cell, and one **Ti^{4+}** ion belonging in total to the cell, which gives us the **$BaTiO_3$** stoichiometry.
  - This kind of crystal structure is called a **Perovskite** structure; it is very common in nature and looks like the drawing below (only three of the six oxygen ions are shown for clarity):



- Often, the lattice is not exactly cubic, but slightly distorted. In the case of **$BaTiO_3$** this is indeed the case: The **Ti** - ion does not sit in the *exact* center of the slightly distorted cube, but slightly off to one side. It thus has *two* symmetrical positions as schematically (and much exaggeratedly) shown below



  - Each elementary cell of **$BaTiO_3$** thus carries a dipole moment, and, what's more important, *the moments of neighbouring cells tend to line up*.
- The interactions between the dipoles that lead to a line-up can only be understood with quantum mechanics. It is not unlike the interactions of *spins* that lead to ferro magnetism.
  - We will not go into details of ferro electricity at this point. Suffice it to say that there are many uses. Traditionally, many capacitors use ferro-electric materials with high **DK** values. In recent years, a large interest in ferro-electrics for uses in integrated circuits has developed; we have yet to see if this will turn into new products.