Homework 5

5.1. In each of the following cases indicate whether the structure is a primitive Bravais lattice. If so, provide the three primitive vectors. If not, then describe it as a Bravais lattice with as small a basis as possible.

(i) Base centered cubic lattice (simple cubic with two additional lattice points at the center of the horizontal faces)

(ii) Side centered cubic lattice (simple cubic lattice with additional lattice points at the center of four vertical faces)

(iii) Edge centered cubic lattice (simple cubic lattice with additional lattice points at the centers of the 12 edges of the cube)

5.2. For the four crystal structures below, identify (i) the type of the underlying Bravais lattice (simple cubic, fcc, bcc, etc.), (ii) the three primitive lattice vectors, (iii) position of the atoms in the basis, (iv) concentration of atoms using a, the side of the unit cube, as the length unit.

(a) CsCl

(b) NaCl

(c) CaF$_2$

(d) BaTiO$_3$
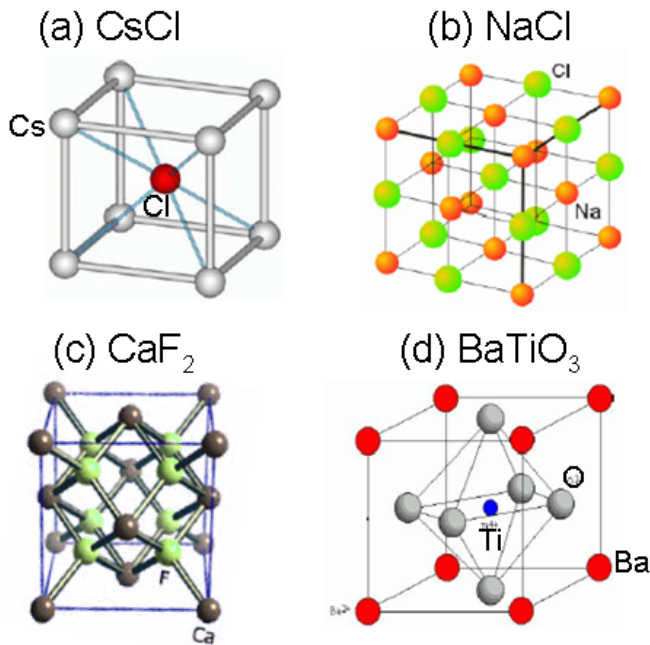
5.3. Consider a two-dimensional triangular lattice described by the two primitive vectors (in an orthogonal coordinate system)

$$\vec{a}_1 = a(1,0) ; \quad \vec{a}_2 = a\left(\frac{1}{2}, \frac{\sqrt{3}}{2}\right) .$$

Find the two primitive lattice vectors $\vec{b}_1, \vec{b}_2$ describing the reciprocal lattice. Find the area of the 1st Brillouin zone and find its relation with the area of the direct lattice unit cell.