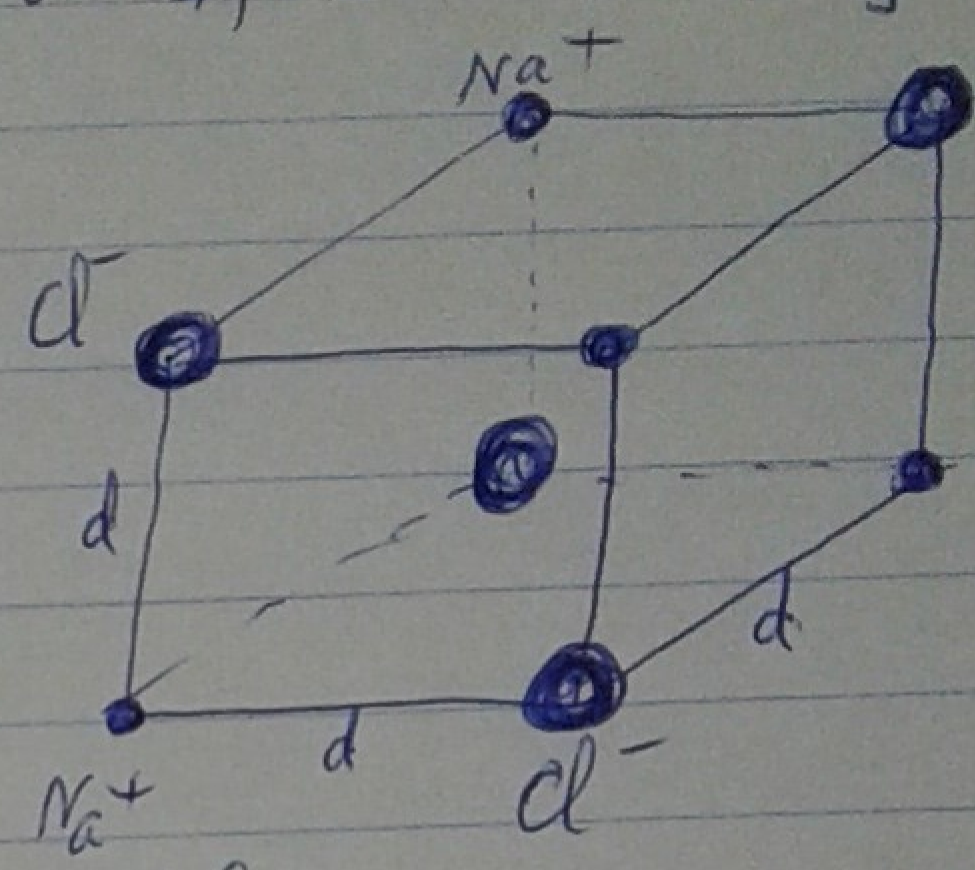
(3-39) Determination of Avogadro's # with X-rays



basic or primitive cell : $d \times d \times d$

$V_{cell} = d^3$

How many NaCl molecules are in each basic cell?

Each ion is shared with 8 neighboring cells

$\therefore$ each cell contains $\frac{4Na^+ + 4Cl^-}{8} = \frac{1}{2}$ NaCl molecule

Determine d by X-ray diffraction

$2d \sin\theta = n\lambda$ for $n=1$ $\theta = 6.41°$ for $\lambda = 0.62$

$\therefore d = \frac{\lambda}{2\sin\theta} = \frac{0.626\ Å}{2\sin(6.41°)} = 2.803\ Å = 2.803 \times 10^{-1}$

Volume of cell $= d^3 = 22.036 \times 10^{-30}\ m^3$

$= 2.20 \times 10^{-29}\ m^3$

$2d^3$ contains one molecule $2d^3 = 4.40 \times 10^{-29}\ m^3$

Atomic weight (or mass) of NaCl $= 58.44\ g/mol$

density $= 2.17\ g/cm^3 = 2.17 \times 10^{+6}\ g/m^3$

Volume of one mole $= \frac{58.44\ g}{2.17 \times 10^{+6}\ g/m^3} = 26.93 \times 10^{-6}\ m^3$

Avogadro's # $= \frac{\text{Volume of one mole}}{\text{Volume of one molecule}} = \frac{26.93 \times 10^{-6}\ m^3}{4.40 \times 10^{-29}\ m^3}$

$= 6.11 \times 10^{23}$