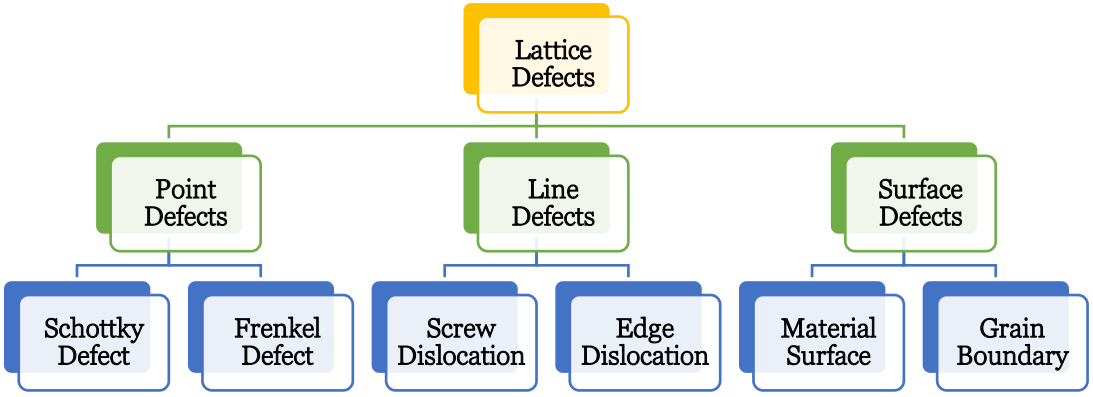
Defects in Solid

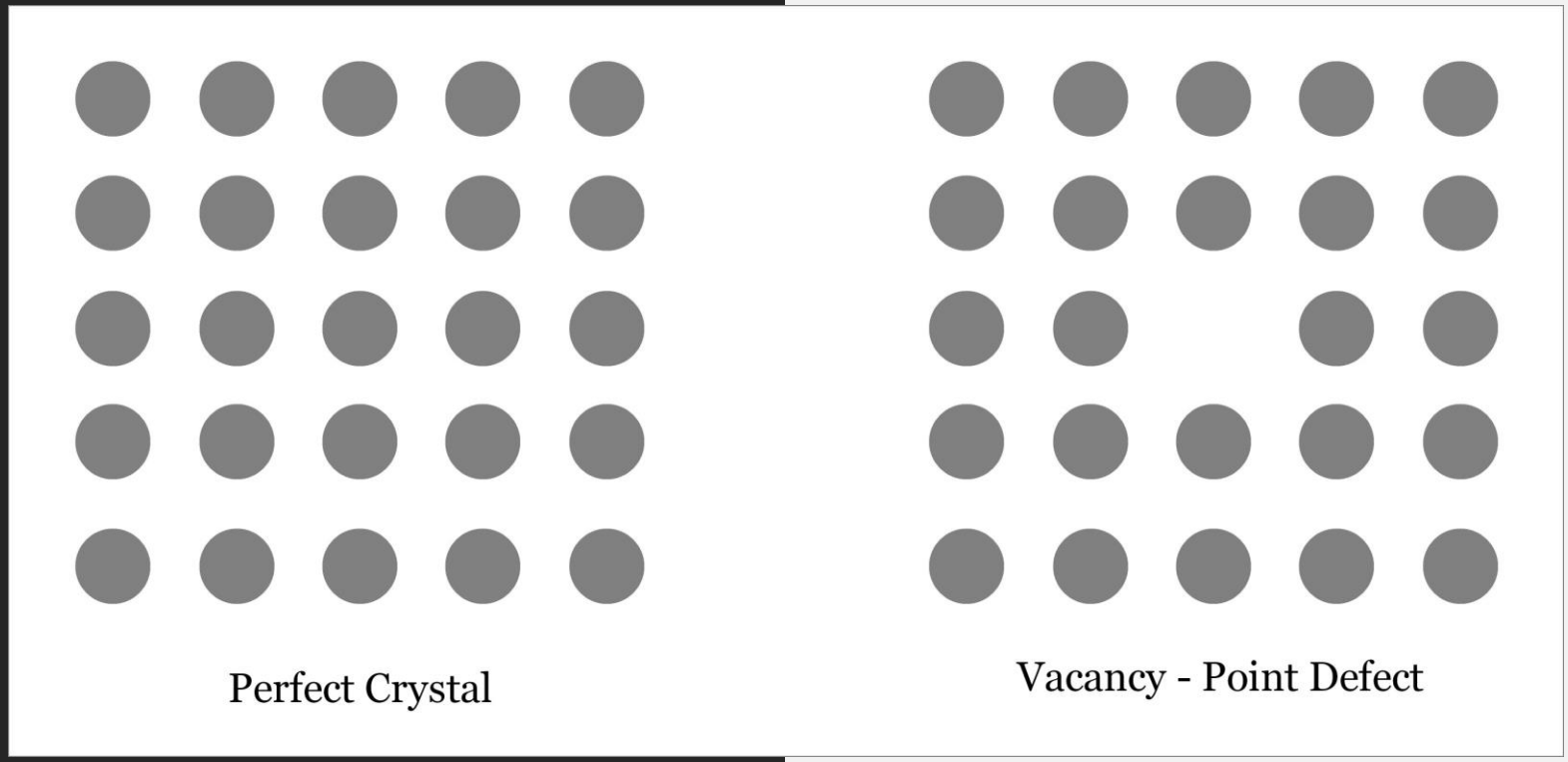
The arrangement of the atoms in all materials contains imperfections which have profound effect on the behavior of the materials. Lattice defects can be shorted in to three categories:



Why defect are important?

There are a lot of properties that are controlled or affected by defects, for example:

- Electric and thermal conductivity in metals (strongly reduced by point defects)
- Electronic conductivity in semi-conductors (controlled by substitution defects)
- Ionic conductivity (controlled by vacancies)
- Colors (affected by defects)
- Mechanical strength (strongly depended on defects)



Point Defects

A perfect crystal with regular arrangement of atoms can not exist. There are always defects, and the most common defects are point defects. This is especially true at high temperatures when atoms are frequently and randomly change their positions leaving behind empty lattice sites, called vacancies. In most cases diffusion (mass transport by atomic motion) - can only occur because of vacancies.

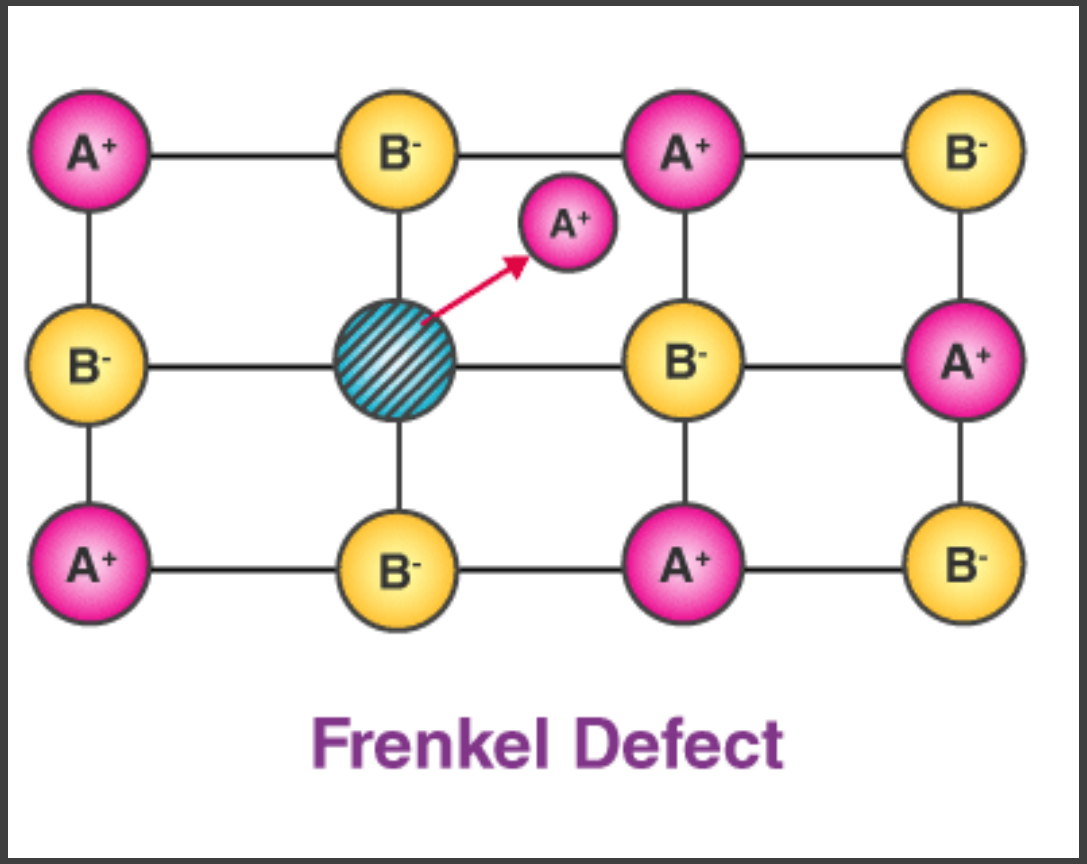
How many Vacancies are there?

The higher is the temperature, more often atoms are jumping from one equilibrium position to another, and larger number of vacancies can be found in a crystal. The number of vacancies, Nv, increases exponentially with the absolute temperature, T, and can be estimated using the equation (Boltzmann Distribution):

- $N_v = Ns\ \exp(-\frac{E_v}{K_b T})$

- where Ns is the number of regular lattice sites, k_b is the Boltzmann constant (1.380649×10^{-23} joule per kelvin (K), and $\mathbf{E_v}$ is the energy needed to form a vacant lattice site in a perfect crystal.

- "**A vacancy is produced when an atom is missing from a normal site"**



Frenkel defect

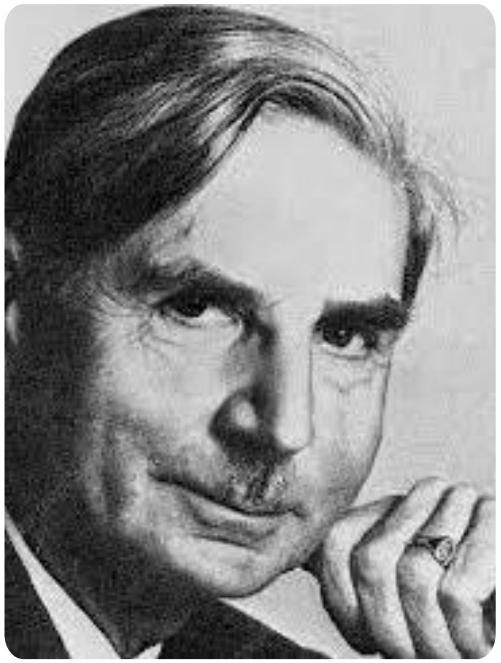
A Frenkel defect is a type of point defect in crystalline solids named after its discoverer **Yakov Frenkel (Soviet physicist)**. The defect forms when an atom or smaller ion leaves its place in the lattice, creating a vacancy, and becomes an interstitial by lodging in a nearby location.

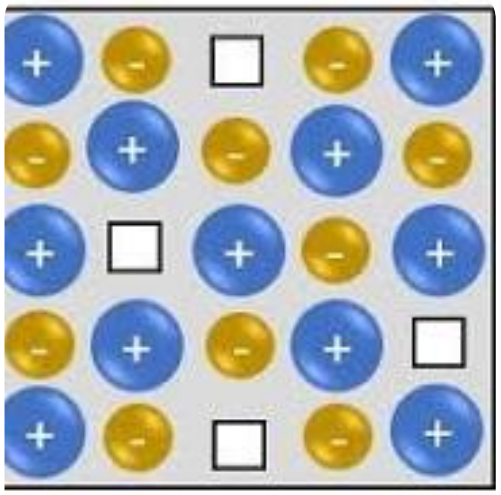
Frenkel defect

Frenkel defects are mostly exhibited in ionic solids (low Co-ordination number) where the smaller ion (usually the cation) is dislocated. Some examples include AgBr (also shows Schottky defects), ZnS, AgCl, and AgI

Characteristic of Frenkel Defect

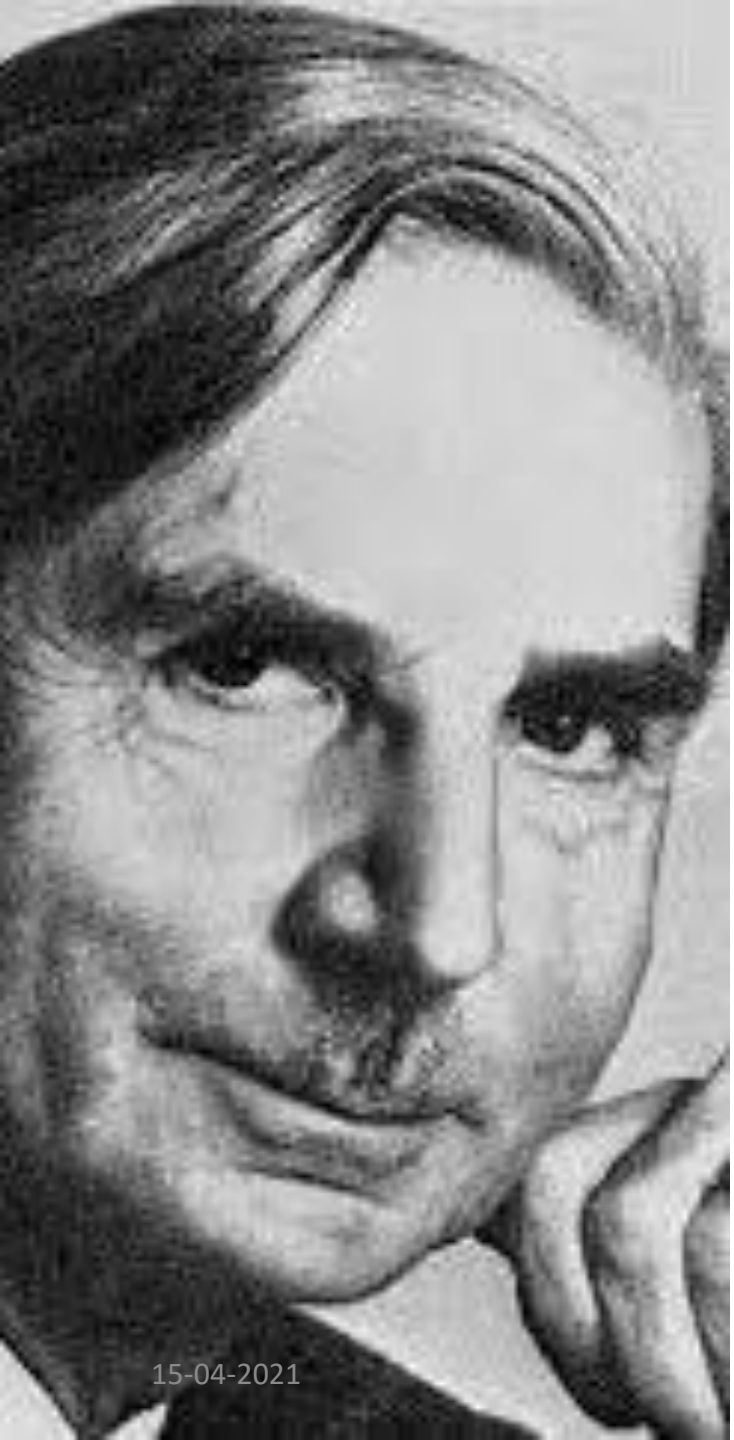
- This defect occurs only when cations are smaller in compared to the anions.
- There are also no changes in chemical properties
- No change on densities of solid
- Volume and mass of the solid is preserved
- Solid material maintain their overall electrical neutrality





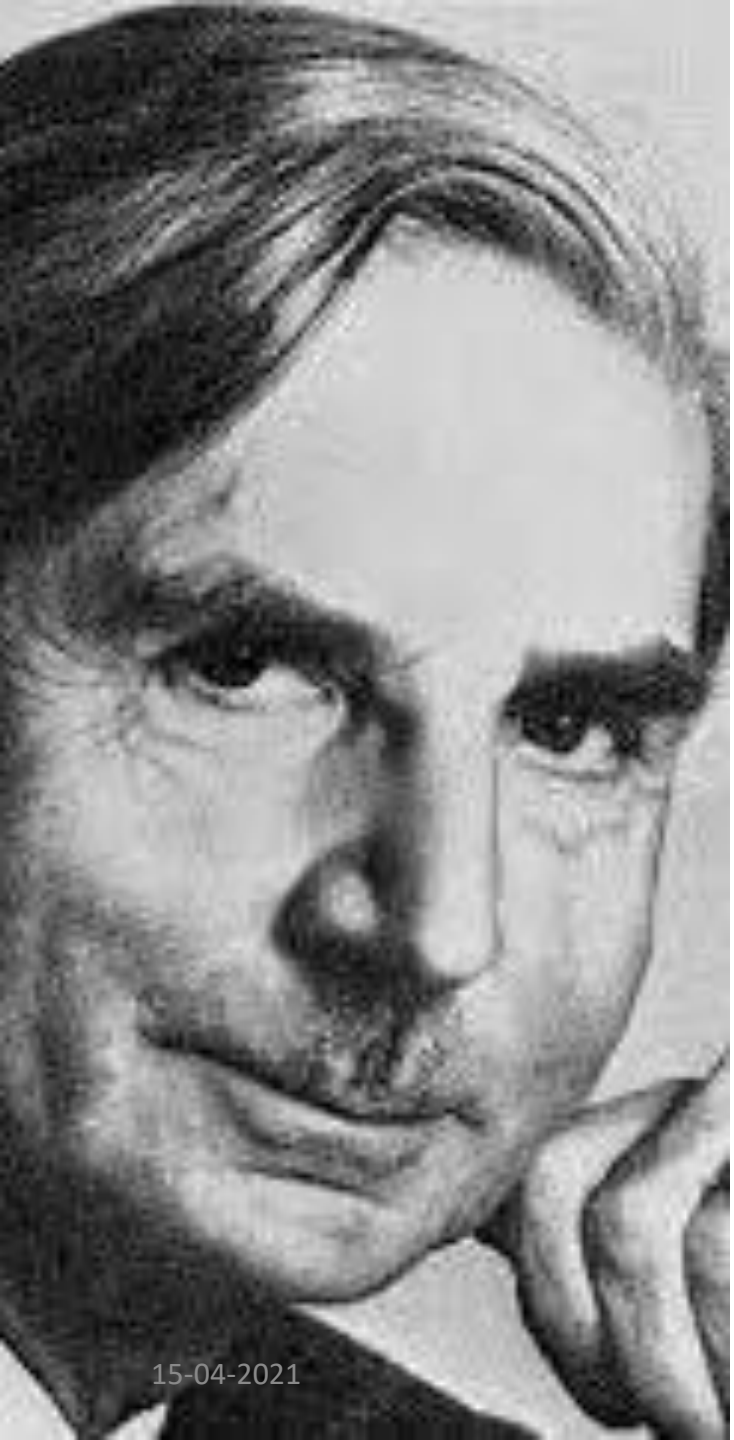
Schottky defect

Schottky defect is a type of point defect or imperfection in solids which is caused by a vacant position that is generated in a crystal lattice due to the atoms or ions moving out from the interior to the surface of the crystal. This defects was observed by **Walter Hans Schottky** (German physicist)



Characteristics Of Schottky Defect

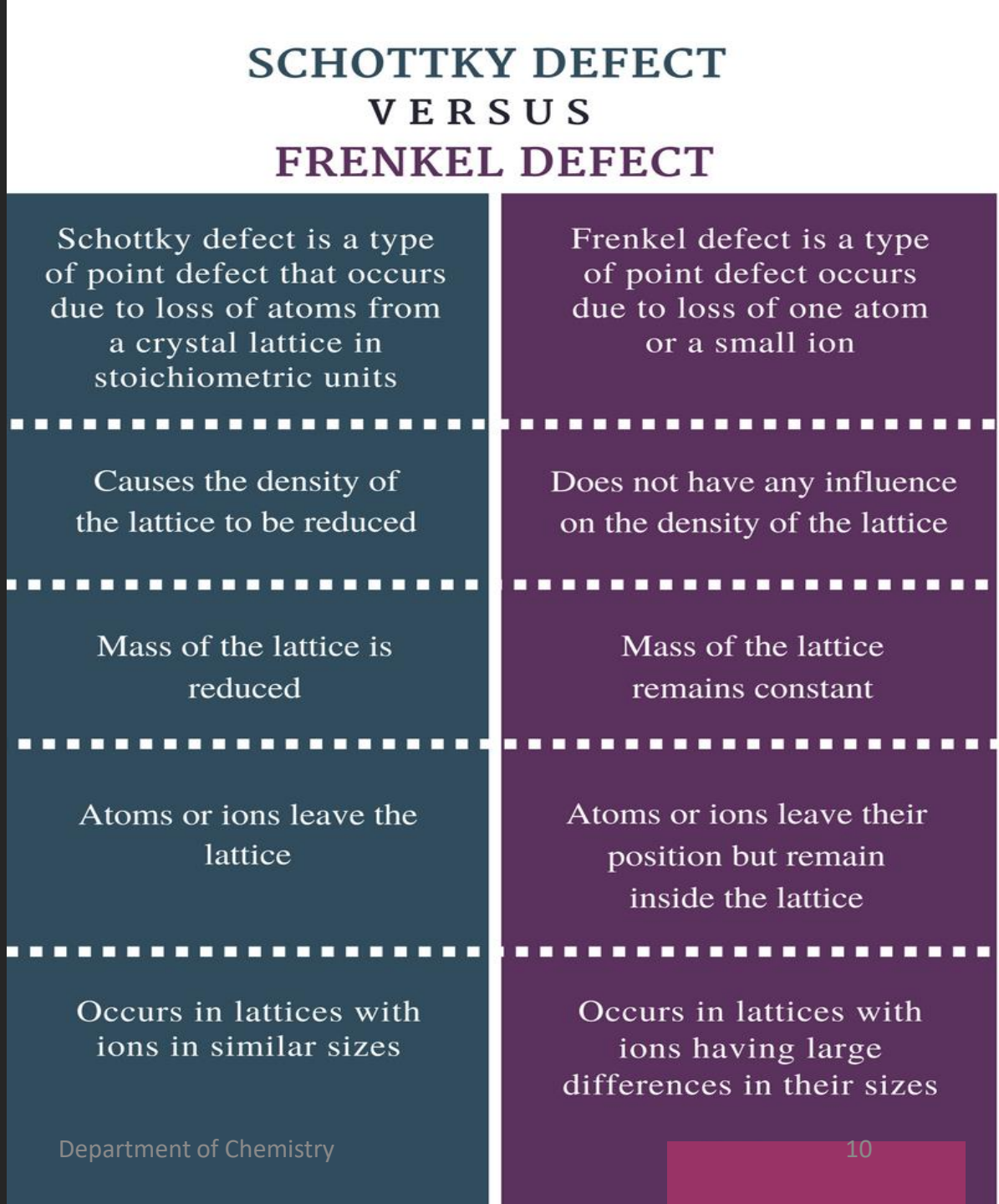
- There is a very small difference in size between cation and anion.
- Cation and anion both leave the solid crystal.
- Atoms also move out of the crystal permanently.
- Generally, two vacancies are formed.
- As for the density of the solid it decreases considerably.



Characteristics Of Schottky Defect

Some common example of salts where Schottky defect is prominent include Sodium Chloride (NaCl), Potassium Chloride (KCl), Potassium Bromide (KBr), Caesium Chloride (CsCl) and Silver Bromide (AgBr).

Frenkel Vs Schottky Defects



Thank you