Chemistry Study Materials for Class 12 (NCERT Based Notes of Chapter- 01)

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The Solid State

Imperfections in solids (Crystal Defects)

The deviation from the regular orderly arrangement of particles of a solid is termed as ***imperfections or crystal defects.*** The crystal defects are broadly classified into two – point defects and line defects.

The imperfection around a point (an atom) in a crystalline substance, it is termed as **point defect**.

The imperfection along a row is termed as **line defect**.

Point defects

Point defects can be classified into three types: Stoichiometric defects, Non-stoichiometric defects and Impurity defects.

1. **Stoichiometric defects:**

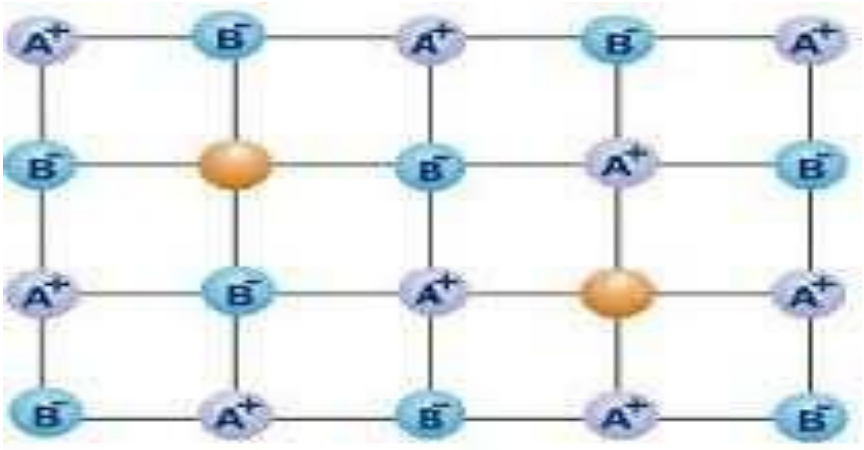
These are point defects which do not disturb the stoichiometry of the solid. They are also called *intrinsic or thermodynamic defects*, because these defects can also develop when a substance is heated. These are of two types – vacancy defects and interstitial defects.

a. Vacancy defect: When some of the lattice sites are vacant, the crystal is said to have vacancy defect. This defect decreases the density of the solid.

b. Interstitial defect: When some constituent particles occupy an interstitial site, the crystal is said to have interstitial defect. This defect increases the density of the solid.

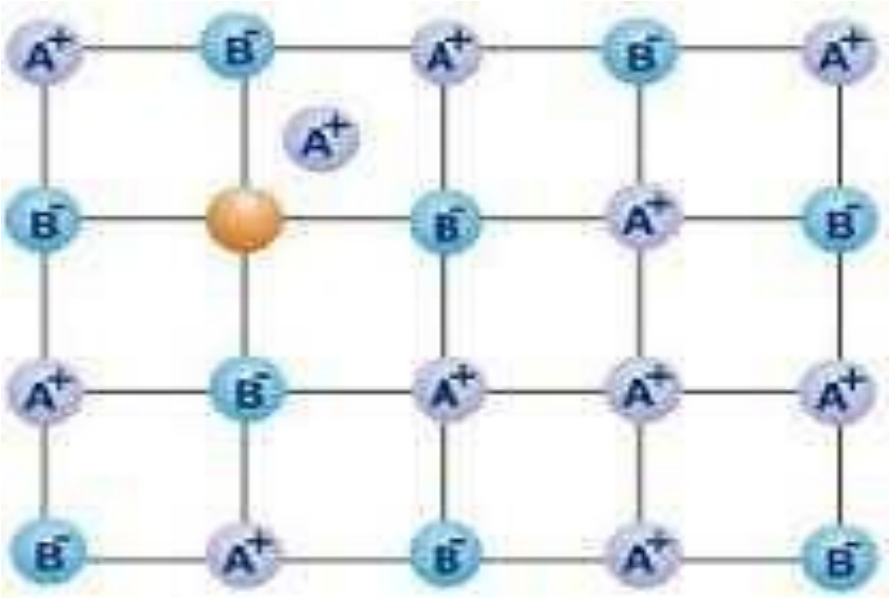
The above two types of defects are shown by *non-ionic solids*. ***Ionic solids*** show two types of stoichiometric defects – **Schottky defect and Frenkel defect.**

i. **Schottky defect:** It is basically a vacancy defect. It arises due to the missing of equal number of anions and cations from the lattice site. It is shown by ionic crystals in which the anionic and cationic sizes are almost equal. NaCl, KCl, CsCl, AgBr etc. show Schottky defect. Due to this defect the density of the solid decreases.



Schottky Defect

ii. **Frenkel defect:** It is a stoichiometric defect arising due to the misplacing of an ion (generally a cation) from the lattice site to the interstitial site. It is also called dislocation defect. This type of defect is shown by ionic solids in which there is a large difference in the size of the ions. E.g. ZnS, AgCl, AgBr, AgI etc. This defect does not change the density of the solid.



Frenkel Defect

b) Non-Stoichiometric defects: These are point defects which change the stoichiometry of a solid. These defects are of two types:

(i) Metal excess defect and (ii) Metal deficiency defect

i) Metal excess Defect:

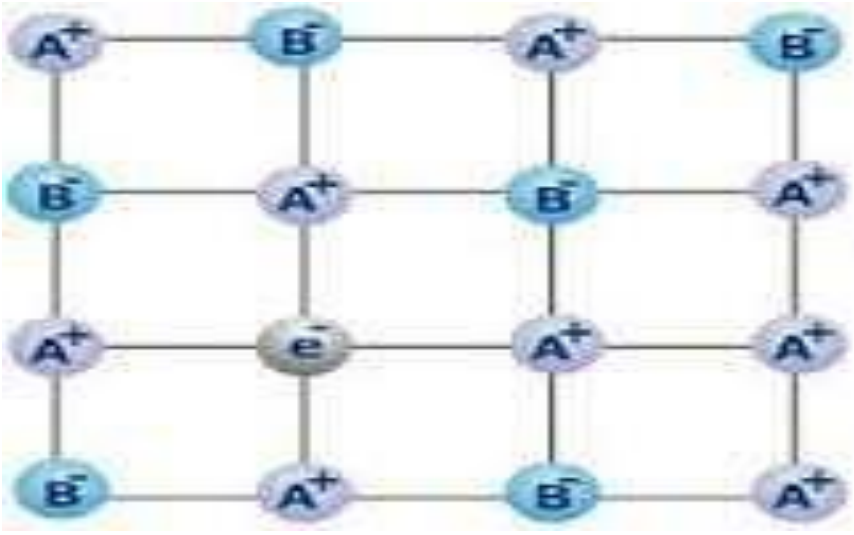
Here the number of cations is greater than the number of anions. This arises in two ways:

- *Metal excess defect due to anionic vacancies*: Here some of the anions are missing from the lattice site. The electrical neutrality is maintained by occupying electrons in the anionic sites. These electrons are called **f-centres** because they give colour to the crystal.

This defect is shown by alkali metal halides. For example when NaCl is heated in an atmosphere of sodium vapour, some sodium atoms are deposited at the surface of the crystal. The Cl^- ions diffuse to the surface of the crystal and combines with Na atom to form NaCl.

$$Na + \tfrac{1}{2}Cl_2^- \longrightarrow NaCl + e^-$$

The electron so formed diffuse into the crystal and occupies the anion vacancy. These electrons absorb light energy and get excited. As a result the crystal becomes yellow in colour. Similarly, *excess of Li makes LiCl crystals pink and excess of K makes KCl crystals violet*.



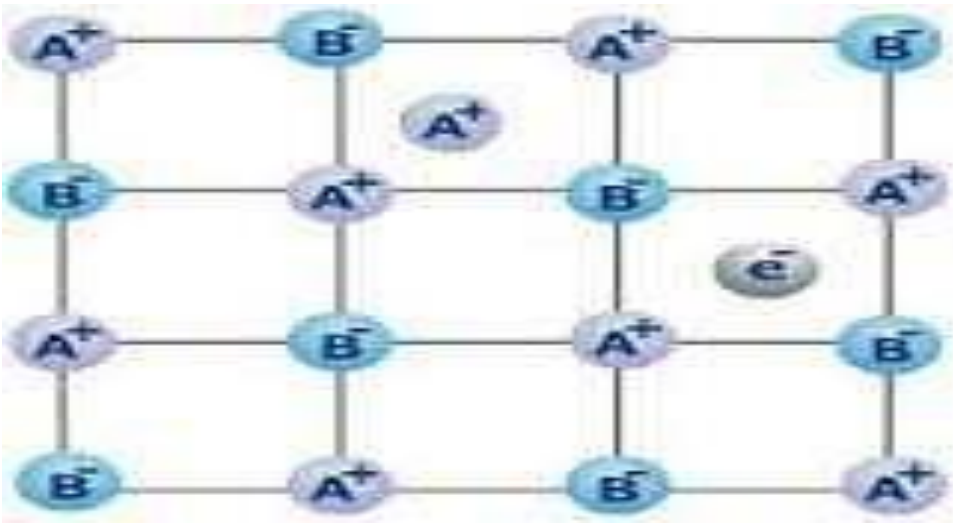
Metal excess Defect (due to anion vacancy)

- *Metal excess defect due to extra cations at interstitial sites:* Here some cations occupy the interstitial sites. The electrical neutrality is maintained by occupying some electrons in adjacent interstitial sites.

E.g. When ZnO crystals are heated, the white coloured crystals becomes yellow. This is because on heating, the crystal loses oxygen as follows:

$$ZnO \longrightarrow Zn^{2+} + \tfrac{1}{2} O_2 + 2e^-$$

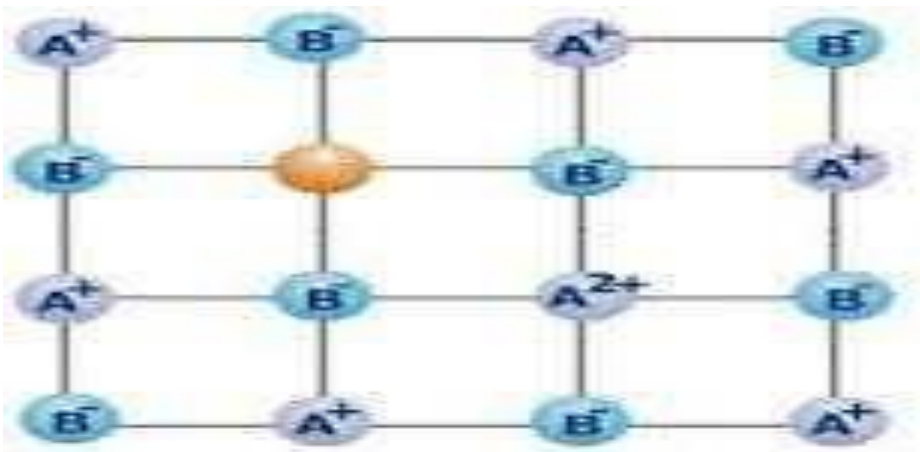
The Zn ions now move to the interstitial sites and the electrons to neighbouring interstitial sites.



Metal excess Defect (due to extra cation)

ii)Metal deficiency Defect:

Here the number of cations is smaller than the number of anions. This is mainly arises due to cation vacancies. This type of defect is commonly shown by transition metal compounds. E.g. FeO



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