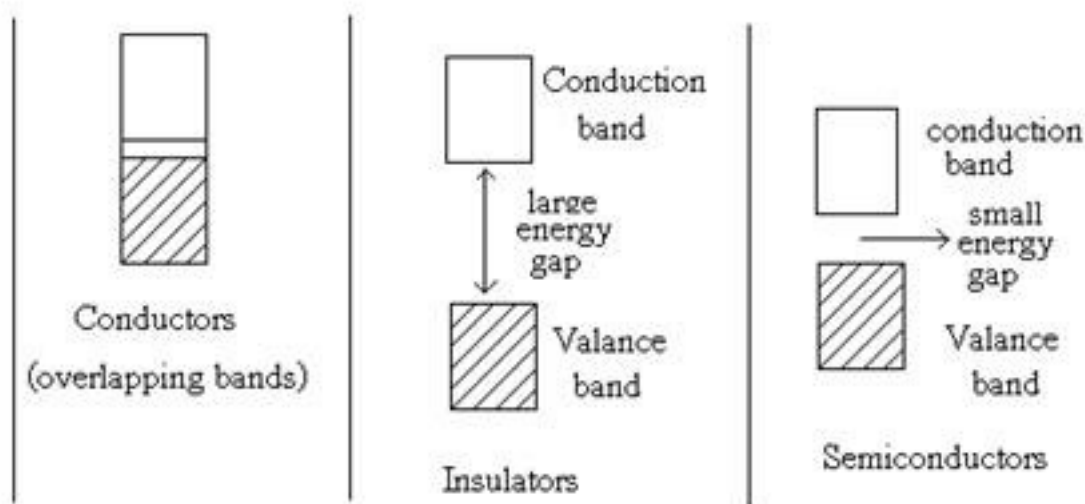


**CBSE Class 12 physics**  
**Important Questions**  
**Chapter 1**  
**Solid State**

**5 Marks Questions**

**1. Explain conduction of electricity on the basis of band theory.**

**Ans.** The conductivity of metals depend upon the no. of valance electrons available per atom. The atomic orbitals of metal atoms form molecular orbitals which are so close in energy to each other as to form a band. If this band is partially filled & overlaps with a higher energy unoccupied, conduction band, then electrons can flow easily under an applied electric field & metal is a conductor. If the gap between filled valance band and conduction band is large, electron cannot jump to it & the substance is an insulator where as if the gap is small & on heating, can be overcome, the substance acts as semiconductor



**2. How will you distinguish between the following pairs of terms:**

- (i) Hexagonal close-packing and cubic close-packing?
- (ii) Crystal lattice and unit cell?
- (iii) Tetrahedral void and octahedral void?

**Ans.** A 2-D hexagonal close-packing contains two types of triangular voids (a and b) as shown in figure 1. Let us call this 2-D structure as layer A. Now, particles are kept in the voids present in layer A (it can be easily observed from figures 2 and 3 that only one of the voids will be occupied in the process, i.e., either a or b). Let us call the particles or spheres present in the voids of layer A as layer B. Now, two types of voids are present in layer B (c and d). Unlike the voids present in layer A, the two types of voids present in layer B are not similar. Void c is surrounded by 4 spheres and is called the tetrahedral void. Void d is surrounded by 6 spheres and is called the octahedral void.

Now, the next layer can be placed over layer B in 2 ways.

**Case1: When the third layer (layer C) is placed over the second one (layer B) in such a manner that the spheres of layer C occupy the tetrahedral voids c.**

In this case we get hexagonal close-packing. This is shown in figure 4. In figure 4.1, layer B is present over the voids a and layer C is present over the voids c. In figure 4.2, layer B is present over the voids b and layer C is present over the voids c. It can be observed from the figure that in this arrangement, the spheres present in layer C are present directly above the spheres of layer A. Hence, we can say that the layers in hexagonal close-packing are arranged in an ABAB.....pattern.

**Case 2: When the third layer (layer C) is placed over layer B in such a manner that the spheres of layer C occupy the octahedral voids d.**

In this case we get cubic close-packing. In figure 5.1, layer B is present over the voids a and layer C is present over the voids d. In figure 5.2, layer B is present over the voids b and layer C is present over the voids d. It can be observed from the figure that the arrangement of particles in layer C is completely different from that in layers A or B. When the fourth layer is kept over the third layer, the arrangement of particles in this layer is similar to that in layer A. Hence, we can say that the layers in cubic close-packing are arranged in an ABCABC.....pattern.

### **3. Calculate the efficiency of packing in case of a metal crystal for**

**(i) simple cubic**

**(ii) body-centred cubic**

**(iii) face-centred cubic (with the assumptions that atoms are touching each other).**

**Ans. (i) Simple cubic**

In a simple cubic lattice, the particles are located only at the corners of the cube and touch each other along the edge.

Let the edge length of the cube be 'a' and the radius of each particle be  $r$ .

So, we can write:  $a = 2r$

Now, volume of the cubic unit cell =  $a^3$

$$= (2r)^3 = 8r^3$$

We know that the number of particles per unit cell is 1.

Therefore, volume of the occupied unit cell =  $43\pi r^3$

Hence, packing efficiency =  $\frac{\text{Volume of one particle}}{\text{Volume of cubic unit cell}} \times 100\%$

$$= \frac{43\pi r^3}{8r^3} \times 100\%$$

$$= 16\pi \times 100\%$$

$$= 16 \times 227 \times 100\% = 52.4\%$$

**(ii) Body-centred cubic**

It can be observed from the above figure that the atom at the centre is in contact with the other two atoms diagonally arranged.

From  $\triangle FED$ , we have:

$$b^2 = a^2 + a^2 \Rightarrow b^2 = 2a^2 \Rightarrow b = 2\sqrt{a}$$

Again, from  $\triangle AFD$ , we have:

$$c^2 = a^2 + b^2 \Rightarrow c^2 = a^2 + 2a^2 \Rightarrow c^2 = 3a^2 \text{ (Since } b^2 = 2a^2 \text{)}$$

$$c = 3\sqrt{a}$$

Let the radius of the atom be  $r$ .

Length of the body diagonal,  $c = 4\pi$

$$= 3\sqrt{a} = 4r$$

$$= a = 4r3\sqrt{}$$

$$r = 3\sqrt{a}4$$

Volume of the cube,  $a^3 = (4r^3\sqrt{ })^3$

A body-centred cubic lattice contains 2 atoms.

So, volume of the occupied cubic lattice =  $2\pi43r^3$

$$= 83\pi r^3$$

Therefore, Packing efficiency = Volume occupied by two spheres in the unit cell / Total volume of the unit cell

$$= 83\pi r^3(43\sqrt{r}) \times 100\%$$

$$= 83\pi r^3(6433\sqrt{r^3}) \times 100\%$$

(iii) Face-centred cubic

Let the edge length of the unit cell be 'a' and the length of the face diagonal AC be  $b$ .

From  $\Delta ABC$ , we have:

$$AC^2 = BC^2 + AB^2$$

$$= b^2 = a^2 + a^2$$

$$b^2 = 2a^2$$

$$b = 2a - -\sqrt{}$$

4. Analysis shows that nickel oxide has the formula  $\text{Ni}_{0.98}\text{O}_{1.00}$ . What fractions of

**nickel exist as  $Ni^{2+}$  and  $Ni^{3+}$  ions?**

**Ans.** The formula of nickel oxide is  $Ni_{0.98}O_{1.00}$ .

Therefore, the ratio of the number of Ni atoms to the number of O atoms,

$$Ni : O = 0.98 : 1.00 = 98 : 100$$

$$\text{Now, total charge on } 100 \text{ } O_2\text{-ions} = 100 \times (-2)$$

$$= -200$$

Let the number of  $Ni^{2+}$  ions be  $x$ .

So, the number of  $Ni^{3+}$  ions is  $98 - x$ .

$$\text{Now, total charge on } Ni^{2+} \text{ ions} = x(+2)$$

$$= +2x$$

$$\text{And, total charge on } Ni^{3+} \text{ ions} = (98 - x)(+3)$$

$$= 294 - 3x$$

Since, the compound is neutral, we can write:

$$2x + (294 - 3x) + (-200) = 0$$

$$\Rightarrow -x + 94 = 0$$

$$\Rightarrow x = 94$$

Therefore, number of  $Ni^{2+}$  ions = 94

And, number of  $Ni^{3+}$  ions =  $98 - 94 = 4$

Hence, fraction of nickel that exists as  $Ni^{2+}$  =  $\frac{94}{98}$

$$= 0.959$$

And, fraction of nickel that exists as  $Ni^{3+}$  =  $\frac{4}{98}$

= 0.041

Alternatively, fraction of nickel that exists as  $Ni^{3+} = 1 - 0.959$

= 0.041

**5. What is a semiconductor? Describe the two main types of semiconductors and contrast their conduction mechanism.**

**Ans.** Semiconductors are substances having conductance in the intermediate range of  $10^{-6}$  to  $10^4 \text{ ohm}^{-1} \text{ m}^{-1}$ .

The two main types of semiconductors are:

(i) *n*-type semiconductor

(ii) *p*-type semiconductor

***n*-type semiconductor:** The semiconductor whose increased conductivity is a result of negatively-charged electrons is called an *n*-type semiconductor. When the crystal of a group 14 element such as Si or Ge is doped with a group 15 element such as P or As, an *n*-type semiconductor is generated.

Si and Ge have four valence electrons each. In their crystals, each atom forms four covalent bonds. On the other hand, P and As contain five valence electrons each. When Si or Ge is doped with P or As, the latter occupies some of the lattice sites in the crystal. Four out of five electrons are used in the formation of four covalent bonds with four neighbouring Si or Ge atoms. The remaining fifth electron becomes delocalised and increases the conductivity of the doped Si or Ge.

***p*-type semiconductor:** The semiconductor whose increased in conductivity is a result of electron hole is called a *p*-type semiconductor. When a crystal of group 14 elements such as Si or Ge is doped with a group 13 element such as B, Al, or Ga (which contains only three valence electrons), a *p*-type of semiconductor is generated.

When a crystal of Si is doped with B, the three electrons of B are used in the formation of three covalent bonds and an electron hole is created. An electron from the neighboring atom can come and fill this electron hole, but in doing so, it would leave an electron hole at its

original position. The process appears as if the electron hole has moved in the direction opposite to that of the electron that filled it. Therefore, when an electric field is applied, electrons will move toward the positively-charged plate through electron holes. However, it will appear as if the electron holes are positively-charged and are moving toward the negatively-charged plate.

**6. Explain the following terms with suitable examples:**

**(i) Schottky defect**

**(ii) Frenkel defect**

**(iii) Interstitials and**

**(iv) F-centres**

**Ans. (i) Schottky defect:** Schottky defect is basically a vacancy defect shown by ionic solids. In this defect, an equal number of cations and anions are missing to maintain electrical neutrality. It decreases the density of a substance. Significant number of Schottky defects is present in ionic solids. For example, in NaCl, there are approximately  $10^6$  Schottky pairs per  $\text{cm}^3$  at room temperature. Ionic substances containing similar-sized cations and anions show this type of defect. For example: NaCl, KCl, CsCl, AgBr, etc.

**(ii) Frenkel defect:** Ionic solids containing large differences in the sizes of ions show this type of defect. When the smaller ion (usually cation) is dislocated from its normal site to an interstitial site, Frenkel defect is created. It creates a vacancy defect as well as an interstitial defect. Frenkel defect is also known as dislocation defect. Ionic solids such as AgCl, AgBr, AgI, and ZnS show this type of defect.

**(iii) Interstitials:** Interstitial defect is shown by non-ionic solids. This type of defect is created when some constituent particles (atoms or molecules) occupy an interstitial site of the crystal. The density of a substance increases because of this defect.

**(iv) F-centres:** When the anionic sites of a crystal are occupied by unpaired electrons, the ionic sites are called F-centres. These unpaired electrons impart colour to the crystals. For example, when crystals of NaCl are heated in an atmosphere of sodium vapour, the sodium atoms are deposited on the surface of the crystal. The Cl ions diffuse from the crystal to its

surface and combine with Na atoms, forming NaCl. During this process, the Na atoms on the surface of the crystal lose electrons. These released electrons diffuse into the crystal and occupy the vacant anionic sites, creating F-centres.

**7. Explain the following with suitable examples:**

**(i) Ferromagnetism**

**(ii) Paramagnetism**

**(iii) Ferrimagnetism**

**(iv) Antiferromagnetism**

**(v) 12-16 and 13-15 group compounds.**

**Ans. (i) Ferromagnetism:** The substances that are strongly attracted by a magnetic field are called ferromagnetic substances. Ferromagnetic substances can be permanently magnetised even in the absence of a magnetic field. Some examples of ferromagnetic substances are iron, cobalt, nickel, gadolinium, and  $\text{CrO}_2$ .

In solid state, the metal ions of ferromagnetic substances are grouped together into small regions called domains and each domain acts as a tiny magnet. In an un-magnetised piece of a ferromagnetic substance, the domains are randomly-oriented and so, their magnetic moments get cancelled. However, when the substance is placed in a magnetic field, all the domains get oriented in the direction of the magnetic field. As a result, a strong magnetic effect is produced. This ordering of domains persists even after the removal of the magnetic field. Thus, the ferromagnetic substance becomes a permanent magnet.

**Schematic alignment of magnetic moments in ferromagnetic substances**

**(ii) Paramagnetism:** The substances that are attracted by a magnetic field are called paramagnetic substances. Some examples of paramagnetic substances are  $\text{O}_2$ ,  $\text{Cu}_2\text{t}$ ,  $\text{Fe}_3\text{t}$ , and  $\text{Cr}_3\text{t}$ .

Paramagnetic substances get magnetised in a magnetic field in the same direction, but lose magnetism when the magnetic field is removed. To undergo paramagnetism, a substance



must have one or more unpaired electrons. This is because the unpaired electrons are attracted by a magnetic field, thereby causing paramagnetism.

**(iii) Ferrimagnetism:** The substances in which the magnetic moments of the domains are aligned in parallel and anti-parallel directions, in unequal numbers, are said to have ferrimagnetism. Examples include  $Fe_3O_4$  (magnetite), ferrites such as  $MgFe_2O_4$  and  $ZnFe_2O_4$ .

Ferrimagnetic substances are weakly attracted by a magnetic field as compared to ferromagnetic substances. On heating, these substances become paramagnetic.

### **Schematic alignment of magnetic moments in ferrimagnetic substances**

**(iv) Antiferromagnetism:** Antiferromagnetic substances have domain structures similar to ferromagnetic substances, but are oppositely-oriented. The oppositely-oriented domains cancel out each other's magnetic moments.

### **Schematic alignment of magnetic moments in antiferromagnetic substances**

**(v) 12-16 and 13-15 group compounds:** The 12-16 group compounds are prepared by combining group 12 and group 16 elements and the 13-15 group compounds are prepared by combining group 13 and group 15 elements. These compounds are prepared to simulate average valence of four as in Ge or Si. Indium (III) antimonide (InSb), aluminium phosphide (AlP), and gallium arsenide (GaAs) are typical compounds of groups 13-15. GaAs semiconductors have a very fast response time and have revolutionised the designing of semiconductor devices. Examples of group 12-16 compounds include zinc sulphide (ZnS), cadmium sulphide (CdS), cadmium selenide (CdSe), and mercury (II) telluride (HgTe). The bonds in these compounds are not perfectly covalent. The ionic character of the bonds depends on the electronegativities of the two elements.