DIODES

Prepared By:
Prof.Hiren D. Patel

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Periodic Table of Elements

Periodic table of the elements

- Alkali metals
- Alkaline-earth metals
- Transition metals
- Other metals
- Other nonmetals
- Halogens
- Noble gases
- Rare-earth elements (21, 39, 57–71) and lanthanoid elements (57–71 only)
- Actinoid elements

period \ group	1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

lanthanoid series 6	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
actinoid series 7	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

*Numbering system adopted by the International Union of Pure and Applied Chemistry (IUPAC).

Characteristics And properties of Semiconductors

- Solid-state devices to vacuum tubes in most applications are their small size and weight, low operating voltage , lower power dissipation, higher reliability and extremely long life.
- There is no warm up-period required since semiconductors are absent a cathode heater.
- Semiconductors typically do not perform as well as vacuum tube for high power, high frequency operation, such as television broadcasting and they are much more vulnerable to electro-static discharge during handling and operation.

SEMICONDUCTOR MATERIAL

	III	IV	V	VI
	5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00
	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06
30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96
48 **Cd** 112.40	49 **In** 114.80	50 **Sn** 118.70	51 **Sb** 121.80	52 **Te** 127.60

Group IV

- element such as Carbon (C), Silicon (Si), Germanium (Ge), Tin (Sn) are known as elemental or single – element semiconductors.
- Ge was widely used on early ; however its thermal sensitivity makes it less useful than silicon.
- Ge is often combined with silicon to make **very high-speed silicon-germanium(SiGe)** devices.
- Silicon is often combined with Carbon to form **Silicon-Carbon(SiC)** devices for **high power and high temperature application.**

➢ Compound Semiconductors that can be synthesized using elements from 3rd and 5th group of periodic table like:

- ❑Gallium-Arsenide(GaAs)
- ❑Gallium-Phosphide(GaP)
- ❑Gallium-Nitride(GaN)
- ❑Gallium-Aluminum-Arsenide(GaAlAs)
- ❑Indium-Phosphorus(InP)
- ❑Indium-Antimony(InSb)

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The Color of light that emits from a Light Emitting Diode depends on which of these compounds are used.

- Compound semiconductors that are synthesized using elements from 2nd and 6th group include;
  - Cadmium-Selenium(CdSe)
  - Cadmium-Tellurium(CdTe)
  - Cadmium-Mercury Tellurium (CdHgTe)
  - Zinc Sulfer(ZnS).

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Ligh Detector Such as photocells are typically made from Insb or CdSe Compounds.

ELECTRON BEHAVIOR IN VALANCE SHELLS

Shell or Orbit Number	1	2	3	4	5
Maximum Number of Electrons	2	8	18	32	50

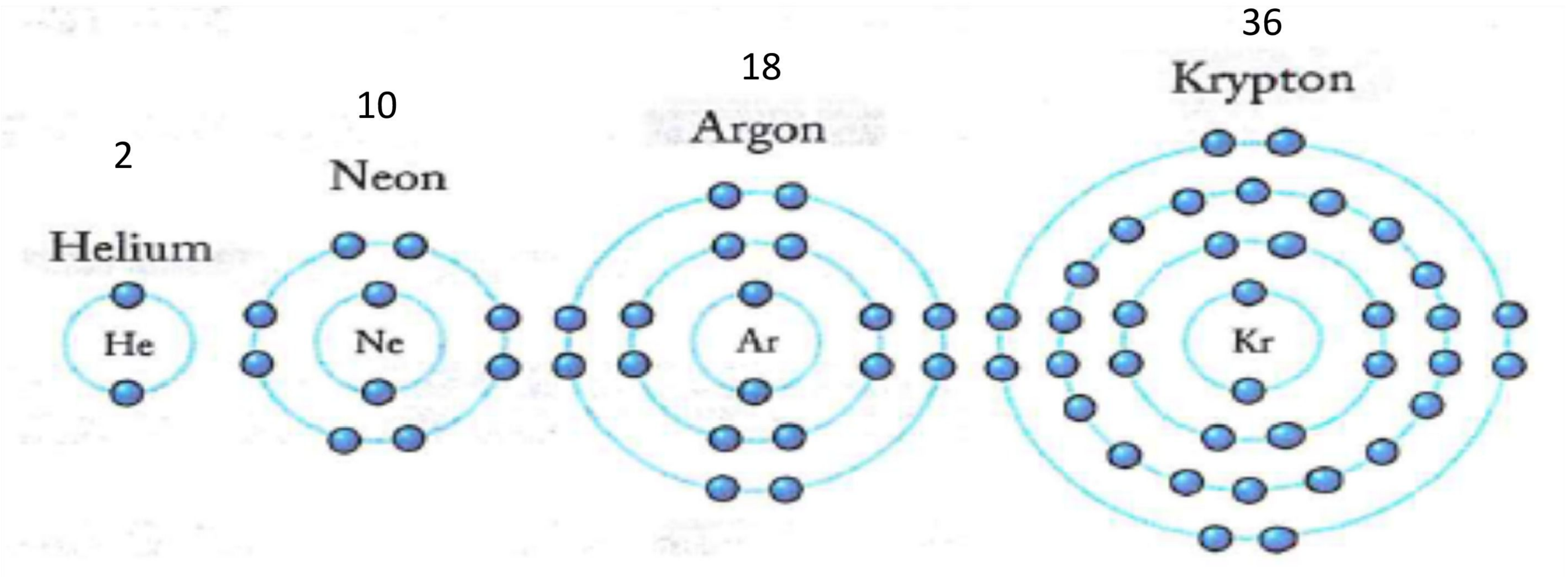


Figure: Elements with full valance Shells are good insulators

GOOD CONDUCTOR

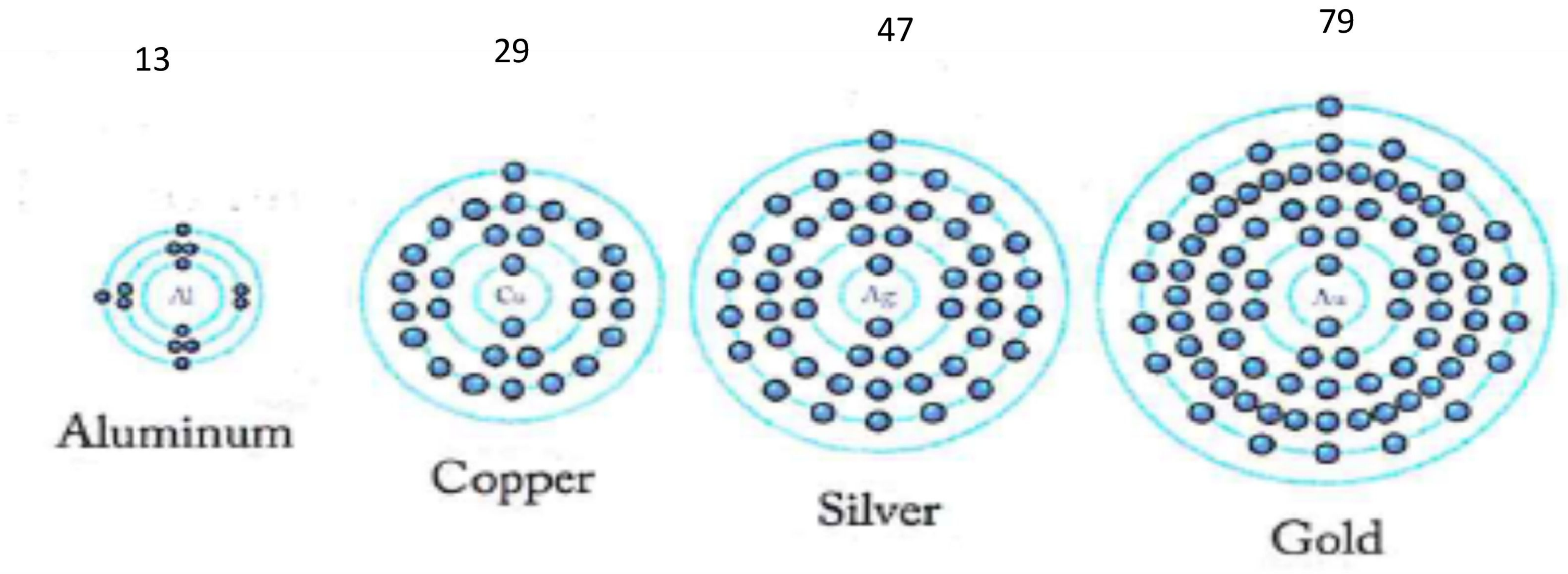


Figure : The Valance shells of elements that are good conductors have 1 or 3 electrons.

Silicon : 14 (2-8-4)

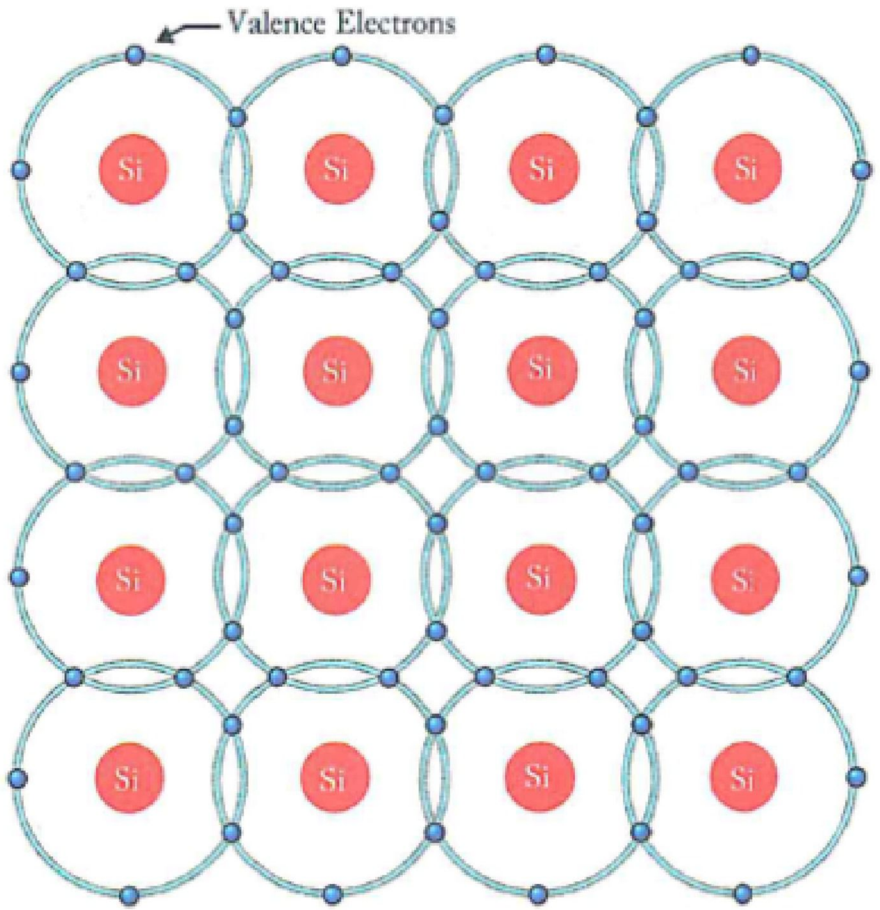
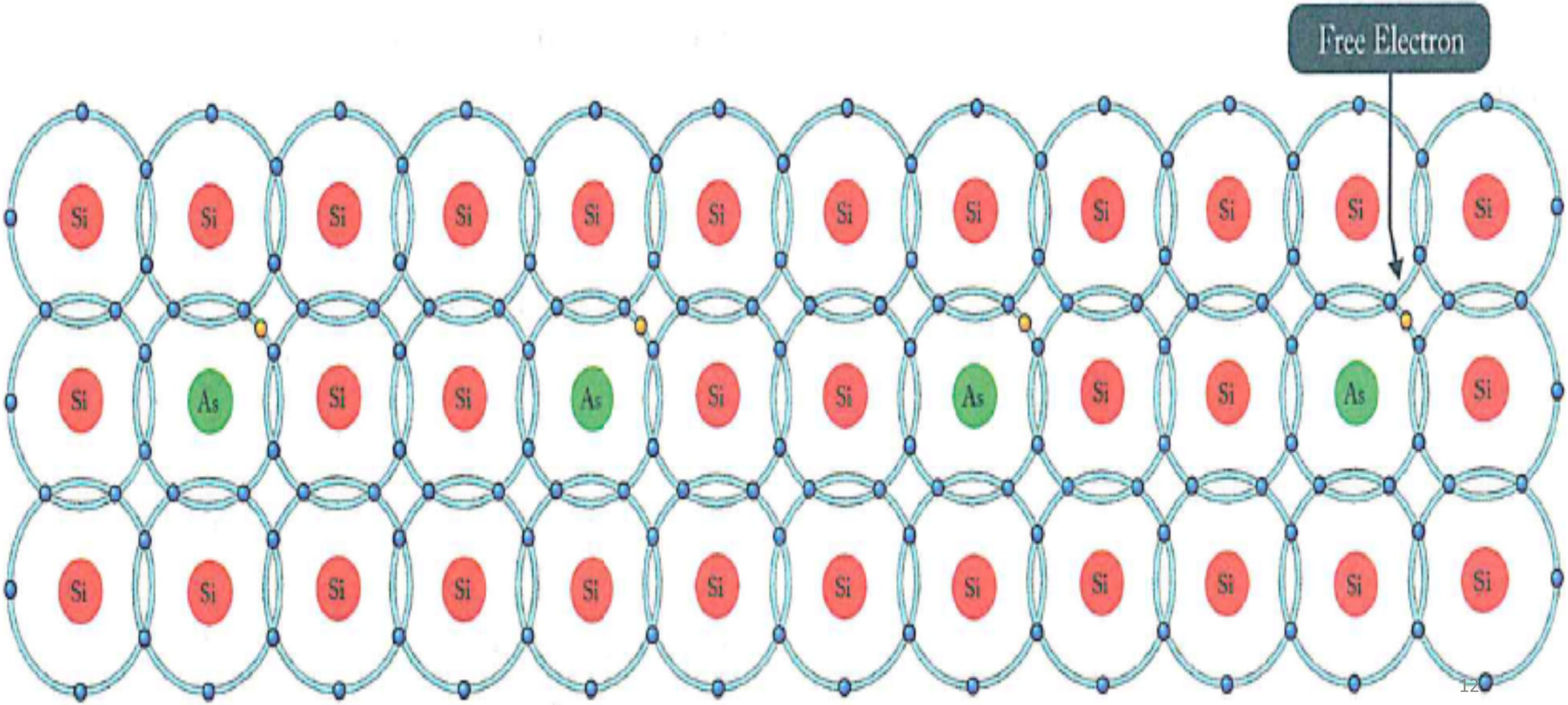


Figure : The Silicon atoms with just the valance shell electrons share.

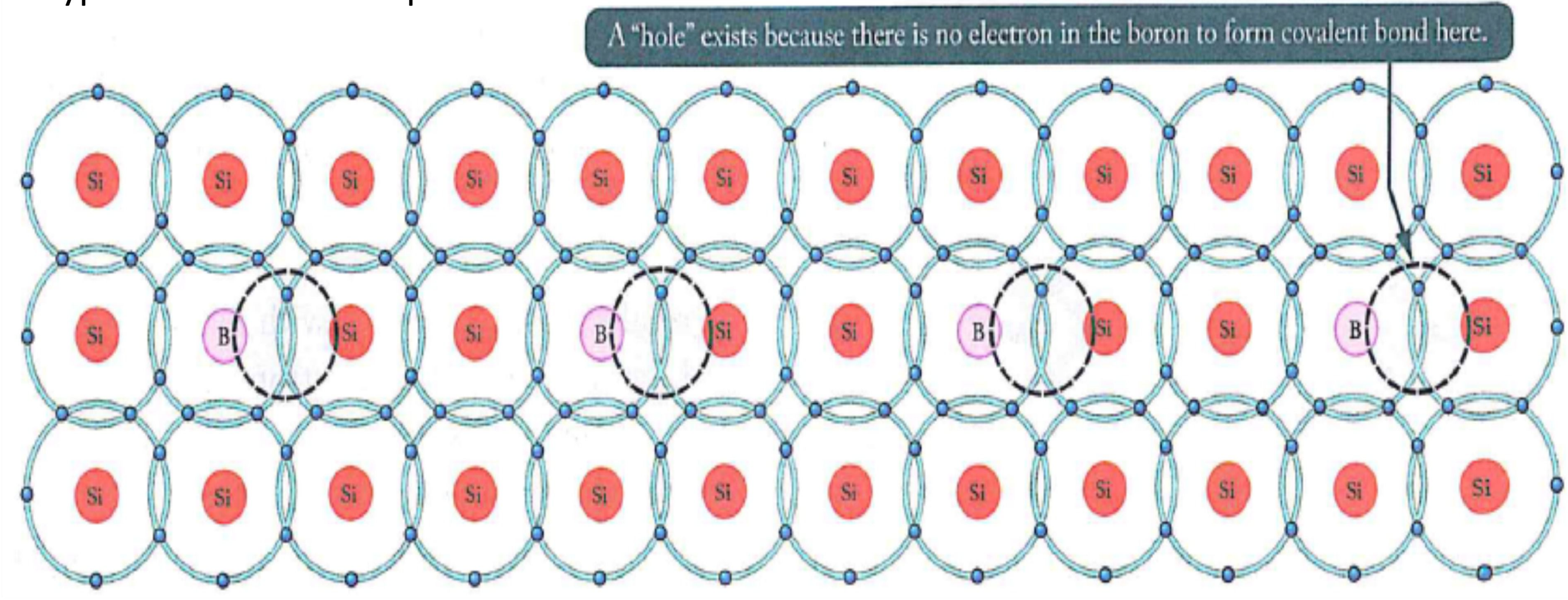
EFFECT OF IMPURITIES ON P AND N TYPE MATERIALS

- Silicon in its ultra-pure form is an insulator, it must ne transformed into a semi-conductive material by adding some impurities to the silicon- this process is known as **Doping**.



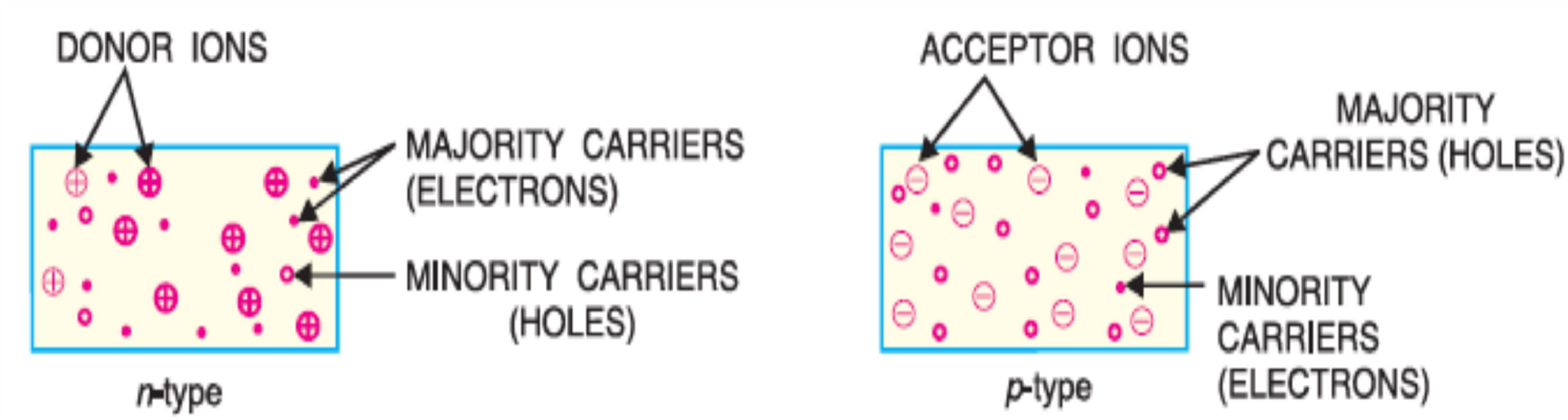
- Arsenic(As), Phosphorus(P) or some other element with five valance electrons in each atom is mixed into Silicon.
- When Silicon is doping with an element or compound containing five electrons in its valance shell, the result is a negatively charged material due to the excess free electrons, and fact that electrons are negatively charged. This is **known as N-type Semiconductor also known as donor Material.**

- Doping Silicon can also be performed with an element that has only three valance electrons, such as boron, gallium or indium.
- P-Type Material or Acceptor material.



MAJORITY AND MINORITY CARRIERS

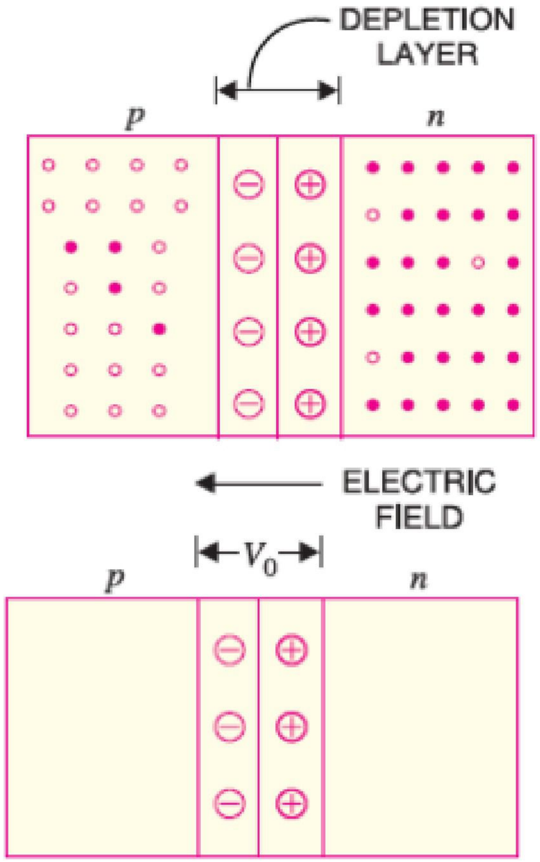
Material	Majority	Minority
P-Type	Hole	Electrons
N-type	Electron	Hole



PN JUNCTIONS

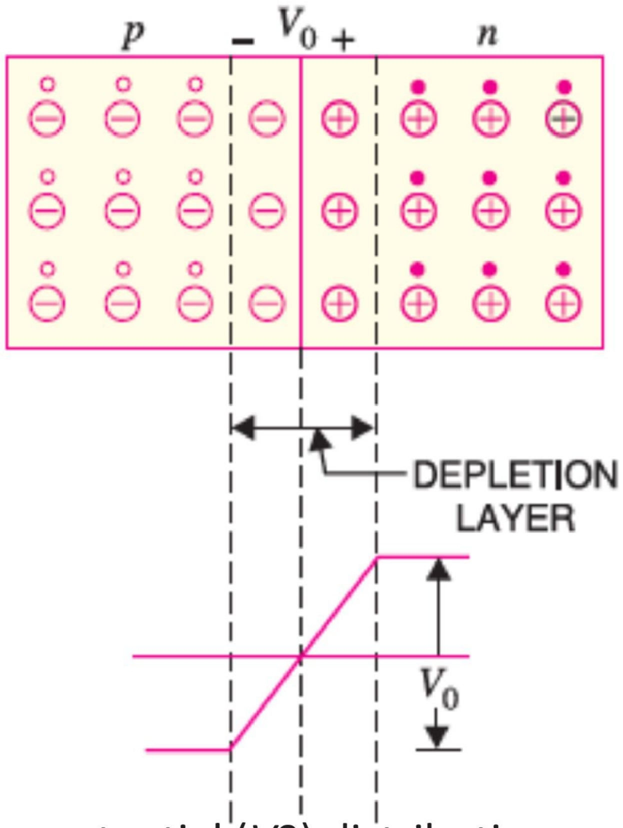
- *When a p-type semiconductor is suitably joined to n-type semiconductor, the contact surface is called* ***PN* junction.**
- *At the instant of pn-junction formation, the free electrons near the junction in the n region begin to diffuse across the junction into the p region where they combine with holes near the junction.*
- *The result is that n region loses free electrons as they diffuse into the junction. This creates a layer of positive charges (pentavalent ions) near the junction. As the electrons move across the junction, the p region loses holes as the electrons and holes combine.*
- *The result is that there is a layer of negative charges (trivalent ions) near the junction. These two layers of positive and negative charges form the* ***depletion region (or depletion layer).***
- *The term depletion is due to the fact that near the junction, the region is depleted (i.e. emptied) of charge carries (free electrons and holes) due to diffusion across the junction.*
- *It may be noted that depletion layer is formed very quickly and is very thin compared to the n region and the p region.*

- Once *PN* junction is formed and depletion layer created, the diffusion of free electrons stops. In other words, the depletion region acts as a barrier to the further movement of free electrons across the junction. The positive and negative charges set up an electric field. This is shown by a black arrow in below Fig.
- The electric field is a barrier to the free electrons in the *n*-region. There exists a potential difference across the depletion layer and is called **barrier potential** (*V*0). The barrier potential of a *pn* junction depends upon several factors including the type of semiconductor material, the amount of doping and temperature.

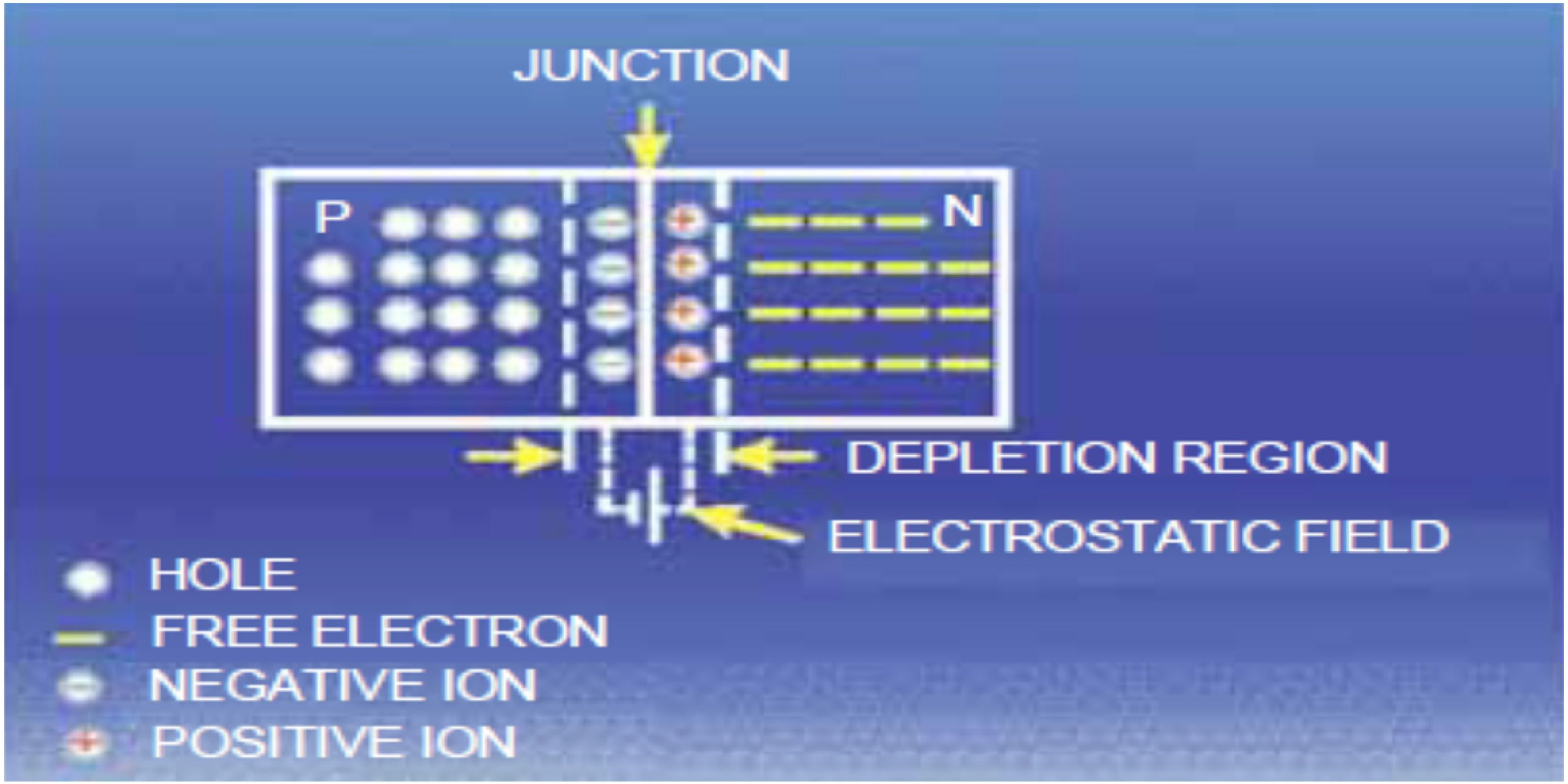


The typical barrier potential is approximately:

silicon, *V*0 = 0.7 V germanium, *V*0 = 0.3 V



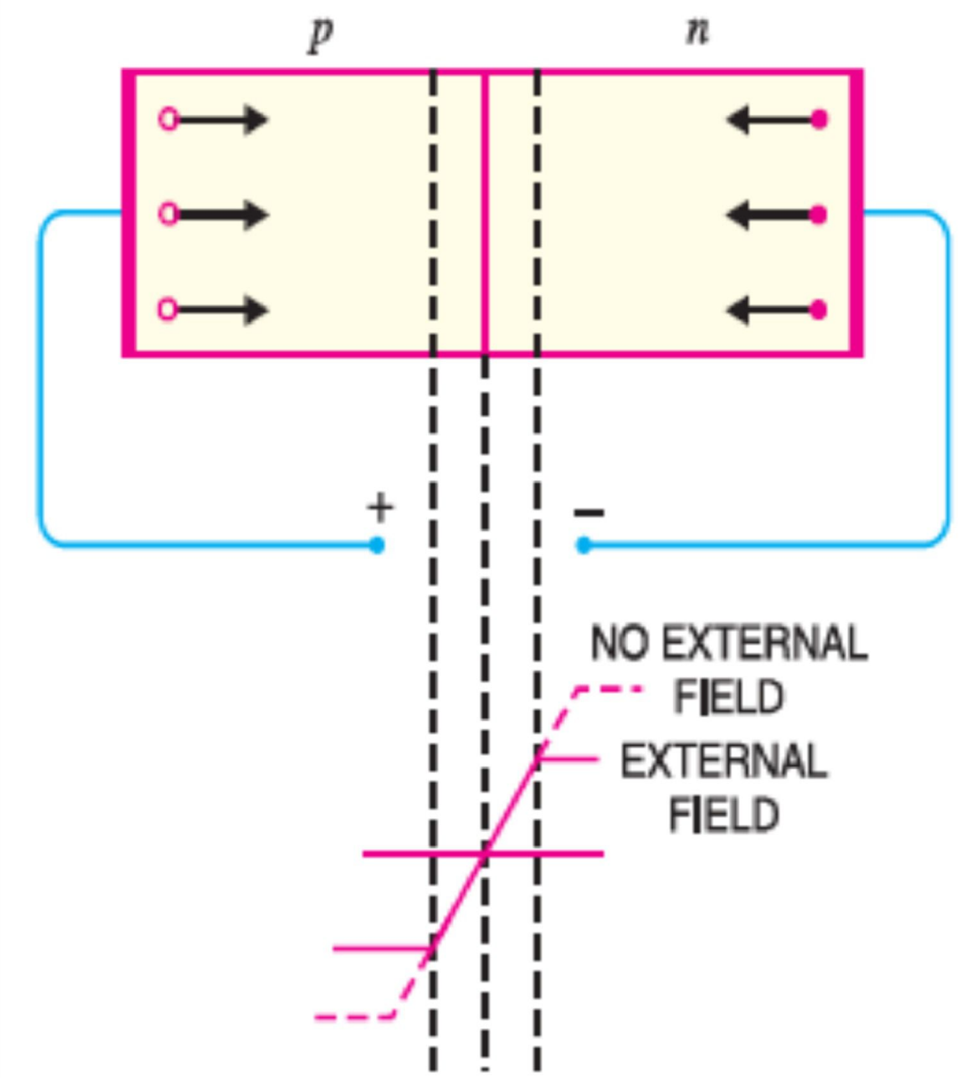
potential (*V*0) distribution curve.


JUNCTION
P
N
DEPLETION REGION
ELECTROSTATIC FIELD
HOLE
FREE ELECTRON
NEGATIVE ION
POSITIVE ION

BIASING A PN JUNCTION

Forward biasing.

- *When external d.c. voltage applied to the junction is in such a direction that it cancels the potential barrier, thus permitting current flow, it is called* **forward biasing.**
- To apply forward bias, connect positive terminal of the battery to *p*-type and negative terminal to *n*-type as shown in Fig.
- The applied forward potential establishes an electric field which acts against the field due to potential barrier.
- Therefore, the resultant field is weakened and the barrier height is reduced at the junction as shown in Fig.
- As potential barrier voltage is very small (0.1 to 0.3 V), therefore, a small forward voltage is sufficient to completely eliminate the barrier.



- Once the potential barrier is eliminated by the forward voltage, junction resistance becomes almost zero and a low resistance path is established for the entire circuit. Therefore, current flows in the circuit. This is called *forward current*. With forward bias to *PN* junction, the following points are worth noting :

(*i*) The potential barrier is reduced and at some forward voltage (0.1 to 0.3 V), it is eliminated altogether.

(*ii*) The junction offers low resistance (called *forward resistance, Rf*) to current flow.

(*iii*) Current flows in the circuit due to the establis