DIAGNOSTIC QUESTIONS

Composite materials

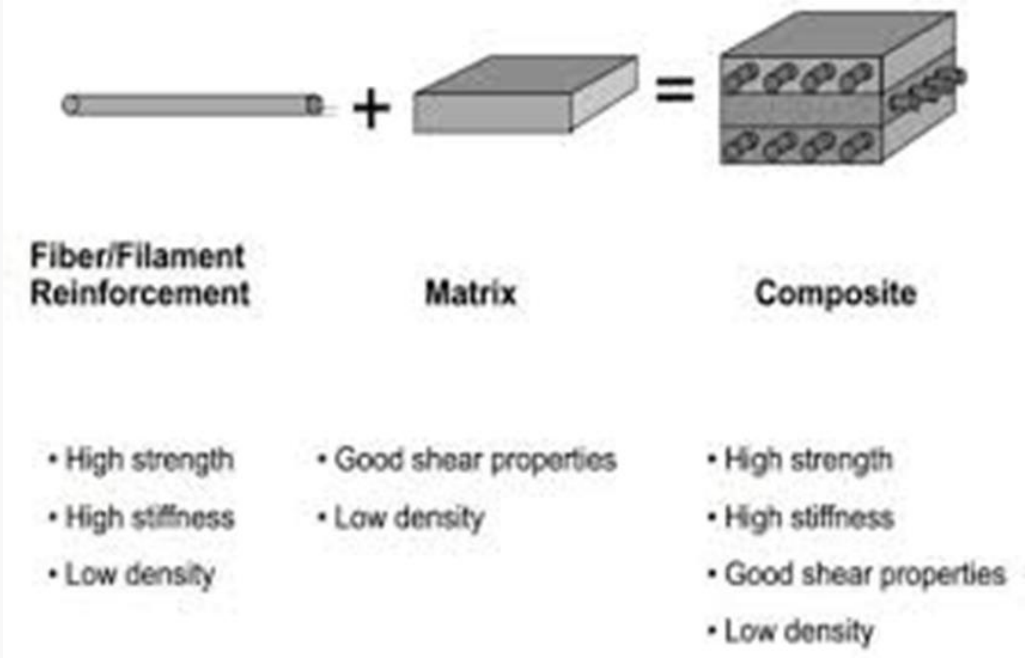
The components of composite materials have to be soluble in each other.

Select one:

- True
- False

The components of these materials are insoluble in each other and they have different chemical composition.

Two phases: Matrix and dispersed phase



Composite materials

There are three types of composite materials; particulate, fiber and laminar. The latter one is mostly found as coating.

Select one:

- ● True
- ○ False

Particulate composites: Designed to produce unusual combinations of properties rather than to improve strength.

Fiber composites: Most fiber-reinforced composites provide improved strength, fatigue resistance, among other properties.

Laminar composites: Laminar composites include very thin coatings. Designed to improve corrosion resistance while retaining low cost, high strength, or light weight.

Composite materials

In porous composite materials, before infiltration, the fraction of the pores is 0.

Select one:

- True
- False

The fraction of the pores is a constant, different to zero. The density, however, is zero due to the neglectable mass

Composite materials

A tungsten matrix with 20% porosity is infiltrated with silver. What is the density of the composite before and after infiltration with silver? The density of pure tungsten is 19.25 g/cm3 and that of pure silver is 10.49 g/cm3.

Select one:

- a. 12.1-18.3 g/cm3 cross out
- b. 15.8 - 16.5 g/cm3 cross out
- c. 14.5-15.3 g/cm3 cross out
- d. 13.7 - 19.3 g/cm3 cross out
- e. 15.4 - 17.5 g/cm3 cross out

- $\rho_W = 19.25 \frac{g}{cm^3}$
- $\rho_{Ag} = 10.49 \frac{g}{cm^3}$
- $f_W = 0.8$

RULE OF MIXTURES

$$\rho_C = \sum_{i=1}^{n}(f_i\rho_i) = f_1\rho_1 + f_2\rho_2 + \cdots + f_n\rho_n$$

$$\frac{\rho_1}{\rho_C} + \frac{\rho_2}{\rho_C} = f_1 + f_2 = 1$$

a) Initial density

0, Because in pores the mass is considered 0 (Zero)

$$\rho_C = f_W\rho_W + f_{Pores}\rho_{Pores}$$

$$\rho_C = f_W\rho_W = 0.8 \cdot 19.25\ g/cm^3$$

$$\rho_C = 15.4\ g/cm^3$$

- $\rho_W = 19.25 \frac{g}{cm^3}$
- $\rho_{Ag} = 10.49 \frac{g}{cm^3}$
- $f_W = 0.8$

RULE OF MIXTURES

$$\rho_C = \sum_{i=1}^{n} (f_i \rho_i) = f_1\rho_1 + f_2\rho_2 + \cdots + f_n\rho_n$$

$$\frac{\rho_1}{\rho_C} + \frac{\rho_2}{\rho_C} = f_1 + f_2 = 1$$

b) Density with silver

$$\rho_C = f_W \rho_W + f_{Ag} \rho_{Ag}$$

$$\rho_C = 0.8 \cdot 19.25 \frac{g}{cm^3} + 0.2 \cdot 10.49 \frac{g}{cm^3}$$

$$\rho_C = 17.5 \frac{g}{cm^3}$$

Composite materials

A tungsten matrix with 20% porosity is infiltrated with silver. What is the density of the composite before and after infiltration with silver? The density of pure tungsten is 19.25 g/cm3 and that of pure silver is 10.49 g/cm3.

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- b. 15.8 - 16.5 g/cm3 cross out
- c. 14.5-15.3 g/cm3 cross out
- d. 13.7 - 19.3 g/cm3 cross out
- e. 15.4 - 17.5 g/cm3 cross out

Electronic Materials

If you increase the cross sectional area of the resistor and keep the voltage the same, what will happen to the current?

Select one:

- a. The current will decrease — cross out
- b. The current will stay the same — cross out
- c. The current will increase — cross out

$$V = IR$$

Where V is the voltage (volts, V), I is the current (amperes or amps, A), and R is the resistance (ohms).

$$R = \rho \frac{l}{A} = \frac{l}{\sigma A}$$

where *l* is the length (cm) of the resistor, A is the cross-sectional area (cm^2) of the resistor, ρ is the electrical resistivity (ohm.cm), and , which is the reciprocal of σ, is the electrical conductivity ($ohm^{-1}\ cm^{-1}$).

Electronic Materials

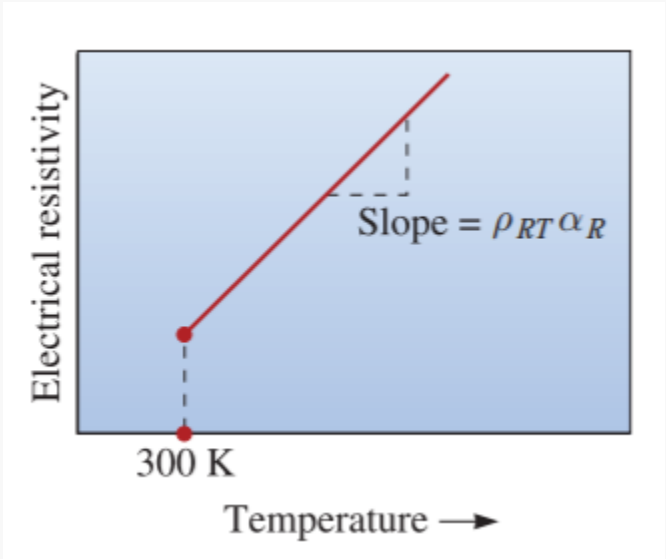
In conductive materials, when temperature is increased, the resistivity increases.

Select one:

- (●) True
- ( ) False

$\Uparrow$ T $\longrightarrow$ $\Downarrow \lambda_e$ $\Downarrow \mu$ $\Downarrow \sigma$

$$\frac{1}{\sigma} = \rho = \rho_{RT}(1 + \alpha_R(T - 25℃))$$



ρ_{RT}: Resistivity at room temperature (Ω*cm)
α_R: Temperature resistivity coefficient (Ω/ Ω ℃)
T: New temperature (℃)

Electronic Materials

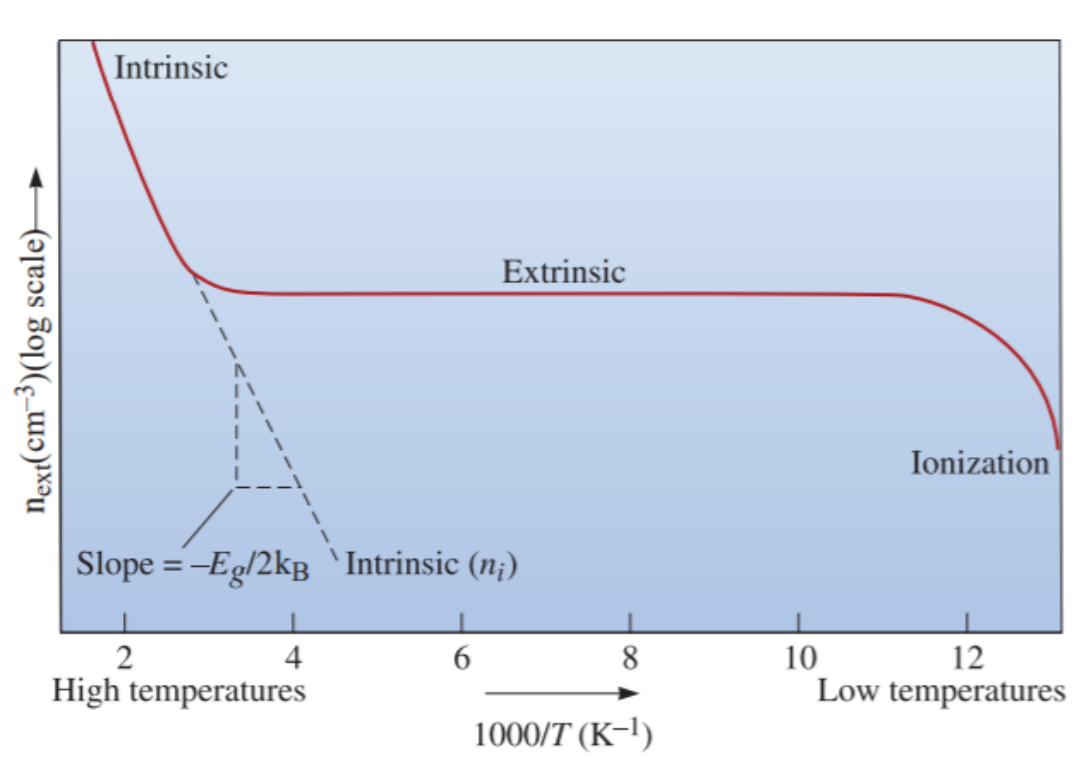
What are the main differences between intrinsic and extrinsic semiconductors?

Select all that apply:

- [ ] a. Conductivity depends on temperature, only in intrinsic materials. cross out
- [ ] b. Properties are controlled by the structure and nature of the material, instead of addition of doping. cross out
- [ ] c. Conductivity depends on temperature, only in extrinsic materials. cross out
- [ ] d. The energy gap in extrinsic materials is smaller. cross out
- [ ] e. Intrinsic materials are soft and extrinsic materials are hard cross out

Electronic Materials

Intrinsic Semiconductors	Extrinsic Semiconductors
No impurities	Conductivity dependent on impurities
Conductivity depends on temperature	Temperature effect neglectable
Study of pure semiconductor Materials	Used in industry



Electronic Materials

What are the main differences between intrinsic and extrinsic semiconductors?

Select all that apply:

- [x] a. Conductivity depends on temperature, only in intrinsic materials. cross out
- [x] b. Properties are controlled by the structure and nature of the material, instead of addition of doping. cross out
- [ ] c. Conductivity depends on temperature, only in extrinsic materials. cross out
- [ ] d. The energy gap in extrinsic materials is smaller. cross out
- [ ] e. Intrinsic materials are soft and extrinsic materials are hard cross out

Electronic Materials

To produce a 5000 ohm resistor from boron-carbide fiber having a diameter of 0.1 mm. What is the required length of the fiber? The conductivity of boron-carbide 1E-1 1/ohm cm

Select one:

- a. 0.039 cm — cross out
- b. 0.017 cm — cross out
- c. 0.479 cm — cross out
- d. 0.028 cm — cross out
- e. 0.0052 cm — cross out

- $R = 5000\Omega$
- $d = 0.1\ mm$
- $\sigma = 0.1\ \frac{1}{\Omega cm}$

$$R = \frac{l}{\sigma A}$$

$$l = \frac{R\sigma d^2\pi}{4}$$

$$l = \frac{5000\Omega \cdot 0.1\ \frac{1}{\Omega cm} \cdot (0.01cm)^2\pi}{4}$$

$$l = 0.0393\ cm$$

Electronic Materials

To produce a 5000 ohm resistor from boron-carbide fiber having a diameter of 0.1 mm. What is the required length of the fiber? The conductivity of boron-carbide 1E-1 1/ohm cm

Select one:

- a. 0.039 cm cross out
- b. 0.017 cm cross out
- c. 0.479 cm cross out
- d. 0.028 cm cross out
- e. 0.0052 cm cross out

Electronic Materials

What is the electrical conductivity of platinum at -200°C? The resistivity at room temperature and the resistivity temperature coefficient are 9.85 E-6 ohm cm and 0.0039 1/C, respectively.

Select one:

- a. 8 E-5 1/ohm cm cross out
- b. 8 E5 1/ohm cm cross out
- c. 6 E-5 1/ohm cm cross out
- d. 4 E5 1/ohm cm cross out
- e. 6 E5 1/ohm cm cross out

- $T = -200℃$
- $\rho_{RT} = 9.85 \times 10^{-6} \Omega \cdot cm$
- $\alpha_R = 0.0039 \frac{1}{℃}$

$$\rho = \rho_{RT}(1 + \alpha_R(T - 25℃))$$

$$\rho_{-200℃} = 9.85 \times 10^{-6} \Omega \cdot cm \left(1 + 0.0039 \frac{1}{℃}(-200℃ - 25℃)\right)$$

$$\rho_{-200℃} = 1.21 \times 10^{-6} \Omega \cdot cm$$

$$\sigma_{-200℃} = \frac{1}{\rho_{-200℃}} = 8.28 \times 10^{5} \frac{1}{\Omega cm}$$

$$8.28 \times 10^{5} \frac{1}{\Omega cm} = 8 \times 10^{5} \frac{1}{\Omega cm}$$

Electronic Materials

What is the electrical conductivity of platinum at -200°C? The resistivity at room temperature and the resistivity temperature coefficient are 9.85 E-6 ohm cm and 0.0039 1/C, respectively.

Select one:

- a. 8 E-5 1/ohm cm — cross out
- b. 8 E5 1/ohm cm — cross out
- c. 6 E-5 1/ohm cm — cross out
- d. 4 E5 1/ohm cm — cross out
- e. 6 E5 1/ohm cm — cross out

Electronic Materials

Match the corresponding definition.

In p-type semiconductors

Choose...

Choose...
the valence of dopant is greater than 4
the valence band and conduction band are misaligned.
an acceptor level is generated

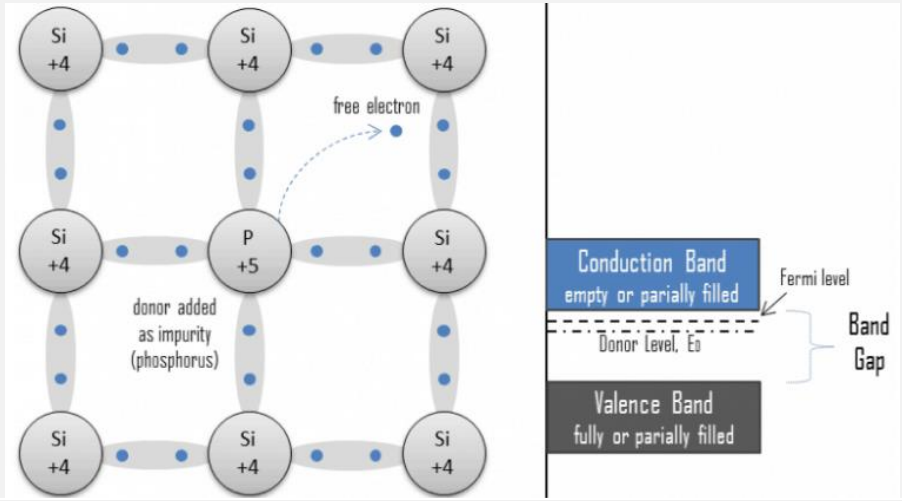
In indirect band-gap semiconductor

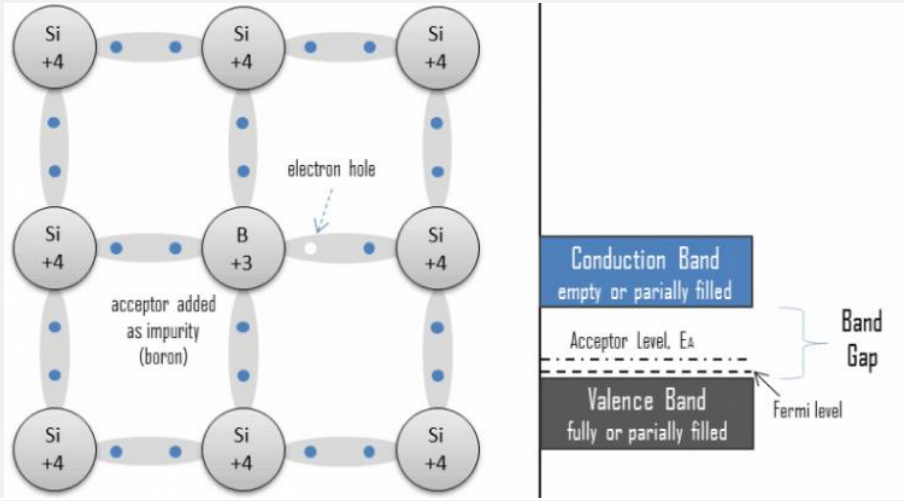
In n-type semiconductors

Choose...

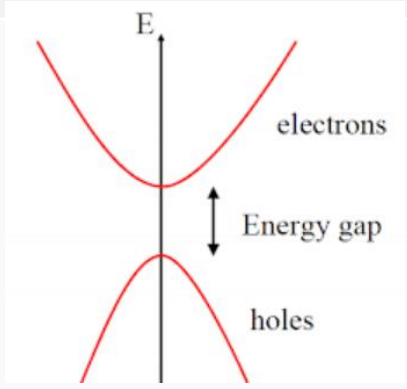
Electronic Materials

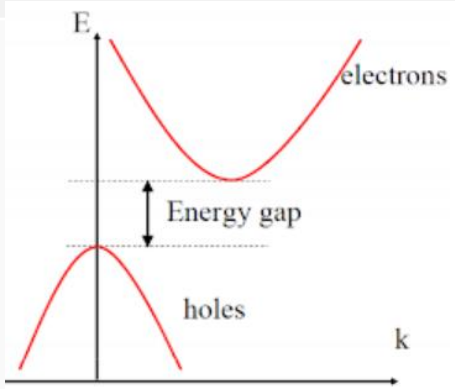
n-Type	p-Type
Negative: Valence of dopant is greater than 4	Positive: Valence of dopant is less than 4





Direct (DBG) semiconductor	Indirect (IBG) semiconductor
• The maximum energy level of the valence band aligns with the minimum energy level of the conduction band.	• The maximum energy level of the valence band and the minimum energy level of the conduction band are misaligned.





Electronic Materials

Match the corresponding definition.

In p-type semiconductors	an acceptor level is generated
In indirect band-gap semiconductor	the valence band and conduction band are misaligned.
In n-type semiconductors	the valence of dopant is greater than 4

Electronic Materials

The displacement of the electrons or ions if the electronic polarization in nickel of 2 E-7 C m2.

The Atomic number is 28

a0: 3.51E-8 cm
FCC structure

Select one:

- a. 5.12E-19 m — cross out
- b. 4.84E-21 m — cross out
- c. 2.94E-21 m — cross out
- d. 4.84E-19 m — cross out
- e. 2.94E-19 m — cross out

Atomic number: 28

$a_0 = 3.51 \times 10^{-8}\ \text{cm}$

FCC structure

$P = 2 \times 10^{-7}\ \frac{\text{C}}{\text{m}^2}$

$q = 1.6 \times 10^{-19} C \cdot m^2$

$$P = zdq$$

$$z = \frac{(4\ \text{at/u. c.})(28\ e^-/\text{at})}{(3.51 \times 10^{-8}\ \text{cm})^3}$$

$$= 2.6 \times 10^{24}\ e^-/\text{cm}^3$$

$$= 2.6 \times 10^{30}\ e^-/\text{m}^3$$

$$d = \frac{P}{zq}$$

$$= \frac{2 \times 10^{-7}\ \text{C/m}^2}{(2.6 \times 10^{30}\ e^-/\text{m}^3) \cdot (1.6 \times 10^{-19} C \cdot m^2)}$$

$$= 4.8 \times 10^{-19}\text{m}$$

Electronic Materials

The displacement of the electrons or ions if the electronic polarization in nickel of 2 E-7 C m2.

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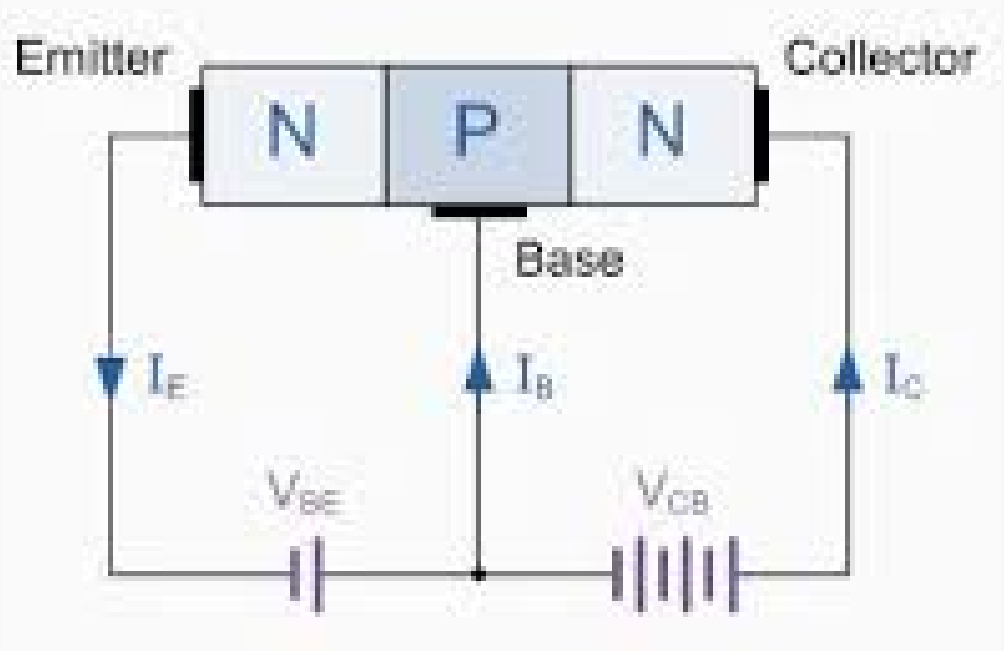
- a. 5.12E-19 m — cross out
- b. 4.84E-21 m — cross out
- c. 2.94E-21 m — cross out
- d. 4.84E-19 m — cross out
- e. 2.94E-19 m — cross out

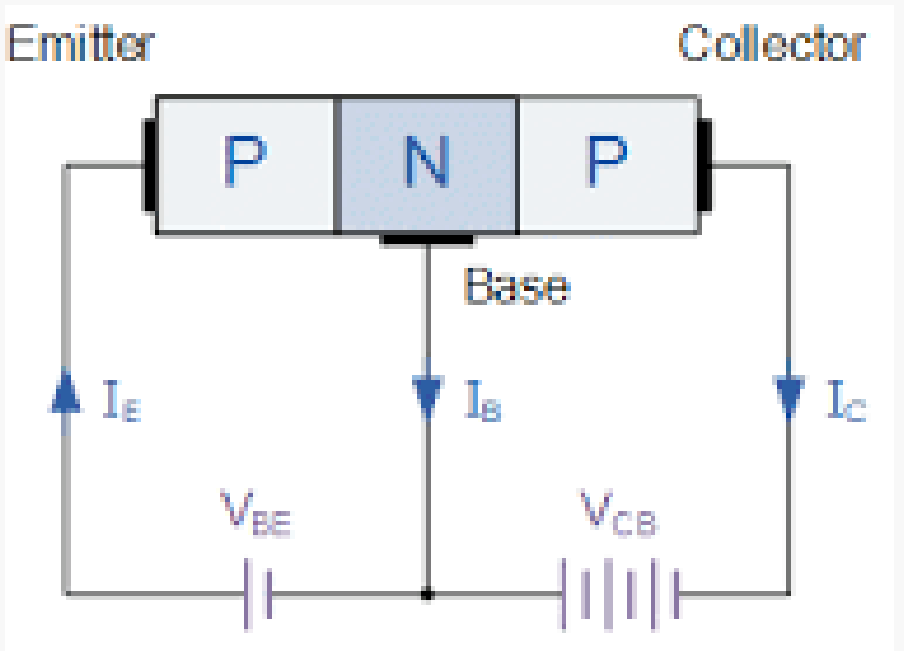
Electronic Materials

In a transistor, the work of the emitter is to supply charge carriers to the collector via the base.

Select one:

- ● True
- ○ False



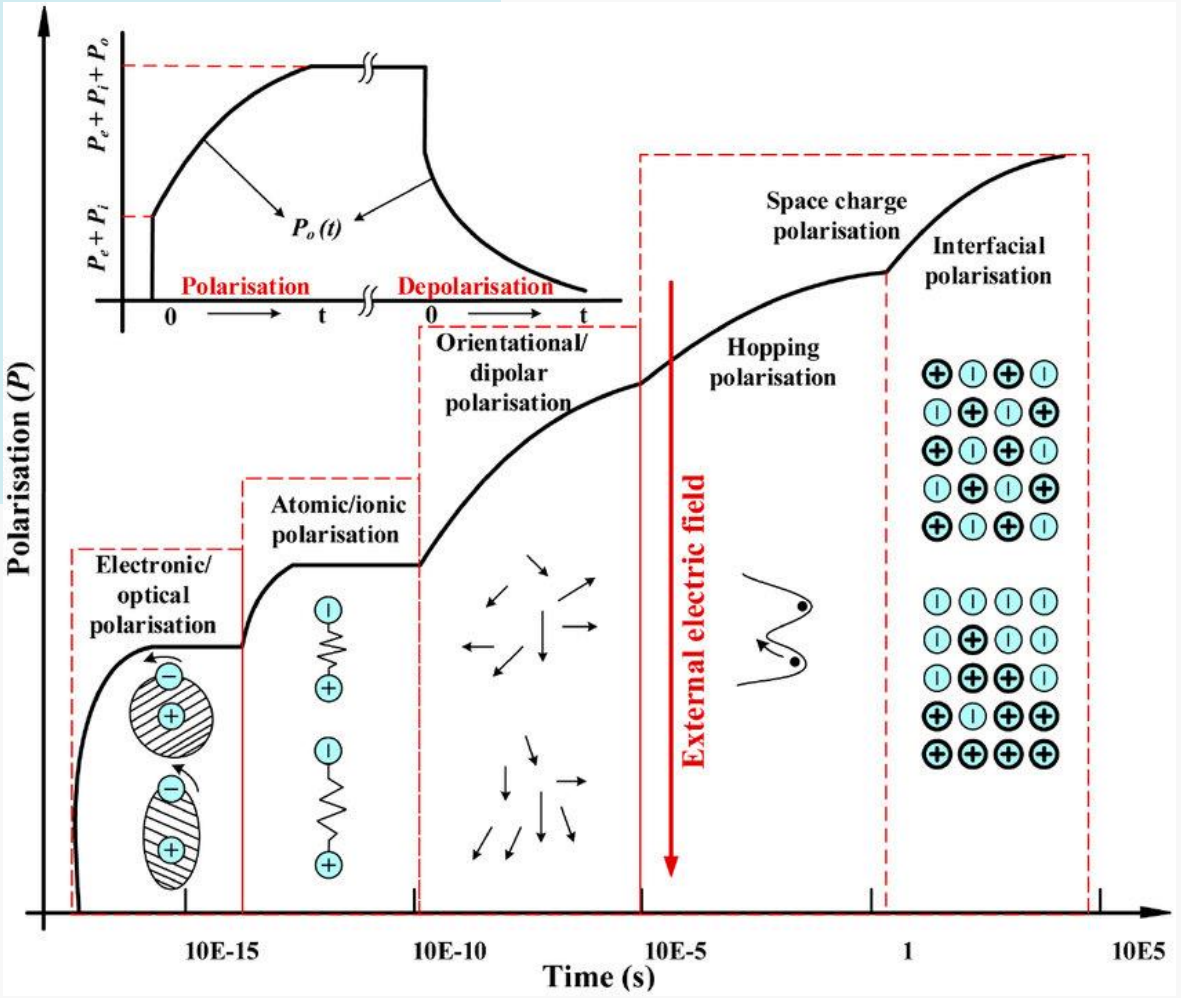


Electronic Materials

What type of polarization occurs to all materials?

Select one:

- a. Orientational polarization.
- b. Ionic polarization.
- c. Electronic polarization.
- d. Space- charge polarization.



Electronic Materials

A simple parallel plate capacitor is design to store 2E-6 C at a potential of 100 V. If the separation between the palates is filed by alumina with thickness ~ 0.10 mm and permitivity of the material is ~ 9.0, then area of each plate is 2.35E-3 m2.

Select one:

- True
- False

$Q = 2 \times 10^{-6}\ C$
$V = 100\ V$

$d = 0.10\ mm$

$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F/m}$

$$C = \frac{Q}{V} = \frac{2 \times 10^{-6}\ C}{100\ \mathrm{V}} = 2 \times 10^{-8}\ \mathrm{F}$$

$$A = C\frac{d}{\kappa\varepsilon_0}$$

$$\kappa = \frac{\varepsilon}{\varepsilon_0} = \frac{9\varepsilon_0}{\varepsilon_0} = 9$$

$$A = \frac{(2 \times 10^{-8}\ \mathrm{F})(0.1 \times 10^{-3}\ \mathrm{m})}{(9)(8.85 \times 10^{-12}\ \mathrm{F/m})} = 0.025\ \mathrm{m^2}$$

Electronic Materials

A simple parallel plate capacitor is design to store 2E-6 C at a potential of 100 V. If the separation between the palates is filed by alumina with thickness ~ 0.10 mm and permitivity of the material is ~ 9.0, then area of each plate is 2.35E-3 m2.

Select one:

- True
- False

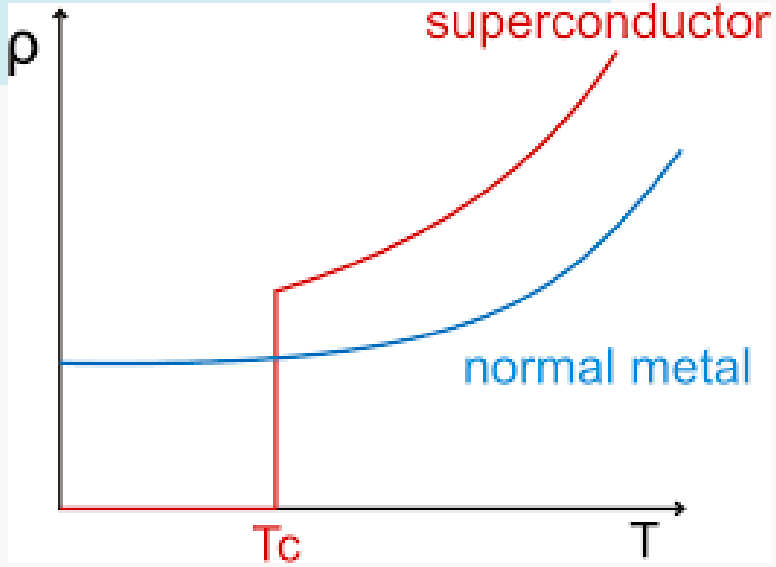
Electronic Materials

All superconductors can lose their superconductivity capacity if they are in contact to a large magnetic field.

Select one:

- True
- False

- Zero resistance
- Temperature dependent



Type I	Type II
Ideal metals (most of them)	Intermetallic compounds
Completely expel magnetic field	Able to lose superconductivity

Magnetic Materials

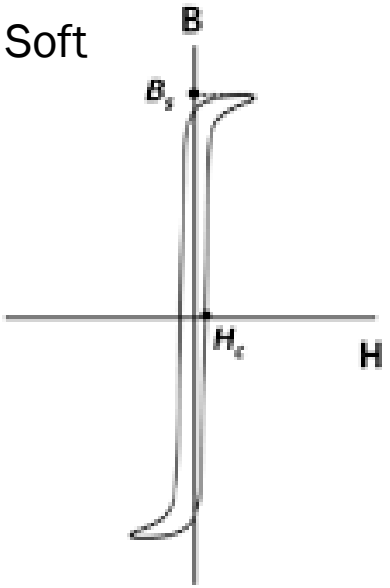
The hysteresis loop of hard magnets is broader than the one of soft magnets.

Select one:

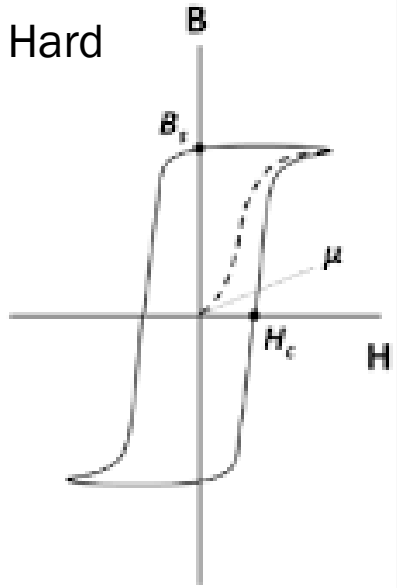
- (●) True
- ( ) False

Soft	Hard
Easily magnetized	Almost impossible to magnetized
Lose of magnetic behavior	Don’t lose magnetic behavior
Large values of susceptibility and permeability	Small values of permeability and susceptibility
Electromagnets	Permanent magnets
Fe-Si, Fe-Ni, ferrites…	Fe-Ni-Al, Co-Alloys

Soft



Hard



Magnetic Materials

A soft material with 23 turns and a coil of 12 cm long experiences a magnetic field of 230 A/m. What is the current needed to produce such magnetic field?

Select one:

- a. 1.2 A — cross out
- b. 12 A — cross out
- c. 0.12 A — cross out
- d. None of the above — cross out
- e. 2.1 A — cross out

$n = 23$

$l = 12\ cm$

$H = 230\,\frac{A}{m}$

$$H = n\frac{I}{l}$$

$$I = \frac{H \cdot l}{n}$$

$$I = \frac{230\,\frac{A}{m} \cdot 0.12m}{23}$$

$$I = 1.2\ A$$

Magnetic Materials

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Select one:

- a. 1.2 A — cross out
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- c. 0.12 A — cross out
- d. None of the above — cross out
- e. 2.1 A — cross out

Magnetic Materials

Estimate the magnetization that might be produced in copper.

Knowing that:

a0 (Cu)=3.61E-10 m

FCC structure

Valence= 1

Select one:

- a. 15.7E5 A/m
- b. 7.8E5 A/m
- c. 0.78E5 A/m
- d. None of the above
- e. 3.94E5 A/m

$a_0 = 3.61 \times 10^{-10}\ m$

FCC

$Valence = 1e^-$

$$M = \frac{\left(\#\frac{at}{uc}\right)(fraction)\left(\#\frac{magnetons}{at}\right)(Bohr\ Magneton)}{a_0^3}$$

$$M = \frac{\left(4\frac{at}{uc}\right)(1)\left(1\frac{magnetons}{at}\right)(9.27 \times\ 10^{-24}\ \text{A·m}^2)}{(3.61 \times 10^{-10}\ m)^3}$$

$$M = 7.8 \times 10^5\ \frac{A}{m}$$

Magnetic Materials

Estimate the magnetization that might be produced in copper.

Knowing that:

a0 (Cu)=3.61E-10 m

FCC structure

Valence= 1

Select one:

- a. 15.7E5 A/m
- b. 7.8E5 A/m
- c. 0.78E5 A/m
- d. None of the above
- e. 3.94E5 A/m

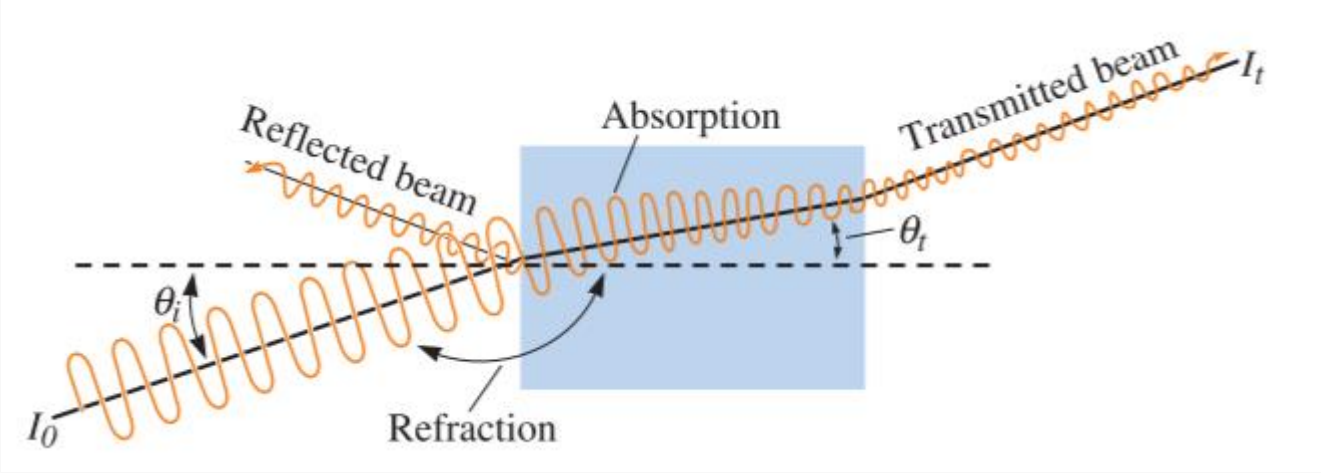
Photonic Materials

The total intensity of the initial beam is the sum of the: Intensity refracted, intensity absorbed and the intensity transmitted.

Select one:

- True
- False

$$I_0 = I_r + I_a + I_t$$



Photonic Materials

We wish to transmit a beam of light through glass, however, the displacement should be less than 0.86 mm. What should be the incident angle, if thickness of the glass is 8.5 mm?

DESIGN QUESTION!

The refractive index of glass is 1.46.

Select one:

- a. 10 degrees — cross out
- b. None of the above — cross out
- c. 7 degrees — cross out
- d. 15 degrees — cross out
- e. 17 degrees — cross out

x= 8.5 cm
Displacement= 0.86 cm
n= 1.46

$\boldsymbol{\theta_i}$?

$$n = \frac{\sin\theta_i}{\sin\theta_t}$$

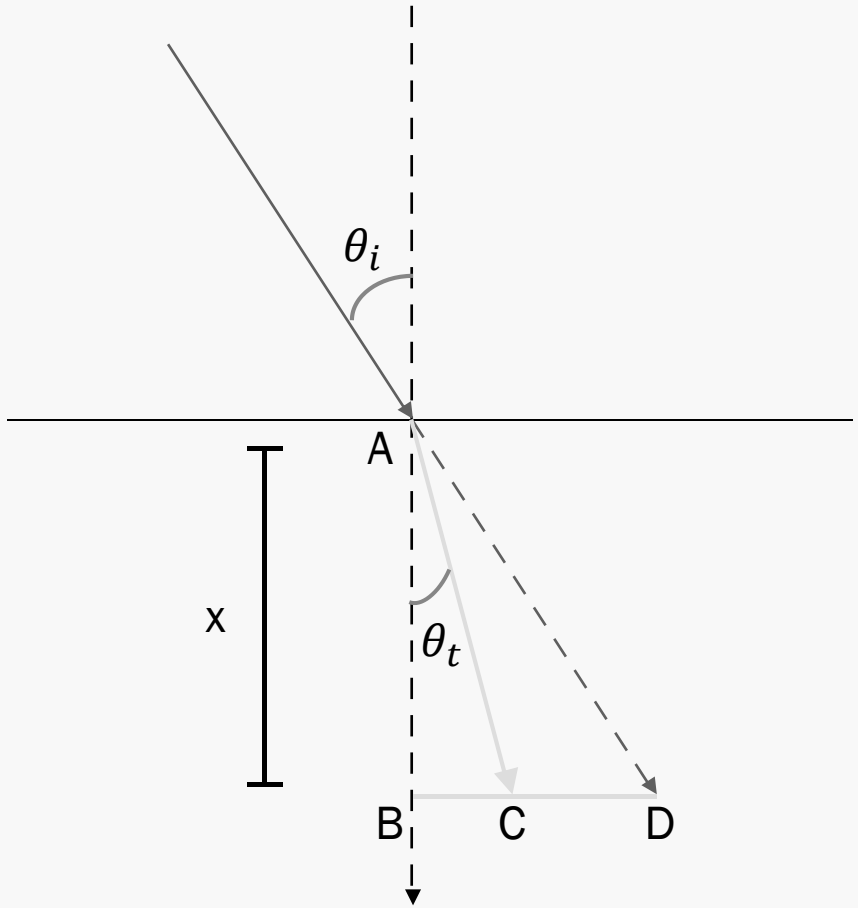
$$CD = BD - BC$$

$$\tan\theta_i = \frac{BD}{AB} \qquad \tan\theta_t = \frac{BC}{AB}$$

$$CD = AB \cdot tan\theta_i - AB \cdot tan\theta_t$$

$$\frac{CD}{AB} = tan\theta_i - \frac{sin\theta_t}{cos\theta_t}$$

$$\frac{CD}{AB} = tan\theta_i - \frac{sin\theta_t}{\sqrt{1 - \sin^2\theta_t}}$$



x= 8.5 cm
Displacement= 0.86 cm
n= 1.46

$\boldsymbol{\theta_i}$?

$$\frac{CD}{AB} = tan\theta_i - \frac{sin\theta_t}{\sqrt{1 - \sin^2 \theta_t}}$$

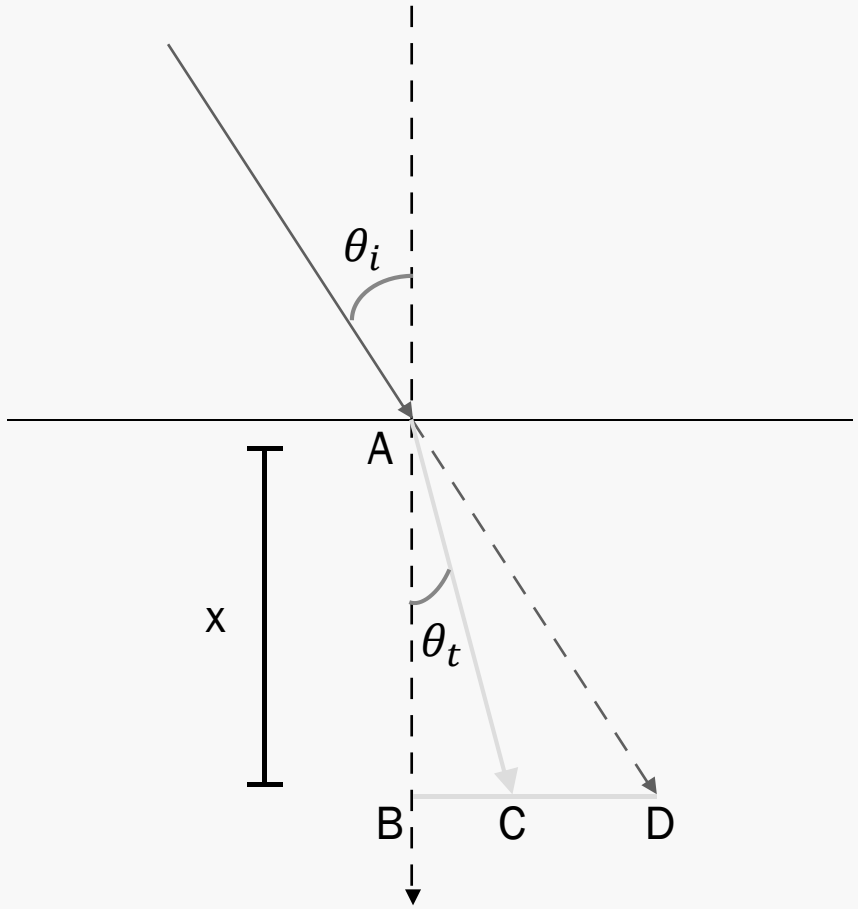
$$n = \frac{\sin \theta_i}{\sin \theta_t}$$

$$\frac{CD}{AB} = tan\theta_i - \frac{\frac{sin\theta_i}{n}}{\sqrt{1 - \frac{\sin^2 \theta_i}{n^2}}}$$

$$\frac{CD}{AB} = tan\theta_i - \frac{sin\theta_i}{\sqrt{n^2 - \sin^2 \theta_i}}$$

$$\frac{0.86cm}{8.5cm} = tan\theta_i - \frac{sin\theta_i}{\sqrt{1.46^2 - \sin^2 \theta_i}}$$

$$0.101 = tan\theta_i - \frac{sin\theta_i}{\sqrt{1.46^2 - \sin^2 \theta_i}}$$



$\boldsymbol{\theta_i = 17°}$

Photonic Materials

We wish to transmit a beam of light through glass, however, the displacement should be less than 0.86 mm. What should be the incident angle, if thickness of the glass is 8.5 mm?

The refractive index of glass is 1.46.

Select one:

- a. 10 degrees — cross out
- b. None of the above — cross out
- c. 7 degrees — cross out
- d. 15 degrees — cross out
- e. 17 degrees — cross out