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Ques.9) a) SUPERCONDUCTIVITY

- Superconductivity is the ability of the certain material to conduct electric current with practically zero resistance.
- It was discovered in 1911 by H.K Onnes
- Low temperature is required for superconductivity and the temperature ~~betwe~~ below which superconductors exists is known as critical temperature.
- The materials which shows the property of superconductivity are known as superconductor

Application
→ superconducting electromagnets are used in maglev trains
→ These are also used in magnetic resonance imaging (MRI)
→ The super-conductors are used to transmit power for longer distances
→ These are also used in generators, particle accelerators, transportation, electric motors, computing, also used in memory or storage element

examples →
Alloy superconductors
→ Gallium arsenide (GaAs)
→ Indium phosphide (InP)

ceramic superconductors
→ yittrium ~~-~~ barium copper oxide ($YBa_2Cu_3O_7$)
→ Bismuth strontium calcium copper oxide (BSCCO)

b)

Given →

room Temperature → 20°C (T_0)

(α) linear coefficient of thermal expansion = $20 \times 10^{-6} (°C)^{-1}$

(E) modulus of elastic of brass = 100 GPA

(σ) = −172 MPa

we have to find the maximum Temperature (T_f)

Solution → we know that

$$\sigma = E \alpha \Delta T$$

$$= E \alpha (T_0 - T_f)$$

$$T_f = T_0 - \frac{\sigma}{E\alpha}$$

$$= 20 - \frac{(-172)}{(100 \times 10^3)(20 \times 10^{-6})}$$

$$T_f = 106°C$$

8. a) Assume as alloy
$80g \to Ag$
$20g \to Pd$

$$\rho_{avg} = \frac{100}{\frac{20}{\rho_{Pd}} + \frac{80}{\rho_{Ag}}} = \frac{100}{\frac{20}{11.9\times10^{6}\ kg/m^3} + \frac{80}{10.49\times10^{6}\ kg/m^3}}$$

$= 10744.63\ kg/m^3$

We know that
- Ag form FCC and Pd is impurity
- there are 4 atoms of Ag in 1 unit cell
-

number of Pd atom impurity in unit cell of Ag = ?
solution →

number of unit cell in 100g of alloy $= \frac{80}{4 \times 107.87 \times 1.66 \times 10^{-29}}$

$= 1.12 \times 10^{23}$ unit cells

homogeneity allows us to approximation the mass of Pd in 1 unit cell
$= \frac{20}{1.12\times10^{23}}\ g$

now

$$\rho_{avg} = \frac{\text{mass of unit cell}}{\text{volume of unit cell}} = \frac{4\times107.87\times10^{-27}\times1.66 + \frac{20}{1.12\times10^{3}}\times10^{-3}}{a^3}$$

$$a = \sqrt[3]{\frac{9 \times 107.87 \times 1.66 \times 10^{-27} + \frac{20}{1.12 \times 10^{23}} \times 10^{-3}}{10744.62}}$$

$$\boxed{a = 4.37\,\text{Å}}$$

(b) Given →

(σ_i) electrical conductivity – 1.05×10^{-6} (ohm-m)$^{-1}$

electron and holes mobility – 0.95 and 0.07 $m^2/V\text{-}s$
(u_n) (u_p)

we know that

$$(\sigma_i) = n_i e (u_n + u_p)$$

$$\frac{(\sigma_i)}{e(u_n + u_p)} = n_i$$

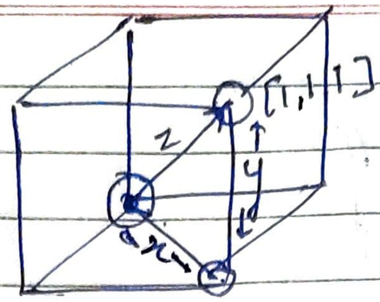
$$n_i = \frac{1.05 \times 10^{-6}}{1.66 \times 10^{-19} (0.95 + 0.07)}$$

$$= \frac{1.5 \times 10^{-6}}{1.66 \times 1.02 \times 10^{-19}}$$

$$= \frac{1.5}{1.6932} \times \frac{10^{-6}}{10^{-19}}$$

$$\boxed{n_i = 0.8858 \times 10^{+13}}$$

6. Linear density for FCC [111]



FCC unit cell
R - raddi of atoms
edge length = $2\sqrt{2}R$

for [111] direction, the vector passes through only the center of single atoms at each of its end and thus there is the equivalence of 1 atom that is centered on the direction vector.

z - The length of vector

$$z = \sqrt{x^2+y^2} \quad \text{--- (1)}$$

x → length of bottom face diagonal (4R)
y → length of unit cell edge length ($2R\sqrt{2}$)

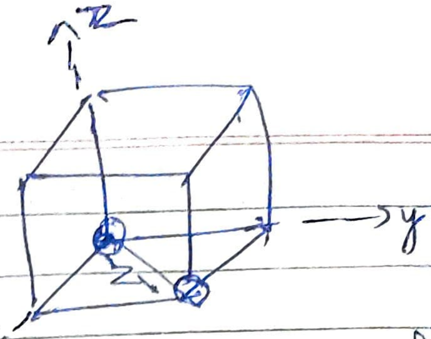
putting these values in eq (1).

$$z = \sqrt{(4R)^2 + (2\sqrt{2}R)^2} = \sqrt{24R^2} = 2R\sqrt{6}$$

the linear density expression

$$L.D = \frac{\text{number of atoms centered on [111] direction vector}}{\text{length of [111] direction vector}}$$

$$= \frac{1 \text{ atom}}{2R\sqrt{6}} = \frac{1}{2R\sqrt{6}}$$



for FCC [110]

we have 2 atoms centered on this direction vector
length of direction vector = 2R (2)

linear density = $\frac{1}{2R}$

values for iron with atomic radii + 1.24Å

for FCC [111]

$L.D = \frac{L}{2\sqrt{6}R} = \frac{1}{2 \times \sqrt{6} \times 1.24 \times 10^{-10}}$

$= \frac{L}{6.05} \times 10^{10}$

$= 0.16528 \times 10^{10}\ m^{-1}$

for FCC [110]

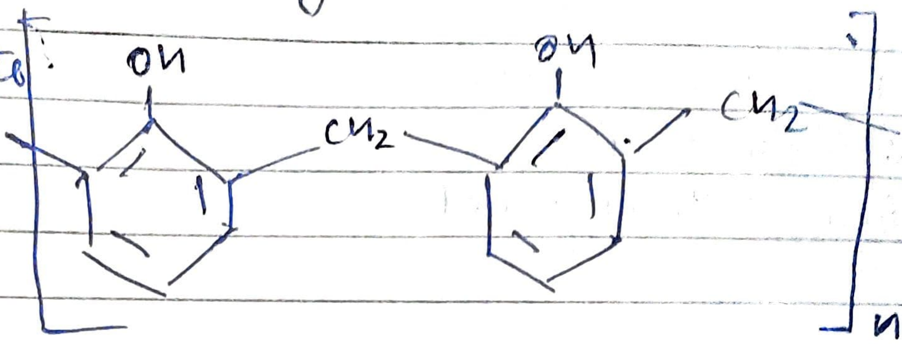
$L.D = \frac{1}{2R}$

$= \frac{1}{2 \times 1.24 \times 10^{-10}}$

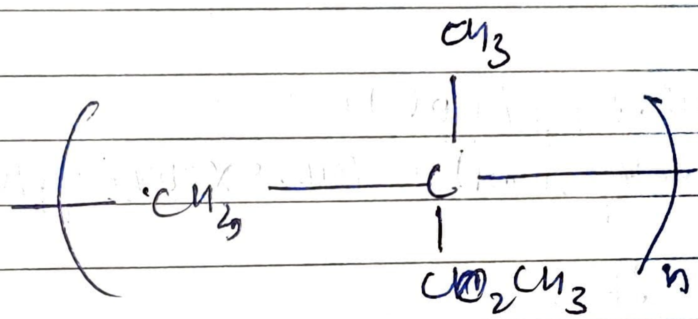
$= 0.4032 \times 10^{10}\ m^{-1}$

Ques. 7. Structures of polymer

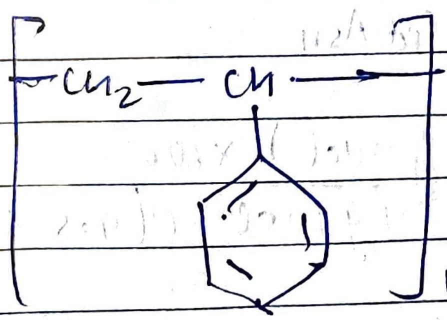
Bakelite



Poly (methyl methacrylate)



Polystyrene



Polytetrafluoroethylene

$$\left(CF_2 - CF_2 \right)_n$$

Ques. 5. Given

$C_{Pd} = 9.5$ wt%

$A_{Pb} = 207.2$ g/mol

$C_{Sn} = 90.5$ wt%

$A_{Sn} = 118.69$ g/mol

$$C'_{Pb} = \frac{C_{Pd} \cdot A_{Sn}}{C_{Pd} \cdot A_{Sn} + C_{Sn} \cdot A_{Pd}} \times 100$$

$$= \frac{9.5 \times (118.69 \text{ g/mol})}{(9.5 \times 118.64 \text{ g/mol}) + (90.5 \times 207.2 \text{ g/mol})}$$

$C'_{Pd} = 5.67$ wt%

$$C'_{Sn} = \frac{C_{Sn} A_{Pd}}{C_{Sn} A_{Pd} + C_{Pd} A_{Sn}} \times 100$$

$$= \frac{(90.5 \times 207.2 \text{ g/mol})}{90.5 \times 207.29 \text{ g/mol} + (9.5 \times 118.69 \text{ g/mol})} \times 100$$

$C'_{Sn} = 94.33$ wt%

Atomic packing factor = $\frac{\text{Volume taken by atoms}}{\text{total volume}}$

In an fcc crystal, any face diagonal is the close - packed direction

So, face diagonal has a length of 4r

$$a^2 + a^2 = (4r)^2$$
$$a = 2\sqrt{2}r$$
$$a^3 = 16\sqrt{2}\,r^3$$

a^3 will be the volume of unit cell

There will be 8 atoms on each corner with 1/8 of its volume inside unit cell + 6 atom on each face, with 1/2 of its volume inside unit cell

$$8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4 \text{ atom per unit cell}$$

$$APF = \frac{4 \times \frac{4}{3} \cdot \pi r^3}{(2\sqrt{2}r)^3} = \frac{\pi}{3\sqrt{2}} = 74\%$$

Ques. 2. THERMOSETTING POLYMERS

A thermosetting polymer which is also known as a thermoset is a polymer consisting of cross-linked structures or heavily branched molecules

examples →

bakelite, melamine

uses →

- It is used in kitchenware and fabrics as well as floor tiles
- Also used in making electrical switches

THERMOPLASTIC POLYMER

All the plastic ~~a~~ material which can be softened and melted by heating but they set again when cool are called thermoplastic

example – polyethylene, polypropylene

uses →

They are used when resistance to heat is important

Ques. 3 Engineering stress – It is the applied load divided by the original cross-sectional area of a material, It is also known as nominal stress

engineering strain – It is the amount that a material deform per unit length in a tensile test.

MCQ

1. two or more different (A)
2. (B) 2C, 3H, 1Cl
3. (A) 2
4. (A) W/m-K
5. (B) more than 2eV
6. (C) 10^{-9}
7. (B) 0.68
8. (A) $BaTiO_3$
9. (A) 8.89 g/cm3
10. (B) Arm chair

Ques. 4.

METALS
- formed by combination of electropositive element
- good conductors of electricity and heat
- higher density
- malleable, ductile

example – Al, Cu, Au, Fe etc

CERAMICS
- They are formed by compounds b/w metallic and non metallic elements
- They are insulators to electricity and heat and resistant to high Temp
- They are hard and brittle

Ex – GaAs

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Composites
- Consist of more than one material, in order to have properties of both material
- Ex - fibre glass (strengths of glass & flexible polymers)

Polymers -
- formed by organic compounds C, H and other non metallic compounds
- They have giant 3-D structure and extremely flexible
- Ex - PVC, thermosetting plastics