Engineering material Science Problems

2. (A) Elastic modulus is the gradient of the stress-strain curve at the linear portion $= \frac{400-200}{0.002-0.001} = \frac{200}{0.001} = 200$ Gpa

(B) Yield strength = 600 Mpa

C) UTS = 730 Mpa (Maximum point on the curve)

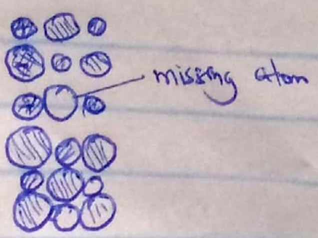
D) ductility of the material = 0.26 (percentage elongation at failure)

(E) Ultimate tensile stress is higher because it is responsible for necking after which stress decreases until fracture.
In physical sense the stress is supposed to rise due to a reduction in area and because stress is inversely proportional to area it increases.

3. A) This is interruption of regular patterns in crystalline solids

(B) Line defect (dislocation) is responsible for ductility of metals. It enables us to extrude metals to thin wires for use in electrical connections

C) Point defect - can be a vacancy (where an atom is missing from a site in the crystal or an impurity atom that occupies either a normal lattice site



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D) Linear defect

Edge dislocation where an extra half plane of atoms is introduced midway through the crystal distorting nearby planes of atoms

(E) Interfacial defect - These are boundaries that have two dimensions and normally seperate regions of the material with different crystal structures or crystallographical orientation

4. (A) Molar mass of Pb = 207.2

Molar mass of Sn = 118.71

Supposing we needed 100g of alloy

60g would be Sn

40g would be Pb

$\% \text{ tin} = \frac{60}{118.71} = 0.5054$ Moles $= 50.54\%$

$\% \text{ Pb} = \frac{40}{207.2} = 0.1929$ Moles $= 19.29\%$

(B) Pb is the solute. Tin melts at a lower temperature and therefore when Pb melts it dissolves in tin.

From the phase diagram the concentration of pb is 2.5%

$2.5\% = \frac{2.5}{100} \times 10 = 0.025 m^3$

density of Lead = 11343 kg/m3

Mass = ρv = 11343 × 0.025 = <u>283.575 kg</u>

5. $\lambda = 0.15405 \, nm$

$\lambda = 2d_{hkl} \sin\theta$

$2d_{hkl} = \frac{\lambda}{\sin\theta}$ ⇒ For (111) $2d_{hkl} = \frac{0.15405 \, nm}{\sin 38.105}$

$= 2.49 \, Å$

2

~~for (1~~

① Crystalline nanoparticles represented by the three peaks and a fourth one (311) corresponds to standard bragg reflection of face centers cubic lattice. The intense peak at 38.1 represents preferential growth in the (111) direction. And sum of $h^2+k^2+l^2$ gives 3, 4, 8, 11, 12, 16 . . .

② Lattice parameter =

For FCC, hkl need to be all odd or even

$\lambda = 2d_{hkl} \sin\theta$

$d_{hkl} = \frac{\lambda}{2\sin\theta} = \frac{0.15405 \times 10^{-9}}{2\sin 38.105} = 1.248 \, Å$

$d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}}$

$1.248 \times 10^{-10} \times \sqrt{3} = a = 2.16 \times 10^{-10}$

③ Atomic radius

$a = 2R\sqrt{2}$.

$R = \frac{a}{2\sqrt{2}} = \frac{2.16 \times 10^{-10}}{2\sqrt{2}} = 0.764 \, Å$

700°c

35%wt - Initial

65%wt - final

42.737% what depth

Let 35 wt % be at 0 m

65 wt % is at maximum distance

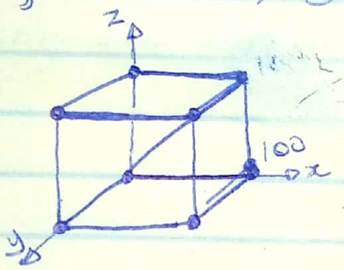
Proportion of 42.737 : 65 = 0.6575 of full thickness

7. (A) It is the number of atoms per length and whose centers lie on the direction vector for a crystallographic direction

$$\text{Linear density} = \frac{\text{No. of atoms centered on direction vector}}{\text{length of direction vector}}$$

(B) This is the direction in which atoms are touching
Vector is repositioned to pass through the origin, projection in terms of 3 axes is read and adjusted to small integer values. Small integer values are enclosed in brackets with no commas

(C) Linear density = No. of atoms | length
No. of atoms = 1 , length = a BCC



$$LD = \frac{1}{a_o/2R} = \frac{2R}{a_o} \Rightarrow a = \frac{4\sqrt{3}}{3}R$$

$4R = \sqrt{3}\, a_o$

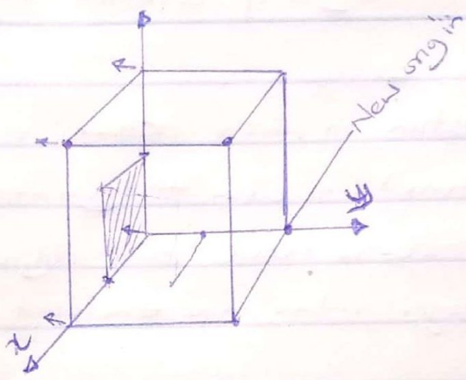
$$LD = \frac{2R}{\frac{4\sqrt{3}}{3}R}$$

$$LD = \frac{1}{(4\sqrt{3})^2}$$

8. Reciprocal of given miller indices is found
The cube is drawn and a proper origin selected, x, y, z axes are shown respectively.
With respect to the origin Mark these intercepts and join through straight lines.
Plane obtained is the required plane

(B) $(2\bar{1}2)$

reciprocals $(\frac{1}{2}\ \bar{1}\ \frac{1}{2})$



c) A family of planes is an infinite set of parallel lattice planes that are equally spaced from each other.

Plane orientations and directions with same indices are perpendicular to one another

(D) $(2\bar{1}\bar{2}), (\bar{2}1\bar{2})$

10) (A) Get the ratio between the image length seen on the micrograph divide by the actual length. Magnification can be read directly without conversion. It is 200X = 80mm/0.4mm = 200X

(B) A line of length 183 mm passes through 10 grain boundaries

$$\text{Magnification} = \frac{80\,mm}{0.4\,mm} = 200$$

$$\text{Actual line length} = \frac{\text{length}}{\text{magnification}} = \frac{183}{200} = 0.915\,mm$$

$$\text{length per grain} = \frac{0.915}{10} = 0.0915\,mm$$

[C] N*

ASTM grain size number n is related with the number of grains countable in a 100X magnification

$$N_m (M/100) = 2^{n-1}$$

$N_m = 3$

$M = 200$

$$3(200/100) = 2^{n-1}$$

$$6 = 2^{n-1} \quad \text{Let } n-1 = x$$

$$6 = 2^x$$

$$\log 6 = x \log 2$$

$$x = \log 6 / \log 2 = 2.58$$

$$n-1 = 2.58$$

$$n = 3.58$$