

# Tutorial sheet 6

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1. In an FCC lattice, the largest interstitial voids occur at positions like  $(\frac{1}{2}, 0, 0)$ ,  $(0, \frac{1}{2}, 0)$ ,  $(0, 0, \frac{1}{2})$  etc.  $\gamma$ -iron crystallizes in FCC structure. Find atomic radius of the largest interstitial void in  $\gamma$ -iron.

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**Ans1.** In FCC lattice: voids = Tetrahedral voids  
= Octahedral voids

The radius of largest interstitial void (octahedral void) is  
 $R = 0.414r$

Where radius of  $\gamma$ -iron crystallizes in FCC structure is  
 $1.292 \text{ \AA}^\circ$

$$R = 0.414 \times 1.292 \text{ \AA}^\circ \\ = 0.534 \text{ \AA}^\circ$$

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**2.** An optical microscope can resolve a step of aluminum width 300 nm. A slip band was observed in a simple cubic crystal ( $a = 3 \text{ \AA}$ ). How many (minimum) dislocations must have slipped out of the crystal?

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**Ans 2.** Width of slip band,  $w = 300 \text{ nm}$

lattice parameter,  $a = 3 \text{ \AA}$

No. of dislocations have slipped out of the crystal =  
(Width of slip band - No. of dislocations) / No. of  
dislocations

$$= (3000 - 3)/3 \text{ \AA}$$

$$= 999 \text{ \AA}$$

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3. Does the Burger vector change with the size of the Burger circuit? Explain.

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**Ans 3.** No, it depends on no. of dislocation not on the circuit.

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4. Distinguish between the direction of the dislocation line, the burgers vector and the direction of motion for both the edge and screw dislocations. Differentiating between positive and negative types.

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- An *edge* dislocation has its Burgers vector perpendicular to the dislocation line. A *screw* dislocation, the Burgers vector is parallel to the dislocation line.
- For an edge dislocation, the Burgers vector is parallel to dislocation motion. For a screw dislocation, the Burgers vector is parallel to the dislocation. The Burgers vector is always parallel to slip.
- During **positive** climb, the crystal shrinks in the direction perpendicular to the extra half plane of atoms because atoms are being removed from the half plane. Since **negative** climb involves an addition of atoms to the half plane, the crystal grows in the direction perpendicular to the half plane.

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5. An aluminum crystal has a dislocation density of  $10^{10} \text{ m}^{-2}$ . The sheer modulus of aluminum is  $25.94 \text{ GNm}^{-2}$ . Calculate the elastic energy of line imperfections stored in the crystal.

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**Ans 5.** Density of aluminum crystal,  $f = 10^{10} \text{ m}^{-2}$

Sheer modulus of aluminum is  $\mu = 25.94 \text{ GNm}^{-2}$

$$E = ?$$

$f = 1/l^2$ , length of dislocation line

$$\text{sheer stress} = \mu b/l$$

For perfect crystal, sheer stress =  $\mu/6$

$$b/l = 1/6$$

$$b = l/6 = 1.67 \text{ } \mu\text{m}$$

$$E = \mu b^2/2$$

$$= 36.17 \text{ J/m}$$

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- 6. Average energy required to create Frenkel defect in an ionic crystal is 1.4 eV. Calculate the ratio of Frenkel defects at 20°C and 300°C in 1 gram of crystal.

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- Ans6. For ionic crystal, no. of point imperfections

$$n = N \exp(-\Delta H_f / 2RT)$$

Where  $H_f$  is enthalpy of formation of one mole of each of cation=anion

$$R = 8.62 * 10^{-5} \text{ evk}$$

$N$ = Avagadro No.

$$H_f = 1.4 \text{ ev}$$

$$n_1/n_2 = \exp(-\Delta H_f / 2RT_1) / \exp(-\Delta H_f / 2RT_2)$$

$$= \exp(-\Delta H_f / 2R(1/T_1 - 1/T_2)) = 1.65 \times 10^{-4}$$