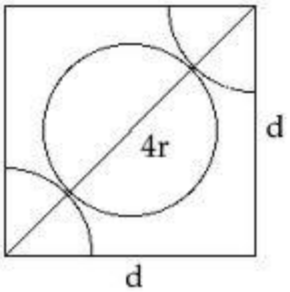
SOLUTION

Q1 (a)



$$4r = \sqrt{a^2 + a^2} = \sqrt{2}a$$

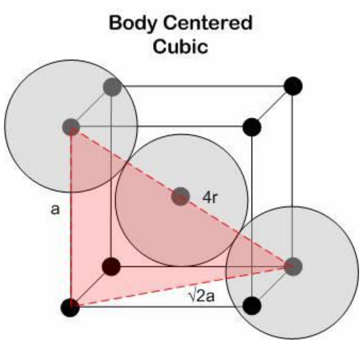
$$a = \frac{4r}{\sqrt{2}}$$

(note a=d)

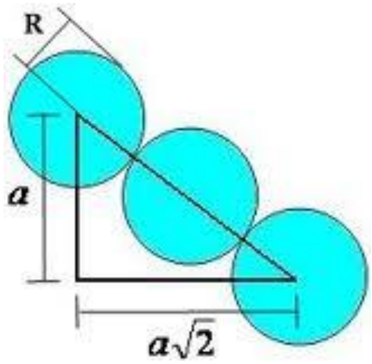
(b) Density = $\frac{\boldsymbol{Mass}}{\boldsymbol{Volume}} = \frac{\boldsymbol{4\ x\ atomic\ weight}}{\boldsymbol{N_A\ x\ 22.6\ x\ r^3}} = \frac{\boldsymbol{4\ x\ 63.54}}{\boldsymbol{6.02x10^{23}\ x\ 22.6\ x\ (0.1278\ x10^{-9})\ ^3}}$ = 8.92gcm^{-3}

(c) Not all lattice points filled in reality due to point/line defects therefore observed density always less than theoretical.

Q2 (a)



AND



$$4r = \sqrt{a^2 + a^2 + a^2} = \sqrt{3}a$$

$$a = \frac{4r}{\sqrt{3}}$$

(b) Density = $\frac{\boldsymbol{Mass}}{\boldsymbol{Volume}} = \frac{\boldsymbol{2\ x\ atomic\ weight}}{\boldsymbol{N_A\ x\ 12.36\ x\ r^3}} = \frac{\boldsymbol{2\ x\ 55.847}}{\boldsymbol{6.02x10^{23}\ x\ 12.36\ x\ (0.1238\ x10^{-9)\ 3}}}$ = 7.91 gcm^{-3}

Not all lattice points filled in reality due to point/line defects therefore observed density always less than theoretical

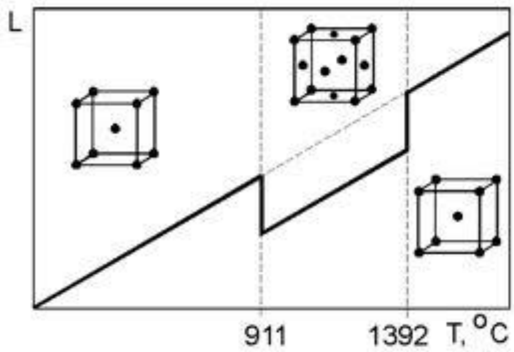
(c) The significance of dislocations is that although slip can occur in some ceramics and polymers, the slip process is particularly helpful in understanding the mechanical behaviour of metals.

Firstly, slip explains why the strength of metals is much lower than the value predicted from the metallic bond. If all of the metallic bonds had to be broken in order to fracture an Iron bar. Then a force of thousands of MPa would be required to deform the bar, however only a small fraction of this would be required to deform the bar by slip i.e. 4 - 5 MPa.

Secondly, slip provides ductility in metals. If no dislocations were present, the iron bar would be brittle, metals could not be shaped by the various metal working processes, such as forging, into useful shapes.

Thirdly, it is possible to control the mechanical properties of a metal by interfering with the movement of dislocations. An obstacle introduced into the crystal prevents a dislocation from slipping unless a greater force is applied, therefore, the metal must be stronger.

Q3 (a)



Volume change = $\frac{V_{bcc}-V_{fcc}}{V_{fcc}} = \frac{2x12.36-22.6}{22.6}$ = +8.1%

(b) FCC,

$$PF_{FCC} = \frac{4 \times \frac{4}{3}\pi R^3}{\left(4R/\sqrt{2}\right)^3}$$

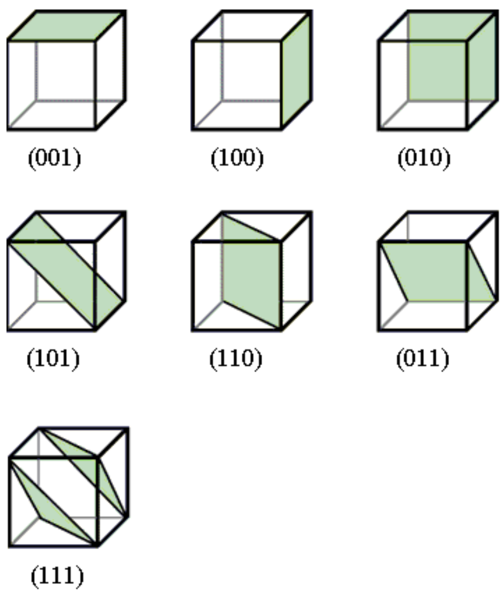
$$PF_{FCC} = 0.74$$

BCC,

$$PF_{BCC} = \frac{2 \times \frac{4}{3}\pi R^3}{\left(4R/\sqrt{3}\right)^3}$$

$$PF_{BCC} = 0.68$$

Q4



5. (a) There are two types of line dislocation:

Edge type - An edge dislocation is a defect where an extra half-plane of atoms is introduced mid way through the crystal, distorting nearby planes of atoms. When enough force is applied from one side of the crystal structure, this extra plane passes through planes of atoms breaking and joining bonds with them until it reaches the grain boundary. A simple schematic diagram of such atomic planes can be used to illustrate lattice defects such as dislocations. The dislocation has two properties, a line direction, which is the direction running along the bottom of the extra half plane, and the Burgers vector which describes the magnitude and direction of distortion to the lattice. In an edge dislocation, the Burgers vector is perpendicular to the line direction

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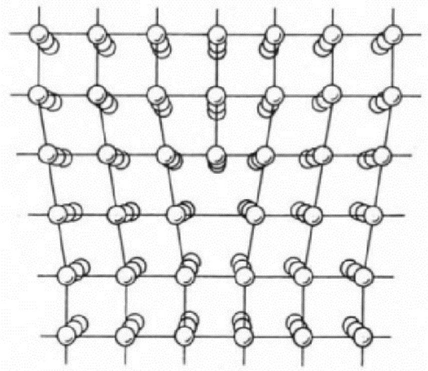
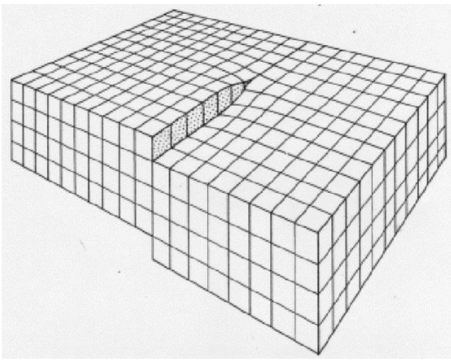
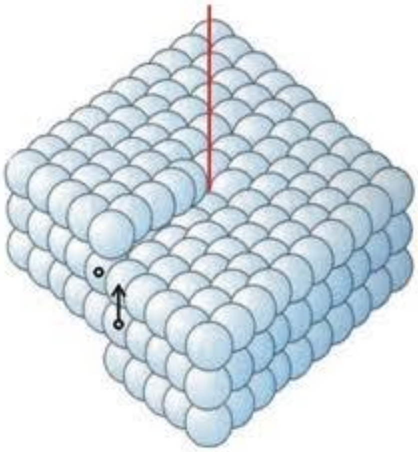


(a)



(b)

Screw type – A *screw dislocation* is much harder to visualize. Imagine cutting a crystal along a plane and slipping one half across the other by a lattice vector, the halves fitting back together without leaving a defect. If the cut only goes part way through the crystal, and then slipped, the boundary of the cut is a screw dislocation. It comprises a structure in which a helical path is traced around the linear defect (dislocation line) by the atomic planes in the crystal lattice. Perhaps the closest analogy is a spiral-sliced ham. In pure screw dislocations, the Burgers vector is parallel to the line direction



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