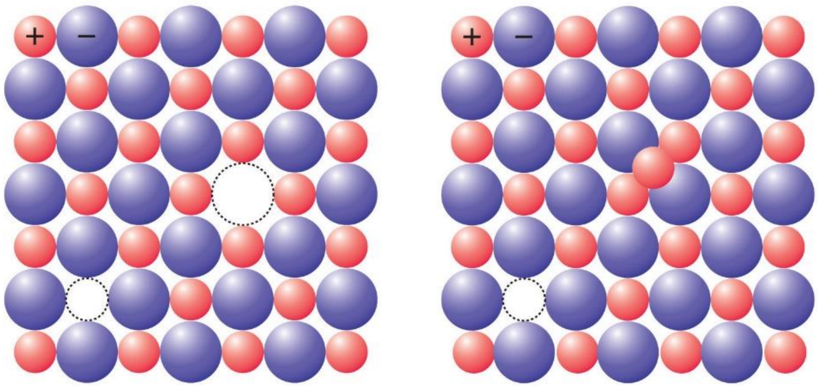
SKPN 4123 NUCLEAR REACTOR MATERIALS — Semester I 2018-2019
Test 1 — 60 minutes

1. Briefly discuss the challenges and issues concerning reactor materials with the current trend of extending the lifetime of current reactors.

   *Monitoring of material degradation is more important. Higher burnup also causes more degradation. Fuel materials has to be monitored for longer burnups. Structural materials might have to be replaced mid-life of the reactor. Better in-line monitoring methods needed. Better computational modeling of materials needed for better prediction of material performance*

2. Explain the difference between Frenkel and Schottky defects with the help of a diagram.

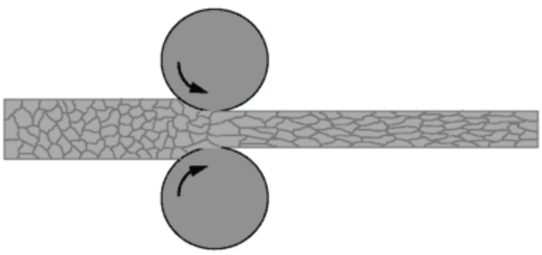
```
Schottky Defect when equal number of cations and anions are missing from
the lattice sites.
Frenkel Defect when a cation leaves the normal lattice site and occupies
an interstitial site.
```




(a) Schottky defect (b) Frenkel defect

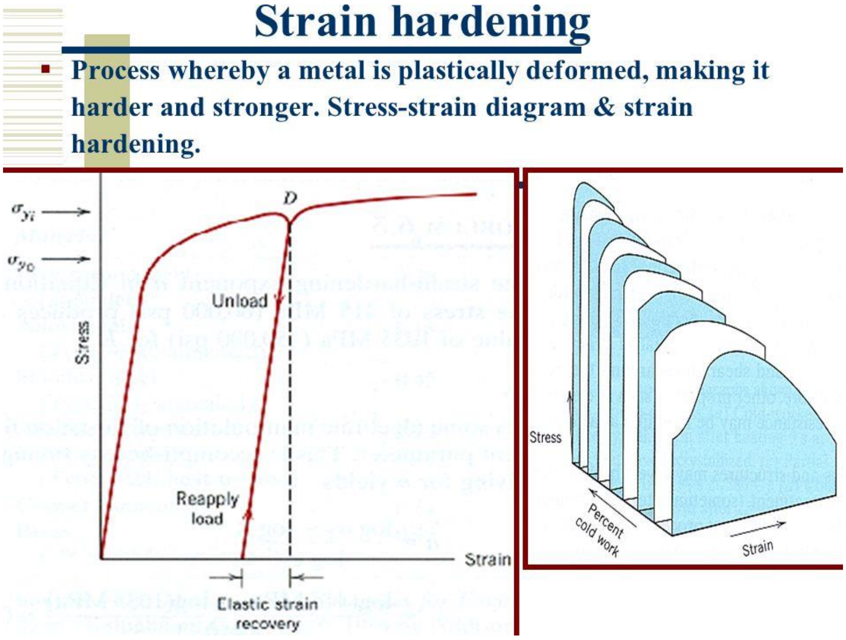
3. Cold working:

   i. Sketch the change of grain structure during cold working.



Cold work being rolled into copper alloy strip.

ii. With the help of the stress-strain diagram, explain how cold working increases the strength of a metal.

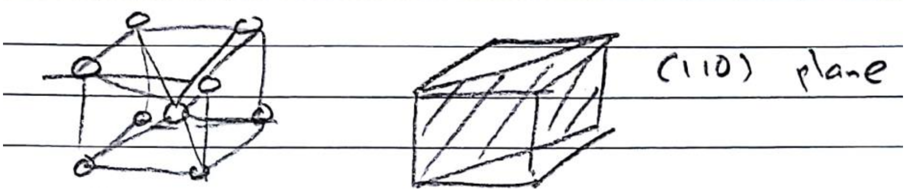



iii. What treatment process can recover the grain structure after cold working?

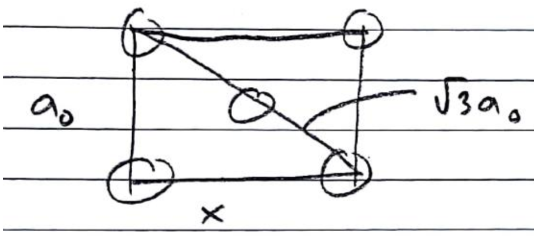
*Annealing*

4. Lithium (M = 6.941 g/mol) has BCC unit cell, with lattice parameter , $a_0$ = 0.3509 nm;

i. Sketch the BCC unit cell and show the (110) plane.




ii. Calculate the planar density of the (110) plane.




$$x^2 + a_0^2 = 3a_0^2$$

$$x^2 = 3a_0^2 - a_0^2 = 2a_0^2$$

$$x = \sqrt{2}\,a_0$$

$$\text{Planar density} = \frac{2 \text{ atoms}}{a_0 \sqrt{2} a_0}$$

$$= \frac{2}{\sqrt{2}\,(0.3509)^2} = \frac{11.4855 \text{ atoms}}{nm^2}$$

$$= 1.1485 \times 10^{19} \frac{\text{atoms}}{m^2}$$

iii. Calculate the density of Lithium and compare with the table value of 0.534 g/cm$^3$.

$$\text{(iii) Density} = \frac{(\#\text{ atoms/cell})(M)}{(\text{vol. unit cell})(N_A)}$$

$$= \frac{2\,(6.941 \text{ g/mol})}{(0.3509 \times 10^{-9})^3 (6.022 \times 10^{23})}$$

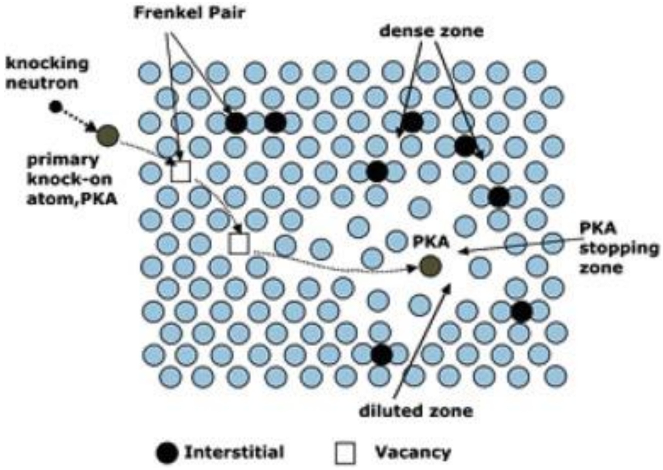
$$= 533532.874 \text{ g/m}^3 \times \frac{1 \text{ m}^3}{100^3 \text{cm}^3}$$

$$= 0.5335 \text{ g/cm}^3 \simeq 0.534 \text{ g/cm}^3 \text{ table value.}$$

within roundoff error

5. For radiation effect on materials;

   i. Sketch and **label** the phenomenon of a heavy particle hitting a material, showing its effect on the atoms in the material



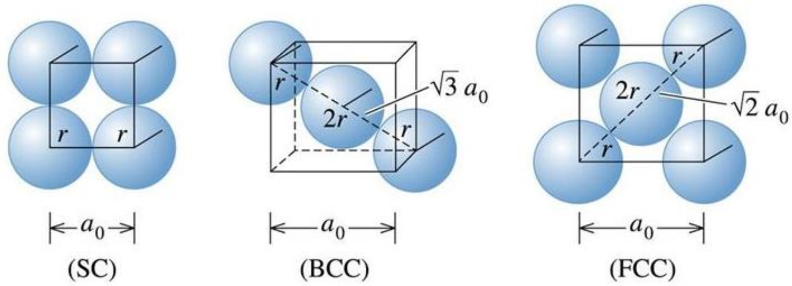

ii. Explain the concept of dpa (displacement per atom), giving some examples.

*The unit of displacement damage is DPA, displacement per atom. DPA is the number of times an atom is displaced for a given fluence. If 1% of target lattice atoms have experienced displacement, the damage level is called 0.01 dpa. 1 dpa means all atoms have experienced displacement once. 10 dpa means all atoms have experienced displacements 10 times.*

(next page →)

You may find these information useful

$1\ nm = 10^{-9} m$




$$a_0 = 2r \qquad a_0 = \frac{4r}{\sqrt{3}} \qquad a_0 = \frac{4r}{\sqrt{2}}$$

$$\text{Density} = \frac{(\text{number of atoms / cell})(\text{atomic mass})}{(\text{volume of unit cell})(\text{Avogadro constant})}$$

$N_A = 6.022 \times 10^{23} atoms/mol$