

**ENGR 1600 Materials Science for Engineers**  
**Section 7. 1<sup>st</sup> quiz, Wed. Jan. 25, 2006.**

Name \_\_\_\_\_

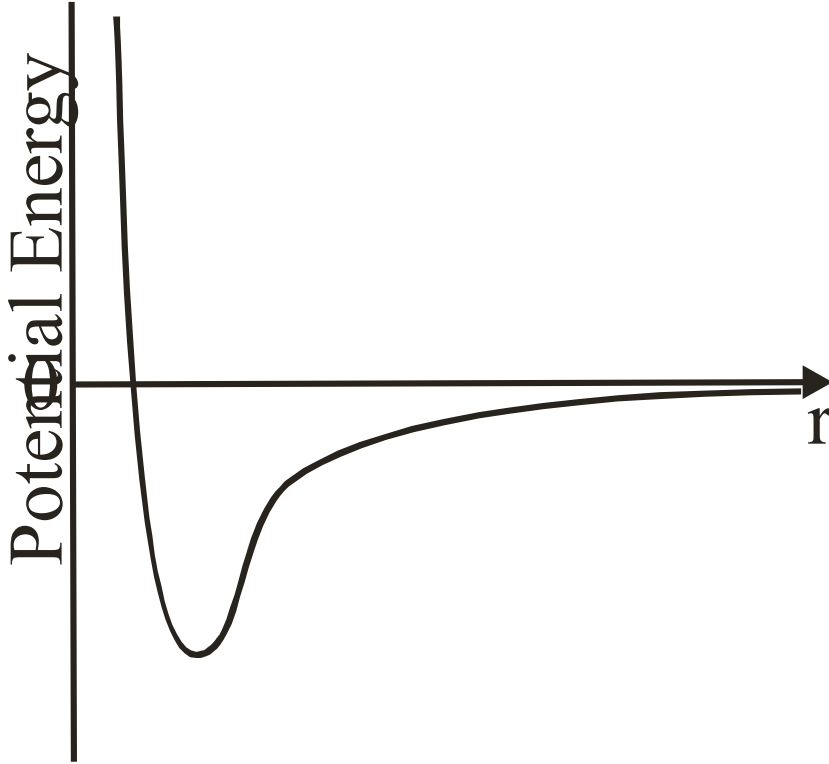
1. Aluminum (Al) has a fcc crystal structure.

(a) [20] Using the atomic radius,  $r = 1.43 \text{ \AA}$  (0.143 nm) and the atomic mass, 26.98 (g/mol), calculate lattice constant,  $a$  (nm), and density,  $d$  (g/cm<sup>3</sup>). Avogadro's number is  $6.02 \times 10^{23}$ /mol.

(b) [20] How many nearest neighbors are there? What is this number also called?

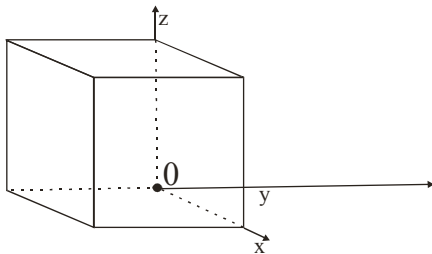
(c) [10] Calculate atomic packing factor of fcc.

2. Potential energy vs. inter-atomic distance for a solid material is shown below. [30] Explain how the potential energy curve is related to (a) stiffness (b) thermal expansion coefficient and (c) the equilibrium spacing of atoms.

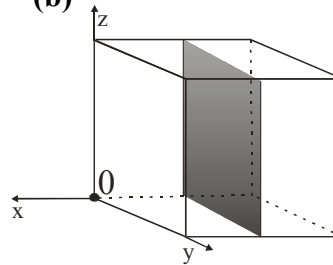


3. (a) [10] Sketch the direction  $[1\bar{1}0]$  in the figure (a).  
 (b) [10] Find the Miller Indices for the plane shown in the figure (b).

(a)



(b)



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1. Aluminum (Al) has a fcc crystal structure.

(a) [20] Using the atomic radius,  $r = 1.43 \text{ \AA}$  (0.143 nm) and the atomic mass, 26.98 (g/mol), calculate lattice constant,  $a$  (nm), and density,  $d$  (g/cm<sup>3</sup>). Avogadro's number is  $6.02 \times 10^{23}$ /mol.

In fcc, atoms are connected along the face-diagonal direction. So the lattice constant,  $a$ , is related to the atomic radius,  $r$ , by

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

Therefore,  $a = 2\sqrt{2}r = 2.828 \times 0.143 \text{ nm} = 0.405 \text{ nm}$

In a unit cell, there are four Al atoms. So the density is given by

$$d = [4 \times 26.98] / [(0.405 \text{ nm})^3 \times 6.02 \times 10^{23}] = 2.70 \text{ g/cm}^3$$

(b) [20] How many nearest neighbors are there? What is this number also called?

12. Also called Coordination Number.

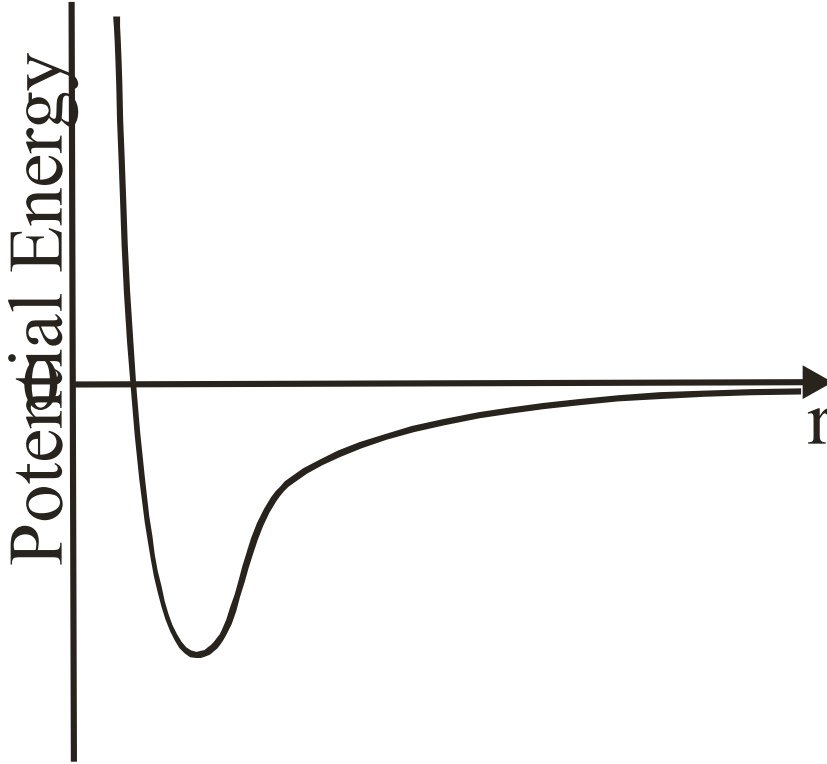
(c) [10] Calculate atomic packing factor of fcc.

$$\text{APF} = 4 \times (4/3)\pi r^3 / a^3$$

Using the relation  $a = 2\sqrt{2}r$

$$\text{APF} = 4 \times (4/3)\pi r^3 / [2\sqrt{2}r]^3 = (16/3)\pi / 16\sqrt{2} = \pi / (3\sqrt{2}) = 0.74$$

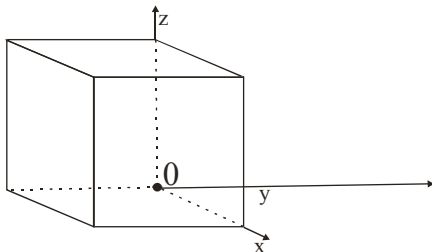
2. Potential energy vs. inter-atomic distance for a solid material is shown below. [30] Explain how the potential energy curve is related to (a) stiffness (b) thermal expansion coefficient and (c) the equilibrium spacing of atoms.



- (a) Stiffness is related to the curvature (or second derivative) of the potential energy curve at the potential minimum.
- (b) Thermal expansion coefficient is related to un-symmetric nature of the potential energy curve. (Greater the deviation from the symmetry, greater the thermal expansion coefficient.)
- (c) The equilibrium spacing of atoms corresponds to the distance from the origin to the value corresponding to the potential minimum.

3. (a) [10] Sketch the direction  $[1 \bar{1} 0]$  in the figure (a).  
 (b) [10] Find the Miller Indices for the plane shown in the figure (b).

(a) **face diagonal to front left on the bottom plane**



(b) **(2̄ 00)**

