

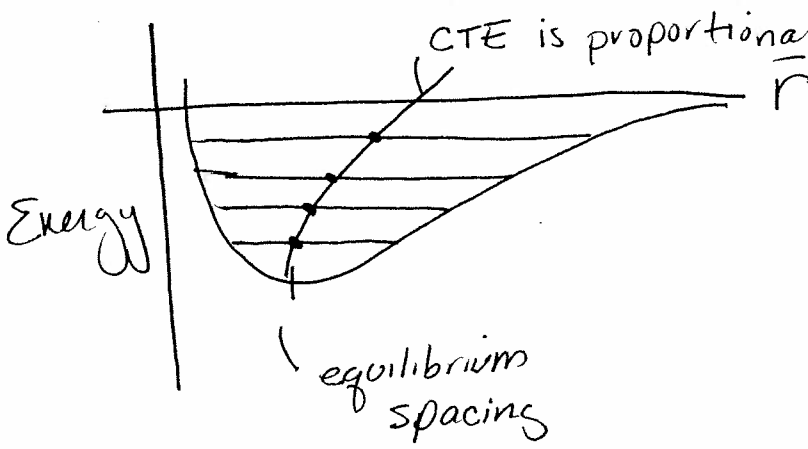
True or False? (2 points each)

1. Structure, processing, properties, and performance of materials are all related. T
2. Interatomic distances represent a balance between attractive and repulsive forces. T
3. Covalent bonds have non-directional character. F
4. To fill space using a unit cell, the only operation necessary is translation. T
5. The stacking sequence of close-packed planes in FCC is ABABAB... F
6. The most efficient packing of atoms with equal size occurs when the APF = 0.74. T
7. Crystalline regions of polymers are typically found in areas with the polymer chains folding back on themselves. T
8. It is uncommon to have both crystalline and amorphous regions in polymeric solids. F
9. Charge balance is all that is necessary to ensure the stability of ionic compounds. F
10. There is a discontinuous change in specific volume through the glass transition temperature. T

Provide calculations and/or short answers to the following questions.

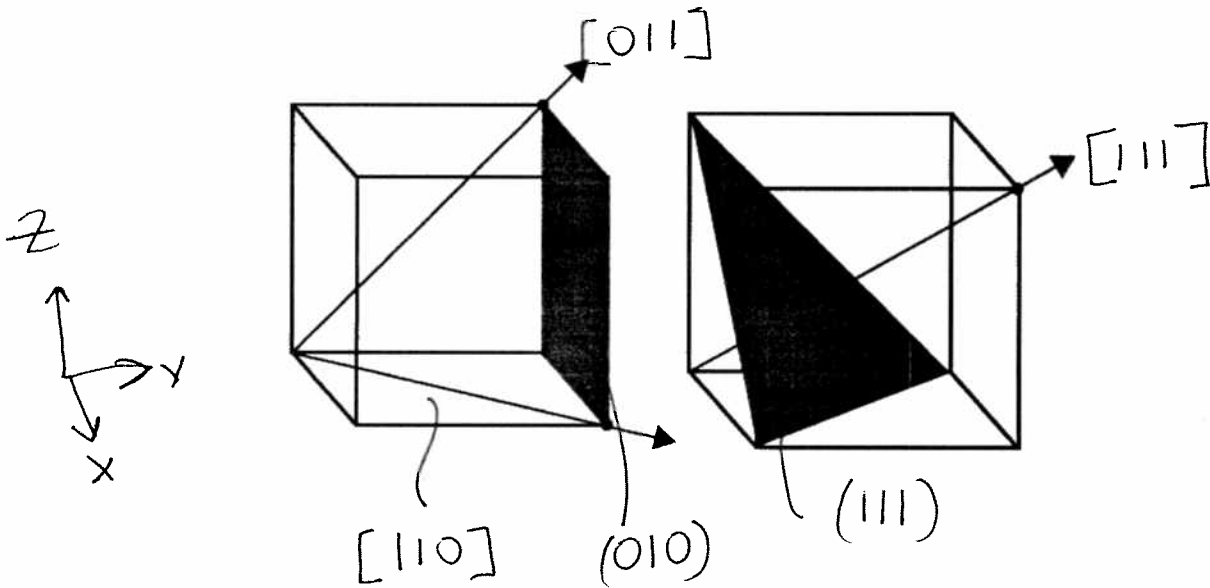
(16 points each)

11. How does the shape of the curve for the energy versus atomic separation affect the coefficient of thermal expansion? Draw a graph and explain.

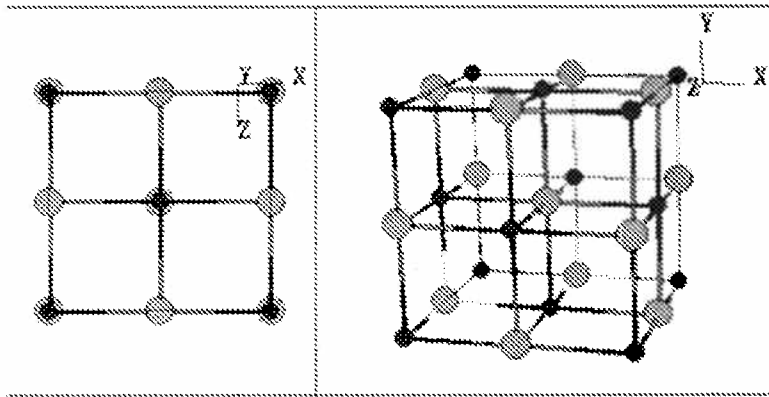


With thermal energy the atoms will vibrate about some mean position. The asymmetry in the energy curve sets the CTE!

12. Identify the sketched planes and directions in the cubic unit cells shown.



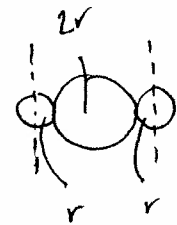
13. A unit cell of NiO is shown below. The ionic radius of Ni^{2+} is 0.069 nm (atomic mass of Ni 58.7 g/mol) and the ionic radius of O^{2-} is 0.140 nm (atomic mass of O 16 g/mol). This crystal has the NaCl structure. Calculate the following:



- a. The number of Ni and O atoms in this unit cell. $\frac{1}{4} \cdot 12 + 1 = 4 \text{ Ni} \ \& \ 4 \text{ O}$
- b. The theoretical density for this material.

$$a = 0.140 + 0.140 + 0.069 + 0.069$$

$$= 0.418 \text{ nm}$$

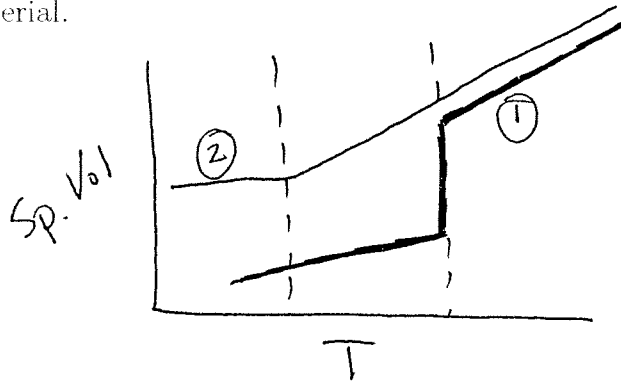


$$\rho \Rightarrow \frac{\text{g}}{\text{cm}^3} \Rightarrow \frac{\text{atom} \left(\frac{\text{g}}{\text{mol}} \right)}{\text{cm}^3 \frac{\text{atom}}{\text{mol}}}$$

$$\rho = \frac{4 \cdot 58.7 \frac{\text{g}}{\text{mol}} + 4 \cdot 16 \frac{\text{g}}{\text{mol}}}{(0.418 \text{ nm})^3 \cdot 6.02 \times 10^{23} \frac{\text{atom}}{\text{mol}}} = \frac{298.8 \text{ g}}{4.398 \times 10^{-5} \text{ m}^3}$$

$$= \frac{0.2988 \text{ kg}}{4.398 \times 10^{-5} \text{ m}^3} = 6793 \frac{\text{kg}}{\text{m}^3} \left(\frac{1000 \text{ g}}{\text{kg}} \right) \left(\frac{1 \text{ m}}{100 \text{ cm}} \right)^3 = 6.7 \text{ g/cm}^3$$

14. Sketch the specific volume versus temperature for 1) a crystalline material and 2) an amorphous material.



15. Do bulky (large molecular weight) side groups tend to increase or decrease the following:
a) the ability to crystallize.

decrease

b) The glass transition temperature (T_g). *increase*

c) the likelihood of chain entanglement. *increase*