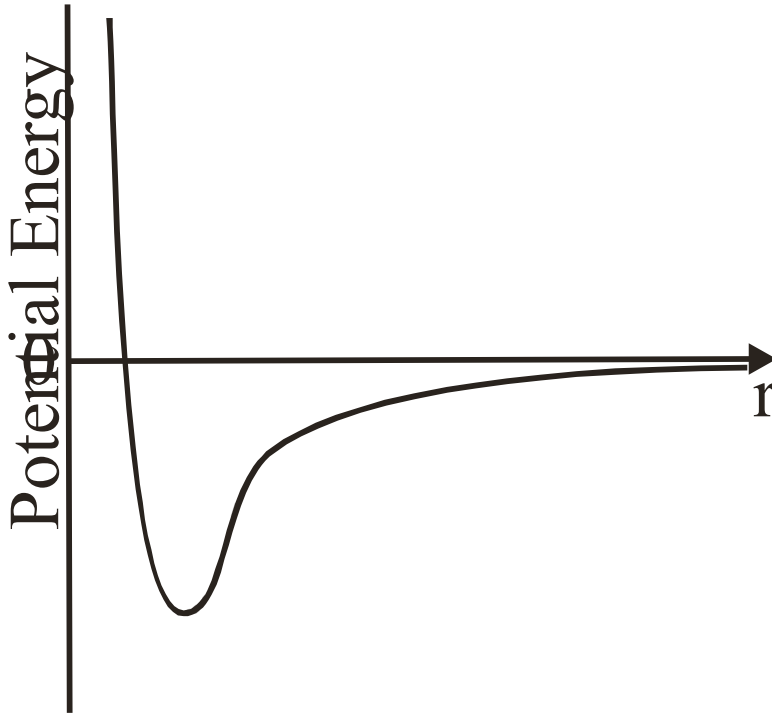


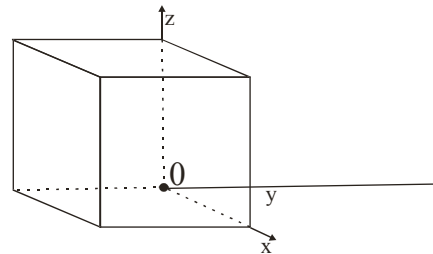
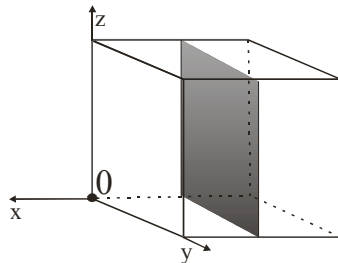
Question #1 (15 points) Mark the following statements as true or false (T or F).

- (1) A plane (111) of a cubic crystal has a triangular shape. _____
- (2) The normal direction to a plane (hkl) is [hkl] for all crystal structures. _____
- (3) The electrical resistivity is proportional to the sample length. _____
- (4) The equilibrium vacancy concentration of a pure metal decreases with increasing temperature. _____
- (5) In the normal diffusion process at a constant temperature, the average diffusion distance is proportional to the diffusion time. _____
- (6) Using a phase diagram, one can predict how quickly liquid turns into solid. _____
- (7) The mechanical strength of a brittle material is influenced by the length of a surface crack as well as by the crack tip radius. _____
- (8) Usually, mobility of an electron in n-type semiconductor increases proportionately with an applied voltage. _____
- (9) As long as Bragg's law is satisfied for a crystallographic plane (hkl), a diffraction peak should appear for that plane. _____
- (10) The tacticity of a polymer has no influence on the rate of crystallization. _____
- (11) Properties of a polymer at room temperature are uniquely determined when its composition and molecular weight are fixed. _____
- (12) In order to provide a galvanic protection of a metal A with a metal B, the metal B has to be more active (or anodic) than the metal A. _____
- (13) An n-type semiconductor can be produced by doping single crystal Si with boron _____
- (14) One can make metals stronger by making their dislocation motion more difficult. _____
- (15) The capacitance is reciprocally proportional the dielectric constant of the material employed. _____

Question #2. (12 points) The potential energy as a function of interatomic distance is sketched below.



- (a) (3 points) What are the physical origins of the potential energy?
- (b) (3 points) Sketch the inter-atomic force vs. distance curve and mark the corresponding points of the two curves.
- (c) (3 points) How is Young's modulus is related to the potential energy curve?
- (d) (3 points) How is thermal expansion coefficient related to the potential energy curve?
- (8) Iron (Fe) changes its crystal structure at $912\text{ }^{\circ}\text{C}$, from FCC at above $912\text{ }^{\circ}\text{C}$ to BCC below this temperature. Calculate the % volume change associated with this change of the structure, from FCC to BCC.
 - (2) Draw a (111) plane in a cubic crystal. Indicate x, y and z axes as well as the origin.
 - (2) Draw a [110] direction in a cubic crystal. Indicate x, y and z axes as well as the origin.
 - (4) Find out the (Miller) indices for the plane and direction shown below.



7. (4) What are the indices of the line of intersection of a (111) plane and a (111) plane in a cubic crystal?
8. (5) Calculate the atomic packing factor for HCP knowing $c/a=1.633$.
9. (10) For intrinsic semiconductors, the intrinsic charge carrier concentration, $n_i (= n = p)$ depends on temperature as follows:

$$n_i \propto \exp(-E_g/2kT) \text{ or } \ln(n_i) = A - E_g/2kT,$$
 A: constant; $k = 8.62 \times 10^{-5} \text{ eV/atom-K}$
 Experimental data for pure silicon showed that $\ln(\text{conductivity})$ vs. $1/T$ had a slope of $-5,833 \text{ (K)}$. Calculate E_g for silicon.
10. (4) Explain why the temperature dependences of the electric conductivity of semiconductors and metals are opposite.

$$\sigma = n|e|\mu$$