

Name _____ (*Please Print Your name*)**Exam-1: Chapters 1-3****Useful equations**

$$F \propto \Delta x, \quad \frac{F}{\Delta x} = aE, \quad \frac{\partial^2 U}{\partial x^2} = aE, \quad \frac{x_e - x_0}{x_0} = \alpha(T_e - T_0)$$

$$\text{BCC: } a_0 = \frac{4r}{\sqrt{3}}, \quad \text{FCC: } a_0 = \frac{4r}{\sqrt{2}}, \quad \text{HCP: } a_0 = 2r, \quad c = \left(\frac{4}{\sqrt{6}}\right)a_0$$

Critical r/R	0~0.155	0.155~0.225	0.225~0.414	0.414~0.732	0.732~1	1
CN	2	3	4	6	8	12

Packing factor = (Number of spheres x vol. of sphere) / vol. of unit cell

$$\rho_L = \frac{\text{Number of atoms centered along direction within one unit cell}}{\text{Length of the line contained within one unit cell}}$$

$$\rho_P = \frac{\text{Number of atoms centered on a plane within one unit cell}}{\text{Area of the plane contained within one unit cell}}$$

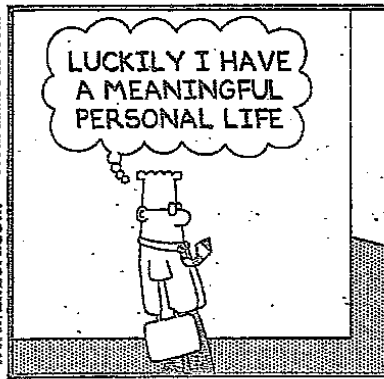
$$\text{APF} = \frac{(\text{Number of atoms in cell}) \times (\text{Volume of an atom})}{\text{Volume of the unit cell}}$$

$$\text{Bragg's law: } m\lambda = 2d_{hkl} \sin \theta$$

$$\text{Spacing between the planes: } d_{(hkl)} = \frac{a_o}{(h^2 + k^2 + l^2)^{\frac{1}{2}}}$$

$$\text{Angle between two directions: } \theta = \cos^{-1} \left[\frac{uu' + vv' + ww'}{(u^2 + v^2 + w^2)^{1/2} (u'^2 + v'^2 + w'^2)^{1/2}} \right]$$

Part	Points	Maximum
A		20
B		20
C		40
D		20
Total		100



Part A. (20 points, 2 points each)

PLEASE FILL IN THE BLANKS.

1. A type of secondary bond in which a temporary dipole induces another dipole in an adjacent atom is referred to as a _____ bond.
2. The principle, known as the _____ principle, states that no two interacting electrons may have the same four values for their quantum numbers.
3. The primary bonds formed between atoms with large difference in electronegativity are referred to as _____.
4. What symmetry elements does a water molecule have?
5. The energy required to remove an electron from an isolated neutral atom is referred to as its _____.
6. The _____ is the strongest type of secondary bond.
7. A lattice together with its basis is referred to as the _____.
8. The ratio of the volume occupied by the atoms to the total available volume is defined to be the _____ for the crystal structure.
9. The term _____ is given to fluids that show some degree of long-range order like molecular orientation.
10. The hard sphere, FCC (Face Centered Cubic) structure has the same packing density as what other close-packed structure?

Part B. (20 points, 2 points each)

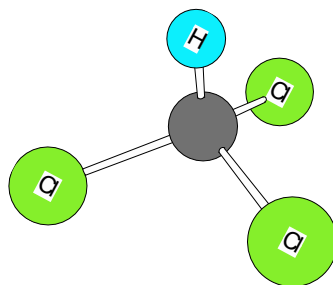
CIRCLE THE APPROPRIATE ANSWERS or WRITE THE ANSWERS AS REQUIRED

1. The coordination number of a(n) covalent / ionic bond is not simply determined by the radius ratio.
2. A lattice together with its basis is referred to as the unit cell / crystal structure.
3. How did we know that there are specific number of energy levels, say for H₂?
4. The lattice parameters of most metals are on the order of a few angstroms / nanometers.
5. Metals / ceramics / polymers have the highest density.
6. How many neutrons are there in an atom of the isotope ⁶⁰Co? [The atomic number is 27].
7. There is (are) 1 / 4 atom(s) per lattice point in FCC nickel.
8. The Spatial distribution of the electrons in orbits can be influenced by external fields (true/false).
9. The secondary bonds between water molecules result from induced / permanent dipoles.
10. Nematic liquid crystals possess long-range orientational order/long-range positional order/possess no order.

Part C. (40 points) ANSWER THE QUESTIONS

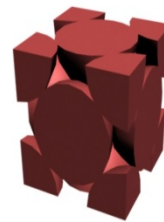
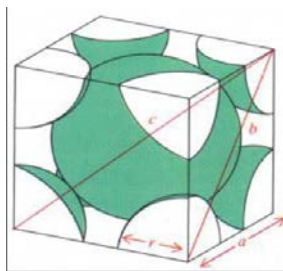
1. (10 Points) Symmetry is defined in terms of *elements* and *operations*: What are all the elements and operations?

2. (10 Points) What *symmetry elements* and *operations* do these objects possess? (you may not get them all but please make an attempt)



3. (10 points) Calculate the length of a face diagonal of Cr, a BCC metal. The atomic radius of Cr = 1.25 \AA .

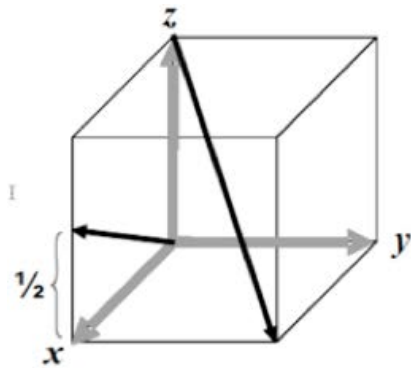
4. (10 points) Calculate the atomic packing factors for a BCC and an FCC structure.



Part D. (20 points) ANSWER THE QUESTIONS

1. (5 Points) What are the relationships between the radius of the sphere and the dimension of the cube edge that are necessary to calculate the packing factor using the hard sphere approximation for the FCC and BCC structures? Sketch a figure to accompany your answer.
2. (5 Points) Show the packing factor for $SC < BCC < FCC$.

3. (5 points, 2.5 points each) Determine the Miller indices of the two directions shown in the figure below.



4. (5Points) Write Miller indices of the points, and directions, in the cubic cell shown below:

Point A: _____

Point B: _____

Direction C: _____

Direction D: _____

