Name _____(<u>Please Print Your name</u>)

Exam-1: Chapters 1-3

Useful equations

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

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

Ī	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

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

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

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

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

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

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

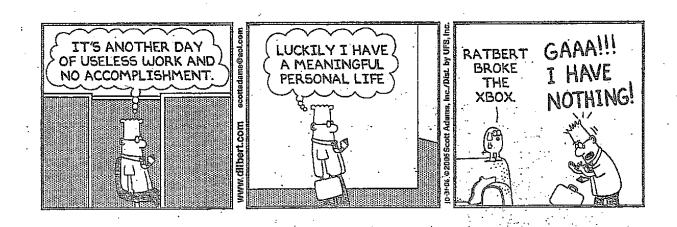
Part	Points	Maximum
A		20
В		20
С		40
D		20
Total		100

hydrogen	_		1151	15%	15-7	1.0	1550		1979	(3.5)	6.6%	11.75	65	(5)5	6.77	(5/5)	60 0	helium
Ĥ																		He
1.0079																		4.0026
lithium 3	beryllium 4												boron 5	carbon 6	nitrogen 7	oxygen 8	fluorine 9	neon 10
	D-												0.000	- 2	Ň		1,322	
Li	Be												В	C	N	0	F	Ne
6.941 sodium	9.0122 magnesium												10.811 aluminium	12.011 silicon	14.007 phosphorus	15.999 sulfur	18.998 chlorine	20.180 argon
11	12												13	14	15	16	17	18
Na	Mg												Al	Si	Р	S	CI	Ar
22.990	24.305												26,982	28.086	30,974	32.065	35.453	39.948
potassium	calcium		scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton
19	20		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.098	40.078		44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546	65.39	69.723	72.61	74.922	78.96	79.904	83.80
39.098 rubidium	40.078 strontium	7.	44,956 yttrium	47.867 zirconium	50.942 niobium	51,996 molybdenum	54.938 technetium	55.845 ruthenium	58,933 rhodium	58,693 palladium	63.546 silver	65.39 cadmium	69.723 indium	72.61 tin	74.922 antimony	78,96 tellurium	79,904 iodine	83.80 xenon
39.098 rubidium 37	40.078 strontium 38		44.956 yttrium 39	47,867 zirconium 40	50.942 niobium 41	51.996 molybdenum 42	54.938 technetium 43	55.845 ruthenium 44	58,933 rhodium 45	58,693 palladium 46	63.546 silver 47	65,39 cadmium 48	69.723 indium 49	72.61 tin 50	74.922 antimony 51	78.96 tellurium 52	79.904	83.80 xenon 54
39.098 rubidium	40.078 strontium		44,956 yttrium	47.867 zirconium	50.942 niobium	51,996 molybdenum	54.938 technetium	55.845 ruthenium	58,933 rhodium	58,693 palladium	63.546 silver	65.39 cadmium	69.723 indium	72.61 tin	74.922 antimony	78,96 tellurium	79,904 iodine	83.80 xenon
39.098 rubidium 37 Rb 85.468 caesium	40.078 strontium 38 Sr 87.62 barium	F7.70	44.956 yttrium 39 Y 88.906 lutetium	47.867 zirconium 40 Zr 91.224 hafnium	50.942 niobium 41 Nb 92.906 tantalum	51.996 molybdenum 42 Mo 95.94 tungsten	54.938 technetium 43 TC [98] rhenium	55.845 ruthenium 44 Ru 101.07 osmium	58,933 rhodium 45 Rh 102,91 iridium	58.693 palladium 46 Pd 106.42 platinum	63.546 silver 47 Ag 107.87 gold	65.39 cadmium 48 Cd 112.41 mercury	69.723 indium 49 In 114.82 thallium	72.61 tin 50 Sn 118.71 lead	74.922 antimony 51 Sb 121.76 bismuth	78.96 tellurium 52 Te 127.60 polonium	79.904 lodine 53 1 126.90 astatine	83.80 xenon 54 Xe 131.29 radon
39.098 rubidium 37 Rb 85.468 caesium 55	40.078 strontium 38 Sr 87.62 barium 56	57-70	44.956 yttrium 39 Y 88.906 lutetium 71	47.867 zirconium 40 Zr 91.224 hafnium 72	50.942 niobium 41 Nb 92.906 tantalum 73	51.996 molybdenum 42 Mo 95.94 tungsten 74	54,938 technetium 43 TC [98] thenium 75	55.845 ruthenium 44 Ru 101.07 osmium 76	58,933 rhodium 45 Rh 102,91 iridium 77	58.693 palladium 46 Pd 106.42 platinum 78	63.546 silver 47 Ag 107.87 gold 79	65,39 cadmium 48 Cd 112,41 mercury 80	69.723 indium 49 In	72.61 tin 50 Sn 118.71 lead 82	74.922 antimony 51 Sb 121.76 bismuth 83	78.96 tellurium 52 Te 127.60 potonium 84	79.904 lodine 53 1 126.90 astatine 85	83.80 xenon 54 Xe 131.29 radon 86
39.098 rubidium 37 Rb 85.468 caesium	40.078 strontium 38 Sr 87.62 barium	57-70 X	44.956 yttrium 39 Y 88.906 lutetium	47.867 zirconium 40 Zr 91.224 hafnium	50.942 niobium 41 Nb 92.906 tantalum	51.996 molybdenum 42 Mo 95.94 tungsten	54.938 technetium 43 TC [98] rhenium	55.845 ruthenium 44 Ru 101.07 osmium	58,933 rhodium 45 Rh 102,91 iridium	58.693 palladium 46 Pd 106.42 platinum	63.546 silver 47 Ag 107.87 gold	65.39 cadmium 48 Cd 112.41 mercury	69.723 indium 49 In 114.82 thallium	72.61 tin 50 Sn 118.71 lead	74.922 antimony 51 Sb 121.76 bismuth	78.96 tellurium 52 Te 127.60 polonium	79.904 lodine 53 1 126.90 astatine	83.80 xenon 54 Xe 131.29 radon
39.098 rubidium 37 Rb 85.468 caesium 55 Cs 132.91	40.078 strontium 38 Sr 87.62 barium 56 Ba 137.33		44,956 yttrium 39 Y 88,906 lutetium 71 Lu 174,97	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49	50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95	51.996 molybdenum 42 Mo 95.94 tungsten 74 W	54.938 technetium 43 TC [98] thenium 75 Re 186.21	55.845 ruthenium 44 Ru 101.07 osmium 76 Os 190.23	58,933 rhodium 45 Rh 102,91 iridium 77 Ir 192,22	58.693 palladium 46 Pd 106.42 platinum 78 Pt 195.08	63.546 silver 47 Ag 107.87 gold 79 Au 196.97	65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59	69.723 indium 49 In 114.82 thallium	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2	74.922 antimony 51 Sb 121.76 bismuth 83	78.96 tellurium 52 Te 127.60 potonium 84	79.904 lodine 53 1 126.90 astatine 85	83.80 xenon 54 Xe 131.29 radon 86
39.098 rubidium 37 Rb 85.468 caesium 55 Cs 132.91 francium	40.078 strontium 38 Sr 87.62 barium 56 Ba 137.33 radium	*	44,956 yttrium 39 Y 88,906 lutetium 71 Lu 174,97 lawrencium	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49 rutherfordium	50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95 dubnium	51.996 molybdenum 42 Mo 95.94 tungsten 74 W 183.84 seaborgium	technetium 43 TC [98] rhenium 75 Re 186.21 bohrium	55.845 ruthenium 44 Ru 101.07 osmium 76 Os 190.23 hassium	58,933 rhodium 45 Rh 102,91 iridium 77 Ir 192,22 meitnerium	palladium 46 Pd 106.42 platinum 78 Pt 196.08 ununnililum	63.546 silver 47 Ag 107.87 gold 79 Au 196.97 unununlum	cadmium 48 Cd 112.41 mercury 80 Hg 200.59 ununbium	69,723 indium 49 In 114,82 thallium 81	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadium	74.922 antimony 51 Sb 121.76 bismuth 83 Bi	78.96 tellurium 52 Te 127.60 polonium 84 Po	79.904 iodine 53 1 126.90 astatine 85 At	83.80 xenon 54 Xe 131.29 radon 86 Rn
39.098 rubidium 37 Rb 85.468 caesium 55 Cs 132.91 francium 87	40.078 strontium 38 Sr 87.62 barium 56 Ba 137.33 radium 88	× 89-102	44,956 yttrium 39 Y 88,906 lutetium 71 Lu 174,97 lawrencium 103	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49 rutherfordium 104	50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95 dubnium 105	51.996 molybdenum 42 Mo 95.94 tungsten 74 W 183.84 seaborgium 106	technetium 43 TC [98] rhenium 75 Re 186.21 bohrium 107	55.845 ruthenium 44 Ru 101.07 osmium 76 Os 190.23 hassium 108	58,933 rhodium 45 Rh 102,91 iridium 77 Ir 192,22 meltnerium 109	palladium 46 Pd 106.42 platinum 78 Pt 195.08 ununniliium 110	63.546 silver 47 Ag 107.87 gold 79 Au 196.97 unununlum 111	65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59 ununbium 112	69,723 indium 49 In 114,82 thallium 81	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadium 114	74.922 antimony 51 Sb 121.76 bismuth 83 Bi	78.96 tellurium 52 Te 127.60 polonium 84 Po	79.904 iodine 53 1 126.90 astatine 85 At	83.80 xenon 54 Xe 131.29 radon 86 Rn
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*Lanthanide series

* * Actinide series

lanthanum	cerium	praseodymium			samarium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	
57	58	59	60	61	62	63	64	65	66	67	68	69	70	
La	CA	Dr	Nd	Pm	Sm	Eu	Gd	Th	Dv	Но	Er	Tm	Vh	
La	CE	1 1	IAC		3111	Lu	Gu	10	Dy	110		1111	ID	
138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04	
actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	
89	90	91	92	93	94	95	96	97	98	99	100	101	102	
Λ -	Th	Do	11	Np	D	Λ	Cm	DI	Cf	Fs	Em	N/I al	NIO	
AC	III	ra	U	ND	Pu	Am	Cm	Bk	Cf	ES	ГШ	IVIC	IAO	
[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]	



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 or 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

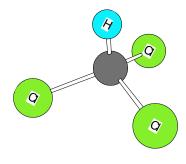
- 1. The coordination number of a(n) <u>covalent / ionic</u> bond is not simply determined by the radius ratio.
- 2. A lattice together with its basis is referred to as the unit cell / crystal structure.
- 3. How did we know that there are specific number of energy levels, say for H_2 ?
- 4. The lattice 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 <u>induced / permanent</u> dipoles.
- 10. Nematic liquid crystals possess <u>long-range orientational order/long-range positional order/possess no order.</u>

Part C. (40 points) ANSWER THE QUESTIONS

1. (10 Points) Symmetry is defined in terms of *elements* and *operations*: What are $\underline{\text{all}}$ the elements and operations?

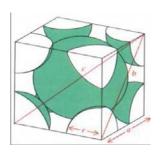
2. (10 Points) What *symmetry elements* and *operations* do these objects possess? (you may not get them all but please make an attempt)





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

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



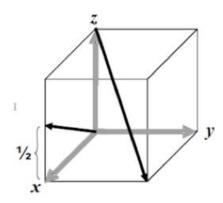


Part D. (20 points) ANSWER THE QUESTIONS

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:_____

