The University Of Jordan **Department Of Physics**

Introduction to Materials Science
Physics 0332201
Course Outlines
Fall 2010

Lectures Monday and Wednesday 12:30 - 2:00 pm,

Course Instructor
Dr. Ahmad Masadeh Department of Physics

Office hours: Monday and Wednesday (11:15 – 12:15). OR by appointment.

Course Description:
Modern science and technology is highly dependent on materials whose properties can be controlled to accommodate a wide range of applications. The multidisciplinary field of materials science outline approaches to enhance the synthesis of new materials, understand their properties, and specifically tailor characteristics for needs. The purpose of this course is to present to students the basic principles necessary to understand structure-property relations in different material types. The properties ranging from structural, electrical, optical to thermal in nature are all considered. Further, examples are given to discuss the manipulation of these structure-property relationships in terms of the engineering of materials for future needs.

Textbook
The Science and Engineering of Materials, 5th ed Donald R. Askeland – Pradeep P. Phulé

Assignments and Grades
Course requirements homework assignments (contributes 10% of the grade); a first exam (20%), second exam (20%) and final examination (50% of the grade). Assignments and their deadlines will be announced. Assignments must be turned in at the requested day before the class.

Course Outline
CH1: Introduction
CH2: Atomic Structure and Bonding
CH3: Crystal Structure and Characterization methods.
CH4: Defects in the Crystals and Growth
CH5: Diffusion

Resources

Other Reference Books and Materials:

1. *Foundations of Materials Science and Engineering*, 4th edition, by Smith W.F., Hashemi J.
2. *Materials Science and Engineering: an Introduction*, 6th edition, by Callister W.D.
3. *The Physics of Solids*, by Turton R., Oxford, 2000.
4. *Crystals and crystal structures*, by Tilley R.J.D., Wiley, 2006.
5. *Elements of X-ray diffraction*, 3rd edition, by Cullity B.D. and Stock S.R., Addison-Wesley, 1978.
6. *Crystal growth for beginners: fundamentals of nucleation, crystal growth, and epitaxy*, by Markov I.V.,World Scientific, 1995.

The University of Jordan Faculty of Science Physics Department	Introduction to Material Science (0332201) Oct. 25th , 2010 – First Semester First Exam. Time: 60 minutes	

الرقم الجامعي:	الاسم بالعربية:

(5 marks) Q1: Fill the brackets with [×] if the sentence is false and with [√] if the sentence is correct.

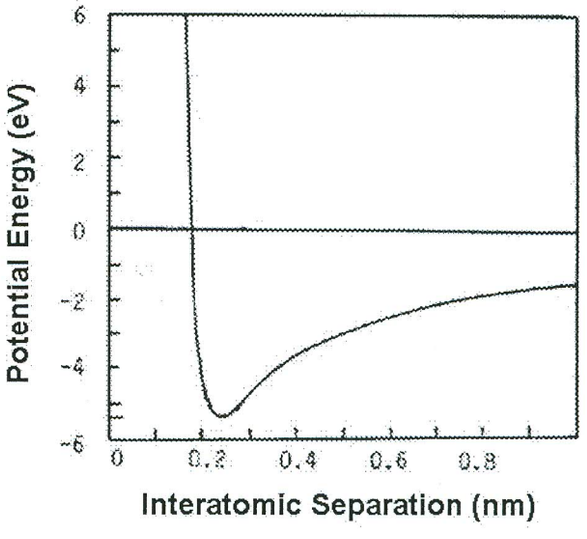
1- The electrical conductivity of many covalently bonded materials (silicon, diamond) is not high. [ ].
2- The Van der Walls force is originated from the fact that in some molecules the positive and negative centers are at different positions, this act as electrical dipoles. [ ].
3- In Triclinic structure, the lattice parameters $a=b=c$ and all angles are equal and none equals 90°. [ ].
4- The number of lattice points per cell in face-centred cubic (BCC) crystal system is 4. [ ].
5- Liquid crystals have long range order and short range order in small volumes. [ ].
6- The corrdination number in SC unit cell is 12. [ ].
7- Most metal and semiconductors have Long-Range Order (LOR). [ ].
8- In the nature there are fourteen types of Bravais lattices grouped in seven crystal systems [ ].
9- In Hexagonal structure, the lattice parameters $a=b=c$ and two angles are equal to 90° and one equal 120° [ ].
10- Atomic number is the number of protons or electrons in an atom. [ ].

(4 marks) Q2: **(a)** If the intermolecular bonding of the **XY** molecule is covalent bond and for the **RZ** molecule is Van der Walls force. Which molecule will have the higher melting temperature? Explain?

(b) Aluminum foil used for storing food weights about 0.3 g per square inch. How many atoms of aluminum are contained in one square inch of foil?

(4marks) Q3: The figure below shows the dependence of the net potential energy on the interatomic separation for two isolated atoms. Show the following on the figure.

1) The binding energy.
2) The interatomic separation at equilibrium.
3) Draw the corresponding force-distance curve showing the region at which the net force is attractive, and the region at which the net force is repulsive (explain).



(7 marks) Q4:

(a) Determine the relationship between atomic radius and lattice parameter in SC, BCC and FCC.

(a) Determine the crystal structure of a metal with $a_0 = 4.9489\ A^0$, $r = 1.75\ A^0$, and one atom per lattice point.

(c) Determine the electron configurations of the following ions. Fe^{2+} , Cu^{+} , S^{2-}

The University of Jordan Faculty of Science Physics Department	Introduction to Material Science (0332201) Dec. 15, 2010 – First Semester Second Exam Time: 60 minutes Dr. Ahmad Masadeh	

الرقم الجامعي:	الاسم بالعربية:

(3 marks) Q1:

(1) The number of lattice points per unit cell in the BCC crystal systems.

(a) 1 (b) 2 (c) 3 (d) 4 (e) 8

(2) If there is only two atoms located at each lattice point, the number of atoms per unit cell in the BCC crystal systems.

(a) 1 (b) 2 (c) 4 (d) 6 (e) 8

(3) If there is only one atom located at each lattice point, the number of atoms per unit cell in the FCC crystal systems.

(a) 1 (b) 2 (c) 4 (d) 8 (e) 16

(4) The packing factor for the hypothetical cell is 0.35, we can call this structure as :

(a) FCC (b) Open (c) BCC (d) SC (e) HCP

(5) The unit cell that we can build by stacking together close-packed planes in ...ABCABC… staking sequence is?

(a) HCP (b) BCC (c) FCC (d) SC (e) None

(6) The packing factor has a unit of:

(a) number/volume (b) 1/volume (c) volume (d) mass/volume (e) has no units

(4 marks) Q2:

(a) Determine the density of BCC iron, which has a lattice parameter of 0.2866 nm
Atomic mass = 55.847 g/mol Avogadro's number NA = 6.02 × 1023 atoms/mol

(b) A metal having a cubic structure has a density of 2.6 g/cm3, an atomic weight of 87.62 g/mol, and a lattice parameter of 6.0894 A^0. One atom is associated with each lattice point. Determine the crystal structure of the metal.

FCC

(5 marks) Q3:

Gallium has an orthorhombic structure, with a_0= 0.45258 nm, b_0 = 0.45186 nm, and , c_0 = 0.76570 nm. The atomic radius is 0.1218 nm. The density is 5.904 g/cm3 and the atomic weight is 69.72 g/mol. Determine

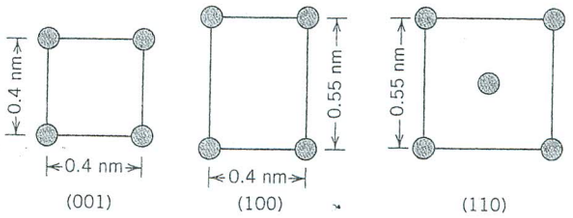
(a) the number of atoms in each unit cell; and 8
(b) the packing factor in the unit cell. 0.38

(3 marks) Q4:

Here are three different crystallographic planes for a unit cell of hypothetical metal. The circles represent atoms.

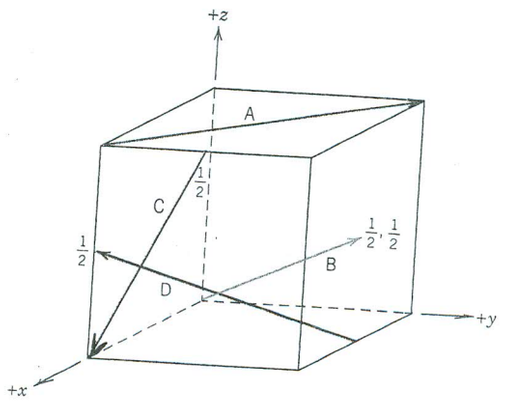
(a) To what crystal system does the unit cell belong?

(b) What would this crystal structure be called?

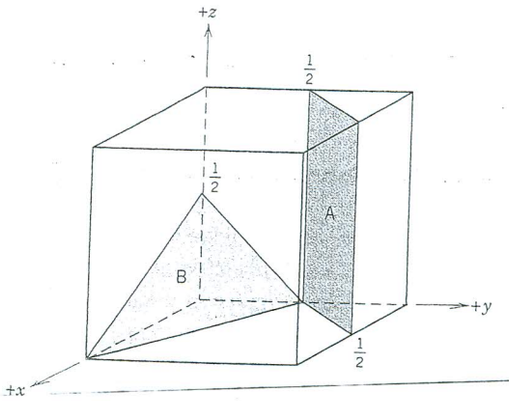


(5 marks) Q5:

(a) Determine the indices of directions *A*, *B*, *C* and *D* in the Figure.



(b) Determine the Miller indices of planes A and B in Figure



Good Luck..

The University of Jordan Faculty of Science Physics Department	Introduction to Material Science (0332201) Jan. 10, 2011 – First Semester Final Exam Time: 120 minutes Dr. Ahmad Masadeh	

الاسم بالعربية:	الرقم الجامعي:

(7 marks) Q1:

(1) The number of atoms in 100 g of silver are :

(a) 5.58×10^{23} (b) 17.92×10^{25} (c) 1.61×10^{23} (d) 6.023×10^{23} (e) 2.78×10^{23}

(2) A diffracted x-ray beam is observed from (311) planes of unknown material at a 2θ angle of 78.3° when x-rays with of 0.15418 nm wavelength are used. The lattice parameter of the material (in nm) is:

(a) 0.2866 (b) 0.45258 (c) 0.54307 (d) 0.3589 (e) 0.40497

(3) If there is only two atoms located at each lattice point, the number of atoms per unit cell in the FCC crystal systems.

(a) 1 (b) 2 (c) 4 (d) 6 (e) 8

(4) Imperfections, such as vacancies, that are located typically at one sites in the crystal, such defects are called:

(a) Point (b) Extended (c) Vacancy (d) Interstitial (e) Substitutional

(5) The coordination number of octahedral site is:

(a) 2 (b) 3 (c) 4 (d) 6 (e) 8

(6) The unit cell that we can build by stacking together close-packed planes in ...ABABAB... staking sequence is?

(a) HCP (b) BCC (c) FCC (d) SC (e) None

(7) Materials, including glasses, that have no long-range order, or crystal structure are called?

(a) Crystal (b) Powder (c) Amorphous (d) Liquid crystal (e) None

(6marks) Q2:

For (CsBr), (a) would you expect the compound to have the cesium chloride, sodium chloride, or zinc blend structure? (b) Calculate the lattice parameter. (c) Calculate the packing factor for the compound

(5 marks) Q3:

(a) Calculate the number of electrons capable of conducting an electrical charge in ten cubic centimeters of silver.

(b) Determine the density of BCC iron, which has a lattice parameter of 0.2866 nm
Atomic mass = 55.847 g/mol Avogadro's number NA = 6.02 × 1023 atoms/mol

(5marks) Q4:

The planar density of the (112) plane in BCC iron is 9.94 × 1014 atoms/cm2. Calculate (1) the planar density of the (110) plane and (2) the interplanar spacings for both the (112) and (110) planes. On which plane would slip normally occur?

(6 marks) Q6:

The results of a x-ray diffraction experiment using x-rays with $\lambda = 0.7107$ Å (a radiation obtained from molybdenum (Mo) target) show that diffracted peaks occur at the following 2θ angles:

Peak	2θ	Peak	2θ
1	20.20	5	46.19
2	28.72	6	50.90
3	35.36	7	55.28
4	41.07	8	59.42

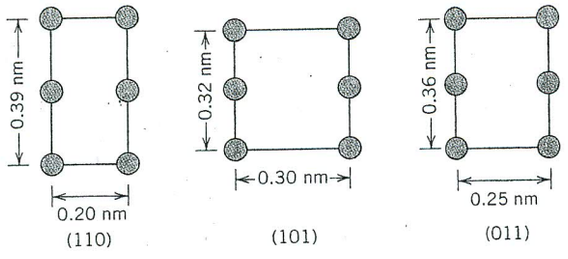
Determine the crystal structure, the indices of the plane producing each peak, and the lattice parameter of the material

(5marks) Q6:

The yield strength of mild steel with an average grain size of 0.05 mm is 20,000 psi. The yield stress of the same steel with a grain size of 0.007 mm is 40,000 psi. What will be the average grain size of the same steel with a yield stress of 30,000 psi? Assume the Hall-Petch equation is valid and that changes in the observed yield stress are due to changes in dislocation density.

(6marks) Q7:

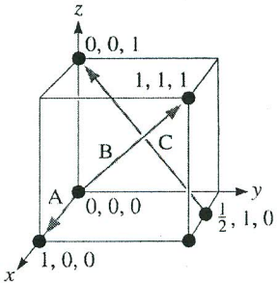
Below are shown three different crystallographic planes for unit cell of some hepothetical metal. The circles represent atoms.



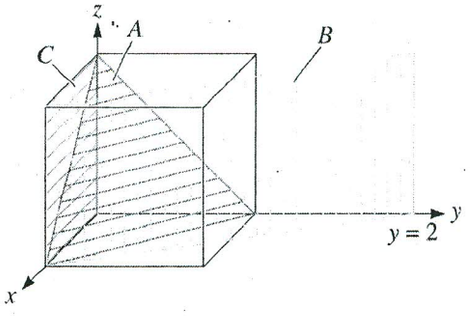
(a) To what crystal system does the unit cell belong?
(b) What would this crystal structure be called?
(c) If the density 18.91 g/cm^3, determine is atomic weight.

(9 marks) Q8:

(a) Determine the Miller indices of directions *A*, *B*, and *C* in the Figure.



(b) Determine the Miller indices of planes A, B, and C in Figure



Good Luck…