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**Department of**  **Physics,**

**College of Education,**

**University of Salahuddin-Erbil .**

**Subject: Materials Science**

**Course Book ( 4th Year )**

**Lecturer's name Asst. Prof. Dr. Ayoub Sabir Karim**

**Academic year : 2022/2023**

**Course Book**

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| **1. Course name** | Materials Science  |
| **2. Lecturer in charge** | Asst. Prof. Dr. Ayoub Sabir Karim |
| **3. Department/ College** | Physics, Education,  |
| **4. Contact** | **e-mail:** **ayoub.karim@su.edu.krd** **dr.ayoubsk@yahoo.com** **Tel: 0750 453 5160** |
| **5. Time (in hours) per week**  | **Theory: 2 hours/week** |
| **6. Office hours** | **Availability of the lecturer to the student during the week** |
| **7. Course code** |  |
| **8. Teacher's academic profile**  | **•** 1981 took baccarat, Kurdistan properties School, Erbil, Iraq **•** 1987B.Sc. in Physics, department of physics , college of Education, University of Salahaddin, Erbil, Iraq **•** 1994 M. Sc. In Solid state physics, College of science University of Salahaddin-Erbil **•** 2000 M. Sc. In Solid state physics, College of science University of Baghdad , Iraq . **•** 2007 Ph.D. In Material science , University of Baghdad,  Iraq. **•** 2013 Certificate of Continuing Education ( English for  professional purpose), Glyndŵr University, Wrexham, Wales, U.K.  |
| **9. Keywords:**  | Metals, alloys ,ceramic, glasses, Crystal Structure, Lattice ,Miller Indices, Lattice. Primitive Cell, atomic bonding, crystal defects, diffusion , Fick’s law. |
| **Course overview** In the 1st part of materials science the engineering materials will be studied including classification of solid materials according to the material properties, will be classified in the form electric conductance, atomic bonding, magnetic properties, lattice types, thermal properties, thermal dilation , and etc . In the 2nd part the structure of crystalline solid materials will be studied including the crystallography of solid, formation of lattices in the shape of bulk crystalline form will be discussed in form of crystalline structure in one, two and three dimensional crystal system. The type of crystals and related factors will be given. The crystal planes will also be given briefly. In the 3rd part atomic bonding and coordination will be studied including electronic configuration of inert gasses to understand the information and formation of the bonds, from this we understand how the bonds can be classified according to their strength to primary and secondary bonds, from the two we understand properties of ionic solids, covalent bond, metallic bon, dispersion bond, dipoles bond and hydrogen bond. In this case the factors that can change the bond length are the most important subjects to be understand. The **4th** part is defects in solid materials, in this part, the crystal defect will be explained according to classification of defects in crystalline solid materials. The information will lead to understand the crystal defects such as point defect, vacancies, extra atoms, schottky defect, Frenkel defect, lattice defect, line defect and surface defect . In the **5th** part of the subject in this course the diffusion in solids will be given. The classification of diffusion, the mechanism of diffusion, and Fick’s laws of diffusion will be the subject of this part. |
| 11. Course objective: There are some topics necessary to discuss, such as, properties of engineering materials, the structure of crystalline solids, the type of bonding, defects in solids, diffusion, dislocations and strengthening mechanisms, those properties are important topics serve his BSc students.  Nowadays a new technology is appeared which is called, nanotechnology. This field in interring all subjects from physics to chemistry, Medicine, Biology, Pollution, Engineering, ….. How to understand nanotechnology, we need to understand materials science, Nanotechnology is the technology of how the material can be made in a size as small as in nanometer range, precisely below 100 nm. We need to understand its formation and properties as well its application  |
| **12. Student's obligation** ·Read the course syllabus carefully. If you have any question (s) about course content or assessment, please see me or bring up the question (s) by the second  class meeting; · You are expected to attend all class ( illness, family emergency, participation in sport or arts competition or club conference ), please notify me before your absence. You are also expected to prepare for all lecture session, and to turn in assignments on time. Late assignments will not be accepted.  · Pay careful attention in class, prepare for each class session, ask questions if you do not understand a particular topic, and be respectful to your classmates and professor, practice |
| **13. Forms of teaching**Datashow and Presentation, whiteboard, Blackboard, sheet |
| **14. Assessment scheme** **University of Salahaddin Materials Science 4th Year Physics****College of Education Quiz ( Short Examination) Duration time: 20 minutes** **Department of Physics 2021– 2022 Date : 2021****Asst. Prof. Dr. Ayoub Sabir Karim***Note; Answer all questions. All questions, branches and sub-branches have* equal marks .**Q1.** **A-** Fill in the blanks; 1- The nearest neighbor distance in the case of bcc structure is ……  2- The number of atoms present in the unit cell of hcp structure is ……. 3- The number of lattice points in a primitive cell are …… 4- The nearest neighbor distance in the case of fcc structure is … 5- The number of ions present in the unit cell of CsCl is …….  **B-** a-Draw the 3d diamond crystal structure indicating 1- Corner lattices, Face  lattices and only one of its internal lattices with its bonding b-Draw the projected on a cubic face for your answer in (a) above indicating all  corner, faces and internal position lattices **Q2. –**In a three dimensional cubic lattice with a lattice of **a**, draw the **hkl** plane of (**122**) **………………………………………………………………………………………………………………….** **Sample Examination Questions and their Answer notes****University of Salahaddin -Erbil Materials Science 4th Year Physics****College of Education First sessional class test Duration time: 1 hour** **Department of Physics 2021– 2022 Date : 4 Nov 2021****Asst. Prof. Dr. Ayoub Sabir Karim** ***Note; Answer all questions.*** **Q.I – A-** How the solid materials can be classified according to their properties? ***(15 marks)*** **B-** What is the difference between crystalline and non-crystalline solids? (***10 marks)*** **Q.2 -** The Potassium chloride( KCl ) crystallizes in the Sodium chloridestructure, in which the cube cell edge **a0** is **6.3 Aº**. Find the following: **(i)** The length of Bravai cell edge. **(ii)** The number of Bravai cell atoms and the type of them. **(iii)** Indicate the important planes, sequence of these planes and the  inter planar distance between them. ***( 25 marks)***  **Q.3 –** Determine the planar density of Ni **(FCC structure) in (100)** plane. Given, the radius of Ni  atom =1.245 A°.  ***(25 marks)*** **Q.4 –** Show that the **ATOMIC PACKING FACTOR** in **FCC** structure is $π/(3\sqrt{2).}$ ***( 25 marks)***.  **SECOND TERM****University of Salahaddin Materials Science 4th Year Physics****College of Education Final examination Trial Duration time: 3 hours** **Department of Physics 20.. – 20.. Date : 20..****Asst. Prof. Dr. Ayoub Sabir Karim*****Note; Answer all questions.*** **Q.I.** (**A)-**What do understand by crystal imperfections? Discuss the similarities and  differences between Schottkly and Frenkel defects. **(*10 mark*)**  (**B)-**Discuss in brief the lattice defects. How these defect affect the properties of  materials?  ***(10 marks )*** **QII.** (**A)**- What do you understand by Burgers vector? What are the the relative orientations of Burgers vector and dislocation line are? . **(*10 mark*)**  (**B)-** What is a solid solution? Explain (i ) Substitutional solid solution and  (ii) Interstitial solid solution. Write two examples of each in alloy system.  **(10 *mark*)**  **QIII**. Choose the most appropriates answer:**1**-The unit of diffusion coefficient is (1) m2 s1 or atomsm-2 s-1 (2) atomsm2 s-1 (3) molesm3 s-1 (4) molesm-1 s-1   . **2-**The unit flux J is(1) mole m-2 s-1 or (2) atoms m2 s-1 (3) moles m2 s-2  (4) molesm2 s2 . **3-**Substitution definition becomes possible if 1. The temperature of solid solution is sufficiently high.
2. The activation energy for vacancy formation is low.
3. Atoms are significantly different in size.
4. Vacancies are present in substitutional solid solution.

 **4-**Formetal atoms, the most probable mechanism of diffusion is 1. Vacancy mechanism. (3) Direct interchange mechanism.
2. Interstitial mechanism. (4) Non of the above.

 **5-**The dependenceof diffusioncoefficient on temperature in a certain temperature range is described by1. D= D˳ exp (Q/T) (3) D= D˳ exp (-Q2/RT)
2. D= D˳ exp (-Q/RT) (4) D= D˳ exp (Q4/RT)

 **6-**The fastest diffusion coefficient in Fe is1. C (2) W (3) Ni (4) H

 **7-** Fick՚ s first law of diffusion is applicable under1. Steady state condition of mass flow
2. Non-sready state conditions
3. Steady as well as non-steady state conditions
4. Non on the above.

 **8-** In the presence of impurities and ddeviation from stoichiometry, the diffusion rate of  Ions in ionic crystals1. Enhances (2) decrease (3) remains unaffected (4) first decrease and enhances.

 **9-** In comparison to lattice diffusion , the activation energy for diffusion along surfaces and grain boundaries is 1. Higher (2) lower (3) almost negligible (4) infinite .

 **10-** When ice , water vapor coexist in equilibrium, the degree of freedom are 1. 0 (2) 1 (3) 2 (4) 3 **(20 marks)**

**QIV.** Fill in the blank spaces:1. The ……………. and …………… dislocations are the limiting types of the imperfections.
2. ……………. Are those associated with one or two atomic positions, including ………. , ………. , and ……….. .
3. A ………… is an infinite array of points, all with identical surroundings.
4. Diffusion is the transfer of ………….. atoms which is accompanied with a chang of concentration of the components in certain zero of an ……………. .
5. ………….. are the combination of two or more metals into one material .

 **( 20 marks )** **QV**. **(A)** What is the significance of phase diagram? **(10 marks)** **(B)** Determine the degrees of freedom of a system of two components, when the  number of phases is one, two , three etc. **(*10 marks*)**   |
| **15. Student learning outcome:** Materials science is one of the subjects which serves students in Physics, Inorganic chemistry, solid state physics, Mechanical Engineering and electronic engineering for understanding the formation and electronic properties of solid materials. In Medical Physics people needs to understand how solid materials can be used to detect radiation signals such as X-ray, Gamma ray and cosmic ray. Understanding Solid State materials will also help to understand how instruments such as CT scan, MR imaging, digital camera, photo detectors and many other similar instruments are working. The information will also give abilities to people to improve their mind to understand and build new instrumentsNowadays a new technology is appeared which is called, nanotechnology. This field in interring all subjects from physics to chemistry, Medicine, Biology, Pollution, Engineering, ….. How to understand nanotechnology, we need to understand solid state physics, Nanotechnology is the technology of how the material can be made in a size as small as in nanometer range, precisely below 100 nm. We need to understand its formation and properties as well its application  |
| **16. Course Reading List and References‌:**Materials Science and Engineering An Introduction, William D. Callister, Jr .Rudiments of Material science . S.O. Pillai Engineering materials Technology W. BoltonIntroduction to Solid State Physics, 8th Edition 2008 *C. Kittel*,Crystallography 1983  *R Stedman* |
| **17. The Topics covered:** |  |
|   **CHAPTER ONE**classification of solid materials according to the material properties, electric conductance, atomic bonding, magnetic properties, lattice types, thermal properties, thermal dilation , and etc .Classification of Engineering Materials, Metals and Alloys, Ceramics and Glasses,Organic polymers.**CHAPTER TWO****The Structure of Crystalline Solids**The Language of Crystals One dimensional monoatomic Bravais lattice, Two Dimensional monoatomic Bravais Lattice, Three Dimensional monoatomic Bravais Lattice,Three Dimensional Lattice with a Basis , Relation to Theory of ElasticityDescribing the Lattice Translation Vector, Linear Lattice, Space LatticePrimitive CellThe Space LatticesElements of Symmetry Rotational Symmetry, Reflection Symmetry, Inversion SymmetryCrystal Planes and Miller IndicesInter Planer SpacingReciprocal Lattice and the Diffraction (Reflection) of Waves by a CrystalThe Reciprocal Lattice and the Bragg Law Diffraction Condition**CHAPTER THREE****Atomic bonding and coordination**, Electron configuration of inert gasses, Formation of a molecule, Bond length, The ionic valence, Temperature, Number of adjacent atoms, Classification of bonds according to their strength, Primary bonds, Secondary bonds.**7th Week:** First Examination**CHAPTER FOUR** **Imperfections in solids**Crystal defect, Classification of crystal defect, Point defect, Vacancies, Extra atoms, schottky defect, Frenkel defect , lattice defect Line defect, Surface defect**CHAPTER FIVE** **Alloys and Slowly Cooled Alloys**Solid solution, Interstitial solid Solution, Substitutional Solid Solution, System, Phase, Equilibrium Phase diagram , Phase Rule, Derivation of Equilibrium Phase diagram, Predication of Composition of phase, Predication of Quantities of phase **CHAPTER SIX****Diffusion in Solids**Classification of diffusion, Mechanism of diffusion, Fick’ s Laws of Diffusion**15th Week :** Second Examination | 5 weeks4 weeks4 weeks  3 weeks 2 weeks2 weeks |
| **18. Practical Topics (If there is any)** |  |
| In this section The lecturer shall write titles of all practical topics he/she is going to give during the term. This also includes a brief description of the objectives of each topic, date and time of the lecture  | Lecturer's nameex: (3-4 hrs)ex: 14/10/2015 |
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| **20. Extra notes:** Encourage students to read and concerning the course book, as we know that all students does not reading it ,at all. |
| **21. Peer review پێداچوونه‌وه‌ی هاوه‌ڵ**   |