# Engineering Materials (INGE 4001)
# 1st Exam – Group -Bonus

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Name :_____ _____

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Section :_____ Date : February 24th, 2005

Notes:
This is an open book examination. Items needed are calculators, pencils, pens and rulers. This exam consists of two parts. Please write in a clear and concise manner.
Total Points = 100 Time Allowed : 80 minutes

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**PART A (76 Points).**

All questions have equal weight (i.e. 3 point/question) unless otherwise specified. Mark the appropriate answer with a clear X inside the parenthesis.

1. (5 points) We want to plate a copper coin with a 75at%Cu-25at%Ni alloy. The coin has a surface area of 6 $cm^2$ with a 0.01cm thick layer of a, how many grams of nickel are required for the plating? Density of the 75at%Cu-25at%Ni alloy = 8.94$g.cm^{-3}$; Atomic Weight of Nickel = 58.71$g.mol^{-1}$, Atomic Weight of Copper = 63.55$g.mol^{-1}$

A ( ) 0.126
B ( ) 0.252
C ( ) 0.536
D ( ) 1.073

2. Calculate the number of atoms of nickel needed in question (1):

A ( ) $1.296x10^{21}$
B ( ) $2.59x10^{21}$
C ( ) $5.18x10^{21}$
D ( ) $1.04x10^{22}$

3. (5 points) Suppose that liquid nickel is cooled at a temperature of 1246K until homogeneous nucleation occurs. Calculate the critical radius (in nanometers) of a homogeneous nucleus. Data : For ***Ni (FCC), $T_F$=1453$^oC$***; Heat of fusion (***$\Delta Hf$***) = 2756J/cm$^3$; Surface Energy (***$\gamma$***) = 255x10$^{-7}$ J/cm$^2$; Lattice parameter of FCC copper = ***a=0.356nm***

A ( ) 1.938
B ( ) 4.85
C ( ) 1.30
D ( ) 0.665

4. The number of nickel atoms required to form the critical radius in question 3 is:

A ( ) 218
B ( ) 109
C ( ) 2180
D ( ) 10900

5. (5 points) Suppose that the liquid nickel in question 3 now is able to nucleate homogenously with an undercooling of ***($\Delta T$) 22$^oC$***. How many atoms would have to group together spontaneously for this to occur? Note: Undercooling (temperature difference in $^oC$)

A ( ) 3.3x10$^8$
B ( ) 2.1x10$^{12}$
C ( ) 1.1x10$^6$
D ( ) 0.66x10$^3$.

6. For an ASTM grain size number 12, calculate the number of grains per square inch at a magnification of 100

A ( ) 2048
B ( ) 1024
C ( ) 612
D ( ) 306

7. (5 points) The density of BCC iron is 7.882g.cm$^{-3}$ and the lattice parameter is 0.2866nm when hydrogen atoms are introduced at the interstitial positions. Calculate the atomic fraction of hydrogen atoms in the alloy. Data: Atomic Mass of Fe = 55.847g/mol and Atomic Mass of H = 1.008g/mol

A ( ) 0.1
B ( ) 0.4
C ( ) 0.02
D ( ) 0.004

8. A metal having a cubic structure has a density of 1.892g.cm$^{-3}$, an atomic weight of 132.91g/mol, and a lattice parameter of 6.183 Angstroms. Determine the crystal structure of the metal. Hint: One atom is associated with each lattice point.

A ( ) BCC
B ( ) FCC
C ( ) SC
D ( ) none of the above

9. Which one of the following statements is not correct?
A ( ) in an element its anion is larger than its atomic size
B ( ) during allotropic transformation the volume of the material changes.
C ( ) isotopes of the same element have the same number of protons.
D ( ) during allotropic transformation the number of atoms in the material changes.

10. The directions, where BCC and FCC ordered atoms maintain contact, are:
A ( ) the <110> and <100> directions respectively
B ( ) the <100> and <110> directions respectively
C ( ) the <111> and <110> directions respectively
D ( ) they maintain contact in all directions.

11. If a material present the following characteristics: poor electrical and thermal conduction; it have a low density; it has low elastic modulus. Then we are describing
A ( ) a ceramic material
B ( ) a metallic material
C ( ) a semiconductor
D ( ) a polymeric material

12. The isotopes are

A ( ) atoms of different element that have same atomic masses.
B ( ) atoms of the same element with different number of neutrons.
C ( ) electrically charged atoms.
D ( ) atoms with different number of protons in the nucleus.

13. Which of the following factors **is not** a contributing factor on the high solubility of a solute in a solvent (Hume-Rothery rules)
A ( ) the crystal structure of the solvent and solute.
B ( ) the electronegativity of the solvent and solute.
C ( ) the size of the solvent and solute atoms.
D ( ) the dislocations on the solvent and solute atoms

14. (5 points) Calculate the ionic packing factor (IPF) of MgO, which has the NaCl structure. ($r_{Mg2+}$=0.066nm; $r_{O2-}$=0.132nm)?

A ( ) 0.157
B ( ) 0.597
C ( ) 0.698
D ( ) 0.941

15. Using the information in question 14, calculate the density of MgO in $g.cm^{-3}$. Data: the atomic weights of Mg and O are 24.31 and $16g.mol^{-1}$ respectively.

A ( ) 2.22
B ( ) 1.80
C ( ) 4.31
D ( ) 14.31

16. (5 points) Suppose that four Schottky defects are present ten unit cells of MgO of questions 14 and 15. Calculate the density of the ceramic in $g.cm^{-3}$.

A ( ) 4.31
B ( ) 3.88
C ( ) 2.10
D ( ) 14.20

17. (5 points) BCC lithium has a lattice parameter of $3.5089 \times 10^{-8}$cm and contains 1 vacancy every 50 unit cells. Calculate the number of vacancies per cubic centimeter:

A ( ) $1.2 \times 10^{10}$
B ( ) $2.51 \times 10^{21}$
C ( ) $9.25 \times 10^{20}$
D ( ) $4.628 \times 10^{20}$

18. (5 points) Calculate the density of lithium (in $g.cm^{-3}$) for question 17. Data: Lattice parameter: 0.3509nm and Atomic Mass of Li: 6.94g/mol

A ( ) 0.528
B ( ) 0.570
C ( ) 0.735
D ( ) 0.450

19. Indicate which one of the following ***statements is not correct*** in heterogeneous nucleation:
A ( ) the critical radius of heterogeneous nucleation is the same as the critical radius of homogeneous nucleation
B ( ) heterogeneous nucleation makes use of solid impurities that exist in the liquid.
C ( ) inoculation is the intentional addition of solid particles to the liquid to aid nucleation
D ( ) the higher the wetting angle ($\theta$), the easy is the heterogeneous nucleation.

20. Which one of the following point defects is present in the Fe-C alloys?
A ( ) interstitial defect
B ( ) substitutional defect
C ( ) screw dislocations
D ( ) schottky defects

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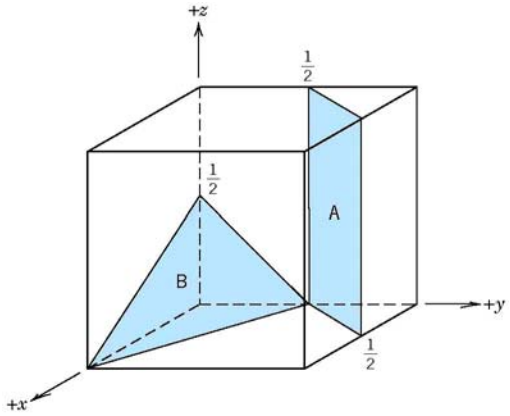
**PART B (24 points)**

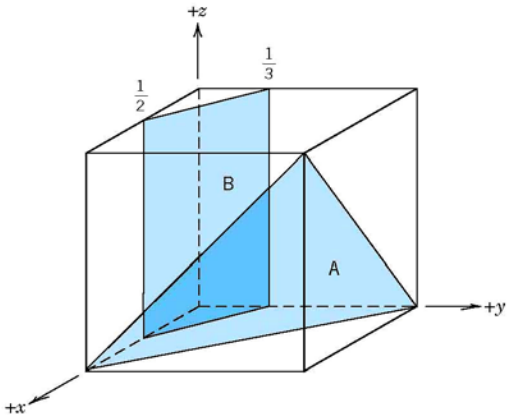
**B1 (14 points).** Calculate the activation energy (in eV) for the formation of vacancies in magnesium, knowing that the number of vacancies at 450°C is $2.71 \times 10^{16}$ vacancies.cm$^{-3}$ and at 600°C is $3.17 \times 10^{17}$ vacancies.cm$^{-3}$. Data: $k_B = 8.62 \times 10^{-5}$ eV/K
Hint. Use the Arrhenius equation at two temperatures and divide.

**B2. (10 Points)**



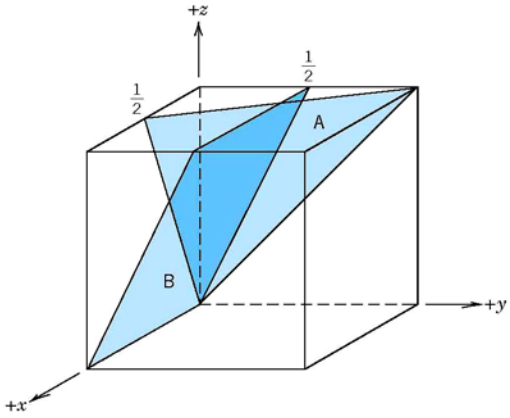

Plane A……..

Plane B……




Plane A……..

Plane B……




Plane A……..

Plane B……

Direction A …….

Direction B …….

Direction C …….

Direction D …….