**COE-C2004 - Materials Science and Engineering**
**2021-2022 Autumn II**

**Assignment 6, 07.12.2021**

**Review & self-testing** (100 points, Lectures 1-12)
*You are recommended to complete A6 as a self-testing after reviewing the lectures. Group work is not recommended for this assignment! It is suggested to run a time meter before the start and record your time for finishing A6.*

**General rules:**

1. When required, always show the step-by-step derivation or calculation processes, without which hinting the number does not qualify for grades.
2. When required, always give a brief and concise explanation or description, without which hinting the right choice or answer does not qualify for grades.
3. Citation is necessary if you are using any figures/data that are not generated by yourself.
4. Handwriting/plotting is acceptable, just make sure that your handwriting/final photo in the system is clear enough, otherwise it may affect the grading for details/calculation process.
5. Please make sure that your scanning documentation is clear enough for evaluation.
6. Only PDF type file is accepted for submission, please summarize all your answers/solutions in one PDF file for every assignment. It is appreciated to sort the PDF pages in the TaskNr order, which is helpful to speed up the evaluation process. Please name your assignment files with the assignment number and your first name and surname, and link them with short underlines: 'ANr_Firstname_Surname.pdf', e.g. for the first Assignment 'A1_Wenqi_Liu.pdf'.
7. Assignment 6 will take 6 points in the final grade system.
8. No extension submission is allowed for A6. The deadliane is 18:00 12.12.2021. The solution will be published at 18:30, 12.12.2021.

**Due date: 18:00, 12.12.2021.**
**Contact: MyCourses 'General discussion' channel**

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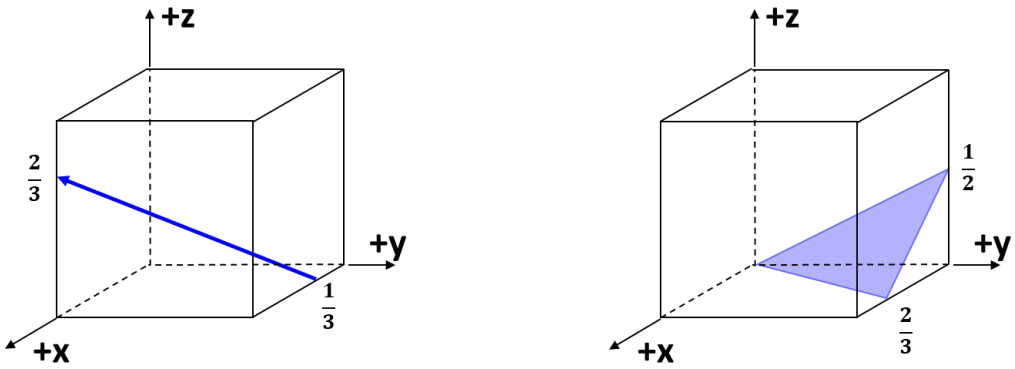
**1** Materials Science and Engineering is the study of material behavior & performance and how this is simultaneously related to structure, properties, and processing. Link the following terms to their corresponding fields. e.g. Annealing-Processing.
Terms: Density, Extrusion, Crystalline, Amorphous, Elastic Modulus.
Fields: Structure, Property, Processing

**2** _____ bonding is similar to ionic bonding, except there are no high-electronegativity atoms present to accept any electrons that the present atoms are willing to donate. _____ bonds are responsible for binding atoms together within a molecule of propane, whereas _____ bonds bind separate propane molecules together in a condensed state (liquid or crystal). _____ bonds are the only primary bonds that are directionally dependent. Materials whose constituent particles are bound by _____ bonding are generally expected to have the lowest melting temperatures.
Choose and fill the blanks from the following options:
(a) Covalent (b) Ionic (c) Van der Waals (d) Hydrogen (e) Metallic

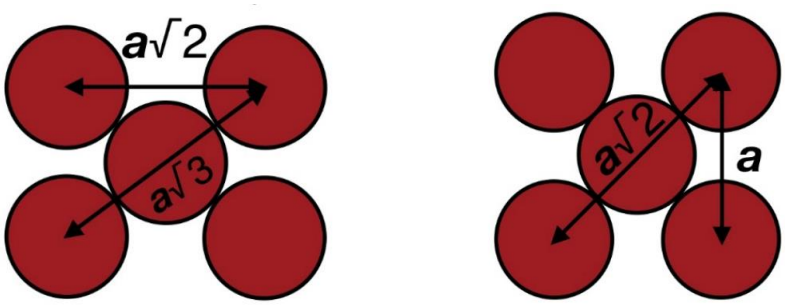
**3** (a) Give the Miller indices for the direction represented by the blue vector and the plane filled by the blue area that have been drawn within a unit cell in Figure 1.




(a-1) (a-2)

Figure 1 Drawings for Q3 (a).

(b) Figure 2 shows two kinds of atomic packing of a plane in a cubic unit cell; atoms drawn to full size are represented by the circles, i.e. the hardball model is used; a represents the unit cell length. Give the Miller indices for the possible crystal plane family and the corresponding structure (e.g. an example for the answer format: FCC {111} planes).




(b-1) (b-2)

Figure 2 Drawings for Q3 (b).

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**4** Consider the schematic nanostructure depicted in Figure 3. Name the structure defects in this region marked with 1, 2, 3, 5, 6, 7.

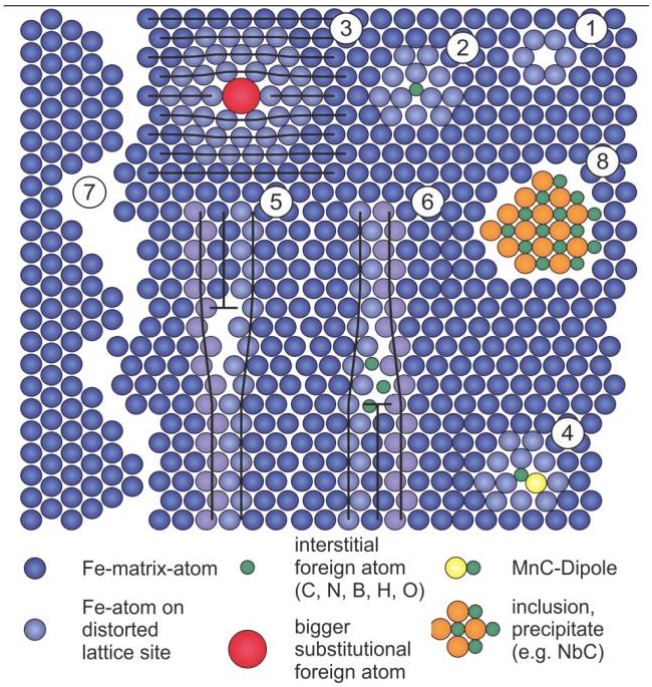


Figure 3 Drawings for Q4.

**5** Draw the schematic curves for (a) the BCC transition curve from Charpy testing; (b) S-N curve from fatigue testing; (c) strain evolution curve from creep testing. Indicate all the axis titles of each curve.

**6** Indicate all the eutectic, eutectoid, and peritectic reaction points in Figure 4 (if any). Give the corresponding reaction equations.

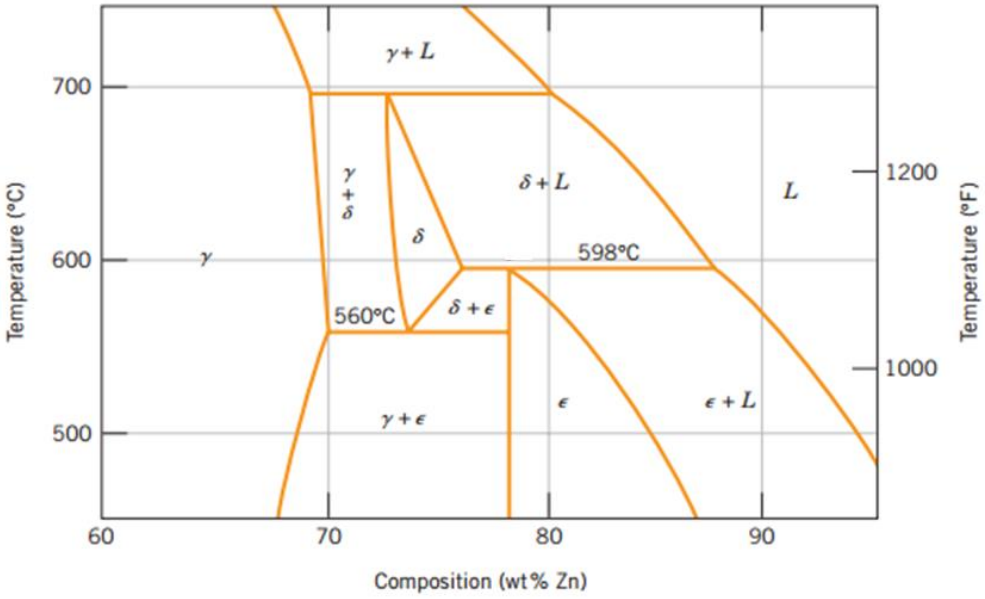


Figure 4 Drawings for Q6.

**7.** The two ends of a cylindrical rod of 1025 steel (75 mm long and 10 mm in diameter) are maintained rigid. If the rod is initially at 25 °C, to what temperature must it be cooled to have a 0.008 mm reduction

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in diameter? The length coefficient of thermal expansion $\alpha_l$ is $12\times10^{-6}$ 1/°C and isotropic, the elastic and shear moduli for this steel are 208 GPa and 80 GPa, respectively. (Step-by-step derivation or calculation processes is necessary!)

**8.** Describe and compare the physical properties of metals, ceramics, and polymers, in terms of (a) electrical conductivity, (b) specific heat, (c) thermal expansion, and (d) thermal conductivity. (Hint: describe with definitions of these terms, then compare the properties of different materials with explanations.)

**9 True or False**

(1) The diffusion coefficient is increased with temperature increases.
(2) Compared to the vacancy diffusion, the interstitial diffusion occurs more rapidly in metal alloys.
(3) After an edge dislocation has passed through some region of a crystal, the atomic arrangement of that region is disordered.
(4) The relationship between elastic and shear moduli is approximately G=0.1E for most metals (with Poisson's ratio of 0.30).
(5) The burger vector of an edge dislocation is parallel to its dislocation line.
(6) Oxidation takes place at the anode.
(7) Galvanizing involves applying a layer of zinc to the surface of the steel to protect the steel from corrosion.
(8) Generally, there is a distinct ductile-brittle transition behavior of HCP metals.
(9) Large supercooling will lead to larger grain size than small supercooling.
(10) Slip system(s) with the largest Schmid factor will be activated firstly when a single crystal is under tension.
(11) Both temperature and cold work will have a significant influence on a material's electrical resistivity.
(12) For a given material, the constant pressure heat capacity, Cp, is always greater than the constant volume value, Cv.
(13) Free electrons play a role in thermal expansion.
(14) The greater the atomic bonding energy, the smaller the value of the thermal expansion coefficient.
(15) The electrical conductivity of a single crystal is normally smaller than that of the polycrystalline material.

**10** How long does it take to complete A6?

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