NAME [redacted]
UNIVERSITY OF CALIFORNIA
Spring 2023

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Question 2	24 / 24
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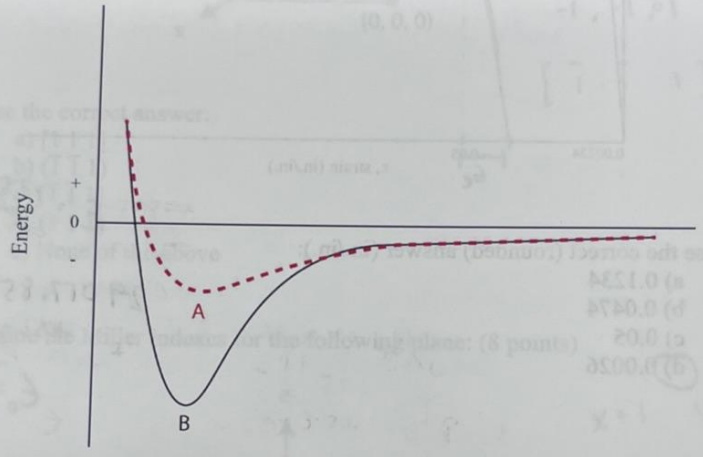
Total	98 **/100**

CE 60 PROPERTIES OF CIVIL ENGINEERING MATERIALS EXAMINATION

Question 1 (30 points)

I) An energy versus interatomic distance plot is shown below. (True/(False)) Curve A has a higher elastic modulus compared with curve B (6 points).



II) The atomic number of Carbon is 6. How many protons, neutrons, and electrons are there in a single atom? (6 points). What is the atomic mass of the atom? Use the unit amu. (2 points). Assume the atom has a net zero charge and no isotopes.

6 protons, 6 electrons, 6 neutrons in a single atom.

atomic mass = # protons + # neutrons

atomic mass = 12 amu

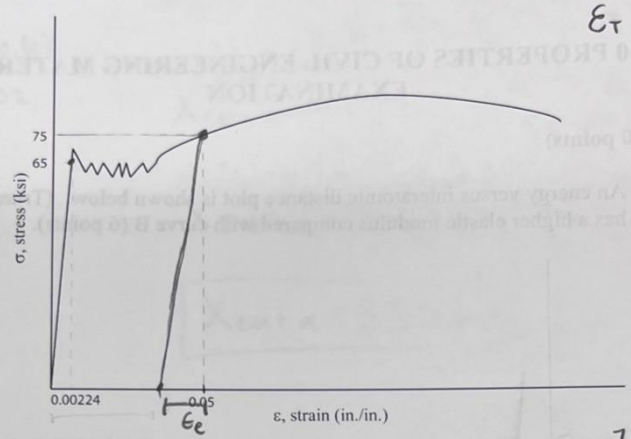
[redacted]

III) A tension test is performed on a low-carbon steel sample with an initial diameter of 0.5 inches and initial gauge length of 2 inches. The stress-strain curve of the sample is shown below. Calculate the **elastic strain** at a stress of 75,000 psi. (8 points)

$E = \frac{\sigma}{\varepsilon} = \frac{65\ ksi}{.00224}$

$E = 29017.857\ ksi$

$\varepsilon_T = 0.05$



$E = \frac{75\ ksi}{\varepsilon_e}$

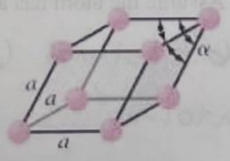
$29017.857\ ksi = \frac{75\ ksi}{\varepsilon_e}$

$\varepsilon_e = \frac{75}{29017.857}$

Choose the correct (rounded) answer (in./in.):

a) 0.1234
b) 0.0474
c) 0.05
d) 0.0026

IV) Identify the following crystal structure: The lattice parameters for this crystal structure are **a=b=c and α=β=γ≠90°**. (8 points)

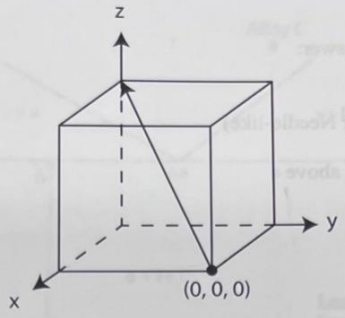


Choose the correct answer:

a) Simple tetragonal
b) Triclinic
c) Rhombohedral
d) Simple orthorhombic
e) None of the above

Question 2 (24 points)

I) Define the Miller indexes for the following direction: (8 points)



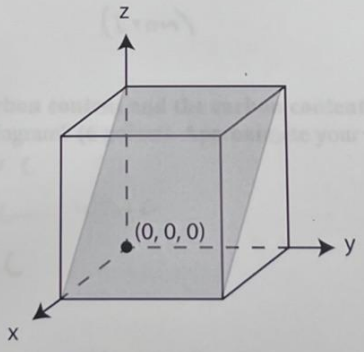
-1, -1, 1

$[\bar{1}\ \bar{1}\ 1]$

Choose the correct answer:

a) [1 1 1]
b) $(\bar{1}\ \bar{1}\ 1)$
c) $[1\ \bar{1}\ 1]$
d) (1 1 1)
e) None of the above

II) Define the Miller indexes for the following plane: (8 points)



$x = 1 \quad y = \infty \quad z = 1$

$\frac{1}{x} = 1 \quad \frac{1}{y} = 0 \quad \frac{1}{z} = 1$

(1 0 1)

no frac

no neg

Choose the correct answer:

a) $(1\ \bar{1}\ 0)$
b) [0 1 0]
c) (1 0 1)
d) [1 1 1]
e) None of the above

[redacted]

III) Pearlite is a combination of eutectoid ferrite and eutectoid cementite. What is the morphology of this combination? (8 points)

Choose the correct answer:

a) Rod-like
b) Lamellar
c) Acicular (or Needle-like)
d) Globular
e) None of the above

Question 3: (46 points)

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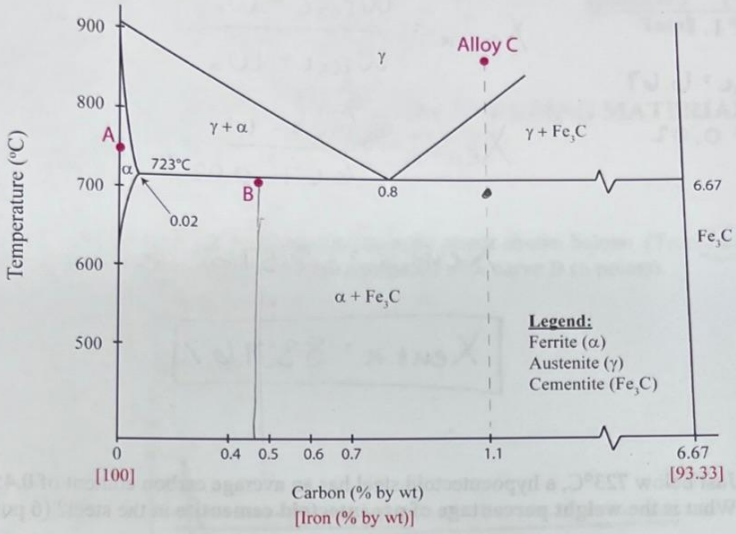
Considering the phase diagram of steel



I) Using Gibbs phase rule as a guide, how many **components and phases** are at point A? Assume pressure is constant. (4 points)

Point A has only 1 component and 1 phase

(Iron) (α)

II) What is the **average carbon content and the carbon content of the phases** at point B indicated in the phase diagram? (6 points). Approximate your answer, if needed.

$W_o = 0.46$ wt%. C

~~$W_\gamma = 0.8$ wt%. C~~ W_{Fe_3C}

$W_\alpha = 0.02$ wt%. C

-2

III) Just below 723°C, a hypereutectoid steel (Alloy C) contains an average carbon content of 1.1 wt %. What is the **weight percentage of pearlite**? (15 points). Show your work.

above 723°C

$X_{pearlite} = X_{eut\,\alpha} + X_{eut\,Fe_3C}$

$X_{eut\,Fe_3C} = X_{tot\,Fe_3C} - X_{pro\,Fe_3C}$

$W_o = 1.1$

$W_{Fe_3C} = 6.67$

$W_\gamma = 0.8$

$W_\alpha = 0.02$

$X_{eut\,\alpha} = \frac{6.67 - 1.1}{6.67 - .02}$

$X_{eut\,\alpha} = .8376$

$X_{eut\,Fe_3C} = \frac{1.1 - .02}{6.67 - .02} - \frac{1.1 - .8}{6.67 - .8}$

$X_{eut\,Fe_3C} = .1113$

$X_{pearlite} = .9489$

94.89 %

IV) Just below 723°C, a ~~hypo~~ hyper eutectoid steel has an average carbon content of 1.1 %. What is the **weight percentage of eutectoid ferrite** in the steel? (15 points). Show your work.

$W_o = 1.1$

$W_{Fe_3C} = 6.67$

$W_\alpha = 0.02$

$$X_{eut\,\alpha} = \frac{W_{Fe_3C} - W_o}{W_{Fe_3C} - W_\alpha}$$

$$X_{eut\,\alpha} = \frac{6.67 - 1.1}{6.67 - 0.02}$$

$$X_{eut\,\alpha} = .8376$$

$$\boxed{X_{eut\,\alpha} = 83.76\%}$$

V) Just below 723°C, a hypoeutectoid steel has an average carbon content of 0.45 %. What is the **weight percentage of proeutectoid cementite** in the steel? (6 points)

There is $\boxed{0\%}$ proeutectoid cementite since the steel was hypoeutectoid so there is only proeutectoid ferrite.