17/11/2022

METE 230 (SEC 5) FUNDAMENTALS OF MATERIALS SCIENCE AND ENGINEERING

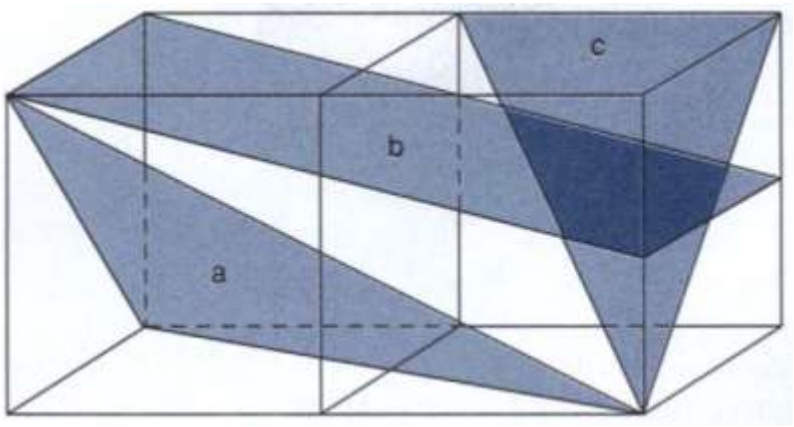
HOMEWORK I

Q1. (a) Cesium metal has a BCC structure with a lattice parameter of 0.6080 nm. What is the atomic radius?

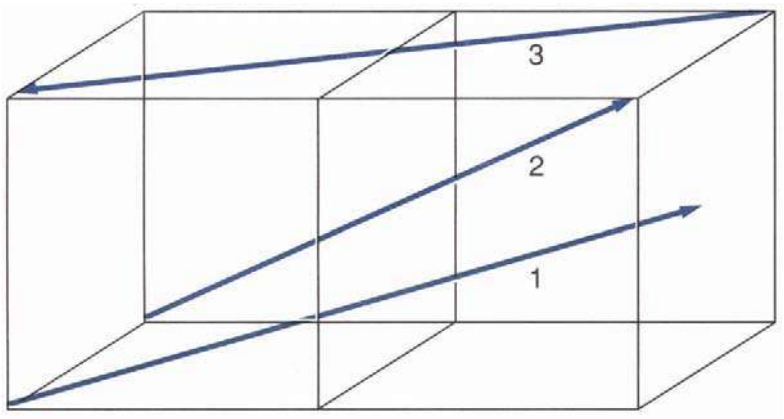
(b) Rhodium has a lattice parameter of 0.3805 nm and the atomic radius is 0.134 nm. Does this metal have a BCC or FCC structure?

Q2. Calculate atomic packing density for the (111) plane of copper. What is the linear atomic density along the $[\bar{1}10]$ direction in this plane?

Q3. What are the Miller indices of planes a, b, and c in the figure below.



Q4. What are the Miller indices of directions 1, 2, and 3 in the figure below?



Q5. Select all of the directions that lie in the (111) plane of a cubic crystal:

(a) [111] (b) $[\bar{1}11]$ (c) [100] (d) [110] (e) $[\bar{1}12]$ (f) $[\bar{1}01]$ (g) $[3\bar{2}1]$ (h) $[\bar{2}11]$ (i) [102]

Q6. Calculate the number of vacancies per cubic meter in silver at 700 °C. The energy for vacancy formation is 1.28×10^{-19} J/atom. The density and atomic weight at 700 °C are 9.35 g/cm^3 and 107.9 g/mol.

Q7. Based on the information below;

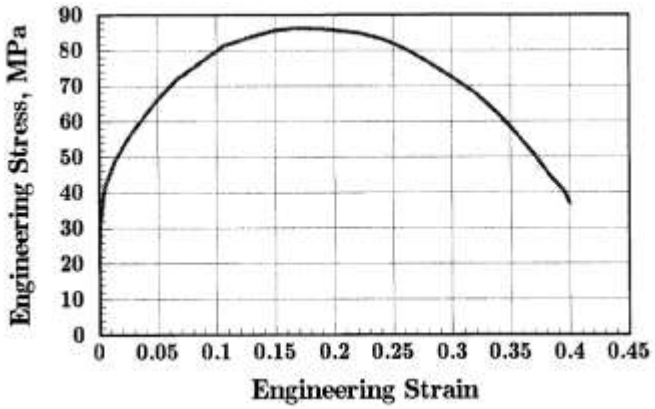
Element	*Atomic Radius (nm)*	*Crystal Structure*	*Electro-negativity*	*Valence*
Ni	0.1246	FCC	1.8	+2
C	0.071			
H	0.046			
O	0.060			
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Pt	0.1387	FCC	2.2	+2
Zn	0.1332	HCP	1.6	+2

(a) Which of these elements form interstitial solid solution with Fe?

(b) Which of these elements form substitutional solid solution with complete solubility with Cr?

(c) Which of these elements form substitutional solid solution with partial solubility with Ni?

Q8. The figure below shows the engineering stress-strain curve for a pure polycrystalline material.



For this material, determine
(a) Young's modulus,
(b) the 0.2% offset yield strength,
(c) the Ultimate Tensile Strength (UTS),
(d) the modulus of resilience, and
(e) the modulus of toughness.

Q9. The following data were obtained during the tension test of a low carbon steel with a specimen having a 12 mm diameter and a 50 mm gage length.

Load, kN	Elongation, mm	Load, kN	Elongation, mm
2	0.0041	25.2	0.51
4	0.0082	28.0	1.52
6	0.0132	30.0	2.03
8	0.0183	34.0	3.05
10	0.0226	38.4	4.57
12	0.0267	40.0	6.60
14	0.0310	40.4	7.62
16	0.0351	40.8	12.7
18	0.0391	40.2	14.7
20	0.0445	38.6	15.7
22	0.0485	36.4	17.8
24	0.0518	32.4	19.3

Yield point=24.8 kN; fracture load=27.2 kN; final gage length=72.8 mm; final diameter=6.3 mm.

(a) Plot the engineering stress-strain curve

(b) Determine the

- proportionality limit,

- modulus of elasticity,
- lower yield point,
- tensile strength
- fracture stress
- percentage elongation
- reduction of area

(c) Plot the true stress-strain curve up to maximum load.

Q10. Estimate the Mohs' hardness for the following materials:

(a) steel file,
(b) chalk,
(c) pine plank,
(d) ball bearing,
(e) sapphire.

DUE: 25/11/2022 – 5 pm