A
A
B
C
D
A
A
C
C
C
B
B
D
C
B

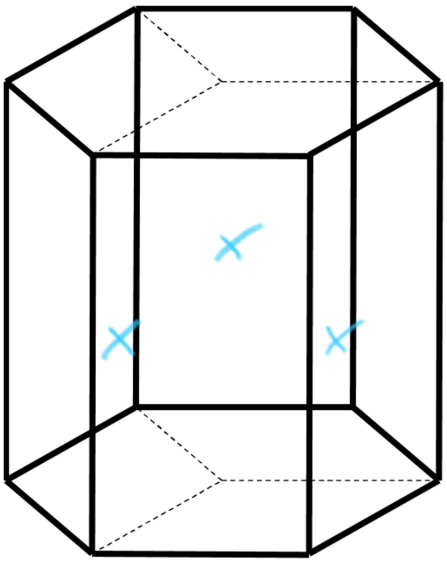
Student No_____

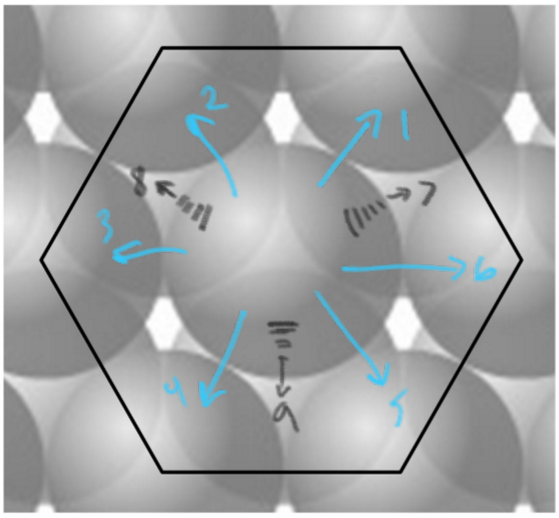
14. Plastic deformation in a metal occurs most often by which of the following mechanisms?
    a) The simultaneous breaking and re-forming of a plane of atoms
    b) The sliding of planes of atoms along grain boundaries
    c) The step-by-step breaking and reforming of rows of bonds
    d) None of the above

15. The coordination number of the anions in the rock salt ceramic crystal structure is which of the following?
    a) 4
    b) 6
    c) 8
    d) 12

Part B

1. (5) This question pertains to the HCP crystal structure.
    a. (3) Within the hexagonal unit cell, indicate, with a small "x" each of the octahedral interstitial sites located within this HCP unit cell.
    b. (2) Using the sketch below as an aid, show the coordination number for atoms within the HCP crystal structure.





3 above the page.

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2. (10) Jake Sparrow is a pirate who hopes to earn money by buying and selling gold. He sat in on 5 minutes of an MSE101 lecture and so is aware that vacancies are thermally generated. He plans to only buy gold on cold days when the number of vacancies will be lower and then to sell the same gold on hot days when the number of vacancies will be higher.
   a. (7) If the energy for vacancy formation in gold is 0.67 eV, and the density of gold is 19.3 g/cm^3, calculate the mass (in g) of the gold atoms that have formed vacancies at 25°C.

(2) $N_v = N \exp\left(\frac{-Q_v}{KT}\right)$

(2) $m = \frac{N_v}{N_A} \cdot A$

$m = \frac{N \exp\left(\frac{-Q_v}{KT}\right) \cdot A}{N_A}$

(1) $N = 1$ (take 1 mol basis) or other reasonable quantity.

$A = 196.97$ g/mol

$K = 8.62(10^{-5})$ eV/atom·K

$T = 298$ K

$m = 1.5(10^{-33})$ g

(1) (1)

b. (3) Will Jake ever make any money this way? Explain.

(1) No. because the atoms don't disappear, they move to other locations.

(2)

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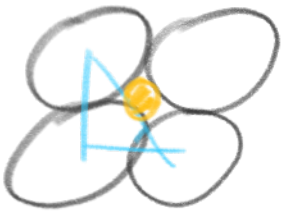
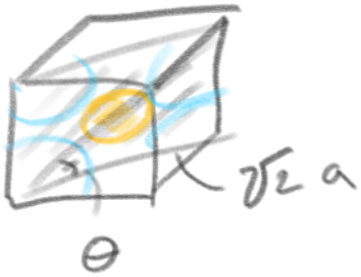
3. (10) Show the range of cation radii, from minimum to maximum, as a fraction of the anion radius, that will occupy the octahedral interstitial size.

Octahedral so must at least fit into CN=6, upper bound will be CN=8.



$$\sin 45 = \frac{2R_A}{2R_A + 2R_C}$$

$$\frac{R_A \sin 45}{R_A} + \frac{R_C \sin 45}{R_A} = \frac{R_A}{R_A} \Rightarrow \frac{R_C}{R_A} = \frac{1 - \sin 45}{\sin 45} = 0.414.$$



$$\theta = \tan^{-1}\left(\frac{a}{\sqrt{2}a}\right) = 35.3^\circ$$

$$\sin 35.3 = \frac{2R_a}{2R_a + 2R_c} \Rightarrow \frac{R_c}{R_A} = \frac{1 - \sin 35.3}{\sin 35.3}$$

$$= 0.732$$

so range is 0.414 - 0.732

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4. (10) A lump of solid gold having a mass of 38 g is placed into a cylinder of water that is already full to the top. How much water spills out of the cylinder? Gold has the FCC crystal structure and assume that the atomic radius of gold is 0.146 nm.

$V = \frac{m}{\rho}$ | $m = 38g$, $\rho = \frac{nA}{V_c N_A}$ | $n = 4$, $A = 196.97\ g/mol$, $V_c = a^3$ | $a = 2\sqrt{2}R$, $R = 0.146\ (10^{-9})\ m$

$$V = \frac{m \cdot N_A \cdot (2\sqrt{2}R)^3}{nA} \quad [=] \quad \frac{g \cdot \#/mol \cdot m^3}{\# \cdot g/mol} = m^3$$

$$V = \frac{38 \cdot 6.022(10^{23}) \cdot \left[2\sqrt{2}\, 0.146(10^{-9})\right]^3}{4 \cdot 196.97} = 2(10^{-6})\ m^3$$

$$2(10^{-6})\ m^3 \cdot \left(\frac{10^2\ cm}{m}\right)^3 = 2\ cc = 2\ ml$$