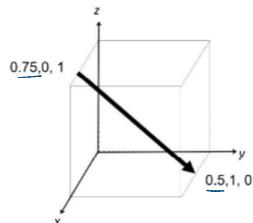


1. Identify the crystallographic planes and directions indicated below using the correct Miller indices or direction indices and correct enclosures.

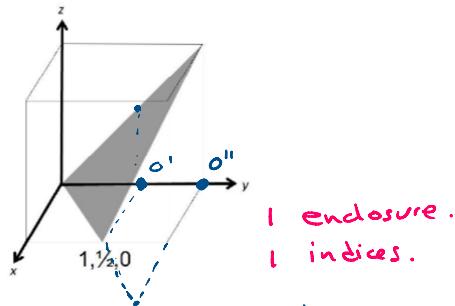
$$\begin{array}{l} \text{proj. } -\frac{x}{4} \quad y \quad z \\ \text{housekeep } -1 \quad 4 \quad -4 \\ \text{enc. } [\bar{1}4\bar{4}] \end{array}$$



| enclosure.
| indices.

or (a) (2 points) $\{\bar{1}4\bar{4}\}$

$$\begin{array}{l} o' \\ \text{int. } x \quad y \quad z \\ \text{rec. } 1 \quad -\frac{1}{2} \quad \frac{1}{2} \\ \text{enc. } (1\bar{2}2) \end{array} \left| \begin{array}{l} o'' \\ \text{int. } 2 \quad -1 \quad 1 \\ \text{rec. } \frac{1}{2} \quad -1 \quad 1 \\ \text{clear. reflec. } 1 \quad -2 \quad 2 \\ \text{enc. } (\bar{1}\bar{2}2) \end{array} \right.$$

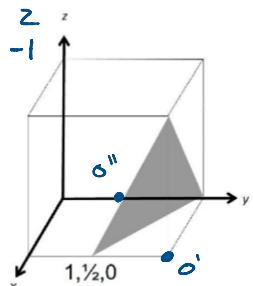


| enclosure.
| indices.

(b) (2 points) $(\bar{1}\bar{2}2)$

$(\bar{1}\bar{2}2)$ okay

$$\begin{array}{l} o' \\ \text{int. } -1 \quad -\frac{1}{2} \quad 1 \\ \text{rec. } -1 \quad -2 \quad 1 \\ (-1) \quad 1 \quad 2 \quad \bar{1} \\ \text{enc. } (\bar{1}2\bar{1}) \end{array} \left| \begin{array}{l} o'' \\ \text{int. } 1 \quad \frac{1}{2} \quad -1 \\ \text{rec. } 1 \quad 2 \quad \bar{1} \\ \text{enc. } (\bar{1}2\bar{1}) \end{array} \right.$$

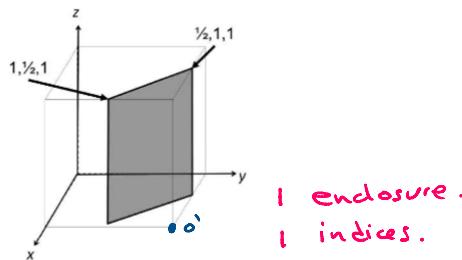


| enclosure.
| indices.

(c) (2 points) $(\bar{1}2\bar{1})$

$(\bar{1}2\bar{1})$ okay

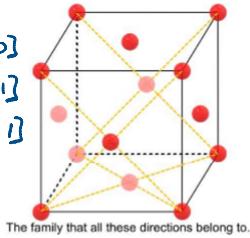
| | | | |
|------|----------------|----------------|----------|
| int. | ∞ | y | z |
| re. | $-\frac{1}{2}$ | $-\frac{1}{2}$ | ∞ |
| (-) | -2 | -2 | 0 |
| end. | (220) | | |



(d) (2 points) $(\bar{2}\bar{2}0)$ okay.

face diagonals $\rightarrow [110], [\bar{1}10]$
 $[101], [T01]$
 $[011], [0\bar{T}1]$
etc...

so $\langle 011 \rangle$ or $\langle 110 \rangle$

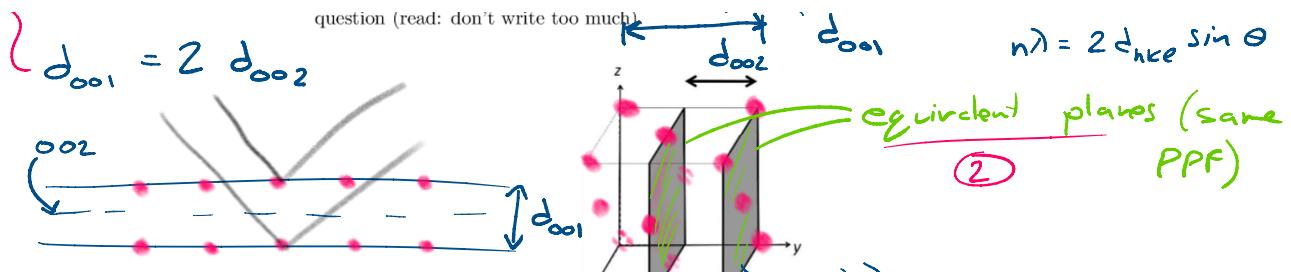


(e) (2 points) | enclosure.
| indices.

- ①
2. (5 points) Making reference to the figure below, and to Bragg's law, explain why peaks in the x-ray diffraction pattern of an FCC crystal would not be expected for the (001) set of planes while they would be expected for the (002) set of planes. Hint: discuss the significance of the interplanar spacing between (002) planes versus (001) planes. Point form answers are acceptable and all of your answer must be written within the space for this question (read: don't write too much).

$$\left. \begin{aligned} d_{002} &= 0.5 d_{001} \\ d_{001} &= 2 d_{002} \end{aligned} \right\}$$

$$n\lambda = 2d_{hkl} \sin \theta$$



if d_{001} satisfies Bragg's Law, because (002) has atoms and $d_{002} = 0.5 d_{001}$

each (002) plane gives shift of $\frac{\lambda}{2}$ = out of phase with (001) = destructive.

(010) (020)

same situation as $(001), (002)$

equivalent planes (same PPF)

②

②

Bratt's Law, because (002) has atoms and $d_{002} = 0.5 d_{001}$

each (002) plane gives shift of $\frac{\lambda}{2}$ = out of phase with (001) = destructive.

②

3. (5 points) An unknown sample of a hypothetical FCC metal has a peak in the diffraction pattern at a 2θ value of 32° for the (111) set of planes for first order ($n=1$) reflection with a Cu K- α x-ray source having a wavelength of 1.504×10^{-10} m. Determine the atomic radius of this material.

$$n\lambda = 2 d_{hkcl} \sin \theta \quad | \quad d_{111} = \frac{a}{\sqrt{3}}$$

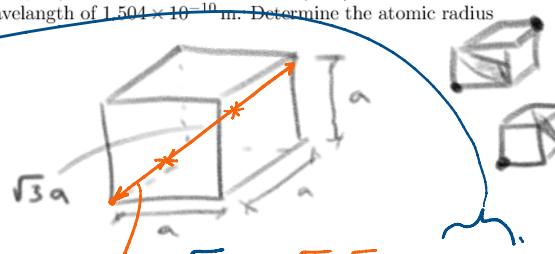
$$a = 2\sqrt{2} R \quad ①$$

$$n\lambda = \frac{2a}{\sqrt{3}} \sin \theta = \frac{2 \cdot 2\sqrt{2} R}{\sqrt{3}} \sin \theta$$

$$R = \frac{n\lambda \sqrt{3}}{4\sqrt{2} \sin \theta} \quad | \quad n=1$$

$$\lambda = 1.504(10^{-10}) \text{ m}$$

$$\theta = \frac{32}{2} = 16^\circ \quad ①$$



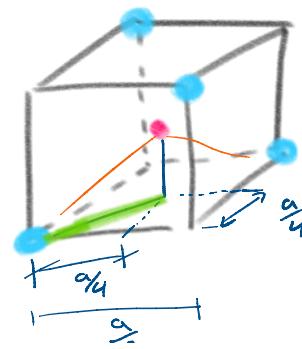
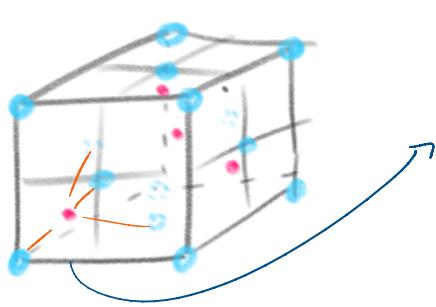
$$d_{111} = \frac{\sqrt{3}a}{3} = \frac{\sqrt{3} \cdot \sqrt{3}}{3 \cdot \sqrt{3}} a = \frac{1}{\sqrt{3}} a$$

② or

$$R = \frac{1.504(10^{-10}) \sqrt{3}}{4\sqrt{2} \sin(16)} = \frac{1.67(10^{-10})}{\text{either okay}} \text{ m} = \frac{167 \text{ pm}}{①}$$

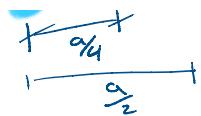
note: also okay to use: $d_{hkcl} = \frac{a}{\sqrt{h^2+k^2+l^2}} = \frac{a}{\sqrt{3}}$

4. (10 points) Cadmium selenide (CdSe) can crystallize in the zinc sulphide crystal structure. If the ionic radii of cadmium and selenium are 109 pm and 184 pm, respectively, determine the theoretical density of cadmium selenide in the zinc sulphide crystal structure.



$$\sqrt{2} \cdot \frac{a}{4}$$

② correct
at. radius.



② correct structure.

② correct Anion-Cation contact along $\langle 111 \rangle$

$$\Theta = \tan^{-1} \left(\frac{1}{\sqrt{2}} \right) = 35.26^\circ$$

$$\sin \Theta = \frac{a}{4 \cdot (R_A + R_c)}$$

$$a = 4 \sin(35.26^\circ)(R_A + R_c)$$

$$= 4 \sin 35.26^\circ (109(10^{-10}) + 184(10^{-10}))$$

$$= 6.7665(10^{-10}) \text{ m}$$

①

determine a

①

each for R_A, R_c

$$\rho = \frac{n_c A_c + n_A \cdot A_A}{V_c \cdot N_A} = \frac{4 \cdot (112.4) + 4 \cdot (78.96)}{[6.767(10^{-10})]^3 \cdot 6.023(10^{23})}$$

$$= 4.1(10^6) \frac{\text{g}}{\text{m}^3} \cdot \left(\frac{1 \text{ m}}{10^2 \text{ cm}} \right)^3$$

$$= \frac{4.1}{①} \frac{\text{g}}{\text{cm}^3} \stackrel{\text{or}}{=} \cdot \left(\frac{1 \text{ kg}}{10^3 \text{ g}} \right) \rightarrow \frac{4.1(10^3) \text{ kg}}{① \quad ① \quad \text{m}^3}$$

② →

Part B: Multiple Choice (1 points per question)

1. Two polymer samples are produced from the same batch of polyethylene. Sample A is placed in a warm room at a temperature of 45 °C while sample B is placed in a room at 21 °C. While in these rooms, both samples are elongated by a strain of 1% and held at that strain. Following 48 hours the load in each sample is determined. Which of the following is most likely to be true?

- (a) Sample A and B are both loaded at the same level.
- (b) Sample A has a lower load than sample B.
- (c) Unable to make a prediction.
- (d) Sample B has a lower load than sample A.

2. Which of the following would be expected to increase the strength of a polymer?

1. Increasing the molecular weight.
2. Increasing the crystallinity.
3. Decreasing the strength of the secondary interactions between