

EE 2800 Test 1 Solution

Q1. a. 10^{-10} m (4', 2' for unit)

b. $10^{-10} \text{ m} = 10^{-8} \text{ cm}$

atoms $= (10^8)^3 = 10^{24} / \text{cm}^3$

[5', 2' if only has answer (10^{23} works too)]

c. $E_g = 1.12 \text{ eV} \times 1.6 \times 10^{-19} \text{ J/eV}$ (3')

$= 1.8 \times 10^{-19} \text{ J}$ (2')

d. i. Neutral

ii. Positive

iii. Negative

(2' each)

Q2. a. $[\bar{1}11]$

(2' for 111 class,
2' for correct label of $\bar{1}$,
1' for correct parenthesis)

(same rule as above)

b. $[1\bar{1}0]$

c. (111)

d. $(1\bar{1}0)$ or $(\bar{1}10)$

e. ACEKIPNR

or other reasonable choices (e.g. HICNEKPL) (10')

f. $\vec{b} \times \vec{c} = \frac{a^2}{4} (\hat{j} + \hat{k}) \times (-\hat{i} + \hat{k})$

$= \frac{a^2}{4} (\hat{k} - \hat{j} + \hat{i})$ (2')

$\vec{a} \cdot (\vec{b} \times \vec{c}) = \frac{a}{2} (-\hat{i} + \hat{j}) \cdot \frac{a^2}{4} (\hat{k} - \hat{j} + \hat{i}) = \frac{a^3}{8} \cdot (-2) = -\frac{a^3}{4}$ (3')

$\vec{a}^* = \frac{2\pi \vec{b} \times \vec{c}}{\vec{a} \cdot (\vec{b} \times \vec{c})} = 2\pi \cdot \frac{\frac{a^2}{4} (\hat{k} - \hat{j} + \hat{i})}{-\frac{a^3}{4}} = \frac{2\pi}{a} (-\hat{i} + \hat{j} - \hat{k})$ (2')

$\vec{c} \times \vec{a} = \frac{a^2}{4} (-\hat{i} + \hat{k}) \times (-\hat{i} + \hat{j})$
 $= \frac{a^2}{4} (-\hat{j} - \hat{k} - \hat{i})$ (2')

$$\vec{b}^* = 2\pi \frac{\vec{c} \times \vec{a}}{\vec{a} \cdot (\vec{b} \times \vec{c})} = \frac{2\pi}{a} (\hat{i} + \hat{j} + \hat{k}) \quad (2')$$

$$\vec{c}^* = 2\pi \frac{\vec{a} \times \vec{b}}{\vec{a} \cdot (\vec{b} \times \vec{c})} = \frac{2\pi}{a} (-\hat{i} - \hat{j} + \hat{k}) \quad (2')$$

$$\begin{aligned} \vec{a} \times \vec{b} &= \frac{a^2}{4} (-\hat{i} + \hat{j}) \times (\hat{j} + \hat{k}) \\ &= \frac{a^2}{4} (-\hat{k} + \hat{j} + \hat{i}) \end{aligned} \quad (2')$$

Q3. a. A: No B: Yes C: No (3' each)

b. $\vec{k} = 0$ (5')

c. $\vec{k} = h\vec{a}^* + k\vec{b}^* + l\vec{c}^*$, h, k, l are integers (6')

Q4. $1s^2 2s^2 2p^6 3s^2$ (7')

Outermost shell electrons are $3s^2$, the quantum numbers are $(3, 0, 0, \frac{1}{2})$ (2') (3')

and $(3, 0, 0, -\frac{1}{2})$ (3')