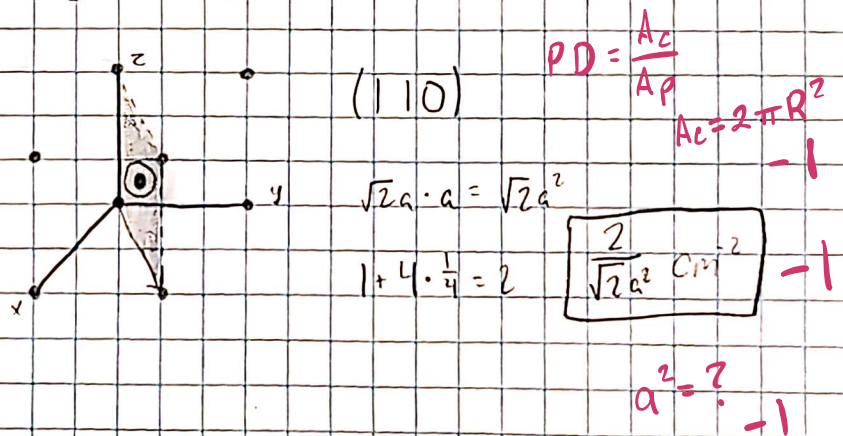
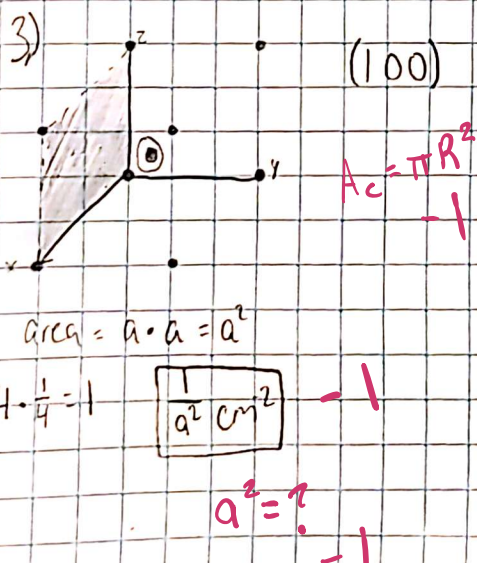
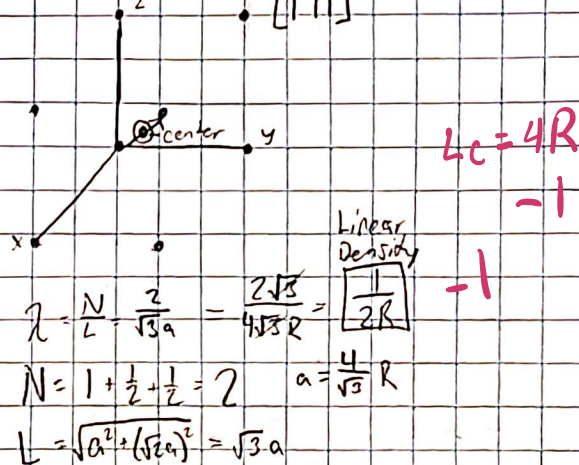
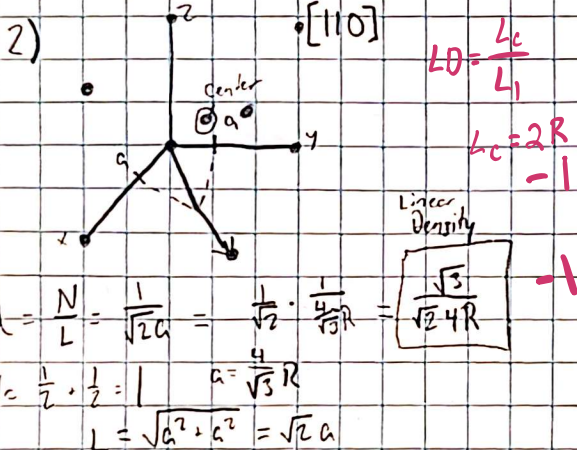
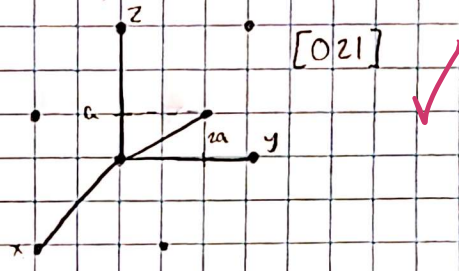
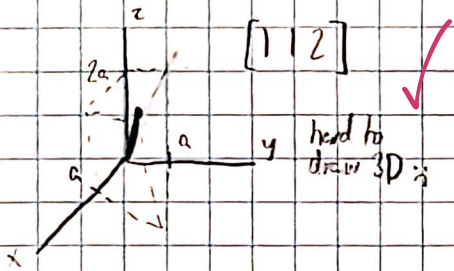
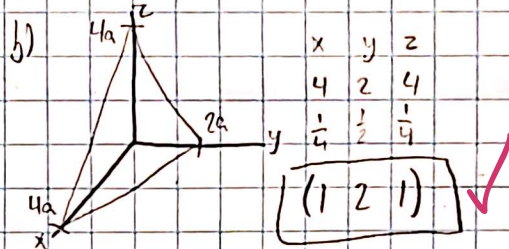
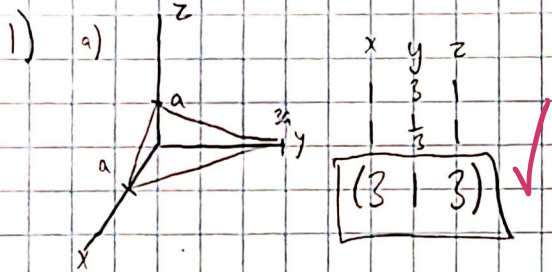
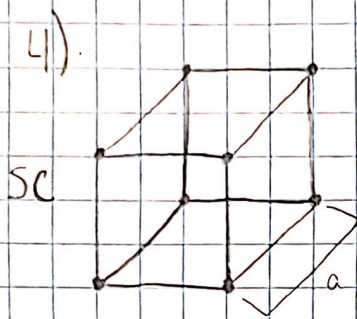


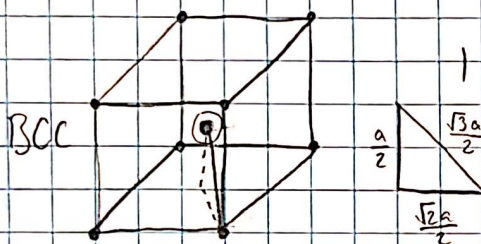
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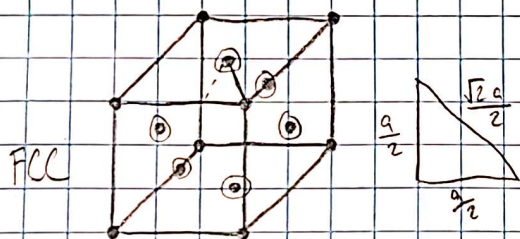
$$8 \cdot \frac{1}{8} = 1 \text{ atom per cell}$$

nearest neighbor distance: a



$$1 + 8 \cdot \frac{1}{8} = 2 \text{ atoms per cell}$$

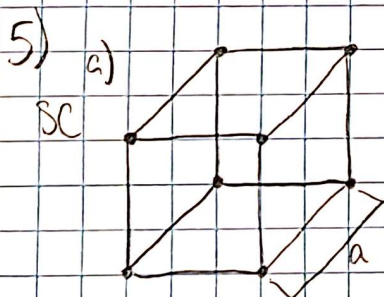
nearest neighbor: $\frac{\sqrt{3}a}{2}$



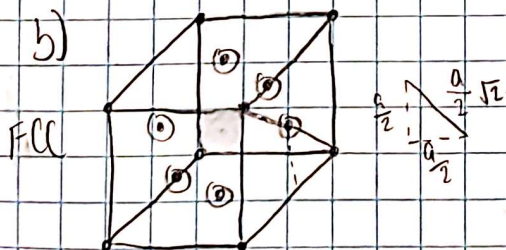
$$6 \cdot \frac{1}{2} + 8 \cdot \frac{1}{8} = 4 \text{ atoms per cell}$$

nearest neighbor: $\frac{\sqrt{2}a}{2}$

Lattice Constant - radius = 1.95 Å



$$a = 2r = 2 \cdot 1.95 = 3.9 \text{ Å}$$

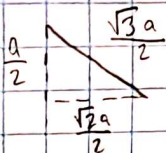
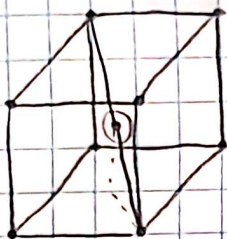


$$\frac{\sqrt{2}a}{2} \cdot 2 = \sqrt{2}a = 4R$$

$$a = \frac{4R}{\sqrt{2}} = \frac{4 \cdot 1.95}{\sqrt{2}} = 5.515 \text{ Å}$$

c)

BCC



$$2 \cdot \frac{\sqrt{3}a}{2} = \sqrt{3}a = 4R$$

$$a = \frac{4R}{\sqrt{3}} = \frac{4 \cdot 1.95}{\sqrt{3}} = \boxed{4.503 \text{ \AA}}$$



d) Diamond Lattice

$$\frac{\sqrt{3}a}{4} = 2R$$

$$a = \frac{8R}{\sqrt{3}} = \frac{8 \cdot 1.95}{\sqrt{3}} = \boxed{9.006 \text{ \AA}}$$

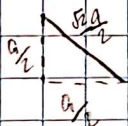
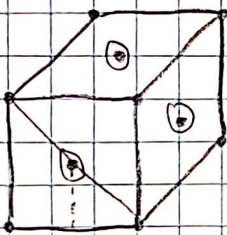


e)

Germanium = $5.65 \text{ \AA} = a$

a) Distance from center Ge atom to center nearest neighbor

FCC



$$2R = \frac{\sqrt{3}a}{4} \quad R = \frac{\sqrt{3}a}{8} = \frac{\sqrt{3} \cdot 5.65}{8} = 1.223 \text{ \AA}$$

$$1.223 \cdot 2 = \boxed{2.446 \text{ \AA}}$$



b) # density of Ge

$$\text{FCC} \cdot 2 = \left(\frac{1}{8} \cdot 8 + \frac{1}{2} \cdot 6 \right) \cdot 2 = (1+3) \cdot 2 = 8$$

$$5.65^3 = 180.362 \text{ \AA}^3 \quad \text{density} = \frac{8}{180.362} = \boxed{4.435 \times 10^{-22} \frac{\text{atoms}}{\text{cm}^3}}$$



c) Mass density of Ge

$$\text{mass per Ge atom} = 72.64 \frac{\text{g}}{\text{mol}}$$

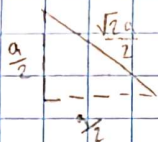
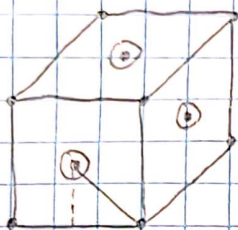
$$\text{mass of atom} = \frac{\text{mol}}{\text{avog.}} = \frac{72.64}{6.022 \times 10^{23}} = 1.21 \times 10^{-22} \text{ g}$$

$$\text{density} = \text{atom density} \cdot \text{mass} = 4.435 \cdot 1.21 \times 10^{-22}$$

$$= \boxed{5.37 \times 10^{-22} \text{ g/cm}^3}$$



7) Lattice constant of silicon $a = 5.43 \text{ \AA}$



2 FCC per unit cell

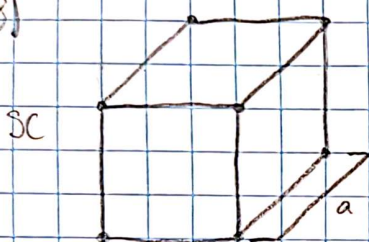
$$\text{Vol of cell} = a^3 = 5.43^3 = 160.103 \text{ \AA}^3$$

4 valence electrons per atom

2 FCC = 8 atoms 4 electrons per atom = 32 electrons

$$\text{density of } e = \frac{e \text{ per cell}}{\text{Volume of cell}} = \frac{32}{160.103 \times 10^{-24}} = 1.9987 \times 10^{25} \text{ e/cm}^3$$

8)



Atomic weight = 35.2 g/mol

density = 3.65 g/cm³

$$a = 2r \quad r = \frac{a}{2} \quad \rho = \frac{nA}{V_c N_A}$$

$$V_c = a^3 = \frac{nA}{\rho N_A} = \frac{1 \cdot 35.2}{3.65 \cdot 6.022 \times 10^{23}} = a^3 = 1.6014 \times 10^{-23} \quad a = \sqrt[3]{1.6014 \times 10^{-23}} = 2.53 \text{ \AA}$$

$$r = \frac{a}{2} = \frac{2.53}{2} = 1.265 \text{ \AA}$$

9) Composition of $\text{AlSb}_x\text{As}_{1-x}$ to lattice match InP

$a_{\text{lattice}} = 5.85 \text{ \AA}$

Vegard's law: $a_{A(1-x)B_x} = (1-x) \cdot a_A + x a_B$

$a_{\text{AlAs}} = 5.67$

$$a_{\text{alloy}} = (1-x) \cdot a_{\text{AlAs}} + x a_{\text{AlSb}}$$

$a_{\text{AlSb}} = 6.13$

$$5.85 = 5.67 - 5.67x + 6.13x \rightarrow 0.18 = 0.46x$$

$$\rightarrow X = 0.3913$$

Band Gap

$$E_g(x) = (1-x) E_g(\text{AlAs}) + x E_g(\text{AlSb}) - b x (1-x)$$

$\text{AlAs} = 2.16 \text{ eV}$

$\text{AlSb} = 1.58 \text{ eV}$

$$E_g(0.3913) = (0.6086) 2.16 + (0.3913) 1.58 - 0.27391(0.6086)$$

$b = 0.7 \text{ eV}$

$x = 0.3913$

$$E_g(0.3913) = 1.71 \text{ eV}$$

10)

SC



atomic weight = 35.2 g/mol

atomic density = 3.65 g/cm³

$$r = \left(\frac{3}{4\pi} \cdot \frac{A}{\rho N_A} \right)^{\frac{1}{3}} = \left(\frac{3}{4\pi} \cdot \frac{35.2}{3.65 \cdot 6.022 \times 10^{23}} \right)^{\frac{1}{3}}$$

$$r = 1.5637 \text{ cm}$$