1.2

(a) Simple cubic lattice: $a = 2r$

Unit cell vol $= a^3 = (2r)^3 = 8r^3$

1 atom per cell, so atom vol

$= (1)\left(\frac{4\pi r^3}{3}\right)$

Then

$$\text{Ratio} = \frac{\left(\frac{4\pi r^3}{3}\right)}{8r^3} \times 100\% = 52.4\%$$

(b) Face-centered cubic lattice

$$d = 4r = a\sqrt{2} \Rightarrow a = \frac{d}{\sqrt{2}} = 2\sqrt{2} \cdot r$$

Unit cell vol

$= a^3 = \left(2\sqrt{2} \cdot r\right)^3 = 16\sqrt{2} \cdot r^3$

4 atoms per cell, so atom vol

$= (4)\left(\frac{4\pi r^3}{3}\right)$

Then

$$\text{Ratio} = \frac{(4)\left(\frac{4\pi r^3}{3}\right)}{16\sqrt{2} \cdot r^3} \times 100\% = 74\%$$

(c) Body-centered cubic lattice

$$d = 4r = a\sqrt{3} \Rightarrow a = \frac{4}{\sqrt{3}} \cdot r$$

Unit cell vol $= a^3 = \left(\frac{4}{\sqrt{3}} \cdot r\right)^3$

2 atoms per cell, so atom vol

$= (2)\left(\frac{4\pi r^3}{3}\right)$

Then

$$\text{Ratio} = \frac{(2)\left(\frac{4\pi r^3}{3}\right)}{\left(\frac{4r}{\sqrt{3}}\right)^3} \times 100\% = 68\%$$

(d) Diamond lattice

Body diagonal

$= d = 8r = a\sqrt{3} \Rightarrow a = \frac{8}{\sqrt{3}} \cdot r$

Unit cell vol $= a^3 = \left(\frac{8r}{\sqrt{3}}\right)^3$

8 atoms per cell, so atom vol

$= (8)\left(\frac{4\pi r^3}{3}\right)$

Then

$$\text{Ratio} = \frac{(8)\left(\frac{4\pi r^3}{3}\right)}{\left(\frac{8r}{\sqrt{3}}\right)^3} \times 100\% = 34\%$$

1.7

(a) Simple cubic: $a = 2r = 3.9\ \mathring{A}$

(b) fcc: $a = \frac{4r}{\sqrt{2}} = 5.515\ \mathring{A}$

(c) bcc: $a = \frac{4r}{\sqrt{3}} = 4.503\ \mathring{A}$

(d) diamond: $a = \frac{2(4r)}{\sqrt{3}} = 9.007\ \mathring{A}$

1.9

(a) $a = 2r = 4.5\ \mathring{A}$

\# of atoms $= 8 \times \frac{1}{8} = 1$

Number density $= \frac{1}{\left(4.5 \times 10^{-8}\right)^3}$

$= 1.097 \times 10^{22}\ \text{cm}^{-3}$

Mass density $= \rho = \frac{N(At.Wt.)}{N_A}$

$= \frac{\left(1.0974 \times 10^{22}\right)(12.5)}{6.02 \times 10^{23}}$

$= 0.228\ \text{gm/cm}^3$

(b) $a = \frac{4r}{\sqrt{3}} = 5.196\ \mathring{A}$

\# of atoms $8 \times \frac{1}{8} + 1 = 2$

Number density $= \frac{2}{\left(5.196 \times 10^{-8}\right)^3}$

$= 1.4257 \times 10^{22}\ \text{cm}^{-3}$

Mass density

$$= \rho = \frac{(1.4257\times10^{22})(12.5)}{6.02\times10^{23}}$$

$$= 0.296 \text{ gm/cm}^3$$

1.16

(a)

$$\left(\frac{1}{1},\frac{1}{3},\frac{1}{1}\right) \Rightarrow (313)$$

(b)

$$\left(\frac{1}{4},\frac{1}{2},\frac{1}{4}\right) \Rightarrow (121)$$

1.19

(a) Simple cubic

(i) (100) plane:

Surface density

$$= \frac{1}{a^2} = \frac{1}{(4.73\times10^{-8})^2}$$

$$= 4.47\times10^{14} \text{ cm}^{-2}$$

(ii) (110) plane:

Surface density $= \dfrac{1}{a^2\sqrt{2}}$

$$= 3.16\times10^{14} \text{ cm}^{-2}$$

(iii) (111) plane:

Area of plane $= \dfrac{1}{2}bh$

where $b = a\sqrt{2} = 6.689 \overset{o}{A}$

Now

$$h^2 = (a\sqrt{2})^2 - \left(\frac{a\sqrt{2}}{2}\right)^2 = \frac{3}{4}(a\sqrt{2})^2$$

So $h = \dfrac{\sqrt{6}}{2}(4.73) = 5.793 \overset{o}{A}$

Area of plane

$$= \frac{1}{2}(6.68923\times10^{-8})(5.79304\times10^{-8})$$

$$= 19.3755\times10^{-16} \text{ cm}^2$$

Surface density $= \dfrac{3\times\frac{1}{6}}{19.3755\times10^{-16}}$

$$= 2.58\times10^{14} \text{ cm}^{-2}$$

(b) bcc

(i) (100) plane:

Surface density $= \dfrac{1}{a^2} = 4.47\times10^{14}$ cm $^{-2}$

(ii) (110) plane:

Surface density $= \dfrac{2}{a^2\sqrt{2}}$

$$= 6.32\times10^{14} \text{ cm}^{-2}$$

(iii) (111) plane:

Surface density $= \dfrac{3\times\frac{1}{6}}{19.3755\times10^{-16}}$

$$= 2.58\times10^{14} \text{ cm}^{-2}$$

(c) fcc

(i) (100) plane:

Surface density $= \dfrac{2}{a^2} = 8.94\times10^{14}$ cm $^{-2}$

(ii) (110) plane:

Surface density $= \dfrac{2}{a^2\sqrt{2}}$

$$= 6.32\times10^{14} \text{ cm}^{-2}$$

(iii) (111) plane:

Surface density $= \dfrac{3\times\frac{1}{6}+3\times\frac{1}{2}}{19.3755\times10^{-16}}$

$$= 1.03\times10^{15} \text{ cm}^{-2}$$

1.20

(a) (100) plane: - similar to a fcc:

Surface density $= \dfrac{2}{(5.43\times10^{-8})^2}$

$$= 6.78\times10^{14} \text{ cm}^{-2}$$

(b) (110) plane:

Surface density $= \dfrac{4}{\sqrt{2}(5.43\times10^{-8})^2}$

$$= 9.59\times10^{14} \text{ cm}^{-2}$$

(c) (111) plane:

Surface density $= \dfrac{2}{(\sqrt{3}/2)(5.43\times10^{-8})^2}$

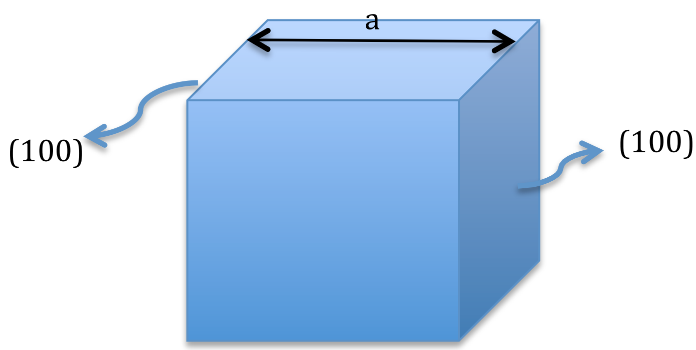
$$= 7.83\times10^{14} \text{ cm}^{-2}$$

Question 2

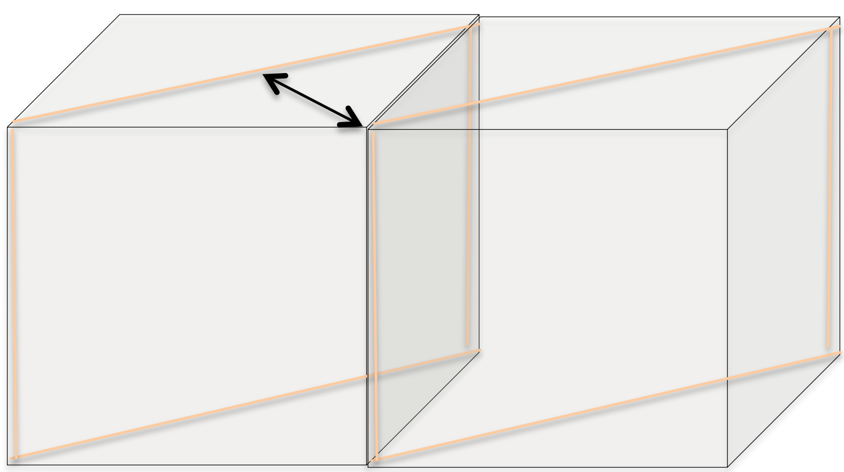
Calculate the surface density of silicon atoms in each plane as it is done in supplemental to module 1, then multiply each by 4 since each silicon atom has four valence electrons.

Question 3

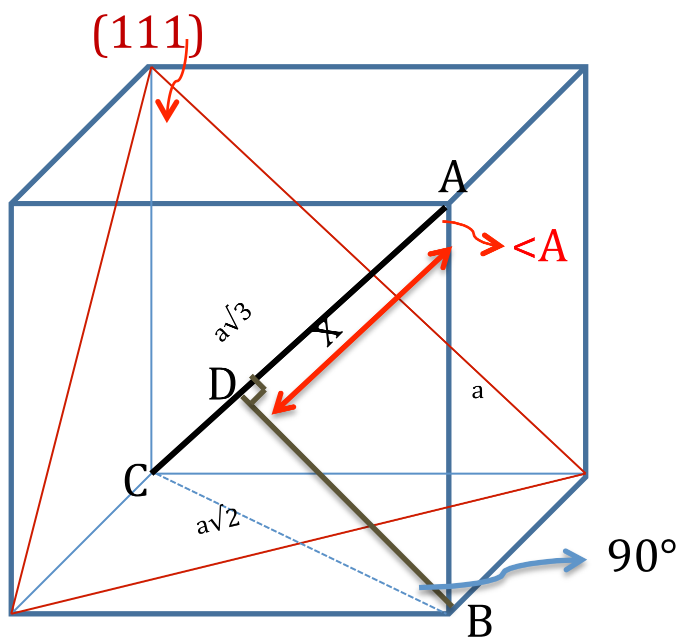
For {100} planes the distance between planes is ***a*** (lattice constant)



For {110} planes it is half of face diagonal (shown in the figure below)



For {111} planes it is 1/3 of body diagonal



In ABC triangle Cos (<A)=a/(a√3)=1/√3
In ABD triangle Cos(<A)= 1/√3=x/a so: x=a/√3

Question 4

Number of atoms in 110 plane is 4* ½ = 2 atoms

Surface density in 110 plane = $\frac{\#\ atoms}{surface\ area\ of\ the\ plane} = \frac{2}{(a)^2\sqrt{2}}$ atoms/cm^3