Problem 1:

$$a) 2\ 1\ 2 \implies \frac{1}{2}\ 1\ \frac{1}{2} \implies (\frac{1}{2}, 1, \frac{1}{2}) \implies (1,2,1) \qquad b) \infty\ 1\ 1 \implies \frac{1}{\infty}\ 1\ 1 \implies (0,1,1)$$

$$5c) \frac{1}{2}\ 3\ 2 \implies \ 2\ \frac{1}{3}\ \frac{1}{2} \implies (2, \frac{1}{3}, \frac{1}{2}) \implies (12,2,3) \qquad 5d) 1\ \bar{1}\ 1 \implies 1\ \bar{1}\ 1 \implies (1, \bar{1}, 1)$$

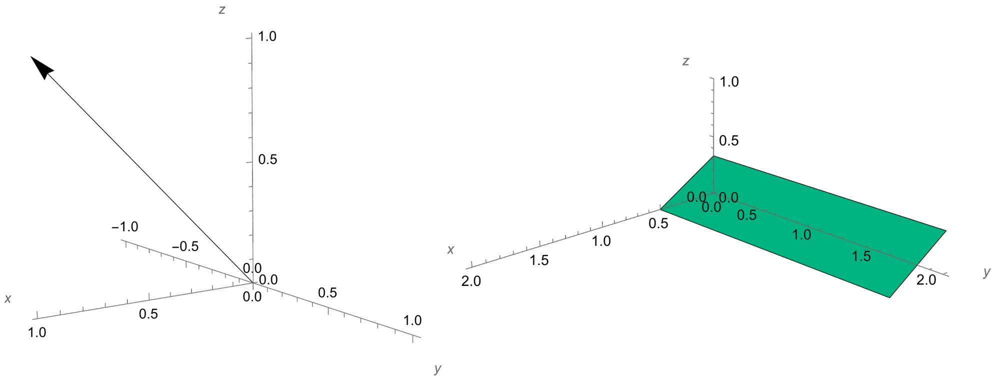
Problem 2:

I will be using this Mathematica code I wrote to solve this problem:

```
h = 1; k = 0; l = 1;
Graphics3D[Arrow[{{0, 0, 0}, {h, k, l}}], Axes → True, AxesOrigin → {0, 0, 0},
 Boxed → False, AxesLabel → {x, y, z}]

h = 2; k = 0; l = 3;
Plot3D[z /. Solve[x h + y k + z l == 1, z], {x, 0, 2}, {y, 0, 2}, Mesh → None,
 PlotStyle → Cyan, PlotRange → {0, 1}, AxesOrigin → {0, 0, 0}, AxesLabel → {x, y, z},
 Boxed → False, ClippingStyle → None]
```

Figure 1: Mathematica code used for Problem 2



(a) [101] (b) (203)

Figure 2: Problem 2

Problem 3:

We will need to calculate the volume of the unit cell V_{Cell}, and the volume of 8 Si atoms V_{Si}. However, we first need to compute the nearest neighbor (NN) distance r_{NN}:

$$\begin{aligned}
r_{NN} &= \text{Distance between} < 0,0,0 > \& < \frac{1}{4}, \frac{1}{4}, \frac{1}{4} > \\
&= \sqrt{(0-\frac{1}{4})^2 + (0-\frac{1}{4})^2 + (0-\frac{1}{4})^2} * a \\
&= \frac{\sqrt{3}}{4} a \\
V_{Si} &= 8 \times \frac{4}{3}\pi(\frac{\sqrt{3}}{8}a)^3 = 0.34a^3 \\
V_{Cell} &= a^3 \\
\frac{V_{Si}}{V_{Cell}} &= \frac{0.34a^3}{a^3} = 34\%
\end{aligned}$$

We can notice that as long as it is a diamond structure, this ratio is independent from the lattice constant.

Problem 4:

a) For diamond silicon structure:

(100): We will have $\frac{2}{5.43^2}$ $atoms/\mathring{A}^2$

(110): We will have $\frac{4}{\sqrt{2}*5.43^2}$ $atoms/\mathring{A}^2$

(111): We will have $\frac{2}{\frac{\sqrt{3}}{4}5.43^2}$ $atoms/\mathring{A}^2$

We can see that (111) > (110) > (100). Hence, (111) will be the best plane.

b) It will be $[1, 1, 1]$. Because it is the direction with the highest atomic density.

Problem 5:

a) The net charge is +1 for region A

b) The net charge is -1 for region B

c) a) The net charge is -1 for region A

b) The net charge is +1 for region B

Problem 6:

To answer this question we must know how many valence electron in each atom:

$$As : 6 \qquad Si : 5 \qquad Ga : 3$$

So, if we exclusively replaced Ga with Si, we will have more ***mobile electrons***. Thus, we will have an ***n-type*** material.
The opposite goes when we replace As with Si, we will have more ***holes***. Thus, a ***p-type*** material.