Solution fys9n4310 Problem 500-3 (problem 5.3 from Stephen Campbells textbook)

```
> restart;
```

Si, substrateconcentration 1e16 cm^-3 B doped;
P,Phosphorous implant, dose 1e15 cm^-2, energy 150 keV,
Determine
a) The depth of the peak of the implant profile and the value of the peak concentration
b) The as implanted "junction" depth

a)

Here we use units cm for depth and cm-3 for concentration and cm-2 for dose if nothing else is stated

Fig 5.9 A gives the answer: R_p=**180 nm**
and ΔRp=48.0 nm, (P in Si E=150keV)

We assume a Gaussian distribution

```
> N:=x-> Phi/sqrt(2*Pi)/delRp*exp(-(x-Rp)^2/2/delRp^2);
```

$$N := x \rightarrow \frac{\Phi \, e^{-\frac{1}{2}\frac{(x-Rp)^2}{delRp^2}}}{\sqrt{2\,\pi}\;delRp}$$

We put the numerical values given (and found) into the parameter set 'pars' with units cm

```
> pars:={delRp=480e-8,Rp=1800e-8,Nbulk=1e16,Phi=1e15};
```

$$pars := \{Nbulk = 1.00 \times 10^{16}, \Phi = 1.00 \times 10^{15}, Rp = 1.80 \times 10^{-5}, delRp = 4.80 \times 10^{-6}\}$$

We have given that the concentration at the peak, Rp, should be a certain value, Npeak. That gives us the following equation

```
> eq1:=Npeak=N(Rp);evalf(subs(pars,eq1));
```

$$eq1 := Npeak = 5.00 \times 10^{-1}\;\frac{\Phi\sqrt{2.00 \times 10^{0}}}{\sqrt{\pi}\;delRp}$$

$$Npeak = 8.31 \times 10^{19}$$

So the **peak P concentration is 8.3 e19 cm-3**.

b)

We need to find when N(x)=Nbulk;

```
> eq2:=N(x)=Nbulk;
```

$$eq2 := \frac{1}{2}\,\frac{\Phi\sqrt{2}\,e^{-\frac{1}{2}\frac{(x-Rp)^2}{delRp^2}}}{\sqrt{\pi}\,delRp} = Nbulk$$

```
> answer_b:=solve(eq2,x);
```

$$answer\_b := Rp + delRp\sqrt{-\ln\left(\frac{2\,\pi\,Nbulk^2\,delRp^2}{\Phi^2}\right)},\ Rp - delRp\sqrt{-\ln\left(\frac{2\,\pi\,Nbulk^2\,delRp^2}{\Phi^2}\right)}$$

```
> answer_b2:=solve(subs(pars,eq2),x);
```

$$answer\_b2 := -2.39 \times 10^{-6},\ 3.84 \times 10^{-5}$$

So we have two solutions one is outside surface and the other is at 3.84e-5 cm =0.384 µm =384 nm

```
> with(plots):
> plot1:=logplot(subs(pars,N(x)),x=0..6100e-8):
> plot2:=logplot([[0,1e16],[6100,1e16]],color=green):#The bulk
  concentration is constant, so we plot a line
> display(plot1,plot2);
```