Solution problem 300-8 FYS9n4310   (maple work sheet)

Rerun of what the problem is:
Need shallow P+/n junction, (zj<0.05µm=5e-6 cm)
Si implant of B low energy, anneal out damage
Drive-in diffusion pars:
QT=5e15 cm^-2
T=1000 C
t=10 sec
a) Find junction depth. zj.
b) Find final concentration of B at surface
c) Compare your calcs with NanoHubs, Process Lab, Concentration-Dependent diffusion.

We have to do simplifications here; And we are explicitely asked to do so
We are asked to ignore high concentration effects (i.e. assume intrinsic diffusion),
and transient diffusion (see for chapter on Ion Implantation, Annealing)

```
> restart;
```

We have the following parameters from chapter 3.2 and table 3.2 in units cm , eV and K ,
See soulution 300-2 to get an idea the meaning of symbols

```
> pars:={k=8.617065e-5,  Do=0.037,Ea=3.46,T=273.0+1000, CB=2e17,QT=5e15,t=10};
```

$$pars := \{CB = 2.\ 10^{17}, Do = 0.037, Ea = 3.46, QT = 5.\ 10^{15}, T = 1273.0, k = 0.00008617065, t = 10\}$$

```
> eq1:=D=Do*exp(-Ea/k/T);
```

$$eq1 := \mathrm{D} = Do\, \mathrm{e}^{-\frac{Ea}{k\,T}}$$

```
> pars:=pars union {evalf(subs(pars,eq1))};
```

$$pars := \{CB = 2.\ 10^{17}, \mathrm{D} = 7.408215384\ 10^{-16}, Do = 0.037, Ea = 3.46, QT = 5.\ 10^{15}, T = 1273.0, k = 0.00008617065, t = 10\}$$

We have equations we can use for calculating concentration profiles , for drive-in constant diffusivity

$$> eq2 := C = \frac{QT\, \mathrm{e}^{-\frac{z^2}{4\,\mathrm{D}\,t}}}{\sqrt{\pi\,\mathrm{D}\,t}};$$

$$eq2 := C = \frac{QT\, \mathrm{e}^{-\frac{1}{4}\frac{z^2}{\mathrm{D}\,t}}}{\sqrt{\pi\,\mathrm{D}\,t}}$$

Surface concentration during drive-in, z=0

```
> eq3 := Cs = simplify(subs(z=0,rhs(eq2)));
```

$$eq3 := Cs = \frac{QT}{\sqrt{\pi}\,\sqrt{\mathrm{D}\,t}}$$

From equation eq 2 we have, by setting C=CB and solving for z, = zj junction depth

```
> eq4:=zj=sqrt(4*D*t*ln(QT/(CB*sqrt(Pi*D*t))));
```

$$eq4 := zj = 2\sqrt{\mathrm{D}\, t \ln\left(\frac{QT}{CB\sqrt{\pi\, \mathrm{D}\, t}}\right)}$$

We can set in the known values for the parameters,

a)

```
> answer_a:=evalf(subs(pars ,eq4),3);# junction depth in cm
```

$$answer\_a := zj = 5.95\ 10^{-7}$$

0.6 e-6 cm

b)

```
> answer_b:=evalf(subs(pars ,eq3),3);
```

$$answer\_b := Cs = 3.28\ 10^{22}$$

We see that this value is higher than the solid solubility

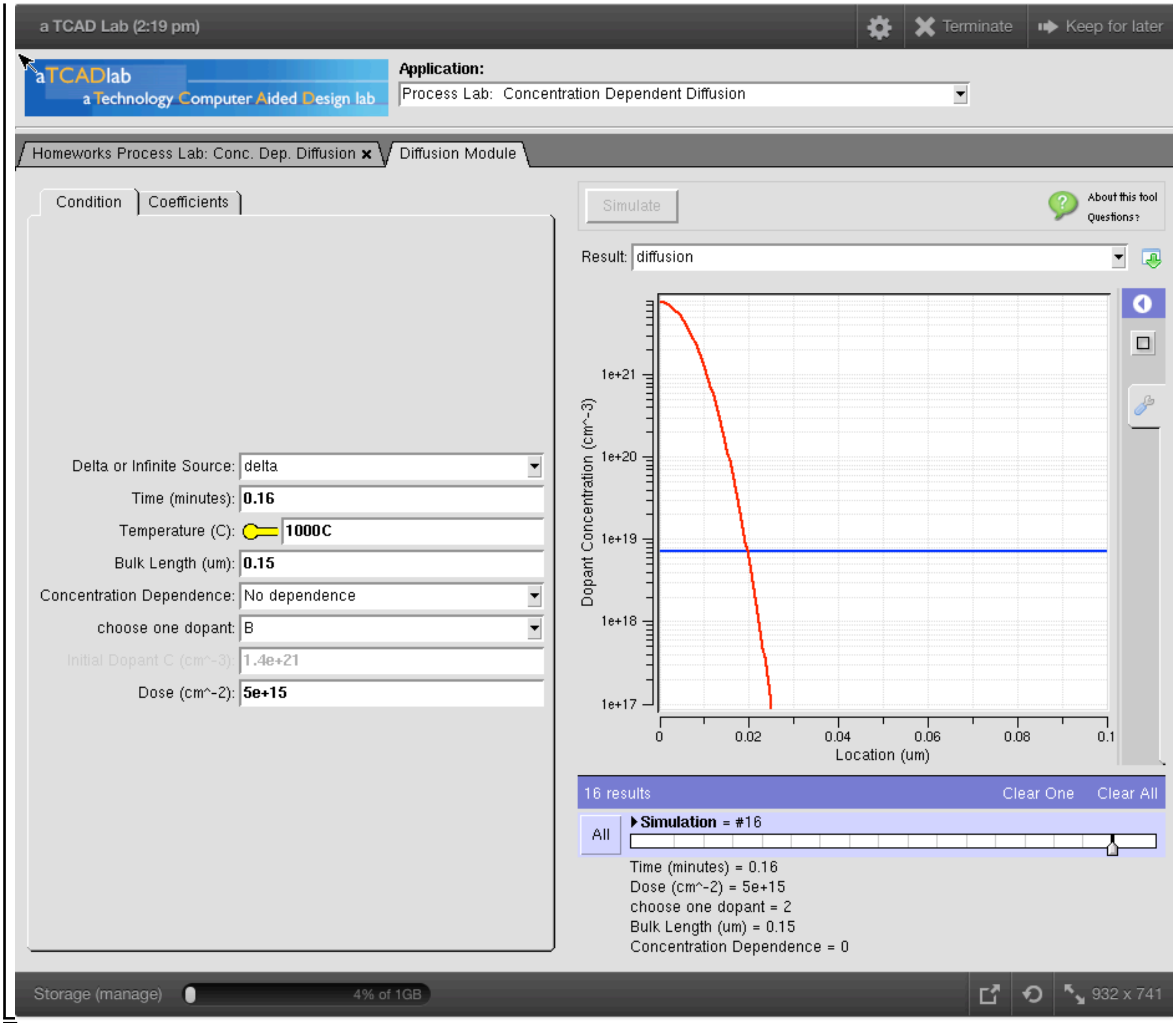
Let us just see what would happen if we did not take the diffusivity, but instead caculated the diffusivity of a concentration corresponding to solid solubility. i.e. 5e20

▶ p=5e20 const D => zj=12.1e-6cm Cs= 1.39e21 cm^-3

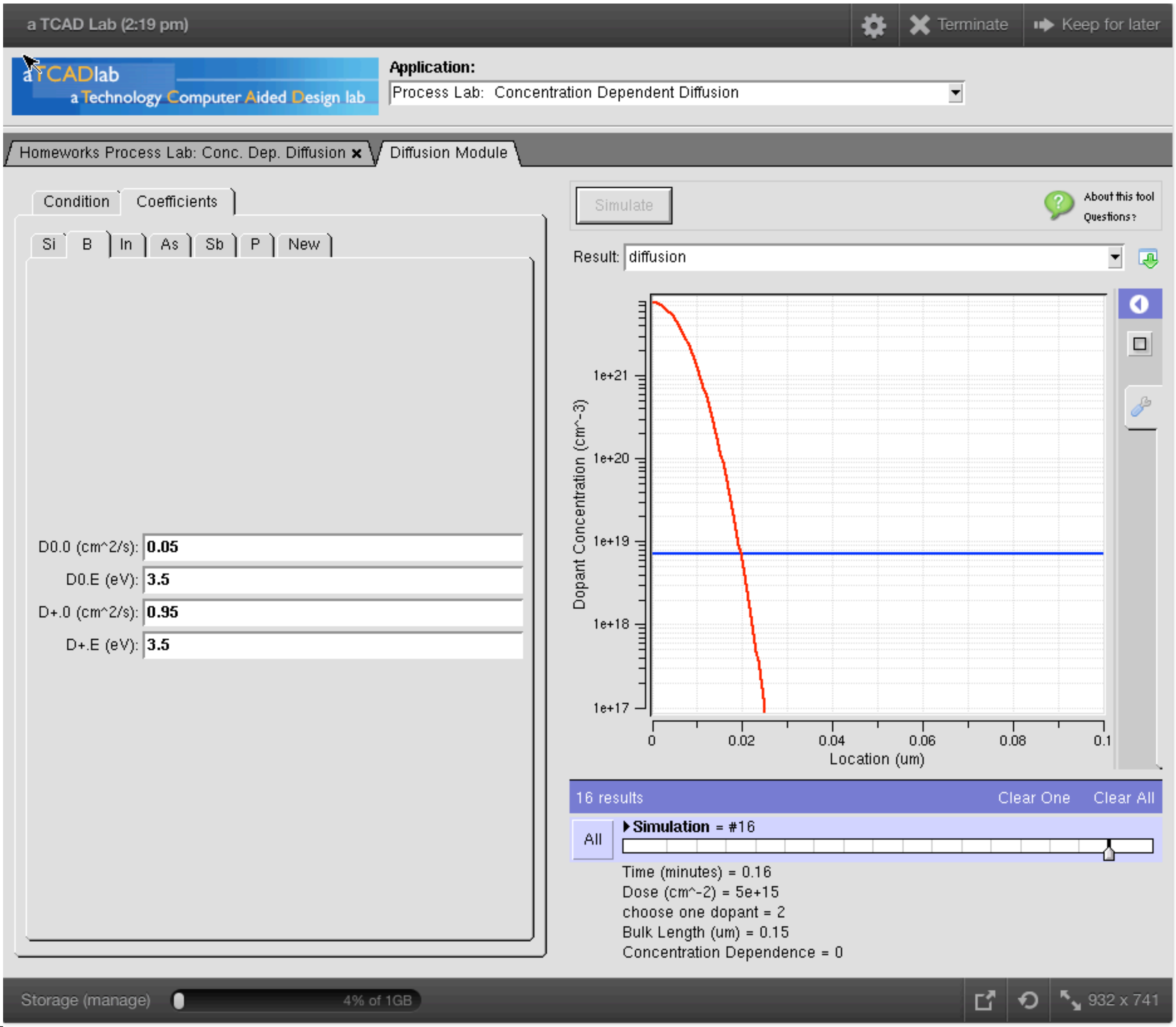
▶ p=ni const D => zj=12.1e-6cm Cs= 9.44e21

LET'S See what the nanohub tool Concentration dependant Diffusion gives

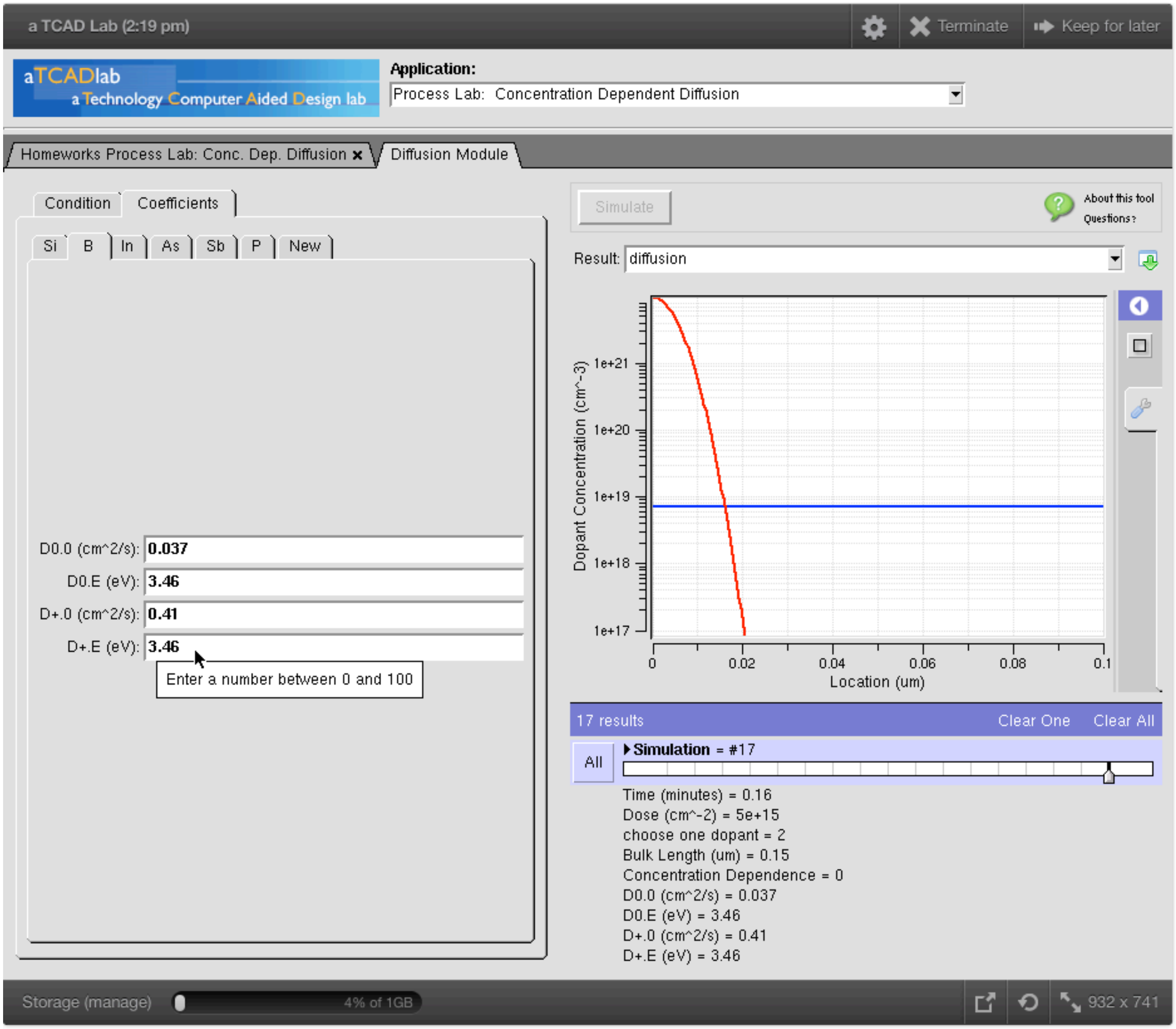
We have that 10 sec = 0.16 min, We see the input pars on the left and resulting concentration on the plot
First concentration independat diffusion - but is that the same as intrinsic?



junction 0.025 um = 2.5e-6 cm Cs 8e21,
We got junction depth 2 by using formulas and the intrinsic carrier concentration
Maybe parameters for diff is different?, yes see parameters below

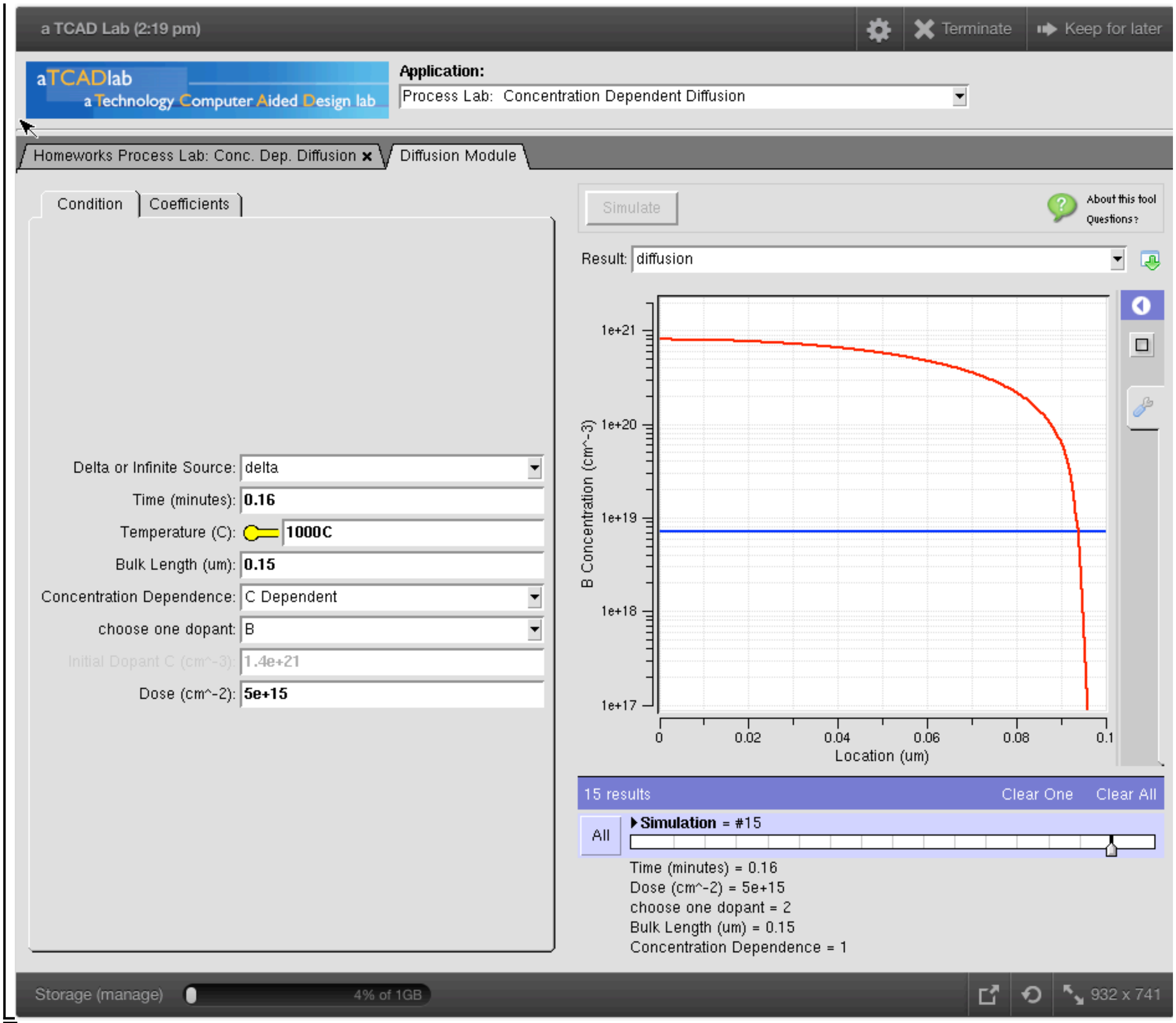


Then we do a sim with the parameters in the book, and assume conc equal to intrinsic conc



Then from above we see junction = 2.01 e-6 cm and Cs=9.5e21.
That is close to the manual calculation 1.97e-6 , 9.44e21

Then concentration dependant diffusion



junction 0.097 um = 9.7e-6, Cs=8e20