homework #7

Nitrogen-hardened titanium alloys are used for hip implants in humans. The surface of a titanium sample is typically hardened by exposing it to a nitrogen-containing atmosphere and allowing nitrogen diffusion into the surface region. The optimum hardness is realized when a nitrogen concentration of 10^{-4} g/cm^3 is obtained at a depth of 10 μm.

You performed one experiment in which you exposed a surface of an initially nitrogen-free titanium sample (Ti sheet of thickness that is so large that the diffusion is not affected by the presence of the back surface) to the nitrogen atmosphere so that the nitrogen concentration at the surface of the titanium sample is maintained at 2×10^{-4} g/cm^3 during the experiment. You kept the Ti sample in the nitrogen atmosphere for 1 hour at a temperature of 500 K. After analysis of the sample you found that the concentration at a depth of 10 μm is 1.5×10^{-4} g/cm^3.

From your earlier experiments you know that the pre-exponential coefficient in the Arrhenius temperature dependence of the diffusion coefficient for nitrogen diffusion in titanium is $D_0 = 1$ cm^2/s.

How much should you change the temperature in this experiment (keeping all other parameters fixed) in order to obtain the optimum hardness?

homework #7 - table of erf(x)

β	erf (β)
0	0
0.05	0.056372
0.1	0.112463
0.15	0.167996
0.2	0.222703
0.25	0.276326
0.3	0.328627
0.35	0.379382
0.4	0.428392
0.45	0.475482
0.5	0.520500
0.55	0.563323
0.6	0.603856
0.65	0.642029
0.7	0.677801
0.75	0.711156
0.8	0.742101
0.85	0.770668
0.9	0.796908
0.95	0.820891
1.0	0.842701
1.1	0.880205
1.2	0.910314
1.3	0.934008
1.4	0.952285
1.5	0.966105
1.6	0.976348
1.7	0.983790
1.8	0.989091
1.9	0.992790
2.0	0.995322
2.1	0.997021
2.2	0.998137
2.3	0.998857
2.4	0.999311
2.5	0.999593
2.6	0.999764
2.7	0.999866
2.8	0.999925
2.9	0.999959
3.0	0.999978