1. The solution to this problem is very similar to the one given in class. The difference
is that the negative energy solutions contain real exponentials instead of complex
exponentials. Because of this we end up with a solution which contains the functions
\( \sinh(ka) \) and \( \cosh(ka) \) instead of \( \sin(ka) \) and \( \cos(ka) \). Following the same procedure
outlined in class you arrive at \( \psi_+(x) = A \sinh(kx) + B \sinh(kx) \) for the region \( 0 < x < a \) and \( \psi_-(x) = e^{-iKa}(A \sinh(k(x + a)) + B \cosh(k(x + a))) \) for the region \( -a < x < 0 \).
Making use of the boundary conditions \( \psi_+(x = 0) = \psi_-(x = 0) \) and \( \Delta d\psi/dx|_{x=0} = 2m\alpha B/\hbar^2 \) you arrive at the constraint equation \( \cos(Ka) = \cosh(z) + \beta \sinh(z)/z \)
where \( z = -ka \) and \( \beta = -m\alpha a/\hbar^2 \). Exactly one of these energy states is a bound
state while the others are unbound. There are \( N-1 \) unbound states in the first band
and 1 bound state which has energy of \( E = -\alpha^2/2\hbar^2 \).

2. (a) \( f = \omega/2\pi \)
(b) \( \lambda = 2\pi c/\omega \)
(c) \( 1/\lambda = \omega/2\pi c = \frac{\sqrt{k}}{2\pi c} \sqrt{1/\mu} \rightarrow \frac{1}{\lambda_{35}} = \frac{1}{\lambda_{35}} \cdot \sqrt{\frac{\mu_{35}}{\mu_{37}}} = 2988\text{cm}^{-1} \).

3. (a) You are given the information to come up with two equations which in turn allows
you to solve for the two unknowns. (1) \( \frac{dV}{dR}|_{R_0} = 0 = \frac{e^2}{4\pi \epsilon_0 R_0^2} - \frac{\Delta e}{\rho} e^{-R_0/\rho} \) and (2) \( V(R_0) = -4.9eV = -\frac{e^2}{4\pi \epsilon_0 R_0} + A e^{-R_0/\rho} \). From these two equations you get \( A = 257eV = 4.1J \)
and \( \rho/R_0 = 0.183 \).
(b) Your graph should look something like the one below.
(c) \( A \) represents the strength of the repulsion of the two electrons while \( \rho \) represents the
length scale of this potential.