1. The Bohr Model and quantized electron energies
   1. What is the meaning of the negative value of energy

Energy for an electron in an atom is negative because the total energy of an electron is the sum of the kinetic energy and its potential energy. The potential energy of a free electron is set to be 0 as a base case. Therefore, the potential energy of an electron in an energy level is negative because it must have less energy than a free electron because work is done on it by the nucleus. Kinetic energy is positive, but it is less than the potential energy as it dissipates through photon emission. Therefore, the total energy in an electron is negative.

* 1. Supposed the atom existed in an environment where the dielectric constant is 100x larger than K. What consequences does this have on the binding of an electron to a nucleus at room temperature?

If the dielectric constant was 100X larger, then the value of electron energy at that absolute value of the energy level would be 10000X less at room temperature than the standard environment. Since the energy would be closer to 0, the energy would be similar to that of a free electron. Therefore, it would more difficult to bind the electron to the nucleus.

1. From Discrete Energy Levels to Bands
   1. Why are the innermost energy states, corresponding to the n = 1 and n = 2 states in the Si atoms not broadened?

The electrons in the inner shell (n = 2, n= 1 in the case of silicon) are unaffected by the distance between different atoms. This is because a very high amount of energy is needed the inner electrons as they are highly stable in the orbitals. As electrons bind in ways to minimize the total energy of the system, atoms try to bind and hybridize the valence electrons and leave the innermost levels untouched.

* 1. Why do we observe broadening into bands for the corresponding higher energy level states, corresponding to the n = 3 states in the Si atom?

There is a maximum and minimum energy state that the electron can reside in when the energy level “splits”. When there is only a few electrons (only a few Si atoms are present) then the distinct levels that occur due to the Pauli Exclusion Principle when splitting occurs can be viewed. However, when the number of electrons available increases, the differences in each energy level is so small that it seems as if all the electrons have energies somewhere between the minimum and maximum energy, in a band, rather than in distinct levels. Therefore, this multiple splitting causes us to observe bands.

1. Behaving More Like a Metal or an Insulator?
   1. If the temperature T = 0 and the bandgap of this semiconductor is 5 eV, will this material conduct a current more like a metal or an insulator? Why?

At T = 0, this semiconductor will act like an insulator because there is no energy around to allow for electrons to move around or jump to the conduction band even if the band gap is 5 eV. With no thermal energy, all the electrons will stay in the valence band and act as an insulator.

* 1. What if the temperature were 300K?

The probability of an electron in the valence band being thermally excited to the conduction band is known by: so the chances of the electron being excited into the conduction band through thermal energy is small.

* 1. What if the bandgap of the material were .05 eV and the temperature were 300K?

A significant number of electrons will be thermally excited across the energy gap into the conduction band. This is because the bandgap is small enough for electrons to have enough energy from heat alone to move into the conduction band.

1. Electron conduction and an Energy Band representation
   1. If the band diagram of the electron is represented by the figure Eg > qV: will current flow through the wire at T = 0K?

Current would not flow through the wire because there is not enough energy to excite the electrons to the conduction band. As such, the energy applied to the system will be transferred to heat rather than to the electrons causing the wire to get hot and not to have any current. If we are viewing the solid as a wire, then it would be like the resistance (the bandgap) is higher than the applied voltage so that it seems like no (or very little) current is flowing.

* 1. What if T = 300 K?

If Eg > qV, then current will still not flow through the wire at T = 300K. Once again, the wire will get very hot and but as long as the voltage + thermal energy does not exceed the band gap, current will not be able to flow through the solid as the electrons have nowhere to flow to. As such, there should not be current flowing in this situation.