

Chemical Bonds and the properties of matter

The questions here are based on the two articles by Eugene Wigner: “The effects of radiation on matter” and “On the structure of solid bodies.”

1. In order to discuss the effects of radiation on metals and other solids, we first need to study the molecular structure of metals. More specifically we will examine what pure metals (for example copper, zinc, or aluminum) look like at the molecular level.
 - a. For simplicity, one can imagine each atom in a piece of metal as a sphere. How many spheres, *all of the same size*, can be placed around a central sphere in the plane? Do they fit together snugly or is there space to move them? To which tiling of the plane do the centers of these spheres correspond (assuming that the pattern is repeated indefinitely)?
 - b. Suppose now that you wish to add a new layer of spheres on top of the first layer. Is there only one way in which this can be done or more than one?
 - c. In the article “on the structure of solid bodies” Wigner discusses some of the properties of metals. What are these? Do they make sense in light of this model of metals at the molecular level?
 - d. A metal *alloy* is of course a combination of different metals: for example steel usually combines iron with a small amount of carbon. Explain how the addition of carbon changes the properties of iron (that is will the alloy be more or less flexible, more or less soft,...?). A beautiful example of an application of this is to the construction of samurai swords– the edge of the sword needs to hold its sharpness and yet the entire sword must be able to absorb a large amount of shock– this requires a very delicate construction using *different* alloys for the different parts of the sword.

2. Wigner explicitly describes the effects of radiation on graphite (a crystal lattice as opposed to a metal).
 - a. What types of damage are done by the radiation as it is absorbed by graphite?
 - b. Why does it make sense for the graphite to be able to “heal” after this damage?

3. Here we will study in what ways metals are influenced by radiation.
 - a. As opposed to graphite which is very rigid in structure, metals are more “fluid.” How does this impact the way a metal is effected by radiation?
 - b. Wigner specifically discusses electrical conductivity and ductility. How and why are these influence by radiation?
 - c. Wigner talks about “graphite storage batteries” and “superhardening of copper” as potential uses of irradiated materials. Explain what he is talking about here.

4. In the second article “on the structure of solid bodies”, Wigner discusses four types of molecular lattices. What are they? How does this relate to the topic of symmetry that we are studying?
 - a. What “general” properties do the four classes of materials have and how are they related to their molecular structure?
 - b. The graphs on page 89 show examples of the electron distribution for examples of the four classes of materials. Explain the meaning of these pictures and how the graphs relate to concrete properties of the substances.

5. On page 133 of the radiation article, Wigner discusses the devastating effects of radiation upon plastics. What reason does he provide for the inability of plastics to recover the way metals or graphite do? What do you think the effects of radiation on human tissue are?