Atoms and Phases

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Opening Discussion

- Have you seen anything interesting in the news?
- What did we talk about last class?
- Java can be installed on Macs.

Potential Energy

- There are many forms of potential energy. The two we care about in astronomy are gravitational potential energy and mass-energy.
- Near the surface of the Earth, gravitational potential energy is given by $E=mgh$. ($g=9.8\ m/s^2$) When we talk about Newton's law of gravity we'll see what it is like more generally.
- Einstein also postulated that mass and energy were equivalent with a conversion of $E=mc^2$. Here c is the speed of light in a vacuum. This is what powers stars.

Exploring Energy

- Let's work through some simple problems to give you a feel for the power of the equations that we have learned for energy.
- Climbing steps. How far must you climb to increase your potential energy by 1 Cal? Why do you burn more than 1 Cal if you actually climb that far?
- How fast do you have to be running to have 1 Cal of kinetic energy?

Structure of Matter

- Matter, at least the stuff we are concerned with, is made of atoms. An atom has a nucleus that contains protons and neutrons. The nucleus is surrounded by a cloud of electrons.
- The electrons have a negative charge and actually take up most of the space.
- The protons have a positive charge while neutrons are neutral. The nucleus is extremely small.
- The type of atom you have is determined by how many protons are in the nucleus.

Molecules

- Atoms bond together to form molecules. Most of the things you interact with are molecules which gives much greater diversity.
- The bonds in molecules result from atoms sharing electrons in ways that lower their overall energy levels.

Phases of Matter

- We talked last time about thermal energy, that is the kinetic energy of the atoms/molecules in a substance.
- The amount of thermal energy determines what phase the substance will be in.
- There are weak bonds between the molecules in most substances. If thermal energy is low these bonds will hold a rigid structure (solid). At higher energies the bonds loosen (liquid). When the bonds between molecules mostly disappear you get a gas.
- If energies get high enough, electrons are knocked off for a plasma.

Electron Energy States

- The electrons in an atom can't take on any energy level they want. Instead, they can only be a certain fixed energy levels.
- This fact is the fundamental aspect of quantum mechanics. It plays a huge role in astronomy as we will see in a few chapters when we talk about light.
- It happens that the energy levels in basically all bound systems are quantized. This includes the energies of the motions of atoms in molecules.
- In the hydrogen atom the energy levels are easily calculated by $13.6*(1-n^2)$ eV.

Minute Essay

- What do you think might be some of the implications of the fact that electrons can't take on any energy level?