F1  Simple gas law: temperature rise in a squeezed gas.

F2  Phase change: evaporation and condensation as moist air is squeezed. This relies on the heating and cooling as you compress and decompress air in a spherical flask with a rubber squeeze-bulb. But if we start with room temperature air, compress and decompress it, why does a cloud appear?

   We see in this experiment the need to have some impurities in the air...dust or smoke, for a cloud to appear. This is discussed below.

F3  Convective circulations: heating a fluid from below, or from the side, will make it circulate. Warm fluid is usually less dense than cold fluid, and rises. The full circulation develops, bringing colder fluid to the source of heat. This is a form of heat engine, and is the primary mechanism driving the atmospheric circulation. One of the results is that the fluid carries thermal energy from the heat source to the cold source much more efficiently than heat flow due to molecular conduction (as in a solid object). Thus we say the atmospheric circulation 'ventilates' the Earth, carrying heat from the tropics toward the poles, where it radiates back to space. The ocean is also a heat engine with some mechanical forcing added: winds. And, it is a salt-water/fresh-water engine as well. Water vapor and liquid water play essential roles in both of these planetary heat engines.

F4  Cloud chamber: this shows how a humble science like meteorology sometimes contributes major discoveries to a 'mother science' like physics or chemistry. On the one hand we want you to think more about water's phase changes, and on the other to see individual atomic particles, a rare treat.

   As a mixture of dry air and gaseous water (water vapor) cools, the water is ready to condense into liquid droplets. But to get started, it would have to make very small droplets which would then grow. This is a problem: very small droplets have so much energy associated with their surface tension that, really they cannot form. What makes it possible is the presence of dust or other particles, upon which the water can condense. Without dust, no rain. Very often the atmosphere is 'super-cooled', that is, it is colder than the temperature at which its water should be liquid, yet the water is still a gas, waiting for an opportunity to condense.

   Another way to condense water would be to make some ionized, charged particles in the air, which can attract the polar water molecules. And this can happen if high-energy, charged particles were to fly through the air, colliding with air molecules. In this way cosmic rays leave tracks of water droplets, if they pass through a supercooled vapor.
Cosmic rays from outer space provide such particles, and so does a small sample of radioactive material. The dominant particles are the alpha particle, α, is the nucleus of helium: 2 protons and 2 neutrons, hence with strong positive charge. The beta (β) particle is a single free electron, much lighter than the α-particle, hence with negative charge ½ as big as the α-particle. While this experiment is very simple to set up, it led to the first sighting of individual atomic particles, and to the discovery of the positron in 1932 (the oppositely charged version of the electron).

From Wikipedia:
Charles Thomson Rees Wilson (1869-1959), a Scottish physicist, is credited with inventing the cloud chamber. Inspired by sightings of the Brocken spectre while working on the summit of Ben Nevis in 1894, he began to develop expansion chambers for studying cloud formation and optical phenomena in moist air. Very rapidly he discovered that ions could act as centres for water droplet formation in such chambers. He pursued the application of this discovery and perfected the first cloud chamber in 1911. In Wilson's original chamber the air inside the sealed device was saturated with water vapor, then a diaphragm is used to expand the air inside the chamber (adiabatic expansion). This cools the air and water vapor starts to condense. When an ionizing particle passes through the chamber, water vapor condenses on the resulting ions and the trail of the particle is visible in the vapor cloud. A diagram of Wilson's apparatus is given here. Wilson, along with Arthur Compton, received the Nobel Prize for Physics in 1927 for his work on the cloud chamber. This kind of chamber is also called a pulsed chamber because the conditions for operation are not continuously maintained.

Our experiment uses a cooled chamber instead:
A more recent design is the diffusion cloud chamber (Langsdorf,1936). In this device a large temperature difference is maintained between the top and bottom of the chamber, usually by cooling the bottom of the chamber with dry ice. The gas in the chamber, usually air, is saturated with a vapor, usually alcohol; the air-vapor mixture cools as it diffuses toward the cool bottom, becoming supersaturated. If the gas is kept saturated with a fresh supply of vapor, e.g., by an alcohol-soaked pad inside the top of the chamber, the operation of the chamber can be essentially continuous. One disadvantage of the cloud chamber is the relatively low density of the gas, which limits the number of interactions between ionizing radiation and molecules of the gas.

Some of the apparatus from lab 1 will still be around too.
In this lab or a later one we will look at a hydrogen fuel cell. First we pass an electric current through water, by putting two electrodes on either side of a beaker of water with some salt to make it more conductive. Gas bubbles appear, hydrogen at one electrode, oxygen at the other. This is 'electrolysis' of water, breaking it into its H and O constituents.

But this reaction can run the other way. If H is present at the cathode (the - charged electrode) and O at the anode (the + charged electrode), the gas can recombine and give up electrons, which pass back into the electrical circuit. This is the simplest form of hydrogen/oxygen fuel cell.

The electrical current in this experiment consists of ions moving in the water (Na⁺ sodium and Cl⁻ chlorine), and electrons moving in the wire. The ion movement can actually be seen using colored dyes (fig. below)

http://www.wpbschoolhouse.btinternet.co.uk/page01/ExIndChem/ExtraElectrochem.htm

http://www2.uni-siegen.de/~pci/versuche/english/v21-2.html