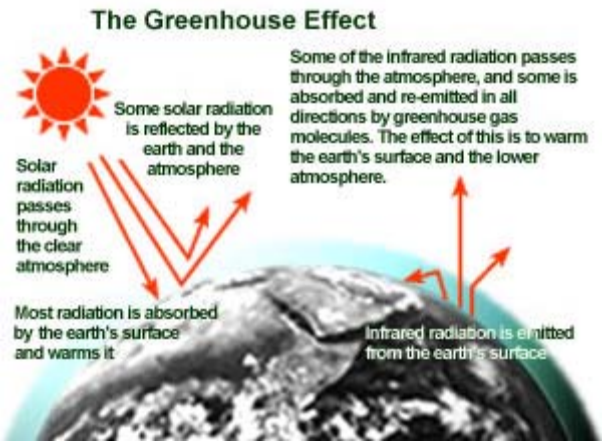
Print Notes – Installment 4
Chem 123 Winter 2003 – Rossi

Image at right[1]:
US EPA, 2002



Big Idea: The Greenhouse Effect

The greenhouse effect is a naturally occruing phenomenon caused in part by the differential absorbtion of light energy by certain gases in the atmosphere. Specifically, certain gases are transparent to visible light, but absorb strongly in the infrared portion of the electromagnetic spectrum. The presence of these gases in the atmosphere causes it to act like a blanket: it keeps heat in, and it keeps heat out. This differential phenomenon, all by itself, would mean less infrared radiation from the sun would reach the earth's surface, and the earth would be cooler. But the surface of the earth is a rather effective photothermal converter: the earth's surface absorbs *visible* light and gets warmer as a result. It then *emits* infrared radiation: in sum, it converts visible light into infrared radiation. Since visible light can get in but infrared can't get out, this leads to a net temperature *increase* on the earth's surface. The extent of this heating effect depends on how effectively the atmosphere absorbs infrared light, which in turn depends on the concentration of the so-called "greenhouse gases," which are transparent to visible light but absorb in the infrared.

The "Top Four" Greenhouse Gases[2]

Substance Name and Chemical Formula	Chemical Formula	Relative IR Absorbing Power	Tropospheric Abundance (%)	Relative Importance in Greenhouse Effect	**Approximate Atmospheric Lifetime**
Water vapor (H_2O)	H_2O	0.1	1	0.1	**very short (a few days)**
Methane (CH_4)	CH_4	30	1.7×10^{-3}	0.051	**12 years**
Nitrous Oxide (N_2O)	N_2O	160	3×10^{-4}	0.048	**120 years**
Carbon Dioxide (CO_2)	CO_2	1 (assigned value)	3.6×10^{-2}	0.036	**50 – 200 years**

Human activity is not thought to have a large lasting impact on the concentration of water vapor in the atmosphere, but we do have an impact on the other top three greenhouse gases. Specifically, our burning of fossil fuels releases significant amounts of carbon (as carbon dioxide) that were sequestered [trapped] underground (and thus not in the atmosphere). We release substantial amounts of methane into the atmosphere as a result of fossil fuel mining operations, and our rudiment (cud-chewing, e.g. grass-eating) livestock release a significant quantity as well (there are a lot more of such animals because of us!) Decaying organic matter also releases methane, and because we generate a lot of waste and have bacteria help us digest it in our landfills and sewage treatment plants, we contribute in this way as well. Nitrous oxide is formed by the degredation of many artificial fertilizers, and is thereby associated with "modern" agricultural activity. It is also produced whenever air is heated to high temperatures, and thus it emerges from the exhausts of engines in significant quantity.

The greenhouse effect is not inherently bad! Without it, the earth would be about 33 C° colder than it is, and thus largely (if not entirely) uninhabitable by water-based life forms! However, if the amount of greenhouse effect to which the the earth is subject changes even a bit, scientists are very concerned the consequences on present earth life could be dire…and we have reason to think that current human activities can/might/do signficantly change the greenhouse gas content of the atmosphere.

Nature has "natural" ways of removing pollutants from the atmosphere and cleaning it up again. Problem is, right now it looks like we're swamping them, making a mess faster than it can clean up after us. We don't know if it will pick up the pace in response to our accelerated mess-making, but at the rate we're going, we are going to find out.

Analogy: You park your car outside with the windows rolled up on a sunny day. When you return and open your car up, it's incredibly hot inside! This is a very real and literal example of the greenhouse effect. The glass of your car windows allows visible light to enter, while absorbing infrared light (heat radiation). The visible light is converted to heat by your car seats and trim – all the more effectively the darker its color. The heated interior of your car then emits infrared readiation, but this radiation can not escape through the glass as easily as the visible light came in. The net result is a four-wheeled toaster oven.

Our current environmental policy amounts to getting into a strange car-like object parked outside on a hot sunny day, and closing the door. We're taking a risk in doing so, that we won't figure out how to open the doors or windows (or turn on the AC) before it gets so hot in there that we die. We really dig this lifestyle, though, so it seems to be a chance we are willing to take.

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[1] http://yosemite.epa.gov/oar/globalwarming.nsf/content/climate.html, accessed on 10/16/02
[2] Stanitski, C. L., Eubanks, L. P., Middlecamp, C. H., and Stratton, W. J., Chemistry In Context: Applying Chemistry to Society, McGraw-Hill: Boston (2000), Table 3.2 and p. 118.

Big Idea: The Ozone Layer

There's another gas in our atmosphere who's interaction with light has a very important impact on our daily lives, and that's ozone, O_3. Ozone is an unstable allotrope (elemental form) of oxygen that acts as a pollutant here at ground level. It burns your lungs and makes it difficult to breathe. But in the upper atmosphere there aren't any lungs to burn, and ozone absorbs ultraviolet radiation. So up there, we like it. It keeps life on earth from suffering undue amounts of sunburn and skin cancer. Our bodies have evolved in an environment where relatively little ultraviolet radiation makes it to the earth's surface, and the design of our bodies (as well of most lifeforms) counts on that not changing too much. We aren't ultraviolet radiation-proof: even if we have tons of melanin in our skin, our outer layer provides meager protection and our fleshy insides are very vulnerable to damage by intense ultraviolet light.

Bonding in Molecular Solids (and its relation to electrical and optical properties!)