Indoor Air Pollution

Pollutants in Indoor Air and their Sources

In the US, 89% of people’s time is spent indoors.

Indoor air pollutants come from a variety of sources.

Some indoor air pollutants:

- **Carbon monoxide (CO):** boilers, heaters, stoves, fireplaces, cigarettes, and in-garage cars. Indoor mixing ratios can reach a factor of 4 or more times that outside.

- **Ozone (O₃):** major indoor source is outdoor air. Lack of UV inside prevents ozone formation. Photocopy machines and electrostatic air cleaners emit enough UV to produce ozone inside.

- **Formaldehyde (HCHO):** emitted from particleboard, insulation, furnishings, paneling plywood, carpets, ceiling tile and tobacco smoke. Indoor mixing ratio > outdoor mixing ratio. Major breakdown process is photolysis by UV light. Without UV light, concentrations can build up indoors.

- **Volatile organic compounds (VOCs):** organic compounds with low boiling points (evaporate readily). Sources of VOCs include adhesives, solvents, room deodorizers, cooking, carpets, among others.

- **Radon (Rn):** radioactive, colorless, tasteless, odorless gas that forms naturally in soils. Its decay products are believed to be carcinogenic. Plays no role in outdoor air pollution.

The source of radon is the solid mineral uranium-238 (²³⁸U), where 238 refers to the isotope, or number of protons plus neutrons in the nucleus of a uranium atom. ²³⁸U has a half life of 4.5 billion years.

Radon formation from uranium follows a long sequence of decay processes outlined in your text. Three types of decay processes:

- α particle: He nucleus; not very penetrating, can be stopped by a thick piece of paper
- β particle: high velocity electron; penetrate deeper than α particles
- γ ray: highly energized, deeply penetrating photon emitted from the nucleus of an atom

Radon enters houses from the ground through the foundation.
Radon itself is not dangerous, but it decay products, $^{218}\text{Pb}$ and $^{214}\text{Pb}$, are believed to be highly carcinogenic.
http://www.epa.gov/radon/
http://www.epa.gov/radon/zonemap/washington.htm

Concentrations are low outside, but can build up indoors because of the lack of ventilation in many homes. Remember the box model equation?

$$ q = \frac{S \times \tau}{V} $$

$q =$ concentration  
$S =$ source/sink rate  
$\tau =$ lifetime  
$V =$ volume

- **Allergens:** particles such as pollen or microorganisms, cat/dog dander.
- **Asbestos:** fire resistant material formerly used as an electrical and thermal insulator. Production is now banned in many countries. Causes lung cancer.
- **Fungal spores, bacteria, and viruses:** sources are soils, plants, people, animals.
- **Tobacco smoke:** both mainstream smoke and sidestream smoke = Environmental Tobacco Smoke (ETS). Mixture of more than 4,000 aerosol particles and gases, at least 50 of which are known carcinogens. Many chemical constituents of ETS are classified as hazardous air pollutants under the Clean Air Act Amendments of 1990, but are not regulated because it only deals with individual sources that emit more than 10 tons of hazardous pollutants per year. However, the sum of all cigarettes smoked combined is much larger than 10 tons per year.

**Regulation of Indoor Air Pollution**

Standards for indoor pollutants are set by the Occupational Safety and Health Administration (OSHA). Indoor standards exist for more than 150 compounds.

**Indoor Air Pollution in Developing Countries**

World Health Organization: http://www.who.int/indoorair/en/

More than 3 billion people worldwide continue to depend on solid fuels for their energy needs. Cooking and heating with solid fuels on open fires results in high levels of indoor air pollution. According to the world health report 2002, indoor air pollution is responsible for 2.7% of the global burden of disease. Causes acute lower respiratory infections in children and chronic obstructive pulmonary disease in adults.