

Assessment questions and answers for “Now You’re Cooking”

Ask students:

- Question: What explains wind chill (or its reverse in hot weather)? (**Note:** Moving air isn’t inherently colder than still air.)

Answer: Moving air strips away the insulating thin air film next to our skin.

- Question: Describe all the heat transfer steps in heating water on a stove.

Answer: A) Heat is **conducted** from the heating element or gas flame into the bottom of the pan. B) The water next to the bottom of the pan is heated by **conduction**. C) The heated water rises by **convection** and is replaced by colder water, which is heated in turn by **conduction**. D) The entire mass of water approaches boiling. Water touching the pan bottom boils first. The bubbles of water vapor rise upward and instantly re-condense in the colder water above. E) When the entire volume of water is at the boiling point, the bubbles of water vapor make it all the way to the surface, making a “rolling boil.”

- Question: Aluminum conducts heat well. Why does it sometimes insulate things?

Answer: The shiny surface of foil **reflects** infrared radiation, which would reduce heating from outside radiation. The surface also does not **emit** IR very well, so it would lose less energy by radiation than a non-shiny surface.

- Question: Can you insulate hot things and cold things with the same material?

Answer: Yes. A material with low thermal conductivity slows the passage of heat in either direction!

- Question: Describe how heat gets from the furnace to the rooms in a house.

Answer: Air is heated by **conduction** from the hot surfaces in the furnace. It carries heat by **convection** through the air ducts and into the room, replacing the cold air. Radiation is

not involved. Note: Steam radiators are so called because the room is warmed primarily by IR **radiation** from the very hot iron radiator; the air heated directly by contact with the radiator plays a smaller role.

- Question: Describe how conduction, convection, and radiation play a role in losing heat through a double-pane window.

Answer: Heat is conducted through the solid glass and through the four air films, two on each side of each sheet of glass. The air films do the bulk of the insulating! If the space between the layers is large (greater than 2 cm), there may be some convective loops in the inside air space. At the same time, each glass surface radiates IR in accordance with its temperature. This radiative loss is reduced by so-called “low-e” (low emissivity) glass, which radiates less IR outward and also reflects more IR back into the room than a normal glass surface.

- Question: What causes a sea breeze and a land breeze?

Answer: Temperatures over water are steadier on clear sunny days, so the land is warmer than the sea during the day and colder during the night. Hot air rises over the warmer area, being less dense, and draws air to it from the cooler area.

- Question: Why does metal feel colder than wood or plastic at room temperature?

Answer: Metal has a very high thermal conductivity, so heat flows more quickly out of one’s skin. The skin drops to room temperature, which is perceived as cold. If the metal and wood/plastic were warmer than body temperature, the metal would feel relatively hotter.

- Question: Hot things “radiate heat.” Do cold things radiate cold?

Answer: Cold things, being above absolute zero, still emit IR radiation, a more accurate description of “radiating heat.” But they emit less at lower temperatures. The emission rate is proportional to the fourth power of the absolute temperature.

- Question: Using heat transfer principles, describe a brake system that doesn't overheat.

Answer: It seems nearly miraculous that brake shoes rubbing on four metal discs could dissipate the kinetic energy of a moving car in the form of heat fast enough to stop it without overheating. It's no wonder that truck brakes can start smoking. How have engineers solved this problem? What would you do? Start by calculating the amount of heat equivalent to a 2,000 kg car coming to rest from a speed of 100 km/hr.