

### Question:

A small, hollow glass ball just barely floats in water. To make the ball sink in the water,

- A. Warm them up.
- B. Cool them down.
- C. There is nothing you can do.

### Thermal Expansion

- Atoms in matter adopt equilibrium spacings
- Equilibrium spacings set by balance of forces
  - Long-range attractive force
  - Short-range repulsive force
- Molecules vibrate about equilibrium spacings

### Thermal Expansion

- As temperature increases, vibration increases
- Atoms average separation increases, too.
- The “softer” the attractive force is, the more the average separation increases with temperature.
  - Liquids expand more than solids
  - Gases expand more than liquids

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### Liquid Crystals

- Rod- or disk -shaped molecules order
  - Little positional order
  - Much orientational order
- Ordering is affected by temperature
- Ordering affects optical properties
- Temperature affects optical properties of liquid crystals

### Thermocouples

- A material with a temperature gradient also has a spontaneous voltage gradient in it.
- The voltage difference between two points on a material indicates the temperature difference between those two points.
- With one point acting as a temperature reference, the voltage of the other point is a measure of its temperature.

## Electric Conductivity

- Cooling a metal makes it more conducting
  - Electrons scatter less and travel more easily
- Cooling an insulator makes it more insulating
  - Fewer electrons are available to travel
- Thermistors are based on semiconductors
  - Poor insulators that become better insulators as they get colder.