

Microwave Ovens

Observations About Microwaves

- Microwave ovens cook food from inside out
- They often cook foods unevenly
- They don't defrost foods well
- You shouldn't put metal inside them?!
- Do they make food radioactive or toxic?

3 Questions about Microwave Ovens

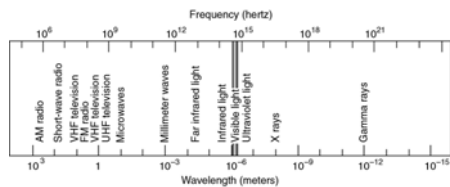
- Why do microwaves cook food?
- How does metal respond to microwaves?
- How does the oven create its microwaves?

Question 1

- Why do microwaves cook food?

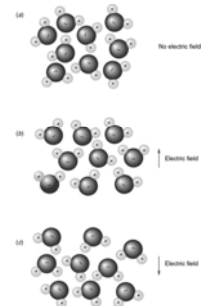
Electromagnetic Spectrum

- Microwaves are a class of electromagnetic waves
 - Long-wavelength EM waves: Radio & Microwave
 - Medium-wavelength: IR, Visible, UV light
 - Short-wavelength: X-rays & Gamma-rays



Water Molecules

- Water molecules are unusually polar
- An electric field orients water molecules
- A fluctuating electric field causes water molecules to fluctuate in orientation



Microwave Heating

- Microwaves have alternating electric fields
- Water molecules orient back and forth
- Liquid water heats due to molecular “friction”
- Ice doesn’t heat due to orientational stiffness
- Steam doesn’t heat due to lack of “friction”
- Food’s liquid water content heats the food

Interference

- Identical waves that overlap can interfere
- Interference is when the fields add or cancel
 - Adding fields are constructive interference
 - Canceling fields are destructive interference
- Reflections lead to interference in a microwave
- Interference causes uneven cooking
- Most ovens “stir” the waves or move the food

Question 2

- How does metal respond to microwaves?

Effects of Microwaves

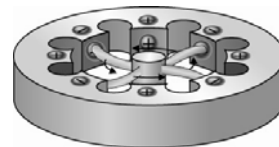
- Non-Conductors: Polarization
 - Mobile polar molecules orient and heat
 - Immobile polar molecules do nothing much
 - Non-polar molecules do nothing much
- Conductors: Current flow
 - Good, thick conductors reflect microwaves
 - Poor conductors experience resistive heating
 - Thin conductors experience resistive heating
 - Sharp conductors initiate discharges in the air

Question 3

- How does the oven create its microwaves?

Generating Microwaves

- Magnetron tube has tank circuits in it
- Streams of electrons amplify tank oscillations
- A loop of wire extracts energy from tanks
- A short $\frac{1}{4}$ -wave antenna emits the microwaves



Magnetron

Summary about Microwave Ovens

- They cook food because of its water content
- Polar water molecules heat in microwave fields
- Thin or sharp metals overheat or spark
- The microwaves are produced by a magnetrons