

1  **Unit 4: Phase Changes and Heat Transfer**

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2  **Heat and Temperature**

What's the difference?

- Do you get burned when sparkler sparks fall on you? Their temperature can be over 2000°C!

- Heat capacity

$$Q = m c \Delta T$$

3  **Table of Specific Heat Capacities**

4  **Heat and Food**

- Heat Units

– 1 cal = 4.184 J

- What about food calories?

5 

6  **Heat and Food**

- Direct calorimetry overestimates food energy content, since not all food is digestible.
- Human body fat is about 87% lipids, so that 1 kg of body fat contains about 7800 kcal of energy.
- And 1 lb contains about 3500 kcal.

7  **Examples**

- Can you eat hot spaghetti right away, or do you have to let it cool down?
- Potatoes vs. tomatoes
- Why is the winter weather in Europe more moderate than Canada's, which is at about the same latitude?
- What burns you when you eat hot apple pie, the crust or filling?

8  **Heat Transfer**

- Conduction
  - Heat flows through matter
- Convection
  - Heat is transferred through a moving fluid
- Radiation
  - Heat transferred by electromagnetic radiation (light)

- Burner Demo
- Campfire

9  **Conduction**

- Thermal Conductivity
- $H = kA(T_2 - T_1)/L$
- A piece of paper does not ignite when wrapped around an iron bar passed through a flame. When the paper is wrapped around a wooden bar, it burns easily.
- Can you burn a paper cup full of water?
- How does a cool piece of wood feel different than a cool piece of metal?

10  **Radiation Examples**

- Wrap baked potatoes with the shiny side of Al foil *in* or *out*?
- Why is summer clothing more often white than black?
- Wrap an ice cube in black cloth and another in Al foil. Place them both in the sun. What happens?
- Why is the pupil of your eye black?

11  **Radiation Examples**

12  **Radiation Examples**

13  **Radiation Examples**

- How does a microwave work?

14  **Radiation Examples**

- How does a microwave work?

15  **Insulation**

- How does a coat keep you warm?
- What about fur coats?
- Vacuum bottles

- How does a blanket work?
- Wet suits

16  **Insulation**

- Example: Thinsulate

17  **Windows**

18  **Windows**

19  **Insulation**

20  **R-Values**

- Definition of R-Value: The reciprocal of the amount of heat energy per area of material per degree difference between the outside and inside.

21  **Ice Dams**

22  **A Bunch of Examples**

- What would you “rather” do: take your clothes off in a 58° house or sit nude in a bathtub at the same temperature?
  - Suppose a human could live for two hours (120 minutes) unclothed in air at 45 F. How long could he live in water at 45 F?

23  **A Bunch of Examples**

- When you step from a shower on a cold morning, why does the tile floor seem so much colder than the air?
- Place a wooden spoon and a metal spoon in the freezer. Which will cool faster? After several minutes, what would they feel like?
- If you reach into the oven to take out a cooked casserole, would you rather grab the aluminum foil covering the dish or stick your finger into the wet food?
- Two identical cups of cocoa are sitting on a table. One has a metal spoon in it and one does not. After five minutes, which cup is cooler?
- In Alaska, a lack of snow allowed the ground to freeze down to a depth of about one meter, causing buried water pipes to freeze and burst. Why did a lack of snow lead to this situation?

24  **A Bunch of Examples**

- Several days after the end of a snowstorm, the roof of a house is completely covered with snow, another house's roof has no snow. Which house is probably better insulated?
- If something freezes in your hand does it feel hot or cold?
  - Quick ice
  - hand warmers
- How does sweating cool the body?
  - How do you use a fan to keep cool?
- Why are steam-heated radiators much more effective than radiators heated with hot water?
- Why does it always feel warmer in a shower stall, even when the air temperature is the same as outside?
  - Same answer: Why is a 95-degree day in Phoenix, Arizona, so much more comfortable than a 95-degree day in New Orleans?
- If you leave a refrigerator open in a closed room, will it make the room cooler?
- Solar energy storage

25  **A Bunch of Examples**

- Does warm water freeze faster than cold water?
    - The Mpemba Effect
  - How does ice keep a Pepsi cold?
    - What temperature is the iced Pepsi?
  - How do buckets of water in greenhouses keep the plants from freezing?
  - Thermometer in space
  - Bill Nye brownies demo
  - So what's the best way to cool a cup of coffee?
  - Wind Chill Factor
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- $T$  = Fahrenheit temp.;  $v$  = windspeed (mph)
  - How does a refrigerator work?
    - Ammonia boils at  $-33^{\circ}\text{C}$ , Freon-11 at  $28^{\circ}\text{C}$ .

26  **A Refrigeration System**