ch 19 heat

Chapter 19: Temperature and Heat

Conceptual problems

19.C.1 (5.00) The standard value for a healthy human's body temperature is $37°C$, to the nearest Celsius degree, although this value is only an approximation. In fact, the temperature of a healthy person varies by as much as $1.5°C$ each day, being lowest in the morning and peaking in the evening. On North American fever thermometers, a "normal" body temperature is usually indicated as $98.6°F$. (a) Explain how this "normal" value in the Fahrenheit system is obtained from the "normal" value in the Celsius system. (b) Explain why stating the value for a "normal" human temperature with three significant digits, as $98.6°F$, is misleading. (c) What would be a better "normal" value in the Fahrenheit system?

(a)

(b)

(c) °F

19.C.2 (5.00) A new website comes out promoting the Cold Water Diet. It proclaims: "On the CWD, you eat all the carbs and fat you want, and just drink cold water. One liter of cold water has a mass of 1000 g, and it takes 1.0 calorie to raise the temperature of 1.0 g of water by 1 Celsius degree. If you ingest a liter of water at 0°C, it will take 37,000 calories to raise the temperature up to 37°C, which is body temperature. That energy has to come from your body, so you can watch those pounds melt away!" What is wrong with the website's claim?

19.C.3 (5.00) A steel block is heated so that the length of each side increases 1%. What happens to its mass?

19.C.4 (5.00) You want to use a calorimeter to measure the specific heat of a very small object that you suspect has a low specific heat value. Assume that you can use any of three liquids to fill the calorimeter: water, ethyl alcohol (which has a specific heat of 2549 J/kg·K), or mercury (which has a specific heat of 139 J/kg·K). Which liquid would you choose, and why?

○ Water ○ Ethyl alcohol ○ Mercury

19.C.5 (5.00) Why does a tiled floor feel colder to your bare feet than a carpeted floor, even though they are both at room temperature?

19.C.6 (5.00) In coastal towns, breezes tend to blow offshore (from the land to the ocean) during the night and early morning, and onshore (from the ocean to the land) during the afternoon and evening. What factors primarily contribute to this effect?

- ☐ Heat conduction
- ☐ Heat convection
- ☐ Specific heat of land vs water
- ☐ Salinity of the water
- ☐ Thermal expansion

19.C.7 (7.00) In outer space environments, such as on the International Space Station, why must every piece of machinery or electronic equipment have its own cooling fan? This makes for a noisy environment. Hint: What is different compared to an Earth-based laboratory, and why should this matter?

19.C.8 (5.00) When people are extremely cold and are not prepared with warm clothing, they will sometimes crouch and curl up into a tight roll, hugging their knees to their chests. How does such a position conserve body heat?

Section 2: Temperature scales

19.2.1 Daniel Fahrenheit first proposed the temperature scale that bears his name in

(5.00) 1724. Originally, his reference points were a well-mixed slurry melted from equal weights of ice and salt (similar to what you use in a hand-cranked ice cream freezer) for 0 degrees, and the temperature of the healthy human body for 12 degrees. Later he subdivided each one of his original "degrees" into eight equal parts to define degrees Fahrenheit. In modern degrees Fahrenheit, what is the temperature of (a) the ice-salt mixture? (b) Fahrenheit's "healthy human"?

(a) _____ °F

(b) _____ °F

Section 3: Temperature scale conversions

19.3.1 **(5.00)** Convert each of the following temperatures to the indicated scale: (a) 100.00 K to the Celsius scale; (b) 100.00 K to the Fahrenheit scale; (c) 72°F to the Celsius scale; and (d) −273.15°C to the Fahrenheit scale.

(a) _____ °C

(b) _____ °F

(c) _____ °C

(d) _____ °F

19.3.2 **(5.00)** What Celsius temperature is the same when converted to Fahrenheit? (There is only one such temperature.)

_____ °

Section 9: Thermal expansion: linear

19.9.1 **(5.00)** The plumbing in an old house uses lead pipes (which are now considered hazardous). Hot water is run through a section of pipe, increasing its temperature from 19.4°C to 36.8°C. If the pipe is initially *L* m in length, what is the change in the length of the pipe?

_____ m

19.9.4 **(5.00)** The aptly-named Steel Bridge over the Willamette River in Portland, Oregon, has a central span steel truss that is 64.1 m long. What is its change in length over the year from the average minimum annual temperature of 0.90°C to the average maximum of 26.3°C? Use a coefficient of linear expansion of 1.17×10^{-5} (1/C°).

_____ m

Section 10: Sample problem: thermal expansion and stress

19.10.1 **(5.00)** A copper rod at a temperature of 22.82°C is bolted in place between two rigid walls. What stress does the rod exert (the force on each of the perfectly rigid

walls, divided by the area of contact) when it is heated to a temperature of 274.2°C? (The coefficient of linear expansion for copper is 1.65×10^{-5} 1/C°, and Young's modulus for the material is 1.08×10^{11} N/m^2.)

N/m^2

Section 12: Thermal expansion: volume

19.12.1 **(5.00)** A lead ball has a volume of 94.3 cm^3 at 19.3°C. What is the change in volume when its temperature changes to *T*°C?

cm^3

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