1. To conserve energy, a certain room's temperature is kept at 68.0°F in the winter and 78.5°F in the summer. What are these temperatures on the Celsius scale?

   - Winter: 20 °C
   - Summer: 25.8 °C

2. (a) At what temperature do the Fahrenheit and Celsius scales have the same numerical value?

   - 233 °F

   (b) At what temperature do the Fahrenheit and Kelvin scales have the same numerical value?

   - 477 °F

3. (a) What is the average kinetic energy of hydrogen atoms on the 5500°C surface of the Sun?

   - 1.20e-19 J

   (b) What is the average kinetic energy of helium atoms in a region of the solar corona where the temperature is 1.90 × 10^6 K?

   - 3.93e-17 J

4. There are two important isotopes of uranium — 235U and 238U; these isotopes are nearly identical chemically but have different atomic masses. Only 235U is very useful in nuclear reactors. One of the techniques for separating them (gas diffusion) is based on the different average speeds $v_{235}$ of uranium hexafluoride gas, UF₆. (Use $k = 1.38 \times 10^{-23} J/K$ for this question.)

   (a) The molecular masses for 235UF₆ and 238UF₆ are 349.0 g/mol and 352.0 g/mol, respectively. What is the ratio of their average speeds? (Enter your answer to at least 4 decimal places.)

   - $v_{235}/v_{238} = 1.00429$

   (b) At what temperature would their average speeds differ by 1.65 m/s?

   - 2080 K

5. A cylinder has a piston at one end that can be moved in or out to change the volume of gas inside. The other end is fitted with a valve. Initially the cylinder contains 2.65 mol of an ideal gas. The piston is now pushed in to decrease the volume of gas to one-third its initial value without causing any change in temperature. In order to keep the pressure constant as well, how many moles of gas need to be released through the valve?

   - 1.77 moles

6. There are 1.5 times as many molecules as Avogadro’s number at a temperature of 1.5°C inside a sealed cubic with dimensions 2.8 cm × 2.8 cm × 2.8 cm. How much force does the gas exert on one of the walls of the cube?

   - 1.22e+05 N
7. The initial temperature of three moles of oxygen gas is 25.5°C, and its pressure is 7.80 atm.
   (a) What will its final temperature be when heated at constant volume so the pressure is 5 times its initial value?
   [320°C]
   (b) Now the volume of the gas is also allowed to change. Determine the final temperature if the gas is heated until
   the pressure and the volume are quadrupled.
   [485°C]

8. A high-pressure gas cylinder contains 90.0 L of toxic gas at a pressure of 2.20 × 10^7 N/m² and a temperature of 25.0°C. Its
   valve leaks after the cylinder is dropped. The cylinder is cooled to dry ice temperatures (−78.5°C), to reduce the leak rate
   and pressure so that it can be safely repaired.
   (a) What is the final pressure in the tank, assuming a negligible amount of gas leaks while being cooled and that
   there is no phase change?
   [1.44 × 10^7 N/m²]
   (b) What is the final pressure if one-tenth of the gas escapes?
   [1.29 × 10^7 N/m²]
   (c) To what temperature must the tank be cooled to reduce the pressure to 1.00 atm (assuming the gas does not
   change phase and that there is no leakage during cooling)?
   [1.37 K]

9. The temperature of a gas increases from 23.5 K to 69.5 K while its volume remains constant. What is the new pressure?
   Give your answer as a multiple of the initial pressure $P_1$.
   [2.96 $P_1$]

10. The same amount of heat entering identical masses of different substances produces different temperature changes.
    Calculate the final temperature when 1.25 kcal of heat enters 1.43 kg of the following, originally at 29.2°C. The specific heat
    capacity for each material is given in square brackets below.
    (a) water [1.00 kcal/(kg · °C)]
    [30.1°C]
    (b) concrete [0.20 kcal/(kg · °C)]
    [33.6°C]
    (c) steel [0.108 kcal/(kg · °C)]
    [37.3°C]
    (d) mercury [0.0333 kcal/(kg · °C)]
    [55.5°C]

11. A 0.470-kg block of a pure material is heated from 20.0°C to 65.0°C by the addition of 2.98 kJ of energy. Calculate its
    specific heat.
    [0.141 kJ/(kg · °C)]

12. Rubbing your hands together warms them by converting work into thermal energy. If a woman rubs her hands back
    and forth for a total of 28 rubs a distance of 7.50 cm each and with a frictional force averaging 61.3 N, what is the temperature
    increase? The mass of tissue warmed is only 0.100 kg, mostly in the palms and fingers. The specific heat of the tissue is
    3500 J/(kg · °C).
    [0.368 °C]
13. Question Details

A piece of iron block moves across a rough horizontal surface before coming to rest. The mass of the block is 2.8 kg, and its initial speed is 1.6 m/s. How much does the block’s temperature increase, if it absorbs 72% of its initial kinetic energy as internal energy? The specific heat of iron is 452 J/(kg \cdot °C).

\[ \Delta T = \frac{0.72 \times \frac{1}{2} \times 2.8 \times 1.6^2}{2.8 \times 452} \]

Supporting Materials

Physical Constants

14. Question Details

You pour 160 g hot coffee at 78.7°C and some cold cream at 7.50°C to a 115-g cup that is initially at a temperature of 22.0°C. The cup, coffee, and cream reach an equilibrium temperature of 63.0°C. The material of the cup has a specific heat of 0.2604 kcal/(kg \cdot °C) and the specific heat of both the coffee and cream is 1.00 kcal/(kg \cdot °C). If no heat is lost to the surroundings or gained from the surroundings, how much cream did you add?

\[ m_{cream} = \frac{\left( m_{coffee} \times c_{coffee} \times (T_{coffee} - T_{eq}) - \left( m_{cup} \times c_{cup} \right) \times (T_{eq} - T_{cup}) \right)}{c_{cream} \times (T_{eq} - T_{cream})} \]

Supporting Materials

Physical Constants

15. Question Details

You have two containers of the same liquid. The first container has 124.0 g at 0°C and the second has 25 g at 21°C. In order to consolidate and save space, you mix the two liquids into one container and find that the two portions have now reached an equilibrium temperature of 42.6°C. What was the initial temperature of the liquid in the first container?

\[ T_{1} = T_{eq} - \frac{m_{2} \times c_{2} \times (T_{2} - T_{eq})}{m_{1} \times c_{1} + m_{2} \times c_{2}} \]

Supporting Materials

Physical Constants

16. Question Details

The number of kilocalories in food is determined by calorimetry techniques in which the food is burned and the amount of heat transfer is measured.

(a) How many kilocalories per gram are there in a 5.00-g peanut, if the energy from burning it is transferred to 0.530 kg of water held in a 0.134-kg aluminum cup, causing a 54.9°C temperature increase? (The specific heat capacity of water is 1.00 kcal/(kg \cdot °C) and the specific heat capacity of aluminum is 0.215 kcal/(kg \cdot °C)).

\[ \text{KCAL/g} = \frac{0.53 \times 54.9 \times 1}{5.00} \]

(b) The labeling information on a package of peanuts states that 1 serving is equal to 28 g and 170 Calories. Compare your answer in part (a) to this labeling information. Are the two values consistent? (Consider the values to be consistent if they are within 0.5 kcal/g of each other.)

Supporting Materials

Yes

No

17. Question Details

An ice bag containing 0°C ice is much more effective in absorbing heat than one containing the same amount of 0°C water. The specific heat capacity of water is 1.00 kcal/(kg \cdot °C), and its latent heat of fusion is 79.8 kcal/kg.

(a) How much heat in kcal is required to raise the temperature of 0.330 kg of water from 0°C to 27.0°C?

\[ \Delta Q = m \times c \times (T_2 - T_1) \]

(b) How much heat is required to first melt 0.330 kg of 0°C ice and then raise its temperature to 27.0°C?

\[ \Delta Q = m \times L_f + m \times c \times (T_2 - T_1) \]

Supporting Materials

Physical Constants

18. Question Details

A 0.0450 kg ice cube at −30.0°C is placed in 0.497 kg of 35.0°C water in a very well insulated container. What is the final temperature? The latent heat of fusion of water is 79.8 kcal/kg, the specific heat of ice is 0.50 kcal/(kg \cdot °C), and the specific heat of water is 1.00 kcal/(kg \cdot °C).

\[ T_f = \frac{m_i \times c_i \times (T_i - T_f) + m_w \times c_w \times (T_f - T_w) + m_f \times L_f}{m_i + m_w + m_f} \]

Supporting Materials

Physical Constants