17.120. Food Intake of a Hamster. The energy output of an animal engaged in an activity is called the metabolic burn rate (MBR) and is a measure of the conversion of food energy into other forms of energy. A simple calorimeter to measure the MBR consists of an insulated box with a thermometer to measure the temperature of the air. The air has density 1.20 kg/m^3 and specific heat 1020 J/kg K. A 50.0-g hamster is placed in a calorimeter that contains 0.5000 m^3 of air at room temperature. (a) When the hamster is running in a wheel, the temperature of the air in the calorimeter rises 1.60 C° per hour. How much heat does the running hamster generate in an hour? Assume that all this heat goes into the air in the calorimeter. You can ignore the heat that goes into the walls of the box and into the thermometer, and assume that no heat is lost to the surroundings. (b) Assuming that the hamster converts seed into heat with an efficiency of 10% and that hamster seed has a food energy value of 24 J/g, how many grams of seed must the hamster eat per hour to supply this energy?

Identify: For the air the heat input is related to the temperature change by $Q = mc\Delta T$.

Set Up: The rate P at which heat energy is generated is related to the rate P_0 at which food energy is consumed by the hamster by $P = 0.10P_0$.

Execute:

(a) The heat generated by the hamster is the heat added to the box;

$$P = \frac{Q}{t} = mc\frac{\Delta T}{t} = (1.20\ \text{kg/m}^3)(0.0500\ \text{m}^3)(1020\ \text{J/kg}\cdot\text{K})(1.60\ \text{C°/h}) = 97.9\ \text{J/h}.$$

(b) Taking the efficiency into account, the mass M of seed that must be eaten in time t is

$$\frac{M}{t} = \frac{P_0}{L_c} = \frac{P/(10\%)}{L_c} = \frac{979\ \text{J/h}}{24\ \text{J/g}} = 40.8\ \text{g/h}.$$

Evaluate: This is about 1.5 ounces of seed consumed in one hour.