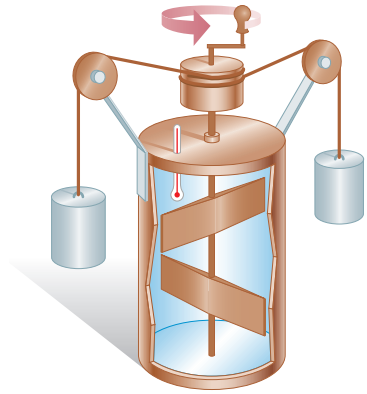
SAMPLE PROBLEM B

Conservation of Energy

PROBLEM

An arrangement similar to the one used to demonstrate energy conservation is shown at right. A vessel contains water. Paddles that are propelled by falling masses turn in the water. This agitation warms the water and increases its internal energy. The temperature of the water is then measured, giving an indication of the water's internal-energy increase. If a total mass of 11.5 kg falls 1.3 m and all of the mechanical energy is converted to internal energy, by how much will the internal energy of the water increase? (Assume no energy is transferred as heat out of the vessel to the surroundings or from the surroundings to the vessel's interior.)



Joule's Apparatus

SOLUTION

1. DEFINE

Given: $m = 11.5\ \text{kg}$ $h = 1.3\ \text{m}$ $g = 9.81\ \text{m/s}^2$

Unknown: $\Delta U = ?$

2. PLAN

Choose an equation or situation:

Use the conservation of energy equation, and solve for ΔU.

$$\Delta PE + \Delta KE + \Delta U = 0$$

$$(PE_f - PE_i) + (KE_f - KE_i) + \Delta U = 0$$

$$\Delta U = -PE_f + PE_i - KE_f + KE_i$$

TIP *Don't forget that a change in any quantity, indicated by the symbol Δ, equals the final value minus the initial value.*

Because the masses begin at rest, KE_i equals zero. If we assume that KE_f is small compared to the loss of PE, we can set KE_f equal to zero also.

$$KE_f = 0 \qquad KE_i = 0$$

Because all of the potential energy is assumed to be converted to internal energy, PE_i can be set equal to mgh if PE_f is set equal to zero.

$$PE_i = mgh \qquad PE_f = 0$$

Substitute each quantity into the equation for ΔU:

$$\Delta U = 0 + mgh + 0 + 0 = mgh$$

3. CALCULATE

Substitute the values into the equation and solve:

$$\Delta U = (11.5\ \text{kg})(9.81\ \text{m/s}^2)(1.3\ \text{m})$$

$$\boxed{\Delta U = 1.5 \times 10^2\ \text{J}}$$

4. EVALUATE

The answer can be estimated using rounded values for m and g. If $m \approx 10$ kg and $g \approx 10\ \text{m/s}^2$, then $\Delta U \approx 130$ J, which is close to the actual value calculated.

CALCULATOR SOLUTION

Because the minimum number of significant figures in the data is two, the calculator answer, 146.6595 J, should be rounded to two digits.