Simple Harmonic Motion

14.33. **IDENTIFY:** The mechanical energy (the sum of the kinetic energy and potential energy) is conserved.

SET UP: $K+U=E$, with $E=\frac{1}{2}kA^2$ and $U=\frac{1}{2}kx^2$

EXECUTE: $U=K$ says $2U=E$. This gives $2(\frac{1}{2}kx^2)=\frac{1}{2}kA^2$, so $x=A/\sqrt{2}$.

EVALUATE: When $x=A/2$ the kinetic energy is three times the elastic potential energy.

14.49. **IDENTIFY:** Apply $T=2\pi\sqrt{L/g}$

SET UP: The period of the pendulum is $T=(136\text{ s})/100=1.36\text{ s}$.

EXECUTE: $g=\dfrac{4\pi^2L}{T^2}=\dfrac{4\pi^2(0.500\text{ m})}{(1.36\text{ s})^2}=10.7\text{ m/s}^2$.

EVALUATE: The same pendulum on earth, where g is smaller, would have a larger period.

Thermal Equilibrating & Latent Heat

17.45. **IDENTIFY:** By energy conservation, the heat lost by the copper is gained by the ice. This heat must first increase the temperature of the ice from –20.0°C to the melting point of 0.00°C, then melt some of the ice. At the final thermal equilibrium state, there is ice and water, so the temperature must be 0.00°C. The target variable is the initial temperature of the copper.

SET UP: For temperature changes, $Q=mc\Delta T$ and for a phase change from solid to liquid $Q=mL_F$.

EXECUTE: For the ice,

$Q_{\text{ice}}=(2.00\text{ kg})[2100\text{ J/(kg}\cdot\text{C°)}](20.0\text{C°})+(0.80\text{ kg})(3.34\times10^5\text{ J/kg})=3.512\times10^5\text{ J}$. For the copper, using the specific heat from the table in the text gives

$Q_{\text{copper}}=(6.00\text{ kg})[390\text{ J/(kg}\cdot\text{C°)}](0\text{°C}-T)=-(2.34\times10^3\text{ J/C°})T$. Setting the sum of the two heats equal to zero gives $3.512\times10^5\text{ J}=(2.34\times10^3\text{ J/C°})T$, which gives $T=150\text{°C}$.

EVALUATE: Since the copper has a smaller specific heat than that of ice, it must have been quite hot initially to provide the amount of heat needed.

17.38. **IDENTIFY:** The latent heat of fusion L_f is defined by $Q=mL_f$ for the solid → liquid phase transition. For a temperature change, $Q=mc\Delta T$.

SET UP: At $t=1$ min the sample is at its melting point and at $t=2.5$ min all the sample has melted.

EXECUTE: **(a)** It takes 1.5 min for all the sample to melt once its melting point is reached and the heat input during this time interval is $(1.5\text{ min})(10.0\times10^3\text{ J/min})=1.50\times10^4\text{ J}$. $Q=mL_f$.

$$L_f=\frac{Q}{m}=\frac{1.50\times10^4\text{ J}}{0.500\text{ kg}}=3.00\times10^4\text{ J/kg}.$$

(b) The liquid's temperature rises 30 C° in 1.5 min. $Q=mc\Delta T$.

$$c_{\text{liquid}}=\frac{Q}{m\Delta T}=\frac{1.50\times10^4\text{ J}}{(0.500\text{ kg})(30\text{ C°})}=1.00\times10^3\text{ J/kg}\cdot\text{K}.$$

The solid's temperature rises 15 C° in 1.0 min. $c_{\text{solid}}=\dfrac{Q}{m\Delta T}=\dfrac{1.00\times10^4\text{ J}}{(0.500\text{ kg})(15\text{ C°})}=1.33\times10^3\text{ J/kg}\cdot\text{K}$.

EVALUATE: The specific heat capacities for the liquid and solid states are different. The values of c and L_f that we calculated are within the range of values in Tables 17.3 and 17.4.