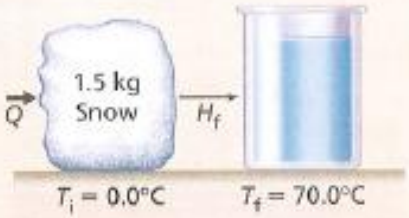
EXAMPLE Problem 3

Heat Suppose that you are camping in the mountains. You need to melt 1.50 kg of snow at 0.0°C and heat it to 70.0°C to make hot cocoa. How much heat will be needed?

1 Analyze and Sketch the Problem

- Sketch the relationship between heat and water in its solid and liquid states.
- Sketch the transfer of heat as the temperature of the water increases.



Known:

$m = 1.50$ kg
$T_i = 0.0°C$
$C = 4180$ J/kg·°C
$H_f = 3.34\times10^5$ J/kg
$T_f = 70.0°C$

Unknown:

$Q_{melt\ ice} = ?$
$Q_{heat\ liquid} = ?$
$Q_{total} = ?$

Physics Online

Personal Tutor For an online tutorial on heat, visit physicspp.com.

2 Solve for the Unknown

Calculate the heat needed to melt ice.

$$Q_{melt\ ice} = mH_f$$
$$= (1.50\ kg)(3.34\times10^5\ J/kg)$$ Substitute $m = 1.50$ kg, $H_f = 3.34\times10^5$ J/kg
$$= 5.01\times10^5\ J$$
$$= 5.01\times10^2\ kJ$$

Calculate the temperature change.

$$\Delta T = T_f - T_i$$
$$= 70.0°C - 0.0°C$$ Substitute $T_f = 70.0°C$, $T_i = 0.0°C$
$$= 70.0°C$$

Calculate the heat needed to raise the water temperature.

$$Q_{heat\ liquid} = mC\Delta T$$
$$= (1.50\ kg)(4180\ J/kg\cdot°C)(70.0°C)$$ Substitute $m = 1.50$ kg, $C = 4180$ J/kg·°C, $\Delta T = 70.0°C$
$$= 4.39\times10^5\ J$$
$$= 4.39\times10^2\ kJ$$

Calculate the total amount of heat needed.

$$Q_{total} = Q_{melt\ ice} + Q_{heat\ liquid}$$
$$= 5.01\times10^2\ kJ + 4.39\times10^2\ kJ$$ Substitute $Q_{melt\ ice} = 5.01\times10^2$ kJ, $Q_{heat\ liquid} = 4.39\times10^2$ kJ
$$= 9.40\times10^2\ kJ$$

3 Evaluate the Answer

- **Are the units correct?** Energy units are in joules.
- **Does the sign make sense?** Q is positive when heat is absorbed.
- **Is the magnitude realistic?** The amount of heat needed to melt the ice is greater than the amount of heat needed to increase the water temperature by 70.0°C. It takes more energy to overcome the forces holding the particles in the solid state than to raise the temperature of water.

PRACTICE Problems

• Additional Problems, Appendix B
• Solutions to Selected Problems, Appendix C

19. How much heat is absorbed by 1.00×10^2 g of ice at −20.0°C to become water at 0.0°C?

20. A 2.00×10^2-g sample of water at 60.0°C is heated to steam at 140.0°C. How much heat is absorbed?

21. How much heat is needed to change 3.00×10^2 g of ice at −30.0°C to steam at 130.0°C?