5. Researchers in Antarctica measure the temperature to be -40°F.
   a. What is this temperature on the Celsius scale?

$$T_F = 1.8\,T_C + 32$$

$-40° = 1.8\,T_C + 32$

$-72° = 1.8\,T_C$

$\frac{-72°}{1.8} = T_C$

$-40° = T_C$

   b. What is this temperature on the Kelvin scale?

$T_K = T_C + 273$

$T_K = -40° + 273$

$T_K = 233K$

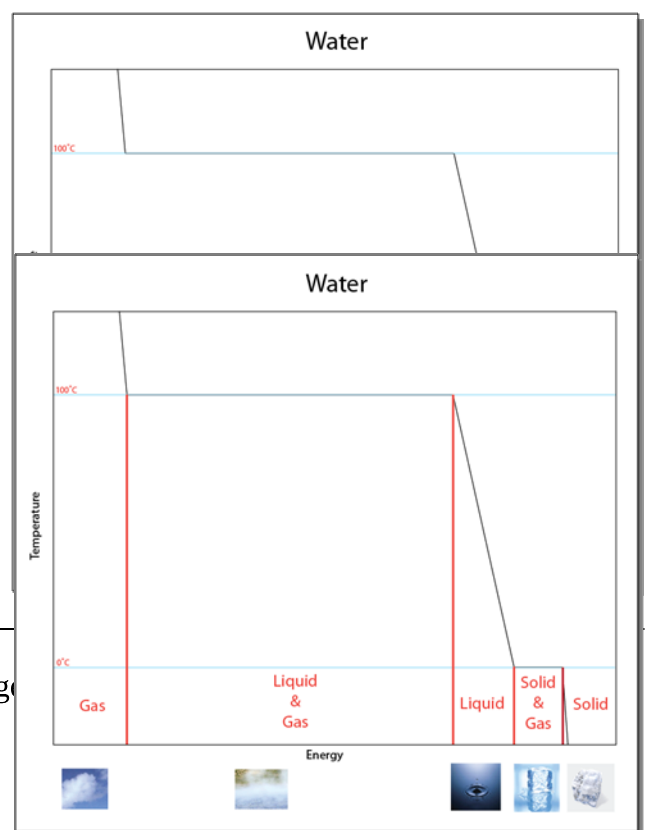
11. On a brisk walk, a person burns about 325 Cal/Hr. At this rate, how many hours of brisk walking would it take to lose a pound of body fat? (One pound of body fat is equivalent to about 3500 Calories.)

$$1\ pound\ of\ fat \cdot \frac{3500\ Calories}{Pound\ of\ fat} \cdot \frac{1\ hour}{325\ Calories} = X\ hours$$

$$10.8\ hours = X\ hours$$

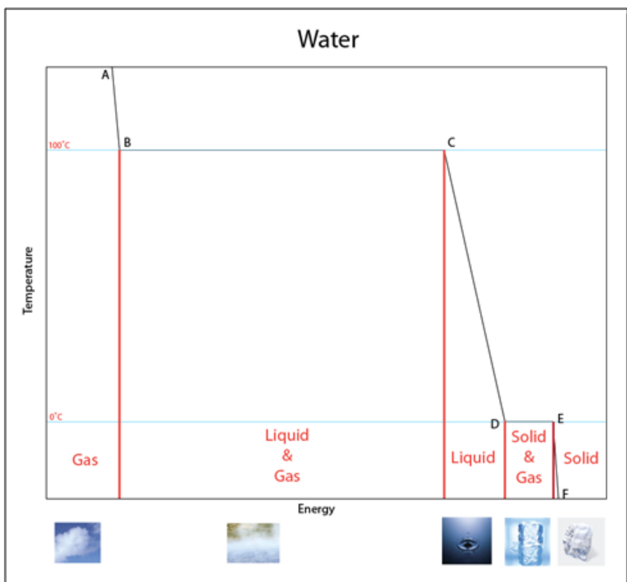
18. A quantity of steam (200g) at 110°C is condensed, and the resulting water is frozen into ice at 0°C. How much heat was removed?

To begin this question, we will draw the diagram to the right. This diagram shows the relationship between the temperature of water and the energy released from water when converted from Steam to Ice.



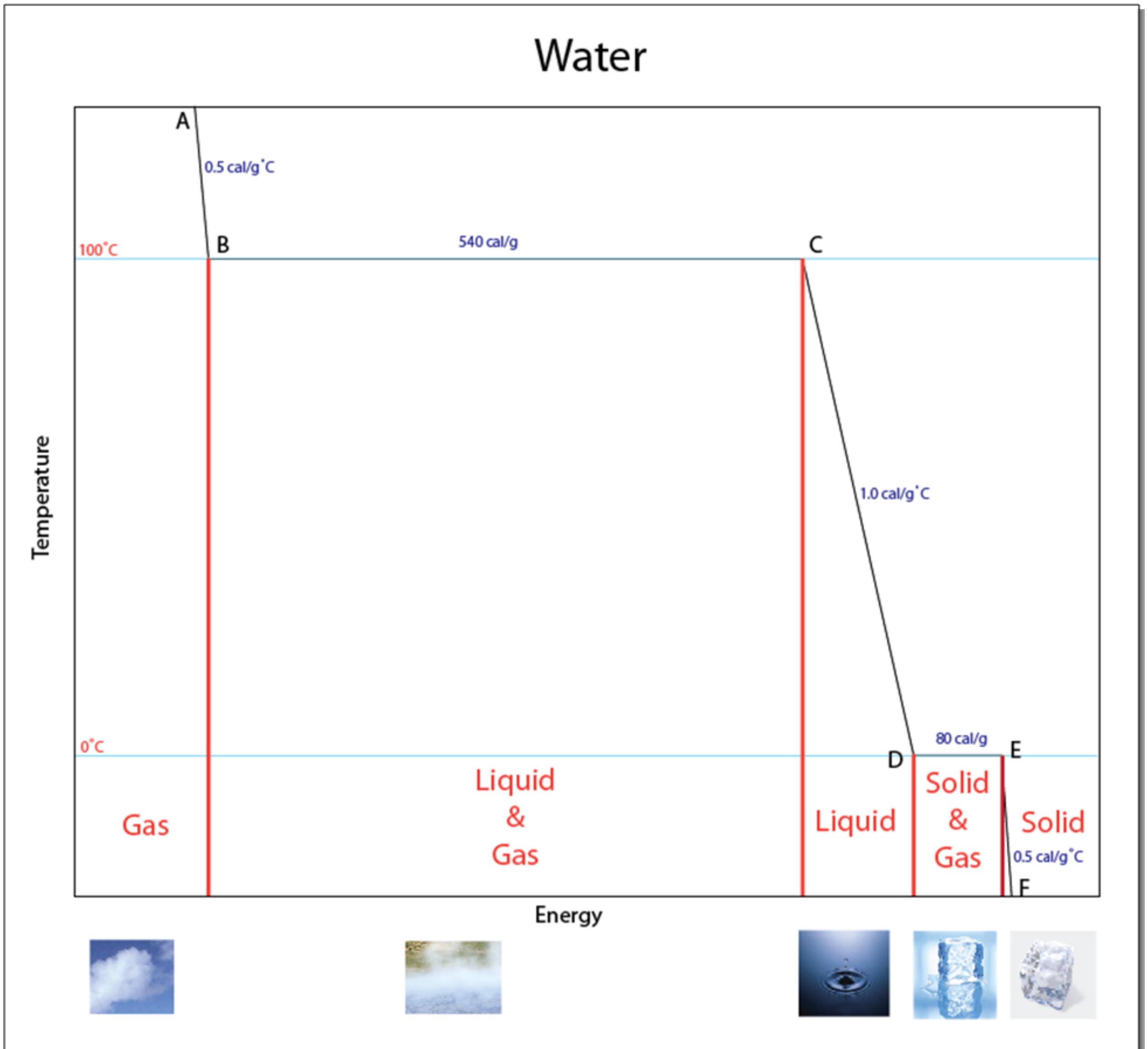
When the water is above 100°C, it will exist as a gas (Steam). When water is between 100°C and 0°C, water will exist as a liquid. And finally when water is below 0°C it will exist as a solid as shown in the diagram to the right.

Also shown in the diagram to the right, energy is released when steam is converted to water and when water is converted to ice. To calculate these conversions you will need to know the Specific Heat of Steam (0.50 cal/g°C), the Heat of Vaporization of Water (540 cal/g), the Specific Heat of Water (1.0 cal/g°C), the Heat of Fusion of Water (80 cal/g) and finally the Specific Heat of Ice (0.50 cal/g). (PLEASE NOTE THAT THESE NUMBERS WOULD BE GIVEN TO YOU ON A TEST AND YOU WOULD NOT BE EXPECTED TO REMEMBER THESE VALUES. YOU WOULD ONLY BE REQUIRED TO KNOW WHAT THEY REPRESENT AND HOW TO USE THEM.)



This problem will required us to calculate the energy released by 200g of water at 110°C and cooled ice at 0°C. The easiest way to visualize this is to break the problem up into four stages. These stages will be A→B, B→C, C→D and finally D→E. I have outlined this in the diagram to the left.

The solution to this problem will use this diagram along with the specific heats and the heat of fusion and vaporization. This has all been combined in the figure on the following page.



A→B

Cooling steam will result in the release of energy following the formula: $Q = S.H. \cdot m \cdot \Delta t$. *Where Q is the heat, S.H. is the specific heat of steam, m is the mass of the steam and Δt is the temperature change of the steam. We will use this formula to find the energy release in going from A to B on the diagram above.*

$$Q_{A \to B} = S.H. \cdot m \cdot \Delta t$$

$$Q_{A \to B} = 0.50 \frac{cal}{g°C} \cdot 2\bar{0}0 g \cdot (110°C - 100°C)$$

$$Q_{A \to B} = 0.50 \cdot 2\bar{0}0 \cdot 10\, cal$$

$$Q_{A \to B} = 1{,}000\, cal$$

B→C

When you convert steam at 100°C to water at 100°C energy will be released. This energy is calculated using the following formula: $Q = Heat\,of\ vaporization \cdot m$. *Where Q is the heat, the Heat of Vaporization of Water (540 cal/g) and the mass is m. We will use this formula to find the energy released in going from B to C in the diagram above.*

$$Q_{B\to C} = Heat\,of\ vaporization \cdot m$$

$$Q_{B\to C} = 540\frac{cal}{g} \cdot 2\bar{0}0g$$

$$Q_{B\to C} = 540 \cdot 2\bar{0}0cal$$

$$Q_{B\to C} = 110{,}000cal$$

C→D

Cooling water will result in the release of energy following the formula: $Q = S.H. \cdot m \cdot \Delta t$. *Where Q is the heat, S.H. is the specific water, m is the mass of the water and Δt is the temperature change of the water. We will use this formula to find the energy release in going from C to D on the diagram above.*

$$Q_{C\to D} = S.H. \cdot m \cdot \Delta t$$

$$Q_{C\to D} = 1.0\frac{cal}{g°C} \cdot 2\bar{0}0g \cdot (100°C - 0°C)$$

$$Q_{C\to D} = 1.0 \cdot 2\bar{0}0 \cdot 100\,cal$$

$$Q_{C\to D} = 2\bar{0}{,}000\,cal$$

D→E

When you convert water at 0°C to ice at 0°C energy will be released. This energy is calculated using the following formula: $Q = Heat\,of\ \ fusion \cdot m$. *Where Q is the heat, the Heat of Fusion of Water (80 cal/g) and the mass is m. We will use this formula to find the energy released in going from B to C in the diagram above.*

$$Q_{D\to E} = Heat\,of\ \ fusion \cdot m$$

$$Q_{D\to E} = 80\frac{cal}{g} \cdot 2\bar{0}0g$$

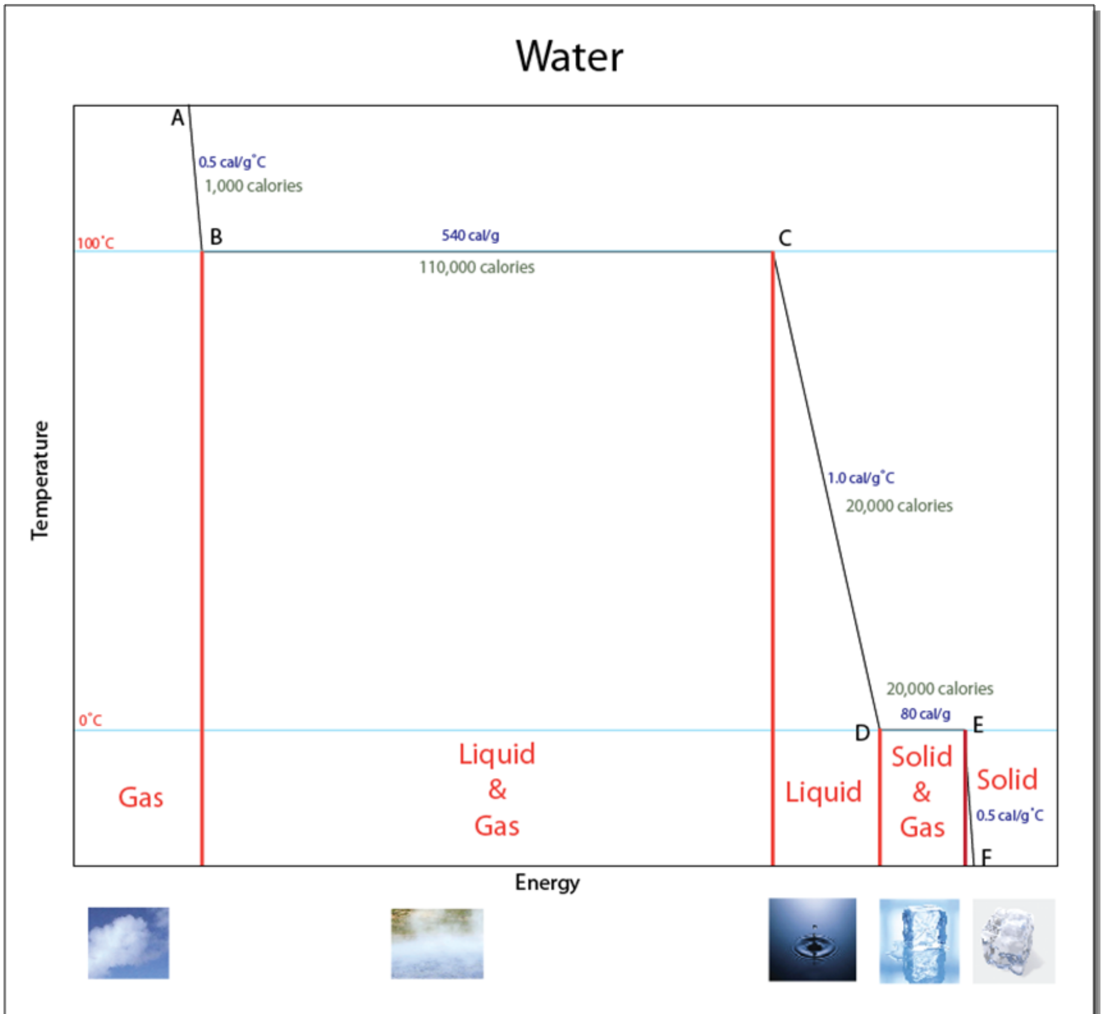
$$Q_{D\to E} = 80 \cdot 2\bar{0}0cal$$

$$Q_{D\to E} = 20{,}000cal$$

Adding these four stages up:

A→B .... 1,000 cal
B→C .... 110,000 cal
C→D .... 20,000 cal
D→E .... 20,000 cal

A→E .... 150,000 cal



21. A cylinder of gas is at room temperature (20°C). The air conditioner breaks down and the temperature rises to 40°C. What is the new pressure of the gas relative to its initial pressure?

$$\frac{P \cdot V}{T} = Constant$$

$$\frac{P_1 \cdot V_1}{T_1} = \frac{P_2 \cdot V_2}{T_2}$$

For this question, the volume is constant, so $V_1 = V_2$. This simplifies the equation to:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Rearranging to solve for the new pressure P_2 verses the original pressure P_1 gives the following equation:

$$\frac{P_2}{P_1} = \frac{T_2}{T_1}$$

Next we need to convert the temperatures into Kelvin for the formula to work. This provides the following formula:

$$\frac{P_2}{P_1} = \frac{40°C + 273}{20°C + 273}$$

$$\frac{P_2}{P_1} = \frac{313}{293}$$

$$\frac{P_2}{P_1} = 1.07$$