What Is the amount of ice at 0 deg C that must be added to a 0.50 kg of water at 20 deg C in order to bring the temperature of the water down to 0 deg C?

Solution.

$t_i = 0°\text{C}$ - ice temperature;

$m_w = 0{,}5\ kg$ – water mass;

$t_1 = 20°\text{C}$ - temperature of water at the beginning;

$t_2 = 0°\text{C}$ - temperature of water after adding ice;

$c = 4200\frac{J}{kg\cdot K}$ – specific heat of water;

$\lambda = 335\frac{kJ}{kg}$ - specific heat of fusion of ice.

Water is 0 degrees when in thermal equilibrium with. So we need to decrease the temperature of water to 0 degrees.

Additional heat is required to change the state of a substance from solid to liquid, or from liquid to gas. This is called the "latent heat". Water is in thermal equilibrium with ice when it freezes at the same rate that the ice melts.

Thermodynamic equilibrium:

$Q_w + Q_i = 0;$

Water cooled, so the heat quantity is negative:

$$Q_w = c\cdot m_w\cdot(t_2 - t_1) = 4200\cdot 0{,}5\cdot(0-20) = -42000 = -42\ (kJ)$$

Formula for melting ice is:

$$Q_i = \lambda\cdot m_i$$

Where λ is specific heat of fusion. In other words, it is necessary to add 80 calories of energy to melt one gram of ice at 0°C. Conversely, it is necessary to remove 80 calories of energy to freeze one gram of water at 0°C.

So the sum is:

$$Q_w + Q_i = -42000 + \lambda\cdot m_i = 0$$

And from this equation we can find mass of ice which is needed to cooled our water from 20 degrees to 0 degrees.

$$m_i = \frac{42000}{\lambda} = \frac{42\ kJ}{335\ \frac{kJ}{kg}} = 0{,}125373\ kg = 125{,}373\ (g)$$

Answer:

The amount of ice we should add is $125{,}373\ g$