Answer on Question #39550, Physics, Other

An ideal calorimeter has 2.5 kg of water at room temp. We put 1.25 kg of aluminum beads that are at a temp of 115 degrees Celsius. We add in .3 kg of ice at -10 degrees Celsius. What final temp. Do the materials in the calorimeter come to?

**Solution:**

a) The ice will warm up to 0 degrees Celsius, then melting and then warming to the final temperature X. The water will warm up (heat energy "flows" in to it). The metal will cool down (heat energy "flows" out of it).

b) The whole mixture will wind up at the same temperature X.

c) The energy which "flowed" out (of the warmer objects) equals the energy which "flowed" in (to the colder objects).

The warmer aluminum beads of mass m = 1.25 kg goes down from to 115.0 to x, so this means its Δt equals 115.0 minus x. Specific Heat of an aluminum c = 910 J/kg K

$$q_{Al} = cm\Delta t = 910 \cdot 1.25 \cdot (115 - x) = 1137.5 \cdot (115 - x) \text{ J}$$

Specific heat capacity, ice: $c_{ice}$ = 2.108 kJ/kg-K

Specific heat capacity, water: $c_{water}$ = 4.187 kJ/kg-K

The heat of fusion (or specific enthalpy of fusion) of ice is L = 334 kJ/kg.

The energy to heat up the ice is the sum of the following

$$q_{ice} = c_{ice}m_{ice}\Delta t_1 + Lm_{ice} + c_{water}m_{ice}\Delta t_2 =$$
$$= c_{ice}m_{ice}\big(0 - (-10)\big) + Lm_{ice} + c_{water}m_{ice}(x - 0)$$
$$q_{ice} = 2108 \cdot 0.3 \cdot 10 + 334000 \cdot 0.3 + 4187 \cdot 0.3 \cdot x = 106524 + 1256.1x$$

We take the room temperature of 20 °C.

The energy to heat up the water of mass $m_2$=2.5 kg is following

$$q_{water} = c_{water}m_2\Delta t_3 = 4187 \cdot 2.5 \cdot (x - 20) = 10467.5 \cdot (x - 20)$$

The heat balance equation:

$$q_{Al} = q_{ice} + q_{water}$$
$$1137.5 \cdot (115 - x) = 106524 + 1256.1x + 10467.5 \cdot (x - 20)$$
$$x = \frac{2336385}{128611} \approx 18.2 \text{ ℃}$$

So the water will not warm up, but will cool down to 18.2 ℃.

**Answer.** The final temp is 18.2 ℃.