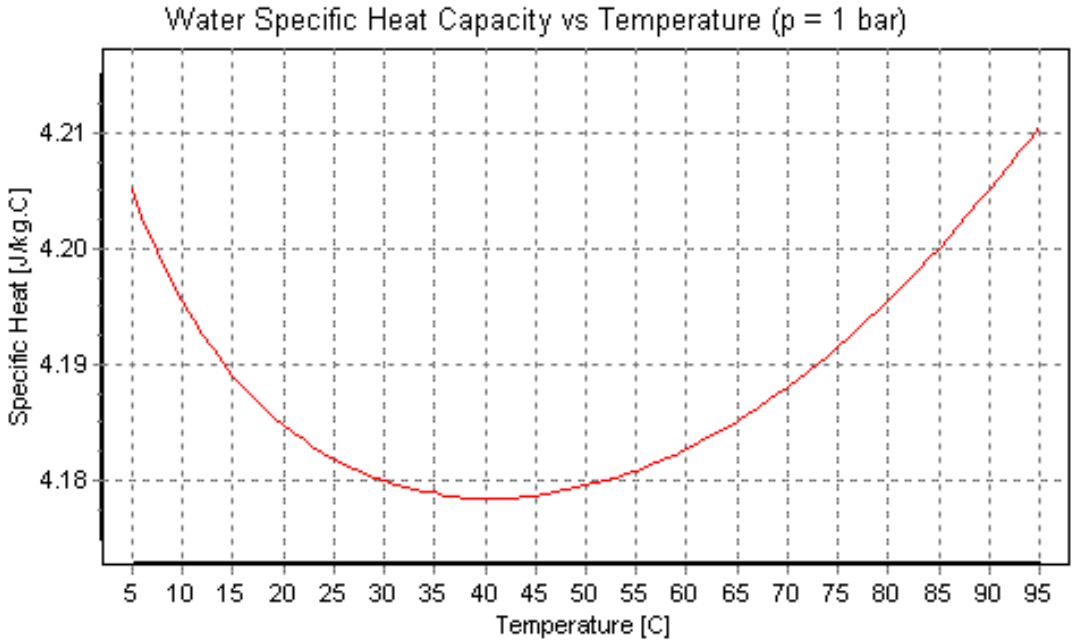
Answer on Question #55740 – Chemistry – General Chemistry

Question:
How many calories are released when 10 g of water cools from its boiling point to its freezing point?

Answer:

The amount of heat needed to increase (or released at cooling) the temperature of one gram of a substance by one degree is the specific heat capacity. It is expressed in joules per gram per degree Celsius.
The quantity of heat is a measurement of the amount of heat is present. The formula of quantity of heat, q, is equal to the mass of substance, m, multiplied with the specific heat and the change in temperature, ΔT.
Q = m × C × ΔT
Specific heat capacity of water is not constant in different temperatures and it depends on the temperature:



But we will assume, that it is constant.
The heat capacity of water is 4.18 joules per gram per degree Celsius.
Boiling point of water is 100°C, freezing point is 0°C. Thus, ΔT = 100 - 0 = 100 °C.
Therefore,
Q = 10 g × 4.18 J/(g*°C) × 100 °C = 4180 J.
The dependence of heat capacity of water can be expressed by formula:

$$C_p(T) = 4.214 - 2.286 \times 10^{-3}T + 4.991 \times 10^{-5}T^2 - 4.519 \times 10^{-7}T^3 + 1.857 \times 10^{-9}T^4$$

And heat, released when water cools can be found by integration this formula:

$$Q = m \int_0^{100} \left(4.214 - 2.286 \times 10^{-3}\, T + 4.981 \times 10^{-5}\, T^2 - 4.519 \times 10^{-7}\, T^3 + 1.857 \times 10^{-9}\, T^4\right) dT$$

Q = 10 g × 418.99 = 4189.9 J.

Calorie is the energy needed to increase the temperature of a given mass of water by 1 °C depends on the atmospheric pressure and the starting temperature. Accordingly, several different precise definitions of the calorie have been used. There are thermochemical calorie (4.184 J),
4 °C calorie (4.204 J), 15 °C calorie (4.1855 J), 20 °C calorie (4.182 J) and other. The 15 °C calorie is the amount of energy required to warm one gram of air-free water from 14.5 to 15.5 °C at standard atmospheric pressure. We will use this calorie for calculation:
Q = 4189.9 J / 4.1855 cal/J = 1001.05 cal = 1 kcal.
Also, we can calculate the heat from definition of calorie:
One calorie is the energy needed to increase the temperature of one gram of water by 1 °C, thus if 10 g of water cools from 100 °C to 0°C, Q = 10*100*1 = 1000 calories are released.