

CH302H – Principles of Chemistry II: Honors
Fall 2014, Unique 51880

Quiz 2, 6 February 2014

A healthy adult produces about 10 MJ of heat each day through normal metabolic activity. Assume a body mass of 65 kg with thermodynamic properties approximately that of water ($C_{p,m}(\text{H}_2\text{O}_{(l)}) = 75.29 \text{ J K}^{-1} \text{ mol}^{-1}$; $\Delta H_{\text{vap}}^0 = 44.02 \text{ kJ mol}^{-1}$, both at 298 K).

Question: If the human body were an isolated system, what temperature rise would the body experience over the course of a day?

EC (not much): Human bodies are actually open systems, and the main mechanism of heat loss is the evaporation of water. What mass of water must evaporate over the course of a day to maintain a constant body temperature.

$$q_p = 10 \text{ MJ} = 10 \times 10^6 \text{ J}$$

$$m = 65 \text{ kg}$$

$$C_p(\text{H}_2\text{O}) = 75.29 \text{ J/Kmol}$$

$$FW(\text{H}_2\text{O}) = 18 \text{ g/mol} = 0.018 \text{ kg/mol}$$

$$n(\text{H}_2\text{O}) = \frac{65 \text{ kg}}{0.018 \text{ kg/mol}} = 3608 \text{ mol}$$

(assuming 100% H₂O)

$$q_p = n C_{p,m} \Delta T; \Delta T = \frac{q_p}{n C_{p,m}}$$

$$\Delta T = \frac{10 \times 10^6 \text{ J}}{(3608 \text{ mol})(75.29 \text{ J/Kmol})}$$

$$\Delta T = 36.8 \text{ K} !$$

EC: The thing you need to recognize is that this $q_p = \Delta H_{\text{vap}}$; i.e. the enthalpy (because $\Delta P = 0$) change from evaporation of H₂O

$$q_p = \Delta H_{\text{vap}} = 44.02 \text{ kJ/mol} = 44020 \text{ J/mol}$$

$$\frac{10 \times 10^6 \text{ J}}{44020 \text{ J/mol}} \approx (227.2 \text{ mol H}_2\text{O})(18 \text{ g/mol}) = 4089 \text{ g H}_2\text{O}$$

$$4089 \text{ g} = 4089 \text{ mL H}_2\text{O} \approx 4.1 \text{ L H}_2\text{O}$$

this is \approx 1 gallon of H₂O per day.
Drink lots of water!