(2) (a) Water: hydrogen bond strength 5-8kT (@ 25°C)

on average, 2 H-bonds per molecule of liquid water

could be some discussion about this. Wikipedia gives ~ 3.24 @ 100°C, 3.59 @ 25°C but also 2.357 @ 25°C

@ 25°C, $k_B T \approx (298\,K)(1.38\times10^{-23}\,\frac{J}{K})(6.02\times10^{23}\,\frac{\text{bonds}}{\text{mole}})$

$= 2477\,\frac{J}{\text{mole}} \approx 2.5\,kJ/\text{mole}$

@ 100°C, $k_B T = (373)(1.38\times10^{-23}\,\frac{J}{K})(6.02\times10^{23}\,\frac{\text{bonds}}{\text{mole}})$

$= 3100\,\frac{J}{\text{mole}} = 3.1\,kJ/\text{mole}$

So: H-bond ~~streat~~ strength $\approx 5\text{-}8\,kT_{25°} \approx 13\text{-}20\,kJ/\text{mole}$ ~~per bond~~ for a single bond

If use 2.35 bonds/molecule, it's 31-47 kJ/mole

using 3.2 bonds/molecule, it's 42-64 kJ/mole

Tabulated heat of vaporization of water is 40.65 kJ/mole, so

clearly breaking H-bonds is a large contribution to the heat of vaporization of water

(b) Energy of 2 electrons separated by dist. r:

$V = \frac{1}{4\pi\epsilon}\frac{e^2}{r^2}$. want $V = k_B T$

$\epsilon = \kappa\epsilon_0$

$\kappa = 80$

so: $k_B T = \frac{1}{4\pi\epsilon_0 \kappa}\frac{e^2}{r^2}$

$r^2 = \frac{(4\pi\epsilon_0)(k_B T)(\kappa)}{e^2}$

for $T = 25°C \longrightarrow r^2 \approx (0.7\,nm)^2$