1. An electric potential energy exists when two protons are separated by a certain distance. Does the electric potential energy increase, decrease, or remain the same (a) when both protons are replaced by electrons, and (b) when only one of the protons is replaced by an electron? (Justify your answer). Use equations.

Solution.

The electric potential energy of the system of two protons (with charges e and e), which are separated by the distance d: $W = k\dfrac{e \cdot e}{d} = \dfrac{ke^2}{d}$,

where $k = 9 \cdot 10^9 \dfrac{N \cdot m^2}{C^2}$ is Coulomb's constant.

a) If both particles are replaced by electrons (with charges $-e$ and $-e$), then the electric potential energy of such a system becomes $W = k\dfrac{(-e)\cdot(-e)}{d} = \dfrac{ke^2}{d}$. So, it remains the same.

a) If only one of the protons is replaced by an electron, then the electric potential energy of a new system becomes $W = k\dfrac{e \cdot (-e)}{d} = -\dfrac{ke^2}{d}$. So, it remains the same by the module, but the sign charges to the opposite. That is because an electron and a proton have the attractive interaction (negative energy). Two charges of the same sign have the repulsive interaction (positive energy).

Answer: a) remains the same; b) changes the sign to minus, but remains equals by the module.