Answer on Question #62543 - Chemistry - General Chemistry

Question:

A volume of 110 mL of H2O is initially at room temperature (22.00 ∘C). A chilled steel rod at 2.00 ∘C is placed in the water. If the final temperature of the system is 21.10 ∘C , what is the mass of the steel bar? Density of water = 1.00 g/mL.
Use the following values:
specific heat of water = 4.18 J/(g·∘C)
specific heat of steel = 0.452 J/(g·∘C)

Solution:

1) As there is no special note that we assume that there is no heat exchange with the environment. In such case the amount of heat taken by the steel rod (Q_s) is equal to the amount of heat lost by water (Q_w) but with opposite sign:
   $Q_s=-Q_w$.
   In future formulas all values related to water will have index w and those for the steel rod will have index s.
2) Let's write the generic expression connecting amount of heat (Q), temperature change of the object ($T-T_0$, where T_0 – initial temperature of the object, T – final temperature of the object), specific heat (C) and the mass of object (m):
   $Q = C*(T-T_0)*m$
3) Let's write condition from 1) using expression from 2):
   $C_s*(T_s-T_{0s})*m_s = - C_w*(T_w-T_{0w})*m_w$.
4) Derive mass of steel rod from 3):
   $m_s = - C_w*(T_w-T_{0w})*m_w / (C_s*(T_s-T_{0s}))$
   Note, that the mass of the water = volume of water * density of water = 110 mL * 1.00 g/mL = 110.00 g.
5) Calculate:
   $m_s = - 4.18\ J/(g^\circ C) * (21.10\ ^\circ C - 22.00\ ^\circ C) * 110.00\ g / (0.452\ J/(g^\circ C) /* (21.10\ ^\circ C - 2.00\ ^\circ C)) = 47.93\ g$.

Answer:

The mass of the steel bar is 47.93 g.