# Mixtures Tutorial Solutions

1. *A mechanic adds 655 g of ethylene glycol at 22.0℃ to your car's radiator. The radiator already contains 6.75 L of water at 92.0℃. If the 4.50 kg radiator is made of copper, calculate the final temperature of the mixture.*

heat lost by water + heat lost by radiator = heat gained by eth. gly.

$m_{water}c_{water}\Delta t_{water} \quad m_{rad}\, c_{rad}\Delta t_{rad} = m_{eth\ gly}\, c_{eth\ gly}\Delta t_{eth\ gly}$

$6.75 \times 4.18 \times 10^3 \times (92.0 - T_{final}) + 4.50 \times 3.90 \times 10^2 \times (92.0 - T_{final}) = 0.655 \times 2.40 \times 10^3 \times (T_{final} - 22.0)$

$2.596 \times 10^6 - 2.82 \times 10^4\, T_{final} + 1.615 \times 10^5 - 1755\, T_{final} = 1572\, T_{final} - 3.458 \times 10^4$

$2.792 \times 10^6 = 3.153 \times 10^4\, T_{final}$

$T_{final} = 88.5^\circ C$

2. *A maintenance worker uses steam to defrost a small freezer that contains 1.50 kg of ice at 0.00℃. Calculate the mass of dry steam at 1.00 x 10*$^2$ *℃ he needs to convert all the ice to water at 21.5℃. Assume the heat absorbed by the freezer's plastic lining is negligible.*

heat lost by steam = heat gained by ice

$m_{steam}L_v + m_{steam}\, c_{steam}\Delta t_{steam} = m_{ice}L_f + m_{ice}c_{ice}\Delta t_{ice}$

$m \times 2.25 \times 10^6 + m \times 4180 \times (100 - 21.5) = 1.50 \times 3.34 \times 10^5 + 1.50 \times 4180 \times (21.5 - 0)$

$m( 2.25 \times 10^6 + 3.28 \times 10^5) = 5.01 \times 10^5 + 1.35 \times 10^5$

$m = 6.36 \times 10^5 / 2.58 \times 10^6$

$= 0.246$ kg

3. *A cook pours 8.00 x 10*$^2$ *g of soup at 98.0℃ into a 1.00 kg vacuum flask of specific heat 32.0 J kg*$^{-1}$ *K*$^{-1}$*. The soup raises the temperature of the flask from 10.0℃ to 97.0℃. What is the specific heat of the soup?*

heat lost by soup = heat gained by flask

$m_{soup}c_{soup}\Delta t_{soup} = m_{flask}c_{flask}\Delta t_{flask}$

$0.800 \times c_{soup} \times (98.0 - 97.0) = 1.00 \times 32.0 \times (97.0 - 10.0)$

$c_{soup} = 2784 / 0.800$

$= 3.48 \times 10^3$ J kg$^{-1}$ K$^{-1}$

4. *You want to raise the temperature of a bath containing 40.0 kg of cold water at a temperature of 16.5℃ to 45.0℃. What mass of hot water at a temperature of 75.3℃ must you add to the cold water if the bath and its surroundings absorb 15% of the heat lost from the hot water as it cools to its final temperature?*

85% of heat lost by hot water = heat gained by bath water

$0.85 \times m_{hot\ water} c_{hot\ water} \Delta t_{hot\ water} = m_{bath\ water} c_{bath\ water} \Delta t_{bath\ water}$

$0.85 \times m_{hot\ water} \times 4180 \times (75.3 - 45.0) = 40.0 \times 4180 \times (45.0 - 16.5)$

$1.077 \times 10^5\ m_{hot\ water} = 4.77 \times 10^6$

$m_{hot\ water} = 44.3$ kg

5. *You want to make a cool drink from some 19.7℃ tap water by adding ice. Calculate the mass of ice at -11.3℃ you need to cool 195 g of such tap water in a 215 g glass to a temperature of 3.60℃. Neglect any heat that your drink would gain from its surroundings.*

heat gained by ice = heat lost by water + heat lost by glass

$m_{ice} c_{ice} \Delta t_{ice} + m_{ice} L_f + m_{m\text{-}ice} c_{m\text{-}ice} \Delta t_{m\text{-}ice} = m_{water} c_{water} \Delta t_{water} + m_{glass} c_{glass} \Delta t_{glass}$

$m_{ice} \times 2100 \times 11.3 + m_{ice} \times 3.34 \times 10^5 + m_{ice} \times 4180 \times 3.60 = 0.195 \times 4180 \times 16.1 + 0.215 \times 840 \times 16.1$

$3.728 \times 10^5\ m_{ice} = 1.603 \times 10^4$

$m_{ice} = 0.0430$ kg

6. *a.* *You find you have let a 12.0 kg stainless steel barbecue plate become much too hot for normal cooking. You decide to cool the plate from 395℃ to 185℃ by spraying water onto the plate. Calculate the mass of water at 20.0℃ tyou will need, assuming all the water evaporates to steam at 100℃.*

heat lost by plate = heat gained by water

$m_{steel}c_{steel}\Delta t_{steel} = m_{water}L_v + m_{water}\, c_{water}\Delta t_{water}$

$12.0 \times 445 \times (395 - 185) = m_{water} \times 2.25 \times 10^6 + m_{water} \times 4180 \times 80$

$1.121 \times 10^6 = m_{water} \times 2.584 \times 10^6$

$m_{water} = 0.434$ kg

*b.* *What mass of ice at 0.00℃ would have the same effect?*

$m_{steel}c_{steel}\Delta t_{steel} = m_{water}L_v + m_{water}\, c_{water}\Delta t_{water} + m_{water}\, L_f$

$12.0 \times 445 \times (395 - 185) = m_{water} \times 2.25 \times 10^6 + m_{water} \times 4180 \times 100 + m_{water} \times 3.34 \times 10^5$

$1.121 \times 10^6 = m_{water} \times 3.002 \times 10^6$

$m_{water} = 0.373$ kg