Name: _____ Date: _____ Class: _____

Heat Transfer Problem Sheet Answer Key

1. Imagine that you mix 1 kilogram of water at 60˚C with 1 kilogram of water at 4˚C. What is the final temperature of the mixture?

   Use the provided energy equation:

   $Q = mC_p\Delta T$

   Apply the conservation of energy:

   Energy (heat) lost by the hot water = Energy (heat) gained by the cold water

   $Q_{lost} = Q_{gained}$

   $m_{hot\ water}\ C_{p,\ water}\ (T_{i,\ hot\ water} - T_{f,\ hot\ water}) = m_{cold\ water}\ C_{p,\ water}\ (T_{f,\ cold\ water} - T_{i,\ cold\ water})$

   Where: T_i = initial temperature

   T_f = final temperature

   Recognizing that the final temperatures of the hot and cold water will be equal and the masses and specific heats cancel:

   $T_{i,\ hot\ water} - T_{f,\ hot\ water} = T_{f,\ cold\ water} - T_{i,\ cold\ water}$

   $T_f = ½\ (Ti_{,\ cold\ water} + T_{i,\ hot\ water}) = ½\ (4˚C + 60˚C) = \underline{32˚C}$

2. What volume of antifreeze is necessary to cool a hot engine from 200˚C to 150˚C? Assume the engine is made of steel with a specific heat of 0.45 kJ/kg˚C and has a mass of 300 kg. The antifreeze is 50% water/50% ethylene glycol with a specific heat of 3.33 kJ/kg˚C and a density of 1,050 kg/m^3. The initial temperature of the antifreeze is 20˚C.

   Calculate the heat lost by the engine:

   $Q_{lost} = m_{engine}\ C_{p,steel}\ (T_{i,\ engine} - T_{f,engine}) = (300\ kg)\ (0.45\ kJ/kg˚C)\ (200˚C - 150˚C) = 6{,}750\ kJ$

   This must equal the heat gained by the antifreeze (assume the final temperature of the antifreeze is also 150˚C):

   $Q_{gained} = Q_{lost} = 6{,}750\ kJ$

   Use the energy equation to determine the required mass of antifreeze:

   $m_{antifreeze} = Q_{gained} / [C_{p,\ antifreeze}\ (T_{f,\ antifreeze} - T_{i,\ antifreeze})]$

   $= 6{,}750\ kJ / [3.33\ kJ/kg˚C\ (150˚C - 20˚C)] = 15.59\ kg$

   Find the volume of the antifreeze:

   $V = m / d = 15.59\ kg / 1{,}050\ kg/m^3 = 0.01485\ m^3 = \underline{14.85\ L}$