Foundations of Physics 2B/3C 2019-2020

Thermodynamics – Workshop 3 Problems

Week Commencing 28th October

1. Entropy Calculations

This problem provides practice at calculating entropy changes. Note problem e) is very similar to c) and d) so you may wish to move onto question 2 first.

a) One mole of an ideal gas undergoes an isothermal expansion when placed in contact with a heat reservoir at $400\ \mathrm{K}$, so that the expanded volume is ten times that of the initial volume. What is the entropy change of the gas?

b) A $2\ \mathrm{kg}$ block of lead having heat capacity $C_p = 0.256\ \mathrm{kJ\ K^{-1}}$ at a temperature of $500\ ^\circ\mathrm{C}$ is dropped into the River Wear on an autumn day, when its temperature is $10\ ^\circ\mathrm{C}$. What is the entropy change for both the lead block and the river, assuming that the river can be treated is an infinite heat reservoir and its temperature does not change?

c) Two equal amounts of water, having mass $10.0\ \mathrm{kg}$ and at temperatures of $90\ ^\circ\mathrm{C}$ and $10\ ^\circ\mathrm{C}$ respectively, are mixed and come to equilibrium. Water, has specific heat capacity given by $c_V = 4180\ \mathrm{J\ kg^{-1}\ K^{-1}}$. Calculate the following:
   i) The overall energy change of the system;
   ii) The final temperature reached;
   iii) The entropy changes of the hot water, cold water and the Universe.

d) A heat engine takes in heat in equal quantities from two hot reservoirs at $800\ \mathrm{K}$ and $1000\ \mathrm{K}$. If the cold reservoir of the engine is at $450\ \mathrm{K}$, what is the maximum possible efficiency of the engine?