ENV-413: Thermodynamics of the Earth systems

Worksheet Lecture 4: Heat, work, cyclic processes, First Law

Work

1. Write an expression for the work (of expansion) in intensive form

2. Referring to Fig 2.2b, consider the cyclic process, consisting of process (A, B) followed by process (B, A). The net work done in this cycle is equal to
a) the area under the curve for process (A, B)
b) the area under the curve for process (B, A)
c) the area under the curve bounded by the curves for process (A, B) and process (B,A)
d) zero

3. The work done in a cyclic process is (always, sometimes, never) equal to zero

4. An exact differential $d\xi$ has the following property: The integral of $d\xi$ about a closed path is equal to zero ($\oint d\xi = 0$). Evaluate the following integral. Is this integral exact or inexact?

$$\int_{V_1}^{V_2} dv$$

5. Consider the following integral, which statement is true?

$$w = \int_{V_1}^{V_2} p\, dv$$

a) the integral can be evaluated by knowing the value of p, and v_2 and v_1
b) the integral can only be evaluated by knowing the specific path over which p varies with v
Is work an exact differential? YES NO

10. List three natural processes that cause air to expand (rise) in the atmosphere

Heat

1. If two bodies have the same temperature, they must also have the same amount of heat (true, false)

2. List two heat transfer processes that occur in the atmosphere.

3. If two equal masses of water at 10°C and 30°C are mixed, what is the resulting temperature?

4. If the same mass of warm mercury is used in place of the warm mass of water, will the resulting temperature be (greater than, equal to, less than) the temperature you found in #3? Hint: specific heat of H_20=4218 J/(kg K); specific heat of Hg=140 J/(kg K).

5. When two bodies of different temperature T_1 and T_2 are brought into contact with each other, the temperature difference eventually disappears, and the final temperature, T' is intermediate between the two initial temperatures: $T_1 > T' > T_2$. The first law of thermodynamics states for this problem that the amount of heat ΔQ lost by the warmer body is equal in magnitude to the amount of heat gained by the cooler body

$$\Delta Q = c_1 m_1 (T_1 - T') = c_2 m_2 (T' - T_2)$$

For the problem in #4, calculate the final equilibrium temperature.

6. Recall that an exact differential $d\xi$ has the following property: the integral of $d\xi$ about a closed path is equal to zero ($\oint d\xi = 0$). Do you think that heat is an exact differential? (YES NO.) Consider whether you must know how the pressure and volume change during the transformation and if any phase changes occur during the transformation (*e.g.,* gas to liquid).