16.050 Thermal Energy

Recitation #4 – Fall 2002

Problem 1:

The Concorde is flying at its cruising altitude of 60,000 ft when suddenly one of the cockpit windows cracks and fails, leaving a hole of 5 cm diameter. How much time do the pilots have to put on their oxygen masks given that they pass out at a pressure of 0.1 bar? The initial pressure and temperature in the cockpit are 1 bar and 290K, and the cockpit volume is 10 m^3. Assume that air is a perfect gas with $\gamma = 1.4$, the cockpit is well insulated, and that the flow out of the cockpit is choked.

Problem 2:

One kg of air undergoes a cycle as follows:

- Irreversible adiabatic compression from P_1= 1 bar, T_1= 300 K, to P_2= 30 bar where s_2-s_1=60 J/kgK [1=>2]
- Constant pressure heat input until T_3= 1500 K [2=>3]
- Adiabatic, irreversible expansion until P_4= 1bar where s_4-s_3=110 J/kgK [3=>4]
- Constant pressure heat rejection [4=>1]

Assume air behaves as a perfect gas with cp= 1 kJ/kgK.

Find:

a) $\oint \frac{dQ}{T}$

b) ΔS_{total} assuming that the source and sink temperatures of the universe are each constant and equal to 2000 K and 300 K, respectively.

c) Sketch the process on a *T*-*s* diagram