Physics I

Thermodynamic Cycles

Carnot cycle efficiency $\eta = 1 - \frac{T_{Low}}{T_{high}}$

Problem 1.- An ideal gas initially occupies a volume of 2L at a pressure of 150,000 pascals. It expands isothermally to a volume of 5L.
How much work is done in the process?
Recall that $\int_{x1}^{x2} \frac{dx}{x} = \ln\left(\frac{x_2}{x_1}\right)$

Problem 1a.- Calculate the work delivered by the isothermal expansion of 5.8 kg of air at T=600 K from an initial pressure of p_1 = 8 atm to a final pressure of p_2 = 2 atm.
Approximate air as an ideal gas of molecular mass 29.

Problem 2.- An ideal gas initially occupies a volume of 2L at a pressure of 200,000 pascals. It expands at constant pressure to a volume of 10L. Then it is cooled down at constant volume until its final temperature is equal to the initial temperature.
Sketch the process in a PV diagram with units and values.
How much work is done in the process?

Problem 3.- A mixture of gasses is found experimentally to have a heat capacity at constant pressure of $C_v = 2R$ per mole, so $C_p = 3R$

Knowing that $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$ calculate the final pressure of the mixture if it expands adiabatically from an initial pressure of 1 atm and volume 1L to a final volume of 2L.

Problem 4.- Draw a P-V diagram of the following cycle:

a) A 2L volume of air initially at 2 atm expands isothermally to a final volume of 4L.

b) The gas is then compressed at constant pressure to a final volume of 2L

c) The gas is heated at constant volume until it reaches a pressure of 2 atm again.

Problem 5.- An ideal gas initially occupies a volume of 2L at a pressure of 200,000 pascals. It expands isothermally to a volume of 10L.
How much work is done in the process?

$$\int_{x1}^{x2} \frac{dx}{x} = \ln\left(\frac{x_2}{x_1}\right)$$

Problem 6.- Calculate the amount of work done by air expanding from an initial temperature of 800K and volume of 0.15 m^3 to a final volume of 0.25 m3 in an adiabatic expansion (gamma for air is 1.4)

Problem 7.- If an engine works between a maximum temperature of 900K and a minimum of 300K, what is the theoretical upper bound of the efficiency?