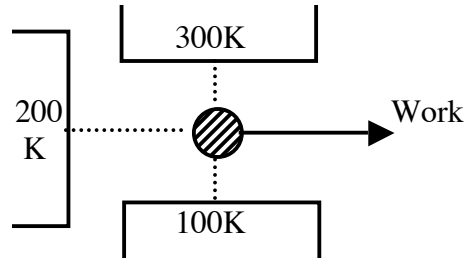


(Please write in pen rather than in pencil. No regrading for quizzes written in pencil.)

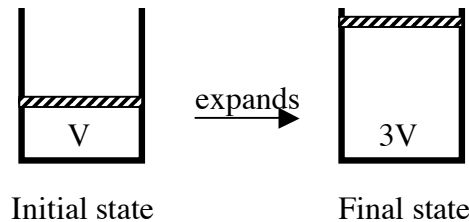
Problem 1 (10 pts)



A heat engine operates between three heat reservoirs, at temperatures 300K, 200K and 100K. In each cycle it absorbs 15 J from the reservoir at 300K.

- What is the maximum possible efficiency of this engine? (efficiency=work performed/heat absorbed).
- Assume in each cycle this engine absorbs 20J from the reservoir at 200K, in addition to the 15 J absorbed from the reservoir at 300K. What is the maximum work (in J) it could deliver in this case per cycle? What is its efficiency in this case?
- Suppose the engine delivers only half the work calculated in (b) per cycle, while absorbing 20J from the 200K reservoir and 15J from the 300K reservoir. Calculate the change in entropy of the engine, of the environment (that includes the heat reservoirs) and of the universe in one cycle for this case.

Problem 2 (10 pts+5pts extra credit)



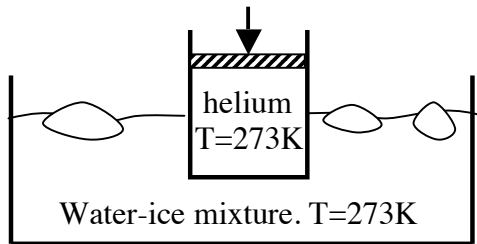
One mol of a monoatomic ideal gas at temperature $T=300\text{K}$ is in a thermally insulated cylinder. It is made to expand through some unspecified process from an initial volume $V=0.2\text{m}^3$ to a final volume $3V$. No heat goes in nor out of the system during this process, since the system is thermally insulated.

- Find the minimum temperature the gas can have at the end of this process, in K.
- Find the maximum temperature the gas can have at the end of this process, in K.
- Find the work done by the gas in the process for cases (a) and (b).
- Find the change in the entropy of the environment for the processes (a) and (b). Justify your answer.
- Find the change in the entropy of the universe for cases (a) and (b). Justify your answer.

Gas constant: $R=8.314\text{ J/mol K}$.

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Problem 3 (10 pts)



A cylinder with 3 mol of helium gas (an ideal gas) at $T=273\text{K}$ is in thermal contact with a mixture of water and ice at $T=273\text{K}$. The gas is slowly compressed from initial volume V to final volume $V/2$.

- How much ice melts in this process? Give your answer in grams.
 - Find the change in entropy of the gas in this process. Give your answer in J/K
 - Find the change in entropy of the water-ice mixture in this process. Give your answer in J/K .
 - Is this process reversible or irreversible? Justify your answer.
- Heat of fusion of ice: 333kJ/kg . Gas constant: $R=8.314\text{ J/mol K}$.