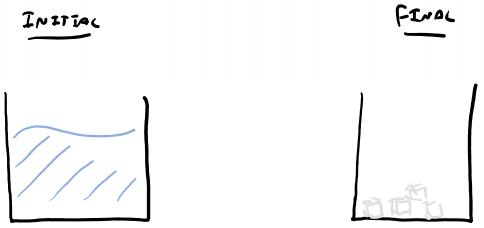
Week 5 Challenge Homework Solutions

Question 1

Liquid supersaturated sugar solution can evaporate in an open beaker. What is left is a solid of sugar crystals.

(a) Did the sugar gain or lose entropy going from a liquid to crystalline form? Explain.

(b) Does this violate the second law of thermodynamics? Explain.



(a) SYSTEM: SUGAR

SUGAR LOST ENTROPY

B/C THERE ARE LESS MICRO CONFIGURATIONS THAT THE CRYSTALS CAN OCCUPY IN FINAL STATE VS INITIAL STATE.

(b) DOES NOT VIOLATE 2ND LAW

ISOLATED SYSTEMS NATURALLY INCREASE TO A MAX ENTROPY.

THE SUGAR IS NOT ISOLATED.... ENERGY FROM ENVIRONMENT ENTERS SUGAR TO EVAPORATE SOLUTION

$$\Delta S_{universe} > \underbrace{\Delta S_{sugar}}_{(-)} + \underbrace{\Delta S_{liquid}}_{(+)} > 0$$

Question 2

3.0 moles of an ideal gas are subjected to the following processes. First the volume is tripled in an isobaric process. Then it undergoes an isothermal process to a pressure of 9.0 kPa. The volume is then halved in another isobaric process. Finally, it returns to the original state in an isochoric process.

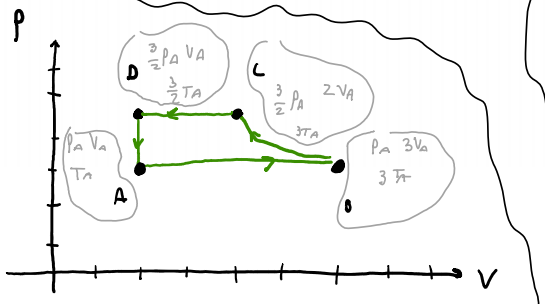
(a) Draw a PV diagram of the cycle. Label each state (vertex) with a letter (A, B, …) and each transition with a number and arrow showing the direction of the process.

(b) If the isothermal process occurs at a temperature of 900 K, what is the pressure, temperature, and volume for each state.

(c) Find the work done on the gas, the heat in and out of the gas, and the change in thermal energy for each of the processes.

PV = nRT

(a)



Isobaric A → B: $T \propto V$; $V \to 3V$; $T \to 3T$

Isothermal B → C: $P \propto \frac{1}{V}$; $4V_A = x\,6V_A$; $x = \frac{2}{3}$; $V \to \frac{2}{3}V$; so $P \to \frac{1}{2}P$

Isobaric C → D: $T \propto V$; $V_C = 2V_A$; $V \to \frac{1}{2}V$; $T \to \frac{1}{2}T$

Isochoric D → A: $P \propto T$; $P \to \frac{2}{3}P$; $T \to \frac{2}{3}T$

(b)

	A	B	C	D
P (Pa)	6000	6000	9000	9000
V (m^3)	1.2471	3.7413	2.4942	1.2471
T (K)	300	900	900	450

$P_C V_C = nRT_C$

$9000\,V_C = (3)(8.314)(900)$

$V_C = 2.4942\ m^3$

$\Delta E^{TH} = \frac{3}{2} nR\,\Delta T$

WORK = ± AREA (Isothermal: $nRT\ln(\frac{V_f}{V_i})$; Isobaric: $P\Delta V$)

$\Delta E^{TH} = W + Q$

(c)

	A→B	B→C	C→D	D→A	COMPLETE
ΔE^{TH} (J)	22448	0	−16836	−5612	0
W (J)	−14965	9102	11224	0	5361
Q (J)	37413	−9,102	−28060	−5612	−5361