Name________________________

Thermodynamic processes

For any *process* that takes a system from an initial state to a final state, the following quantities can be determined:

Change in internal energy of the system

- This can be calculated from equipartition:

$$U = \frac{1}{2}(\text{modes})nRT \rightarrow \Delta U = \frac{1}{2}(\text{modes})nR\Delta T.$$

Work done on/by system

- This can be calculated from the area under a *PV* curve:

$$\boldsymbol{W = -P\Delta V} \text{ (at constant pressure)}$$

Heat transferred from/to system

- This can be obtained via the First Law of thermodynamics:

$$\boldsymbol{Q = \Delta U + W}$$ (W = work done *by the system* on the environment)

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The above relations are always true for an ideal gas system that goes through any type of process!

Cyclic processes

One mole of an ideal monatomic gas undergoes the following states:

State	P	V	T
I	1.93×10^5 Pa	1.72×10^{-2} m^3	400 K
II	1.50×10^5 Pa	2.22×10^{-2} m^3	400 K
III	1.50×10^5 Pa	1.72×10^{-2} m^3	310 K

1. Draw a *PV* diagram, showing the processes I→II, II→III, and III→I. (Process I→II is an isotherm, but approximate it here by a straight line.)

2. Fill in this table.

Process	ΔU [J]	W [J]	Q [J]
I→II			
II→III			
III→I			

3. In process I→II, there is both heat added to the system, and the system also does work. Explain how the U of the system changes. Then how are Q and W related for this process?

4. In process II→III, was there more or less heat transferred than work done? Explain how the U of the system changed.

More With Cyclic processes

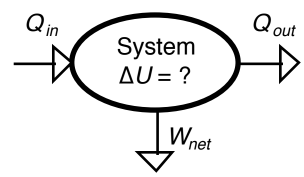
We will analyze the cyclic process from above further.

Consider the amounts of W, Q, and ΔU totaled over one complete cycle (use your table above).

1. What is the net amount of work W_{net} transferred in/out?
What is the net amount of heat Q_{net} transferred in/out?
What is the net change ΔU_{net} of the system?

2. Calculate the total area contained *inside* the *PV* diagram "triangle." How does this area compare to the net amount of work W_{net} transferred out of the system?

3. Find the amounts of energy transfers (Q) for this whole cyclic process. Carefully distinguish between the amount of heat transferred into the system (Q_{in}), and the amount of heat transferred out of the system (Q_{out}).
(Note: $Q_{net} = Q_{in} - Q_{out}$.)



4. This system takes in heat (Q_{in}), transfers some of it out as work (W_{net}), and then transfers out more heat (Q_{out}). Write an algebraic (energy conservation) equation relating Q_{in}, Q_{out}, and W_{net}.