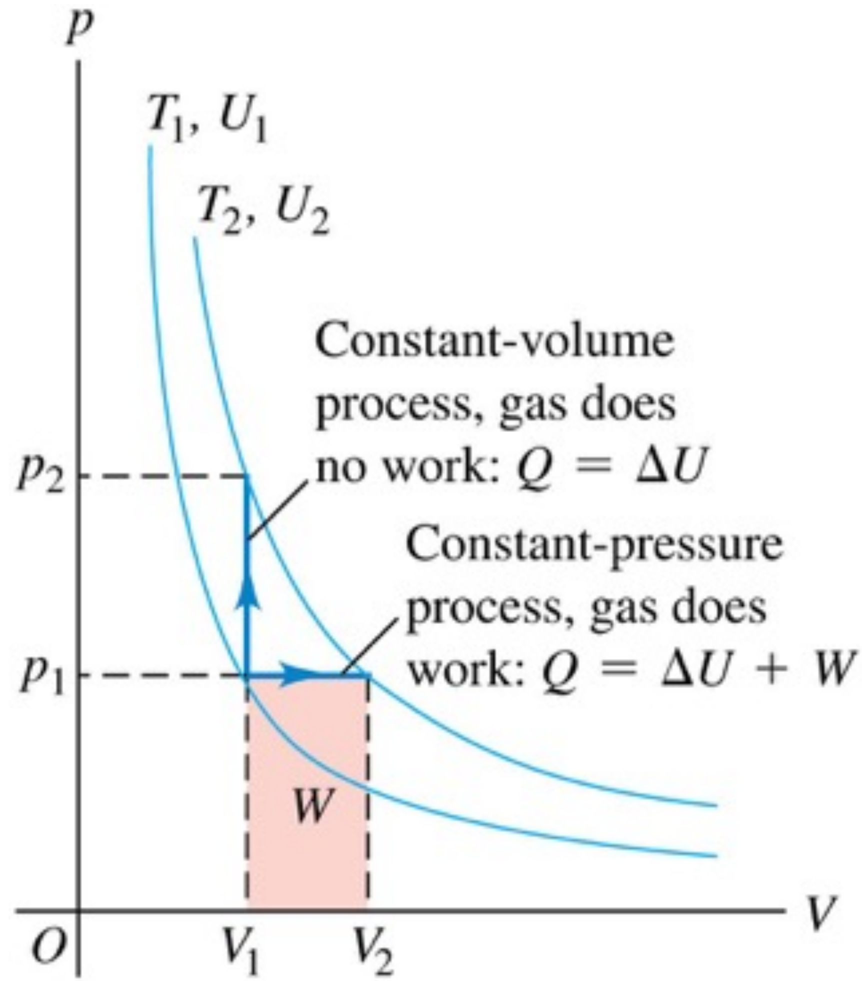
Lecture 6

PHYC 161 Fall 2016

Relating C_p and C_V for an ideal gas

- To produce the same temperature change, more heat is required at constant pressure than at constant volume since ΔU is the same in both cases.
- This means that $C_p > C_V$.
- $C_p = C_V + R$.
- R is the gas constant $R = 8.314$ J/mol · K.



The ratio of heat capacities

- The *ratio of heat capacities* is:

Ratio of heat capacities → $$\gamma = \frac{C_p}{C_V}$$

C_p: Molar heat capacity at constant *pressure*

C_V: Molar heat capacity at constant *volume*

- For monatomic ideal gases,

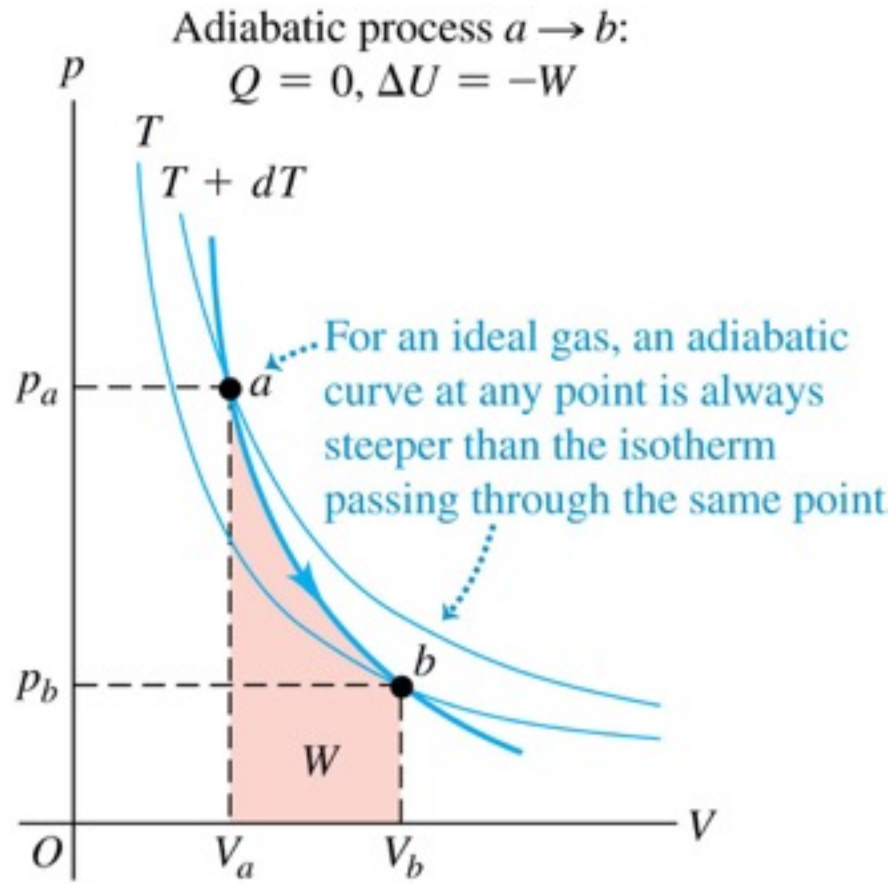
$$\gamma = 1.67.$$

- For diatomic ideal gases,

$$\gamma = 1.40.$$

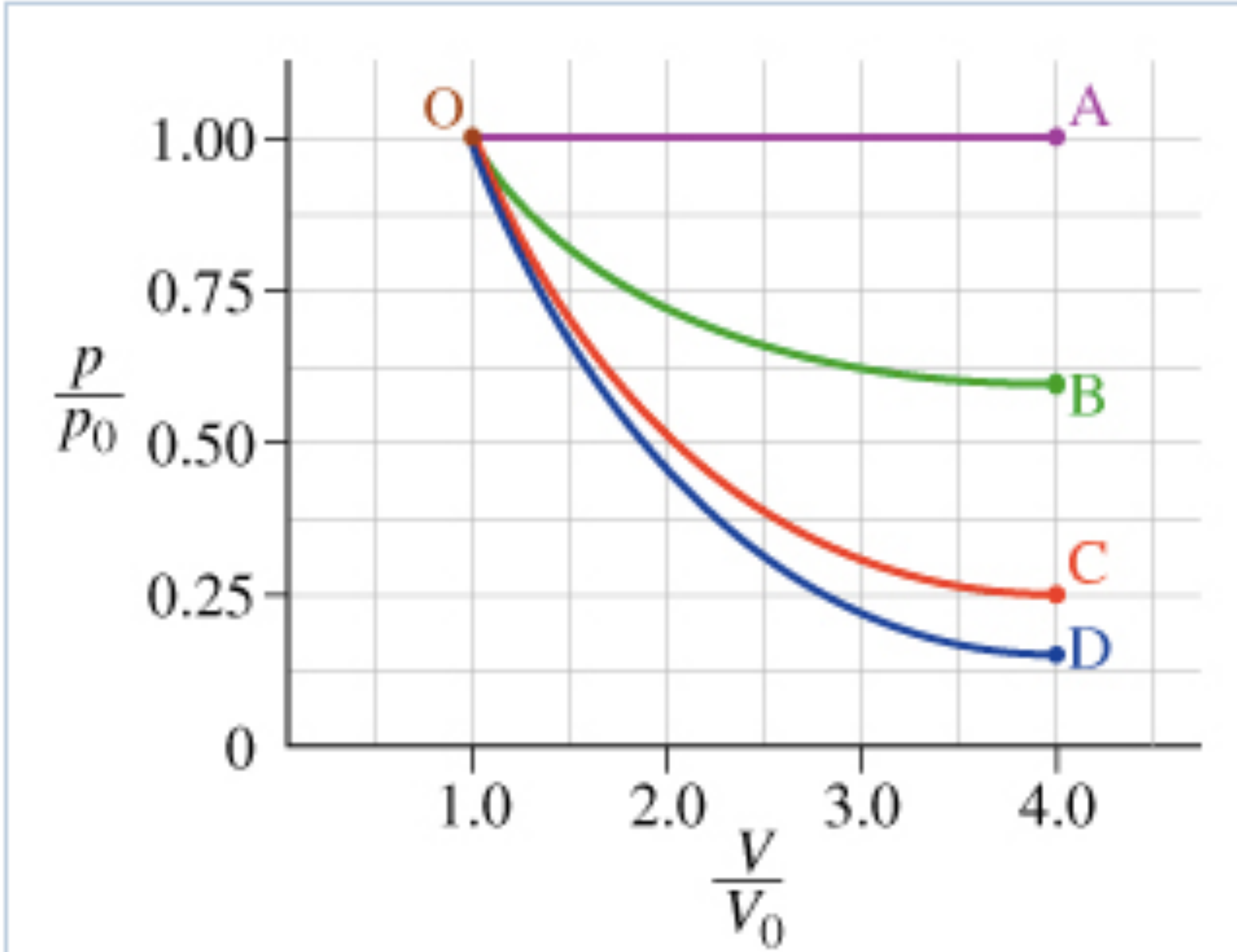
Adiabatic processes for an ideal gas

- In an adiabatic process, no heat is transferred in or out of the gas, so $Q = 0$.
- Shown is a pV-diagram for an adiabatic expansion.
- As the gas expands, it does positive work W on its environment, so its internal energy decreases, and its temperature drops.



- Note that an adiabatic curve at any point is always steeper than an isotherm at that point.

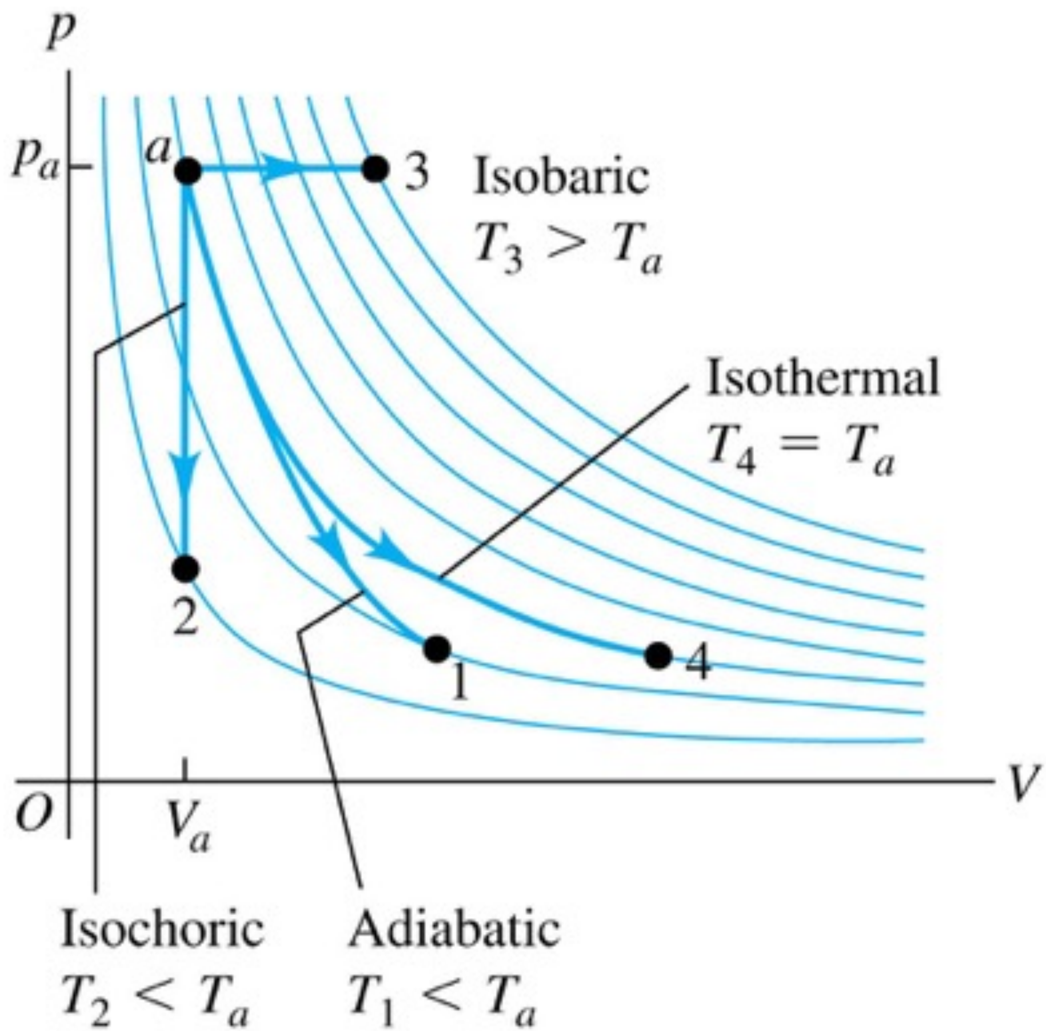
Expansion of a gas



- *Adiabiatic*: No heat is added or removed during the expansion.
- *Isobaric*: The pressure remains constant during the expansion.
- *Isothermal*: The temperature remains constant during the expansion.

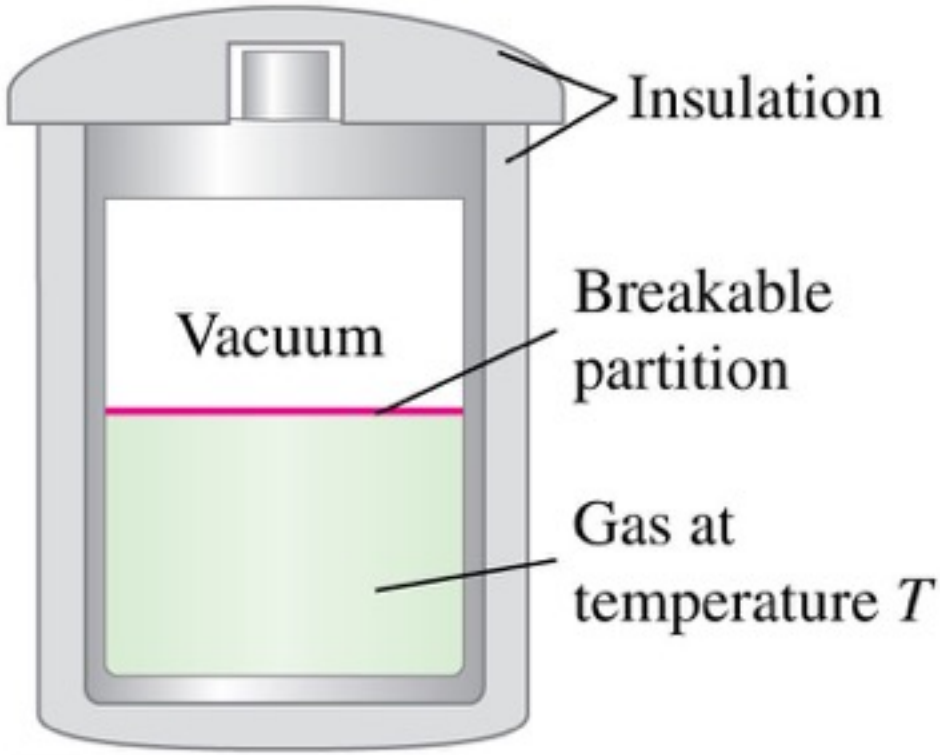
The four processes on a *pV*-diagram

- Shown are the paths on a pV-diagram for all four different processes for a constant amount of an ideal gas, all starting at state a.



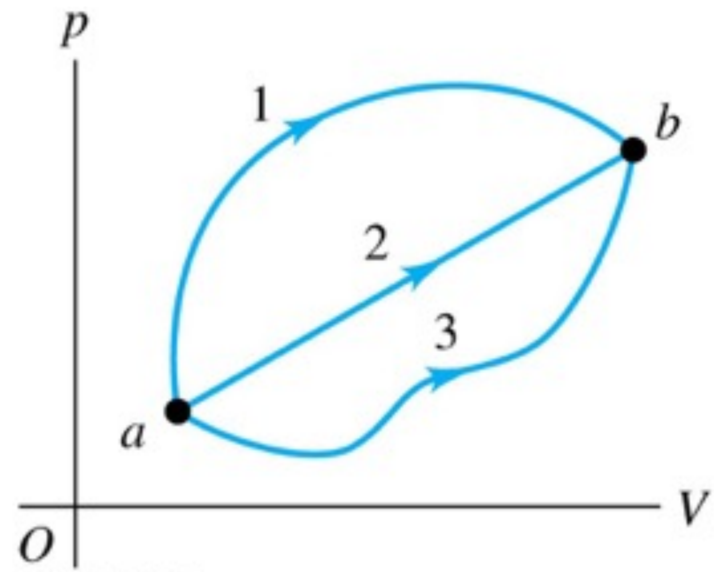
Internal energy of an ideal gas

- The internal energy of an ideal gas depends *only* on its *temperature*, not on its pressure or volume.
- The temperature of an ideal gas does *not* change during a free expansion.



Q19.1

A system can be taken from state *a* to state *b* along any of the three paths shown in the *p*-*V* diagram. If state *b* has greater internal energy than state *a*, along which path is the absolute value |*Q*| of the heat transfer the greatest?



A. path 1

B. path 2

C. path 3

D. |*Q*| is the same for all three paths.

E. Not enough information is given to decide.

Q19.4

In an isothermal expansion of an ideal gas, the absolute value of the heat that flows into the gas

A. is greater than the amount of work done by the gas.

B. is equal to the amount of work done by the gas.

C. is less than the amount of work done by the gas, but greater than zero.

D. is zero.

Clicker question

- You have 10 moles of a monatomic gas, with an initial volume V_i. You then compress the gas to half the initial volume in two ways:
- A. ISOTHERMAL compression
- B. ADIABATIC compression
- Q: In which process, A or B, is the final pressure of the gas higher?

2nd Law of Thermodynamics

- Why does heat flow from the hot lava into the cooler water?
- Could it flow the other way?
- It is easy to convert mechanical energy completely into heat, but not the reverse. Why not?
- We need to use the second law of thermodynamics and the concept of entropy to answer the above questions.

Directions of thermodynamic processes

- The direction of a *reversible process* can be reversed by an infinitesimal change in its conditions.
- The system is always in or very close to thermal equilibrium.
- For example, a block of ice melts *irreversibly* when we place it in a hot metal box.
- A block of ice at 0°C can be melted *reversibly* if we put it in a 0°C metal box.