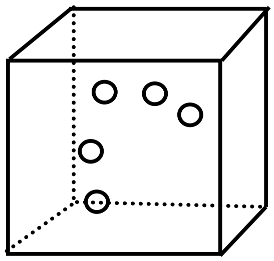
Lecture Notes A: Thermodynamics I

1) Definitions

Thermodynamic state



There are about 10^{23} atoms in a macroscopic sample of a gas.
To completely specify the microscopic state of a system, you would need to specify the position and velocity of each of these atoms.

Yet, we know from experience that it only takes a few variables to uniquely specify the state of the gas, for example: P, V and T.

This is the difference between the detailed microscopic state of a system and the macroscopic THERMODYNAMIC state of a system.

2) The First Law of Thermodynamics

$$\Delta E = q + w$$

E = internal energy of the system

Two ways to change the energy of system:

exchange heat with the surroundings (heat flows in response to a temperature difference)

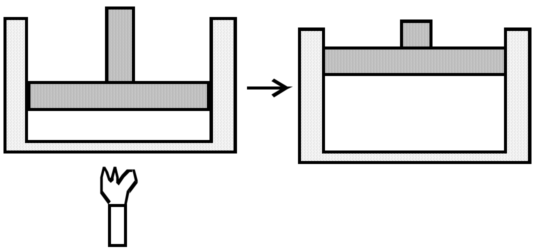
do work on the system, or have the system do work on the surroundings

q = heat	positive when heat is transfered to the system (gains energy from surroundings)
	negative when heat is lost from the system (loses energy to the surroundings)
w = work	positive when work is done on the system (gains energy from surroundings)
	negative when the system does work (loses energy to the surroundings)

1 cal = 4.184 J

1 nutritional calorie = 1000 cal

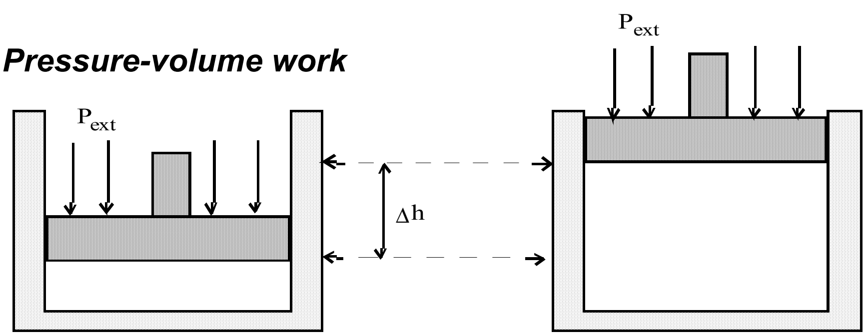
Concept



The flame on the right is turned on, which heats up the gas causing it to expand. The piston is connected to a drive train that causes a car to move. The signs of q and w for the gas in the cylinder are:

a)	q +	w +
b)	q +	w -
c)	q -	w +
d)	q -	w -

3) Pressure-volume work

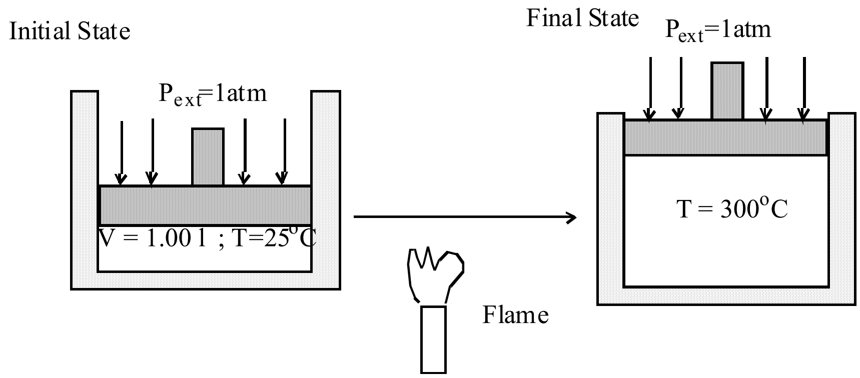


A gas expanding against a constant external pressure.
Amount of work = (external force acting on a body) * (distance through which the force acts)

Problem

A cylinder containing an ideal gas has an initial volume of 1.00 liters, and an initial temperature of 25^{o}C.

It is heated to 300^{o}C. What is the work done on the system (w) in both joules and calories?



4) *Other types of work*

5) *Heat and heat capacity*

For a constant volume process, $q_v = n\ C_v\ (T_{final}-T_{initial}) = n\ C_v\ \Delta T$

n = number of moles of the substance being heated
C_v = molar heat capacity

specific heat capacity is heat capacity per gram (instead of per mole)
The specific heat capacity of water is C_v = 1cal/(g ^{o}K)

Problem

In the movie "Back to the Future", a DeLorian car is transformed into a time machine. To travel through time, the car must be powered with 1.21 GigaWatts of energy. They get this amount of power from a bolt of lightning. Suppose the time machine malfunctioned, and instead of this energy going to time travel, it went to heat. Estimate the temperature of the car after this unfortunate accident.

Car: We will model as 500 kg of Fe, with a heat capacity of C_v(iron) = 0.45 J/(g ^oK).

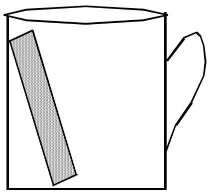
Heat: Assume a lightning stroke with a power of 1.21 GigaWatts ($1.21x10^9$ J/s) lasts for 120 microseconds ($120x10^{-6}$ s) [source: ftp://nofc.forestry.ca/pub/fire/docs/ltg.faq]

Concept

Suppose that instead of the energy going into the entire car, it went only into the flux capacitor (which we will model as a 50 g block of iron). What is the temperature of the flux capacitor after being hit with the lightning bolt considered above?

a) 364^oK a) 940^oK a) 6700^oK a) 64300^oK

Problem



Pioneers used to heat their coffee by placing an iron poker from the fire directly into the coffee. If a cup initially held 0.50 l of coffee at 20^{o}C, what would be the final temperature of the coffee when a 500g iron poker at 800^{o}C was placed in it? (Assume no heat is lost to the surroundings during the process). The density of water is 1g/ml. C_v(iron) = 0.45 J/(g ^{o}K).

Problem

In making a scotch and water, you mix 4 liquid ounces of ice-cold water (0^oC) with 1 liquid ounce of alcohol at (25^oC). What is the final temperature of the mixture (assuming the heat capacity of water is the same as that of alcohol)?

Concept

The heat capacity of alcohol is actually less than that of water. What effect will the use of the correct heat capacity for alcohol have on the temperature obtained above.

a) The temperature will be the same.
b) The temperature will be smaller than that obtained above.
c) The temperature will be larger than that obtained above.
d) Not enough information is given to answer this question.