Unit4Day1-Crawford

Monday, November 04, 2013
5:55 PM

Vanden Bout/LaBrake/Crawford

CH301

THERMODYNAMICS
HEAT AND WORK

UNIT 4 Day 1

Important Information

LM26 & LM27 DUE T 9AM

LM27 contains a link to Unit 4 worksheets
You should complete the worksheets associated with properties and change and the first law

Exam Grades should be posted by the end of Friday

What are we going to learn today?

Chemical and Physical changes are accompanied by changes in energy

Energy moves in the form of **HEAT (q)** and **WORK (w)**

Get a feel for heat and work

Get a feel for energy units

Energy

EVERY change (physical or chemical) is accompanied by a change in energy

The First Law of Thermodynamics

All energy is conserved, it can not be created or destroyed. It is simply transferred from one form to another

POLL: iCLICKER QUESTION 1

When I think of types of energy, I think:

a) KE and PE are the same as heat & work
b) PE and KE are the same as heat & work
c) PE and KE are the only two forms of energy
d) Heat and work are the only two forms of energy

KE = Kinetic Energy PE = Potential Energy

Energy Definitions

What is Energy?

Potential Energy (PE)
energy due to position or composition

atoms
bonds
e⁻
molecules

Kinetic Energy (KE)
energy of the motion of an object or particle

movement of molecules

Units: J

Energy Definitions

How does Energy move?

Heat (q)
transfer of energy from a hotter body to a colder body (NOTE: This is **not** temperature)

unorganized molecular

How does Energy move?

Heat (q)

transfer of energy from a hotter body to a colder body (NOTE: This is **not** temperature)

unorganized molecular motion

Work (w)

transfer of energy via applied force over distance

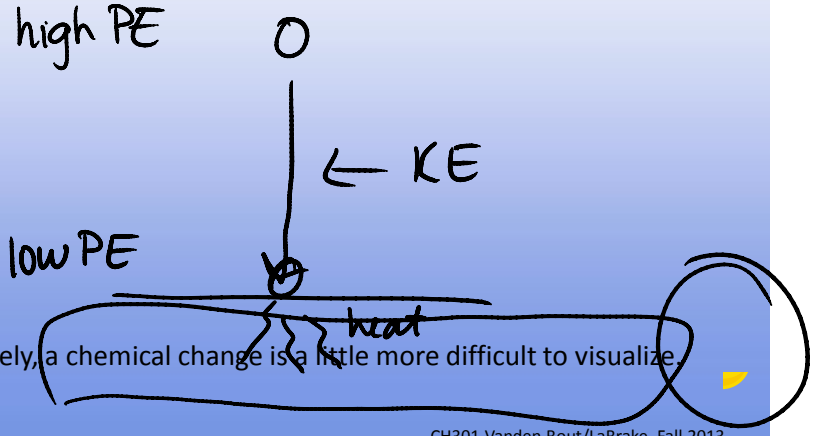
$W = F \times D$

organized molecular motion

Units: J

Demonstration

Drop a ball to the floor. Where did the Energy go? Please describe the Energy of the *Ball*.



Unfortunately, a chemical change is a little more difficult to visualize.

System and State

A system is the part of the universe on which we want to focus our attention. The *surroundings* are everything else

The *universe* is the system and the surroundings

Universe = system + surroundings

We also describe chemical changes with beginning and end *states*

A change in a chemical reaction is described as

$\Delta State = State_{end} - State_{beginning}$

Δ = Final - Initial

Demonstrations

Physical Change (doing *work*)

$CO_2(s) \rightarrow CO_2(g)$

Physical Change (absorbing *heat*)

$heat + CO_2(s) \rightarrow CO_2(g)$ sublimation

Chemical Change (releasing *heat*)

$2\,CH_3OH(g) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 4\,H_2O(g) + heat$

Energy Changes (Burning Fossil Fuels)

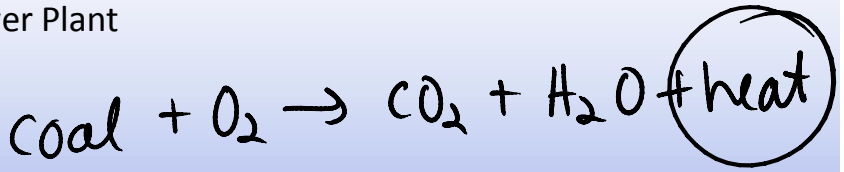
Power Plant

$coal + O_2 \rightarrow CO_2 + H_2O + heat$

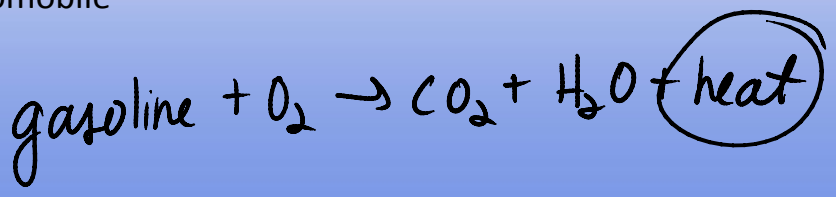
Automobile

Energy Changes (Burning Fossil Fuels)

Power Plant



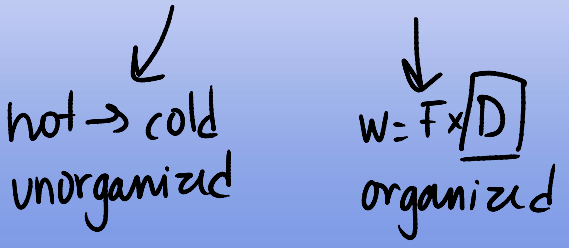
Automobile



Thermodynamics

Chemists care about understanding and quantifying the amount of energy that moves into or out of a system upon a change.

Energy moves in the form of **heat (q)** and **work (w)**



Gummy Bear Demonstration

Kilocalorie (Calorie) – nutritional unit

calorie – the amount of energy it takes to raise the temperature of 1 gram of water 1 degree C.

1 cal = 4.184 J

1 bear = 10 Cal = 10,000 calories = 41,184 J

lot of E

Heat (q)

Heat is energy transferred as a result of temperature difference. Temperature is a property that reflects the random motions of the particles in a particular substance.

q is the symbol used to indicate energy changed by receiving or losing heat

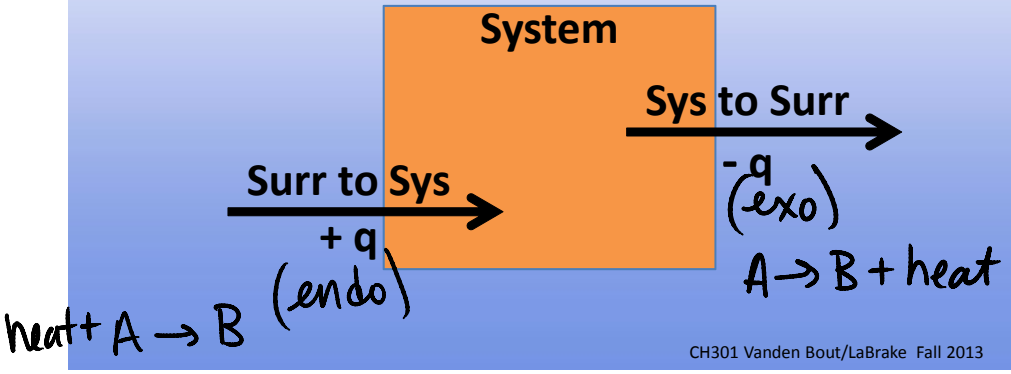
q [J] movement (flow)

T [°C, K] static

Heat (q)

Sign Notation of q

- **+** when system receives heat from surroundings
- **-** when system gives heat to the surroundings



CH301 Vanden Bout/LaBrake Fall 2013

Work (w)

$P = \frac{F}{A}$ $F = P \times A$

Work is transfer of energy via applied force over distance

w = Force x distance

$W = F \times d$

Chemists are mostly concerned with PV work

P = pressure and V = volume

w = - PΔV

$W = P \times A \times \Delta h$

$W = P \Delta V$

Expansion work is an expansion against an external force

$w = - P_{ex} \Delta V$

Δh

by definition

Can you think of an example of PV work?

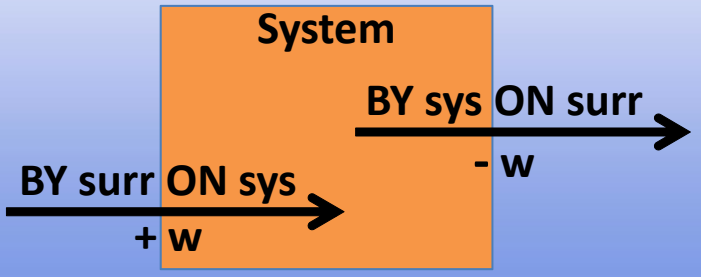
CH301 Vanden Bout/LaBrake Fall 2013

Work (w)

Sign Notation of w

+ work done **ON** the system **BY** the surroundings

- work done **BY** the system **ON** the surroundings



CH301 Vanden Bout/LaBrake Fall 2013

POLL: iCLICKER QUESTION 2

Today you saw a demonstration in which a lid popped off a container that contained a piece of $CO_{2(s)}$. In this situation:

a) Heat was transferred **into** the system, Work was done **by** the system.
b) Heat was transferred **out** of the system, Work was done **by** the system.
c) Heat was transferred **into** the system, Work was done **on** the system.
d) Heat was transferred **out** of the system, Work was done **on** the system.
e) Heat was not transferred, only Work was done **by** the system.

CH301 Vanden Bout/LaBrake Fall 2013

POLL: iCLICKER QUESTION 3

Today you saw a demonstration in which a lid popped off a container that contained a piece of $CO_{2(s)}$. In this situation:

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

POLL: iCLICKER QUESTION 4

The gases in the four cylinders of an automobile engine expand from 0.22 L to 2.2 L during one ignition cycle. Assuming that the gear train maintains a steady pressure of 9.60 atm on the gases, how much work can the engine do in one cycle? (1 L•atm = 101.325 J)

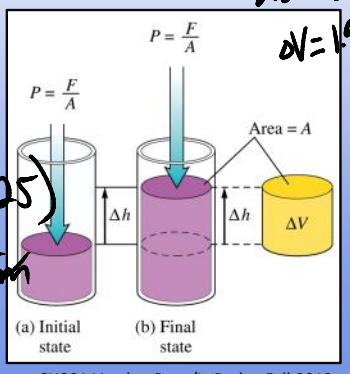
P = 9.6 atm
ΔV = 2.2 − 0.22
ΔV = 1.98 L

A. 19 J
B. -19 J
C. 1925 J
D. -1925 J

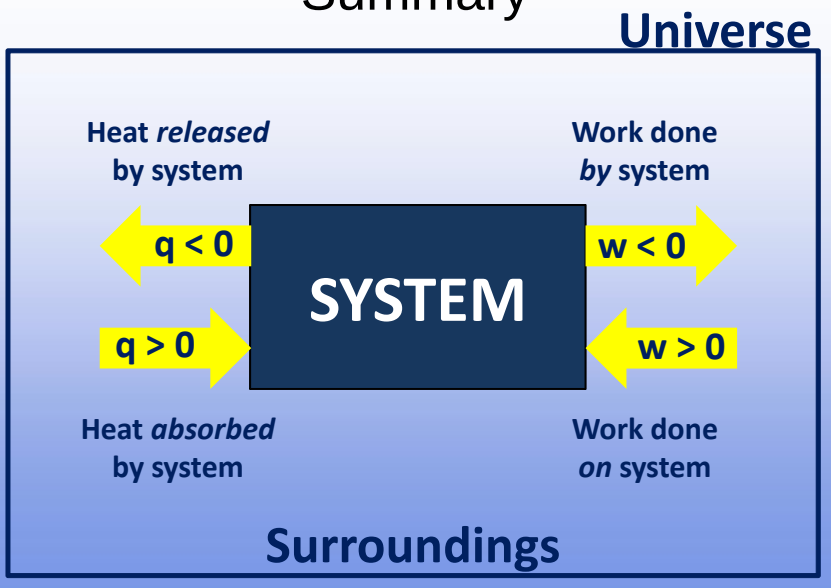
$W = -P\Delta V$

$W = -(9.6)(1.98)(101.325)\ \text{atm} \cdot \text{L} \cdot \frac{\text{J}}{\text{L atm}}$

$W = -1925\ \text{J}$



Summary



Thermodynamics

First Law of Thermodynamics

Energy can not be created or destroyed
Law of Conservation of Energy
Universe = System + Surroundings

Internal Energy (U or E) is the sum of all the energy in a system, that is all the KE and PE in the system at a particular state.

$$\Delta U = q + w$$

J

POLL: iCLICKER QUESTION 5

A system absorbs 72 J of heat while 35 J of work is done on it. Calculate ΔU.

A. -107 J
B. 107 J
C. -37 J
D. 37 J
E. 0 J

ΔU = q + w

work is done on it. Calculate ΔU.

A. -107 J
B. 107 J
C. -37 J
D. 37 J
E. 0 J

$\Delta U = q + w$

$\Delta U = +72 + 35 = 107\,J$

POLL: iCLICKER QUESTION 6

$q = +600$

A system was heated by using 600 J of heat, yet it was found that the internal energy decreased by 150 J . Calculate w.

$\Delta U = -150$

$\Delta U = q + w$

$-150 = 600 + w$

$-750 = w$

A. 450 J
B. -450 J
C. 750 J
D. -750 J

POLL: iCLICKER QUESTION 7

Was work done on the system or by the system?

A. On
B. By

$W = -750\,J$

POLL: iCLICKER QUESTION 8

The air inside a balloon is heated, allowing for the balloon to fill to its full capacity. The volume of the balloon changes from 4.0×10^6 L to 4.5×10^6 L by the addition of 1.3×10^8 J of energy as heat. Assuming the balloon expands against a constant pressure of 1.0 atm, calculate the ΔU for the process. (1 L•atm = 101.325 J)

A. 1.2×10^8 J
B. -1.2×10^8 J
C. 7.9×10^7 J
D. -7.9×10^7 J

$\Delta V = 4.5 \cdot 10^6 - 4 \cdot 10^6 = 5 \cdot 10^5\,L$

$q = +1.3 \cdot 10^8\,J$

$w = -P\Delta V = -(1\,atm)(5 \cdot 10^5\,L)(101.325\ \frac{J}{L\,atm})$

$w = -5.06 \cdot 10^7\,J$

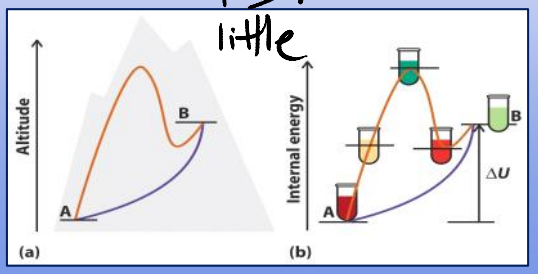
$\Delta U = q + w = 1.3 \cdot 10^8 + (-5.06 \cdot 10^7)$

$\Delta U = 7.9 \cdot 10^7\,J$

State Functions

A property with a value that depends only on the *current* state of the system and is *independent* of the pathway. If the system is changed from one state to another, the change in a state function is independent of how that change was brought about! (E is a state function, w and q are not state functions!)

A property with a value that depends only on the *current* state of the system and is *independent* of the pathway. If the system is changed from one state to another, the change in a state function is independent of how that change was brought about! (E is a state function, w and q are not state functions!)



$\Delta X = X_f - X_i$

Definitions from LMs

Extensive

Intensive

State Function

System

Surroundings

Universe

What have we learned today?

First Law of Thermodynamics: Energy is conserved in universe- Law of Conservation of Energy

$\Delta U = q + w$

Heat – movement of energy from hotter body to colder body
Work – force x distance – $P\Delta V$

Sign convention important
"-" work done by system
"+" work done on the system

Learning Outcomes

Understand the concept of the energy units: calorie, kilocalorie and kilojoule

Understand the concept of internal energy, heat and work

State and use the equation for change in internal energy, ΔU

Understand all sign conventions in for all the thermodynamic concepts

Calculate w for expansion or compression against a constant pressure.