

NOTES #15/THERMOCHEMISTRY, an Introduction to Energy/AP Chemistry

UNITS OF ENERGY:

Joule-

calorie-

Kilocalorie = Calorie = kcal

NATURE OF ENERGY:

-Kinetic vs Potential

-Kinetic-

$$E_k = \frac{1}{2} mv^2$$

-Potential-

$$E_p = mgh$$

-Electrostatic Potential Energy
(attraction/repulsion between +/- objects)

$$E_{el} = \frac{kQ_1Q_2}{d^2}$$

SYSTEM vs SURROUNDINGS:

System (What we portion out to study).

Surroundings (everything else)

Two types of systems:

1. Closed System

2. Open System

TRANSFERRING ENERGY:

$$W = F \times D$$

Force = F (mass x gravity)

$$\text{Work} = W$$

Distance = D

Example: gravitational force pulling on a 1.0 kg object as we carry it 1.0 meter up a ladder.

$$W = 1.0\text{kg} \times 9.8\text{m/s}^2 \times 1.0\text{m} \rightarrow \text{What are your units? } \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$$

Heat vs Temperature:

Heat-

Temperature-

CONCLUSION: ENERGY IS THE ABILITY TO DO _____ OR TO TRANSFER _____.

FIRST LAW OF THERMODYNAMICS STATES:

Energy cannot be _____ or _____, but it can change forms (heat/electrostatic/potential/kinetic/chemical/nuclear) an infinite number of times.

Enthalpy changes (ΔH) and their symbolic representations:

In Greek, *enthalpein*, means _____.

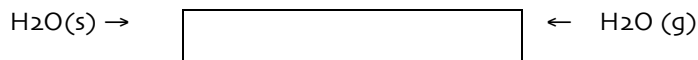
Overall Equation:

Endothermic-

Exothermic-

State Functions:

A property of a system that depends only on its current condition and not how it arrived at this condition (specifying temperature, pressure or location).



Thermal Stoichiometry: Did you think stoichiometry was going away? Ha ha, never!

Change in enthalpy is an _____ property so it is _____ on the stoichiometry of the reaction.

Standard Heat of Reaction (ΔH°):

If you reverse the reaction, you _____ the sign of the change in enthalpy.
You must ALWAYS SPECIFY STATES (remember state functions?).

Example 1: Combustion of Methanol

Example 2: When 0.2 g of methanol is combusted, how much heat is released?

More thoughts about systems, work and heat:

- According to the enthalpy equation, $\Delta H = \Delta E + P\Delta V$, we are talking about ΔE (internal energy).
 - Remember, since we cannot determine the total energy of the universe, we can't measure a finite amount of energy that a system contains. However, (because energy is a *state* function) we can measure *changes* in energy.

$$\Delta E = E_f - E_i$$

- What does ΔE of a system involve?
 - a. It's the total _____ energy of that system.
 - b. ΔE has two components:

(1) _____ (KE) - energy associated with the *motion* of the particles.

(2) _____ (PE) - energy associated with the *composition* and *position* of the particles.

- According to the 1st Law of Thermodynamics, Energy gained (or lost) by the system must be lost (or gained) by the surroundings in order to keep the energy of the universe constant.

$$\Delta E_{\text{sys}} = -\Delta E_{\text{surr}}$$

How can we measure ΔE ??

1. Define a new ΔE expression:

- rearrange the ΔH equation..... $\Delta E =$ _____

- redefine the variables: $\Delta H = \text{heat absorbed/released} = q$
 $-P\Delta V = \text{the work done on/by the sys.} = w$

- ** - Put the new variables in and we get: $\Delta E = q + w$
- So, is the amount of heat released/absorbed = to the energy released/absorbed? _____

WHY? _____

2. So, what exactly does work refer to?

Balloon Demo:

** Is work being done on the surroundings or vice versa. Explain.

** What sign (+ or -) would w have in this demo?

** What sign (+ or -) would q have in this demo?

3. Establish a sign convention for work and heat.

<u>PROCESS</u>	<u>SIGN</u>
EXOTHERMIC - heat given off to the surroundings; q is.....	-
ENDOTHERMIC - heat absorbed by the system; q is.....	+
Work done by the system on the surroundings; w is.....	-
Work done <i>on</i> the system by the surroundings; w is.....	+

ex 1: (an analogy): You get paid on Friday. By Monday, you have \$83 in your pocket. Over the weekend, you took a date to the movies and spent a whopping \$30. How much was your pay-check worth? Explain how this problem is analogous to $\Delta E = q + w$.

ex 2: A system does 975 J of work on the surroundings. At the same time, the system absorbs 625 J of heat. What is the change in energy for the system?

Let's be more specific about work and heat.

- In Thermodynamics, we can focus on a number of different types of work.....mechanical, electrical, etc. In this chapter, we are going to focus on MECHANICAL work.

- An EXPANDING GAS (from the demo) is an example of mechanical work.

- According to your physical science class, the definition of work is $w = \text{_____}$. When dealing with mechanical energy, the F is the opposing pressure (equal to _____ in the demo) and d is the change in V (of the balloon in the demo). So, $w = -F\Delta d = -P\Delta V$ (Why the negative sign?)

- **Take home messages concerning work:**

1. GAS EXPANSION = Volume of a system increases = Work will always be + or - because

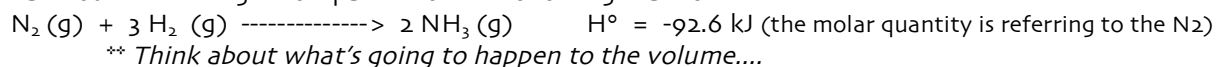
GAS COMPRESSION = Volume of a system decreases = Work will always be + or - because

2. $-P\Delta V$ has units of _____. These units can easily be converted into more familiar units of energy, Joules, by the following conversion factor. $1 \text{ L}\cdot\text{atm} = 101.3 \text{ J}$

ex 3. Calculate the work done on a gas in Joules when 22.4 L of the gas is compressed to 2.24 L under a constant external pressure of 10.0 atm.

ex 4. The work done when a gas is compressed in a cylinder is 462J. During this process, there is a heat transfer of 128 J from the gas to the surroundings. Calculate the energy change for this process.

ex 5. What would be the signs for q and w of the following reaction?



F. Now, let's incorporate the above into enthalpy changes of reactions.

- Back to the original equation for ΔH , $\Delta H = \Delta E + P\Delta V$ or $\Delta E = \text{_____}$

ex 6. Consider the reaction: $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \text{ -----} > 2 \text{NH}_3(\text{g}) \quad H^\circ = -92.6 \text{ kJ}$

If 2 moles of N_2 react with 6.0 moles of H_2 to form NH_3 , (a) calculate the work done (in joules) against a pressure of 1.0 atm at 25°C. (b) What is ΔE for this reaction? Assume the reaction goes to completion. (assume 1 mol of gas occupies a volume of 22.41 liters. We will learn this later in the study of the gas laws)