

Thermochem Review

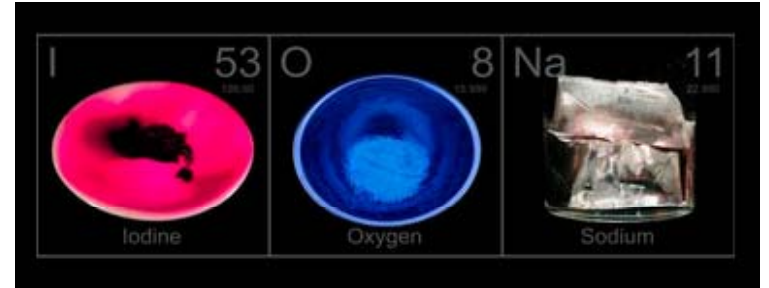
Mardi

Avril 20 2011

SCH 4U1

DVORSKY!!

Significant Digitz



- The number of significant digits in an answer to a calculation will depend on the number of significant digits in the given data, as we will discuss in the next few slides.



When are Digits Significant?

Non-zero digits are always significant. Thus, 22 has two significant digits, and 22.3 has three significant digits.

With zeroes, the situation is more complicated:

a. Zeroes placed before other digits are not significant; 0.046 has two significant digits.

b. Zeroes placed between other digits are always significant; 4009 kg has four significant digits.

c. Zeroes placed after other digits but behind a decimal point are significant; 7.90 has three significant digits.

d. Zeroes at the end of a number are significant only if they are behind a decimal point as in (c). Otherwise, it is impossible to tell if they are significant. For example, in the number 8200, it is not clear if the zeroes are significant or not. The number of significant digits in 8200 is at least two, but could be three or four. To avoid uncertainty, use scientific notation to place significant zeroes behind a decimal point:

8.200×10^3 has four significant digits

8.20×10^3 has three significant digits

8.2×10^3 has two significant digits

- **Significant Digits in Multiplication, Division, Trig. functions, etc.** In a calculation involving multiplication, division, trigonometric functions, etc., the number of significant digits in an answer should equal the least number of significant digits in any one of the numbers being multiplied, divided etc.
- Thus in evaluating $\sin(kx)$, where $k = 0.097 \text{ m}^{-1}$ (two significant digits) and $x = 4.73 \text{ m}$ (three significant digits), the answer should have two significant digits.
- Note that whole numbers have essentially an unlimited number of significant digits. As an example, if a hair dryer uses 1.2 kW of power, then 2 identical hairdryers use 2.4 kW:
- $1.2 \text{ kW} \{2 \text{ sig. dig.}\} \times 2 \{\text{unlimited sig. dig.}\} = 2.4 \text{ kW} \{2 \text{ sig. dig.}\}$

- **Significant Digits in Addition and Subtraction**

- When quantities are being added or subtracted, the number of *decimal places* (not significant digits) in the answer should be the same as the least number of decimal places in any of the numbers being added or subtracted.

- Example:

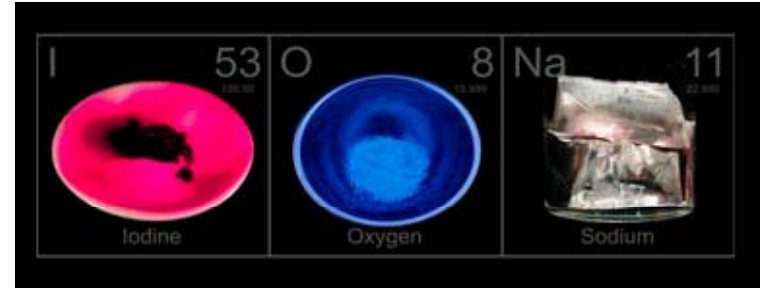
- 5.67 J (two decimal places)

1.1 J (one decimal place)

0.9378 J (four decimal place)

7.7 J (one decimal place)

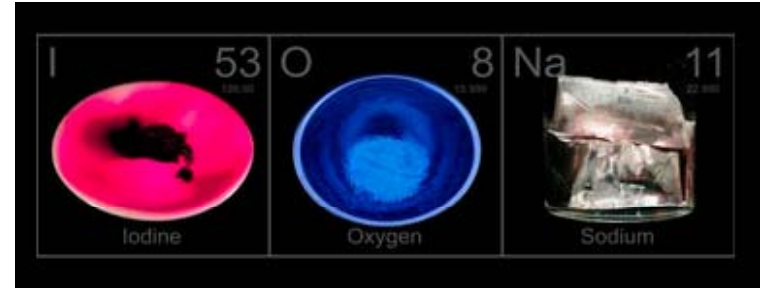
- **Keep One Extra Digit in Intermediate Answers**
- When doing multi-step calculations, *keep at least one more significant digit in intermediate results* than needed in your final answer.
- For instance, if a final answer requires two significant digits, then carry at least three significant digits in calculations. If you round-off all your intermediate answers to only two digits, you are discarding the information contained in the third digit, and as a result the *second* digit in your final answer might be incorrect. (This phenomenon is known as "round-off error.")



Try:

$ab/c = ?$, where $a = 483 \text{ J}$, $b = 73.67 \text{ J}$, and $c = 15.67$

$x + y + z = ?$, where $x = 48.1$, $y = 77$, and $z = 65.789$



Definitions:

chemical system versus surroundings

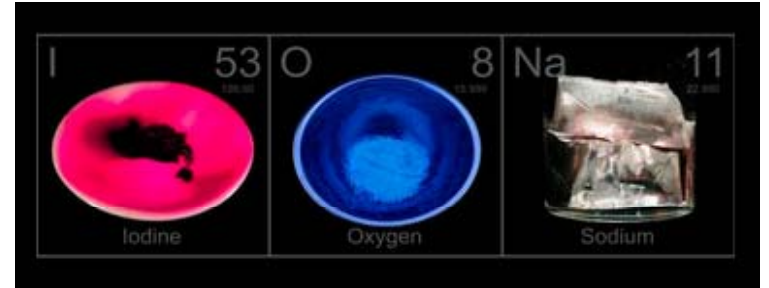
exothermic

endothermic

open system versus closed system

heat (q)

Read 298 – 299 in text

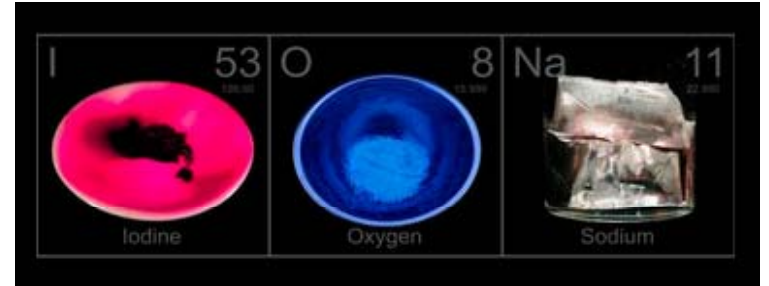


Heat (q) is the energy transferred from one place to another place.

versus Enthalpy

Enthalpy is the total measure of energy in a system

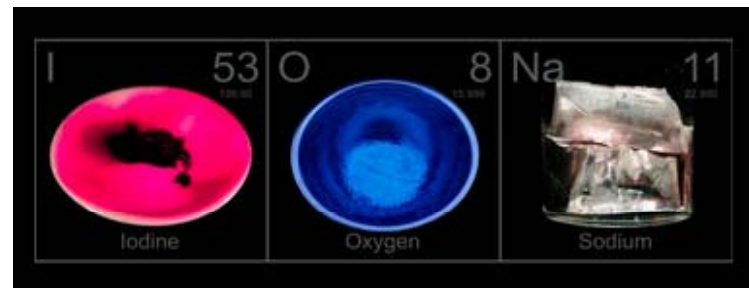
How do they relate? The increase in enthalpy of a system is exactly equal to the energy added through heat.



Our first calculations of the chapter were about calculating quantity of heat.

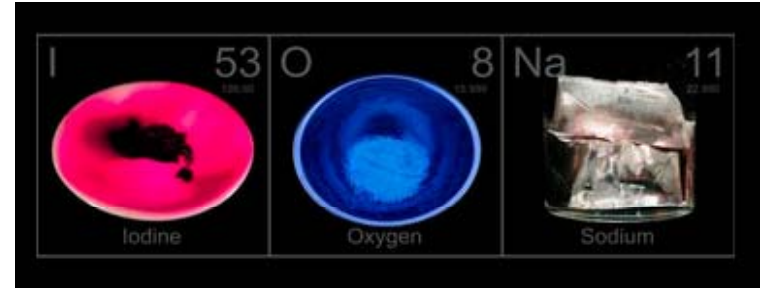
$$q = mc \Delta T$$

-when figuring out the quantity of heat that flows into a substance, the following is key: 1. how much of the substance there is (mass), the type of substance it is (some absorb more heat), and the temperature change.

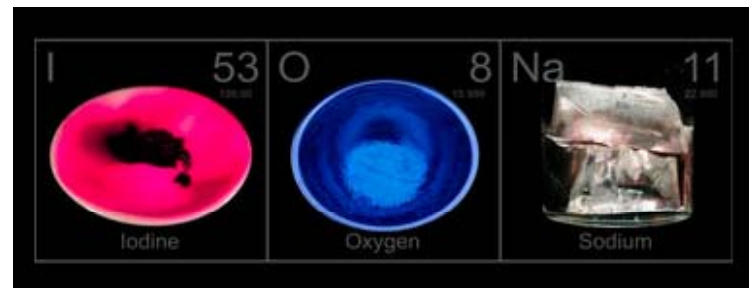


1. While in Nova Scotia collecting lichens, Dvorsky heats water from 0 C to 50 C. Calculate the mass of water that could be warmed by the addition of 8.00 kJ of heat.

Now we are ready
for more definitions



- An enthalpy change is the name given to the amount of energy released or absorbed in a reaction, given the symbol ΔH , read as "delta H."

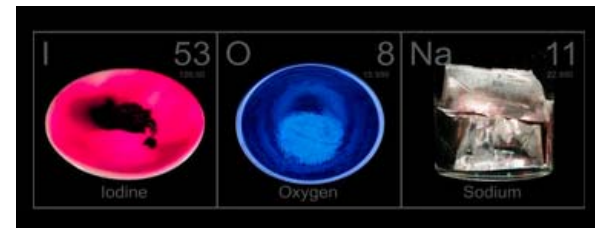


Ways for us to express enthalpy change:

1. Thermochemical Equation with Energy Terms

2. Thermochemical equation with ΔH values

The third way is molar enthalpy of reaction



Molar enthalpy of reaction is the energy change associated with the reaction of one mole of a substance

Molar enthalpy is represented by the symbol ΔH_x where x is the letter or combination of letters to indicate the type of reaction happening

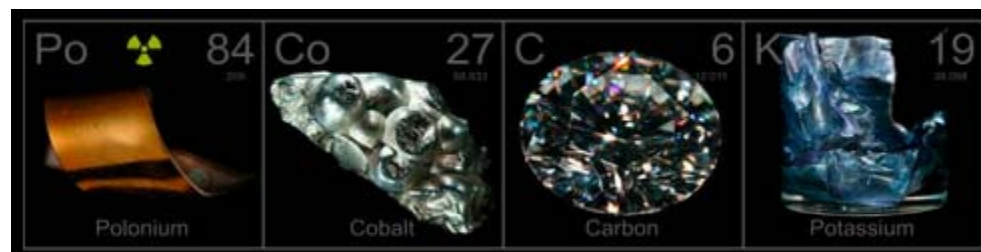
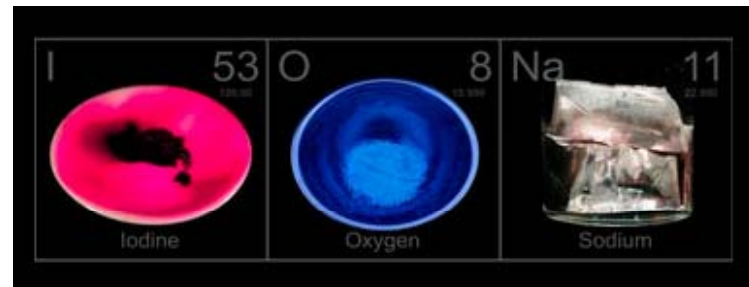


Table 1 Some Molar Enthalpies of Reaction (ΔH_x)

Type of molar enthalpy	Example of change
solution (ΔH_{sol})	$\text{NaBr}_{(s)} \rightarrow \text{Na}^+_{(aq)} + \text{Br}^-_{(aq)}$
combustion (ΔH_{comb})	$\text{CH}_{4(g)} + 2 \text{O}_{2(g)} \rightarrow \text{CO}_{2(g)} + \text{H}_2\text{O}_{(l)}$
vaporization (ΔH_{vap})	$\text{CH}_3\text{OH}_{(l)} \rightarrow \text{CH}_3\text{OH}_{(g)}$
freezing (ΔH_{fr})	$\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(s)}$
neutralization (ΔH_{neut})*	$2 \text{NaOH}_{(aq)} + \text{H}_2\text{SO}_{4(aq)} \rightarrow 2 \text{Na}_2\text{SO}_{4(aq)} + 2 \text{H}_2\text{O}_{(l)}$
neutralization (ΔH_{neut})*	$\text{NaOH}_{(aq)} + 1/2 \text{H}_2\text{SO}_{4(aq)} \rightarrow 1/2 \text{Na}_2\text{SO}_{4(aq)} + \text{H}_2\text{O}_{(l)}$
formation (ΔH_f)**	$\text{C}_{(s)} + 2 \text{H}_{2(g)} + 1/2 \text{O}_{2(g)} \rightarrow \text{CH}_3\text{OH}_{(l)}$

* Enthalpy of neutralization can be expressed per mole of either base or acid consumed.

** Molar enthalpy of formation will be discussed in more detail in Section 5.5.



Standard molar enthalpy changes

Standard enthalpy changes refer to reaction of one mole of a substance under *standard conditions*,

Standard conditions:

- Standard conditions are:
- 298 K (25°C)
- a pressure of 1 bar (100 kPa).

The symbol for standard enthalpy changes

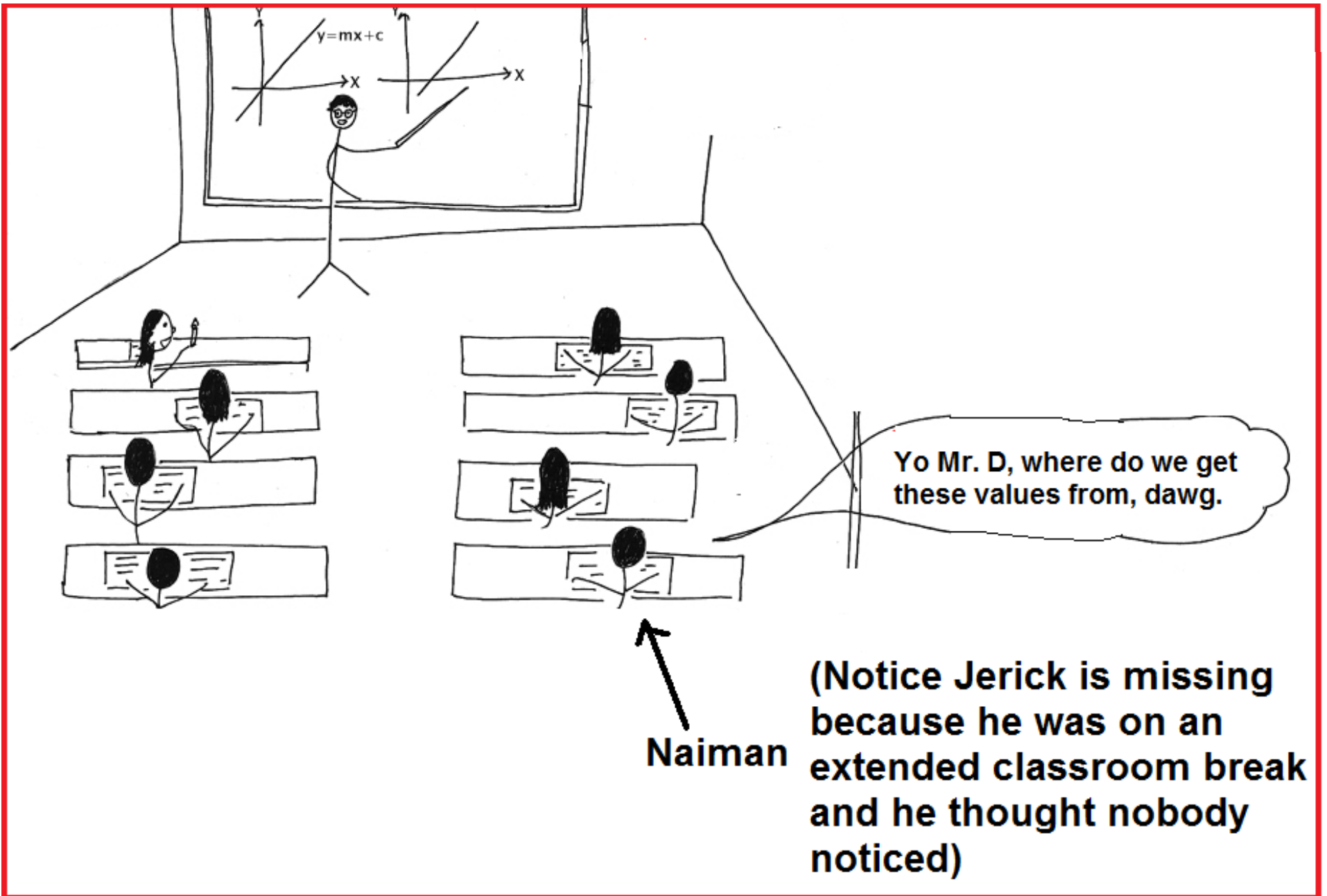
The symbol for a standard enthalpy change is ΔH° , read as "delta H standard" or, perhaps more commonly, as "delta H nought".

Molar enthalpy lead to this type of question:

The amount of solar radiation received annually in a certain location is about 8.4×10^6 kJ/m².

How much coke (C) must be burned into carbon dioxide in the following reaction to produce the same amount of energy?



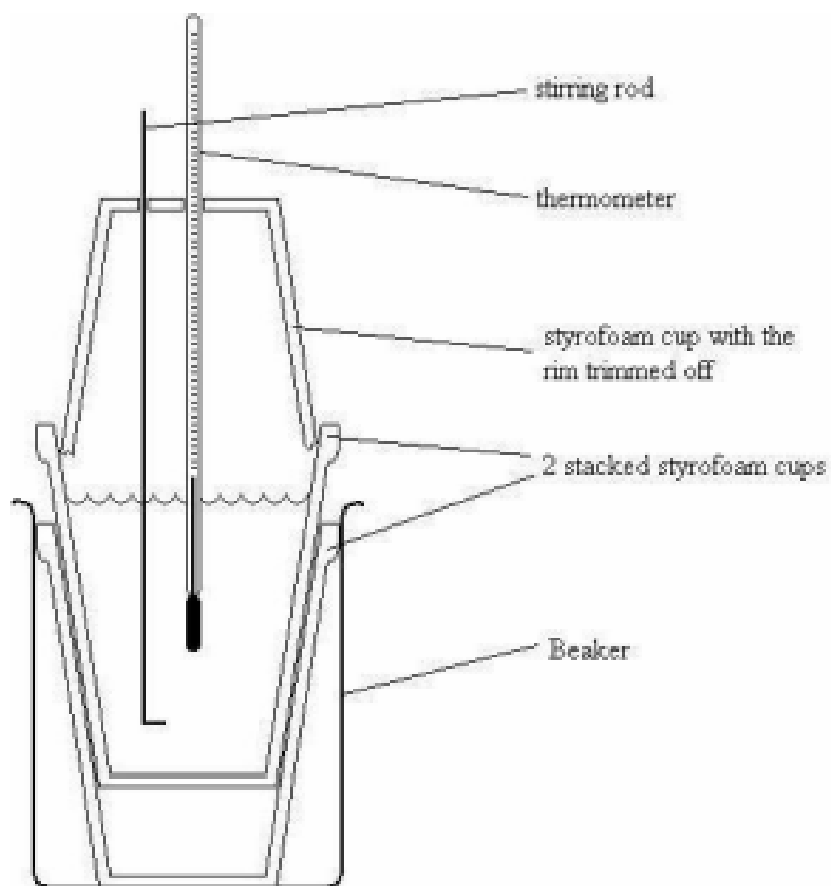


Studying energy changes requires an Isolated system.

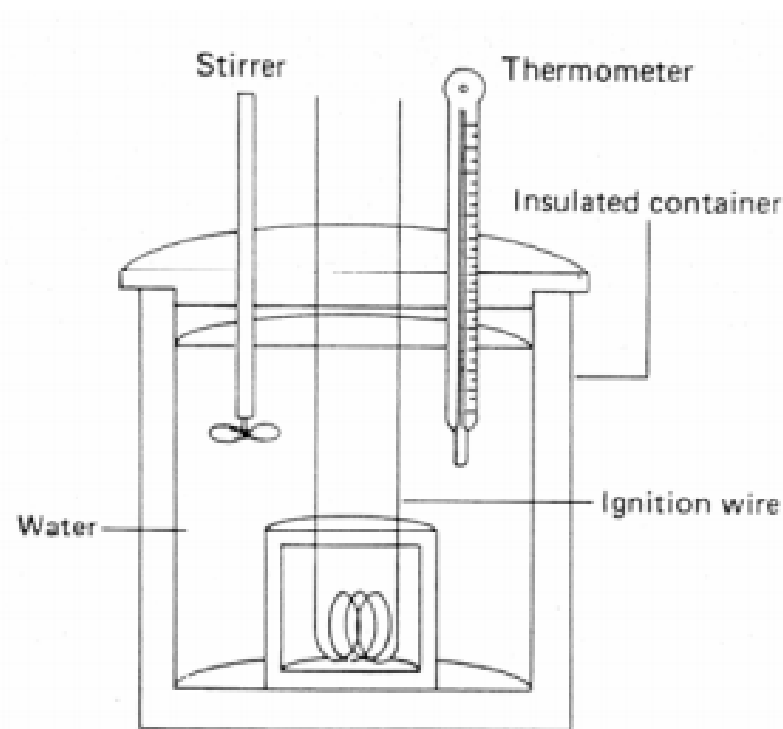
-one in which neither matter nor energy can move in or out.

-carefully designed experiments and precise measurements are also needed.

For this we use the calorimeter!



A Simple Calorimeter



A Bomb Calorimeter

- To carry out calorimetry, three assumptions are made:
 1. No heat is transferred between the calorimeter and the outside environment
 2. Any heat absorbed or released by the calorimeter materials, such as the container, is negligible
 3. A dilute aqueous solution is assumed to have a density and specific heat capacity equal to that of pure water (1.00 g/ml and 4.18 J/g x C)

All of this is dependent on the law of conservation of energy:

The total energy change of a chemical system is equal to the total energy change of the surroundings

$$\Delta H_{\text{sys}} = \pm |q_{\text{surroundings}}|$$

If $q_{\text{surroundings}}$ is positive then the change is exothermic ($-\Delta H$).

If $q_{\text{surroundings}}$ is negative then the change is endothermic ($+\Delta H$).

Calculating Heat of Reaction using Calorimetry

As energy is added or removed from a substance, the temperature of a substance changes.

- amount of energy (q in Joules)
- amount of material (m or mass in grams)
- type of material (c , the specific heat capacity in $J/g\cdot^{\circ}C$)
- temperature change ($\Delta T = T_f - T_i$)

$$q = mc \Delta T$$

In calorimetry, the energy change is usually calculated by the change in temperature of a known quantity of water inside the calorimeter.

Therefore the molar enthalpy (heat of reaction) can be found:

$$\Delta H = \frac{q_{rxn}}{n}$$

A bit of a tangent...

We use bond energies to find ΔH :

$$\Delta H = \sum H_{\text{bonds broken}} - \sum H_{\text{bonds formed}}$$

