Calorimeter

- Used to measure heat changes during chemical or physical processes
- As simple as a styrofoam cup filled with water with a cover and thermometer

- Works on the principle of energy conservation (1st Law of Thermo.)
- The heat released (or absorbed) by the material or reaction is absorbed (or released) by the calorimeter

$$\Delta q_{system} = -\Delta q_{surroundings}$$

reaction or material — calorimeter and water

Ex: A piece of iron with a mass of 21.5g at a temperature of 100.0°C is dropped into a calorimeter containing 132g of 20.0°C water. If the final temperature of the system is 21.4°C, what is the specific heat capacity of the iron?

$$\Delta q_{iron} = -\Delta q_{calorimeter}$$

$$m\Delta TCp = -m\Delta TCp$$

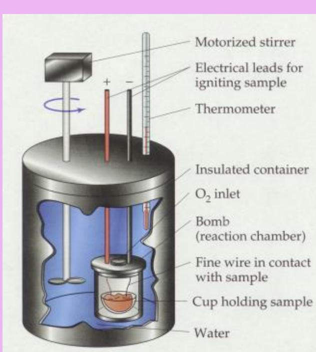
$$21.5g(21.4°C-100°C)\mathbf{Cp} = -132g(21.4°C-20.0°C)4.184J/g°C$$

$$Cp = -\frac{132g(1.4°C)4.184J/g°C}{21.5g(-78.6°C)}$$

$$Cp = 0.457\ J/g°C$$

Bomb Calorimetry

- Used to measure heat evolved when a substance is burned.
- Gives an indication of the quality or value of the substance as a fuel
- Heavy duty apparatus, tightly sealed with an inner chamber (bomb) containing the sample and pressurized with oxygen
- Bomb is submerged into a set amount of water
- Sample is ignited by a high voltage current burst



- Should we be concerned with any energy that might not be accounted for by the water? Yes, probably.
- Some energy is absorbed by the metal containers.
- Each bomb calorimeter gets "calibrated" and has a "**heat capacity**" specific to *that* calorimeter, expressed in J/°C or kJ/°C
- Energy released by combustion is calculated by:
  Heat capacity X Temp change

- But just reporting the energy evolved is not enough.
- Ex: Fuel A released 3000J
  Fuel B released 1000J
  Is A a better fuel?
- How much fuel did it take to produced that energy??
- Let's say 300g of A was burned, but only 50 g of B
- So that comes to…

  Fuel A 3000J/300g = 10J/g
  Fuel B 1000J/50g = 20J/g
  B is the better fuel!

- Heat of combustion is the energy released *per amount of sample burned* (usually in J/g or J/mol)
- Divide energy released (J) by sample size (grams or moles)

- Ex: A 48g sample was burned in a bomb calorimeter, whose heat capacity is 218 J/°C. Its temperature increases by 12°C. What is the energy per gram of the sample? (called "heat of combustion", ΔH)

$$\frac{218\ \text{J}}{{}^{o}\text{C}} \left| \frac{12^{o}\text{C}}{} \right. = 2616\ \text{J} \qquad \frac{2616\ \text{J}}{48\text{g}} = 55\ \text{J/g}$$

- Ex: Express this in kJ/mol. (molar mass = 53 g/mol)

$$\frac{55\ \text{J}}{\text{g}} \left| \frac{\text{kJ}}{1000\ \text{J}} \right| \frac{53\text{g}}{\text{mol}} = 2.9\ \text{kJ/mol}$$

Calorimetry – coffee cup/bomb
https://www.youtube.com/watch?v=EAgbknIDKNo