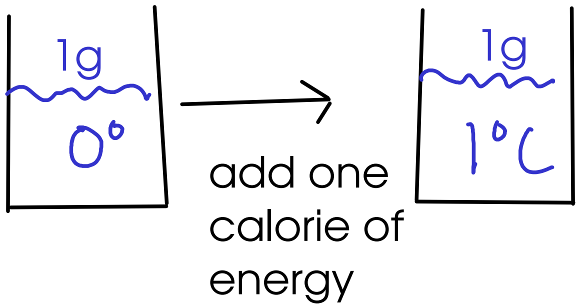
ENERGY UNITS

- calorie (cal): the amount of energy required to change the temperature of one gram of water by one degree Celsius (or Kelvin)



1g ≈ 1mL for water

- Calories in food? The "Calorie" that is given on American food labels is actually the kilocalorie (kcal)

- Joule (J): SI unit for energy. It's defined based on the equation for kinetic energy.

$$1\ J = 1\ \frac{kg\ m^2}{s^2}$$, from

$$E_K = \frac{1}{2} m v^2$$

kinetic energy

mass

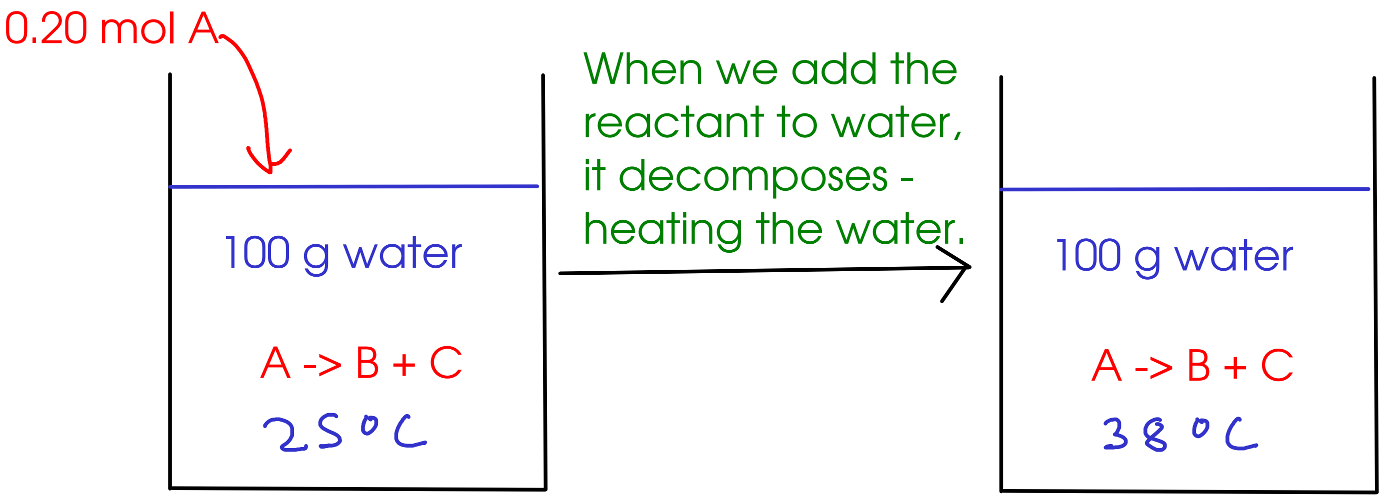
velocity

$$\boxed{4.184\ J = 1\ cal}$$

- the Joule is a small unit. For most reactions at lab scale, we'll use kilojoules (kJ).

CALORIMETRY

- the measurement of heat. How do we measure heat flow?



When we add the reactant to water, it decomposes - heating the water.

... what is Q for this reaction?

Assuming that no heat is lost from the water to the surrounding air,

$$\underbrace{Q_r}_{\text{reaction}} + \underbrace{Q_w}_{\text{water}} = 0$$

Conservation of energy. The terms add to zero because they have opposite signs.

... if we knew something about the WATER, we could use that to find the heat of the REACTION!

SPECIFIC HEAT

- a measured quantity. The amount of energy required to change the temperature of one gram of a particular substance by one degree Celsius.

- Specific heat information for common substances is readily available. For water,

$$4.184\ \frac{J}{g\,^{\circ}C} \quad \overset{\text{or}}{=} \quad 1.000\ \frac{cal}{g\,^{\circ}C}$$

$$Q = m \times S \times \Delta T$$

m = mass
s = specific heat
ΔT = Tfinal - Tinitial

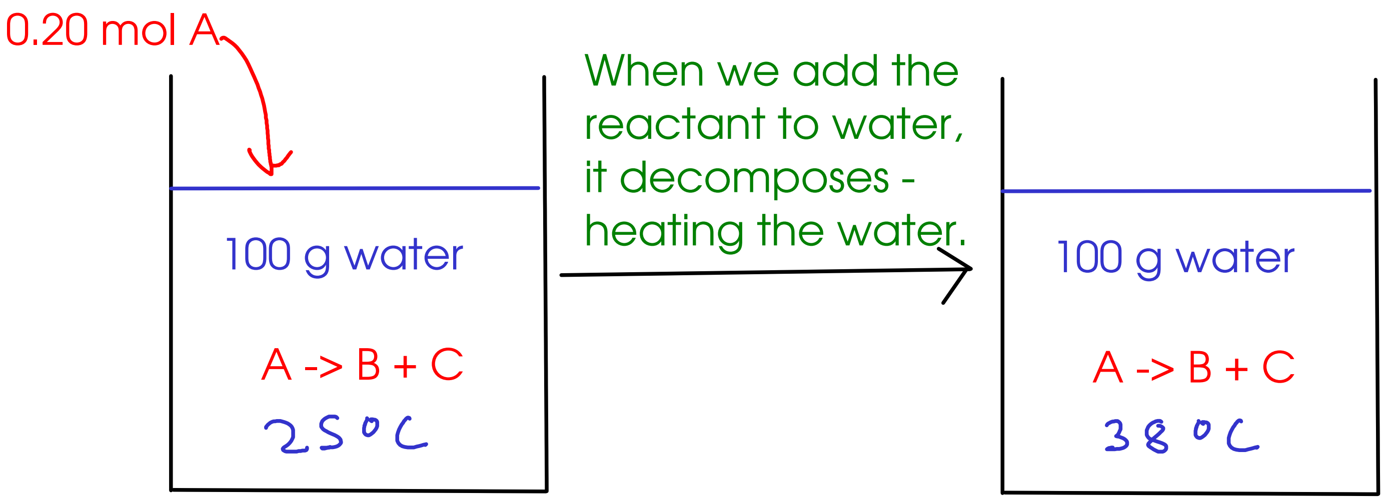
This is ALWAYS final temp minus initial temp!

- For objects, like reaction vessels, you might know the HEAT CAPACITY, which is the amount of energy required to change the temperature of an object by one degree Celsius

Units: $J/^{\circ}C$ or $cal/^{\circ}C$

$$Q = C \times \Delta T$$

c = heat capacity



0.20 mol A

100 g water

A -> B + C

25°C

When we add the reactant to water, it decomposes - heating the water.

100 g water

A -> B + C

38°C

Specific heat of water:

$4.184\ J/g°C$

$$Q_r + Q_w = 0$$

$$Q_w = m_w \times S_w \times \Delta T_w$$
$$= (100\,g)(4.184\ J/g°C)(38°C - 25°C)$$
$$= 5439.2\ J$$

$$Q_r + Q_w = 0;\quad Q_r + 5439.2J = 0;\quad Q_r = -5439.2J$$

To report the energy change in this reaction to others, we should express it in terms of heat transfer per mole of something. A different amount of reactant would have a different Q

$$Q_{rxn} = \frac{Q_r}{\text{moles A}} = \frac{-5439.2J}{0.20\ \text{mol A}} = -27196\ \frac{J}{\text{mol A}} = \boxed{-27\ \frac{kJ}{\text{mol A}}}$$

This number is called the HEAT OF REACTION

One problem ...

PATH. The amount of energy required for a process depends on how the process is carried out.

Example: Driving from Florence to Columbia. How much energy is required? (gas)

2000 Jeep Cherokee vs 2008 Toyota Prius. The Jeep will use much more fuel than the Prius even though they start and end from exactly the same place. So the fuel usage is what we call a PATH FUNCTION, while the location is a STATE FUNCTION.

- so the heat of reaction depends on how the reaction is done.

  - we need (for reporting) some kind of standard condition. At constant pressure, we can define a state function called ENTHALPY (H)

$$H = U + PV$$

$$\Delta H = Q_{\text{constant pressure}}$$

... we record the "enthalpy change of reaction" in our data books.

$$\Delta H_r$$