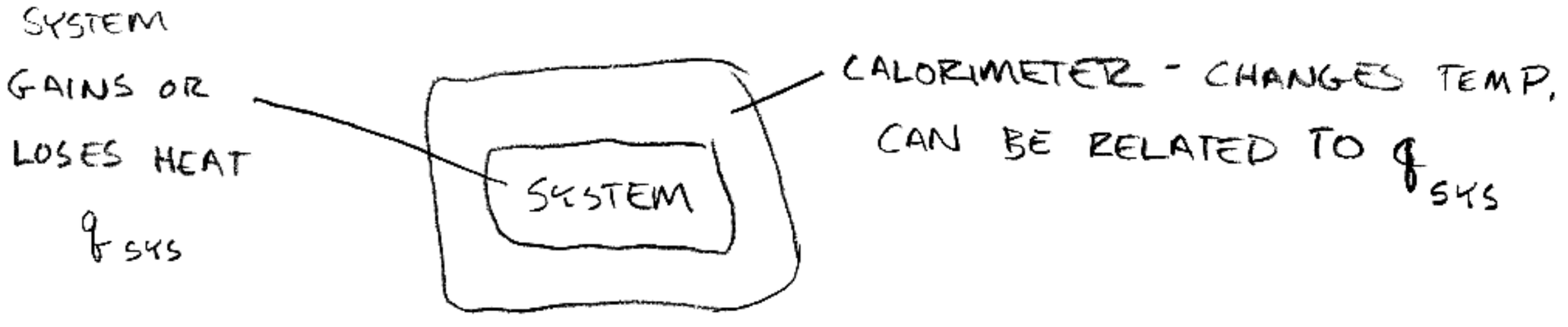
CALORIMETRY:

WE CAN MEASURE q DIRECTLY USING A CALORIMETER.



TO UNDERSTAND HOW CHANGES IN TEMP CAN BE RELATED TO q, WE NEED TO UNDERSTAND A COUPLE OF POINTS!

1) HEAT LOST BY SYSTEM IS GAINED BY SURROUNDINGS AND VICE VERSA (CONSERVATION OF ENERGY):

FROM THIS: $-q_{sys} = q_{surr}$ OR $q_{sys} = -q_{surr}$

↑ HEAT LOST BY SYSTEM = ↑ HEAT GAINED BY SURROUNDINGS

OFTEN WE NEED TO INCLUDE THE CALORIMETER IN THE SURROUNDINGS (OR IT IS THE SURROUNDINGS):

$-q_{sys} = q_{H_2O} + q_{CAL}$

$-q_{sys} = \underbrace{q_{CAL}}_{\text{SURROUNDINGS}}$

q_{sys} CAN ALSO BE EXPRESSED AS q_{rxn} FOR A REACTION

q_{rxn} = "HEAT OF REACTION"

2) HEAT CAPACITIES:

THE TEMPERATURE CHANGE FOR A SUBSTANCE WHEN BEING HEATED OR COOLED (ADDING OR REMOVING HEAT), DEPENDS ON:

- THE AMOUNT OF SUBSTANCE
- THE HEAT CAPACITY OF THE SUBSTANCE

TWO TYPES OF HEAT CAPACITY:

SPECIFIC HEAT CAPACITY: (OR "SPECIFIC HEAT")

→ THE AMOUNT OF HEAT REQUIRED TO CHANGE THE TEMP OF 1 g OF THE SUBSTANCE BY 1 °C (OR K)

MOLAR HEAT CAPACITY:

- THE AMOUNT OF HEAT REQUIRED TO CHANGE THE TEMP OF 1 MOLE OF THE SUBSTANCE BY 1 °C (OR K)

SOME COMMON HEAT CAPACITIES:

WATER$_{(l)}$: $4.184 \frac{J}{g\,°C}$

WATER$_{(s)}$: $2.059 \frac{J}{g\,°C}$

WATER$_{(g)}$: $1.865 \frac{J}{g\,°C}$

LEAD: $0.128 \frac{J}{g\,°C}$

COPPER: $0.385 \frac{J}{g\,°C}$

IRON: $0.449 \frac{J}{g\,°C}$

ALUMINUM: $0.903 \frac{J}{g\,°C}$

HEAT CAPACITY $\Rightarrow$ C

HOW MUCH HEAT IS REQUIRED TO RAISE THE TEMP OF A 25.00 g SAMPLE OF LEAD 10.0°C ?

HEAT CAPACITY OF LEAD: $0.128 \frac{J}{g\,°C}$

$$25.00\,g \times \frac{0.128\ J}{g\,°C} \times 10.0\,°C = 32.0\ J$$

$$m \qquad C \qquad \Delta T \qquad = \qquad q$$

$q = mC\Delta T$ "HEAT EQUATION"

HOW MUCH HEAT IS REQUIRED TO RAISE THE TEMP OF A 25.00g SAMPLE OF WATER 10.00°C ?

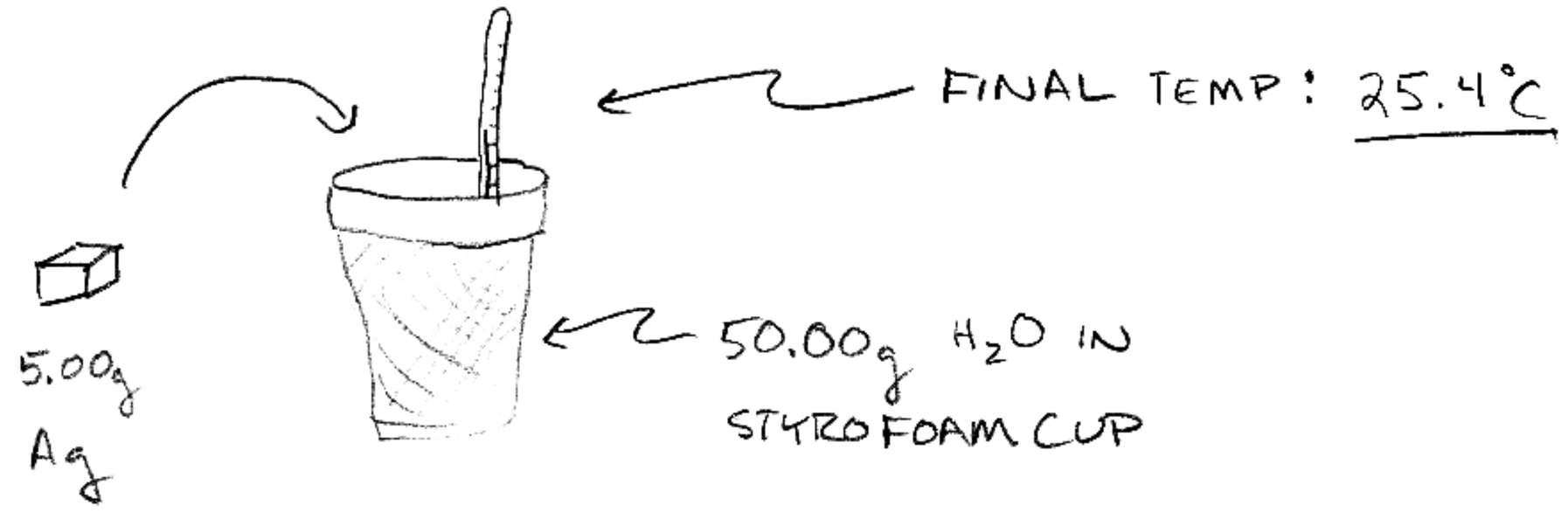
HEAT CAP. OF H_2O: $4.184 \frac{J}{g\,°C}$

$$q = mC\Delta T = 25.00\,g \times \frac{4.184\ J}{g\,°C} \times 10.0°C$$

$$q = 1050\ J$$

NOTICE, A HIGHER HEAT CAPACITY MEANS IT TAKES MORE HEAT TO CHANGE THE TEMP.

WHAT IS THE HEAT CAPACITY OF SILVER IF 5.00 g OF SILVER AT 100.0 °C IS PLACED IN 50.00 g OF WATER INITIALLT AT 25.0 °C (ASSUME NO HEAT IS LOST TO SURR.) ?



SILVER WILL LOSE HEAT, WATER WILL GAIN HEAT!

$$-q_{Ag} = q_{H_2O}$$

$$-\left(m_{Ag} C_{Ag} \Delta T_{Ag}\right) = m_{H_2O} C_{H_2O} \Delta T_{H_2O}$$

$$C_{Ag} = \frac{m_{H_2O} C_{H_2O} \Delta T_{H_2O}}{-\left(m_{Ag} \Delta T_{Ag}\right)}$$

$$C_{Ag} = \frac{(50.00\,g)\left(4.184 \frac{J}{g\,°C}\right)(25.4°C - 25.0°C)}{(-5.00\,g)(25.4°C - 100.0°C)}$$

$$C_{Ag} = 0.224 \frac{J}{g\,°C}$$

IF A REACTION IS EXOTHERMIC, THE REACTION LOSES HEAT TO THE SURROUNDINGS.

IF ENDOTHERMIC, THE REACTION ABSORBS HEAT FROM THE SURROUNDINGS.

REMEMBER:

$$\Delta E = q + w$$

$$\Delta E = q - P\Delta V$$

CONSTANT PRESSURE

CONSTANT VOLUME

$$q_p = \Delta H \qquad q_v = \Delta E$$

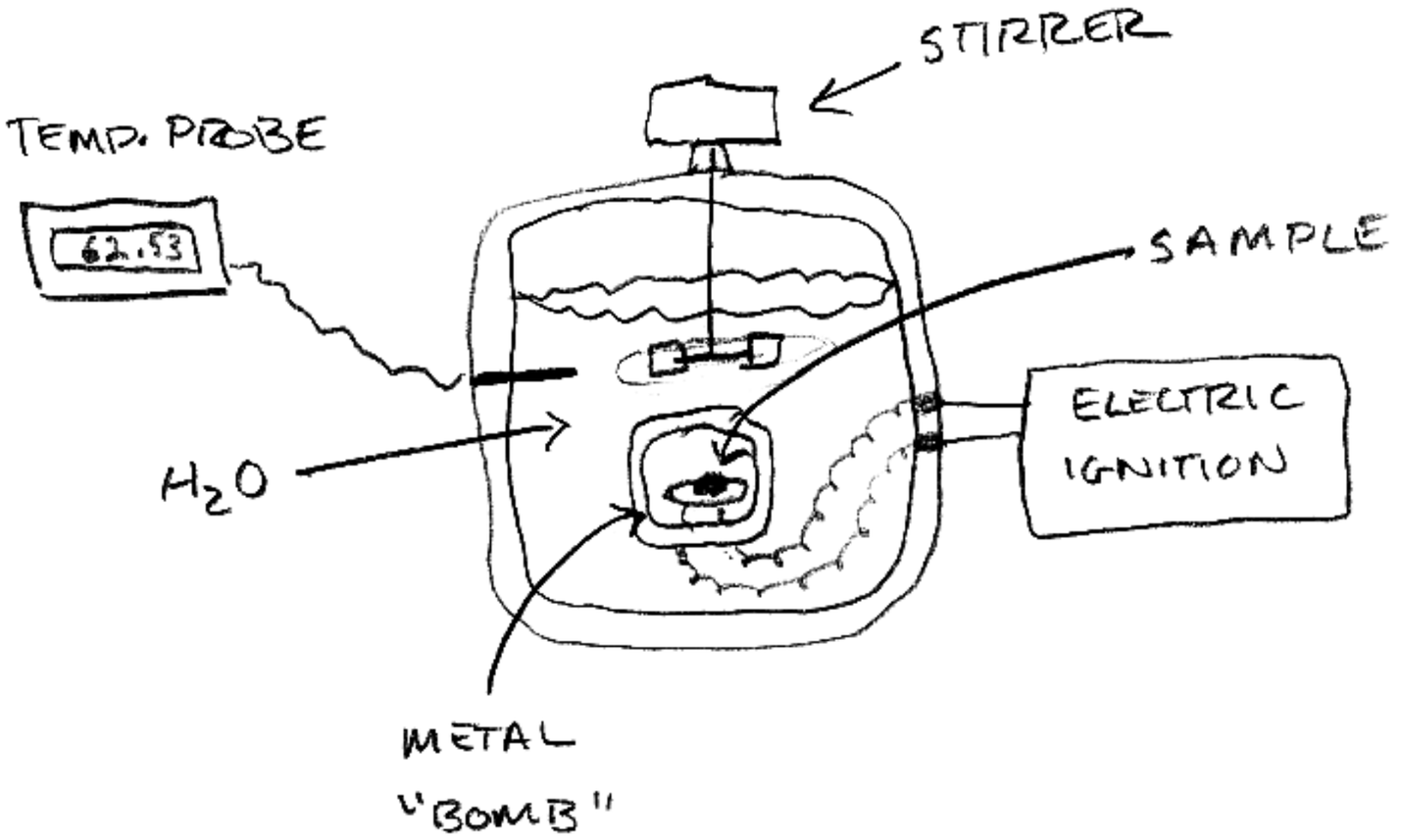
$$\Delta E = \Delta H - P\Delta V \quad \Rightarrow \quad \Delta H = \Delta E + P\Delta V$$

ENERGY ASSOCIATED WITH VOLUME CHANGES } USUALLY VERY SMALL, BUT NOT ALWAYS

FOR US, WE WILL ASSUME $q_{rxn} = \Delta H_{rxn} = \Delta E_{rxn}$

CONSTANT VOLUME CALORIMETRY:

"BOMB" CALORIMETER



CONSTANT PRESSURE CALORIMETRY:

"COFFEE CUP" CALORIMETER