

Calorimetry

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the science of measuring heat

**based on observing the temperature change
when a body absorbs or discharges energy as
heat.**

$$q = nC \Delta T$$

moles

grams

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Molar heat capacity

Specific heat capacity

Heat Capacity (C)

the amount of heat needed to raise the temperature of a certain amount of material 1K or 1°C

Molar heat capacity $\frac{\text{J}}{\text{K mol}}$ or $\frac{\text{J}}{^{\circ}\text{C mol}}$

Specific heat capacity $\frac{\text{J}}{\text{K g}}$ or $\frac{\text{J}}{^{\circ}\text{C g}}$

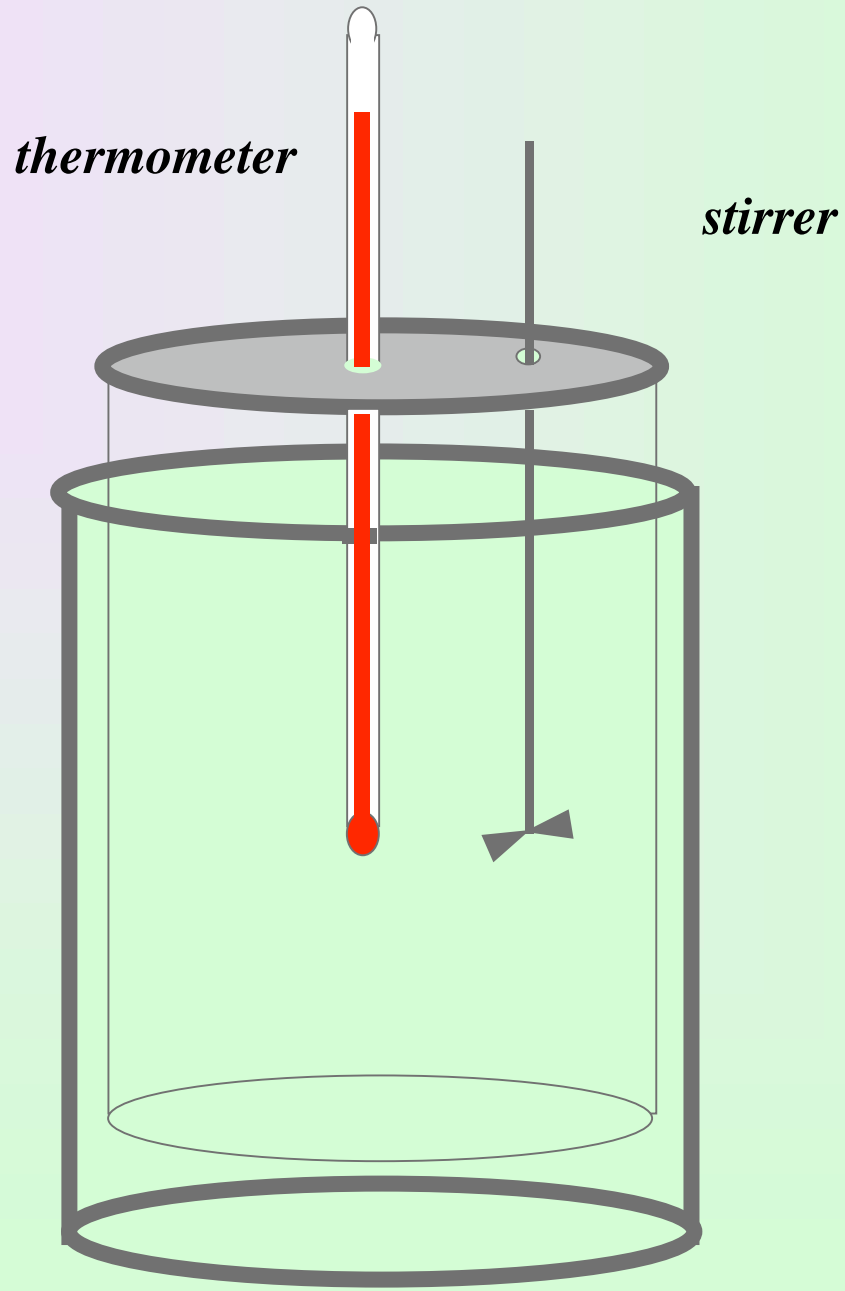
Constant Pressure Calorimeter

takes place at constant pressure

(atmospheric pressure)

**used to determine the changes in heat occurring
in a solution**

Coffee Cup calorimeter



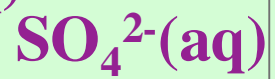
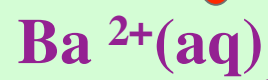
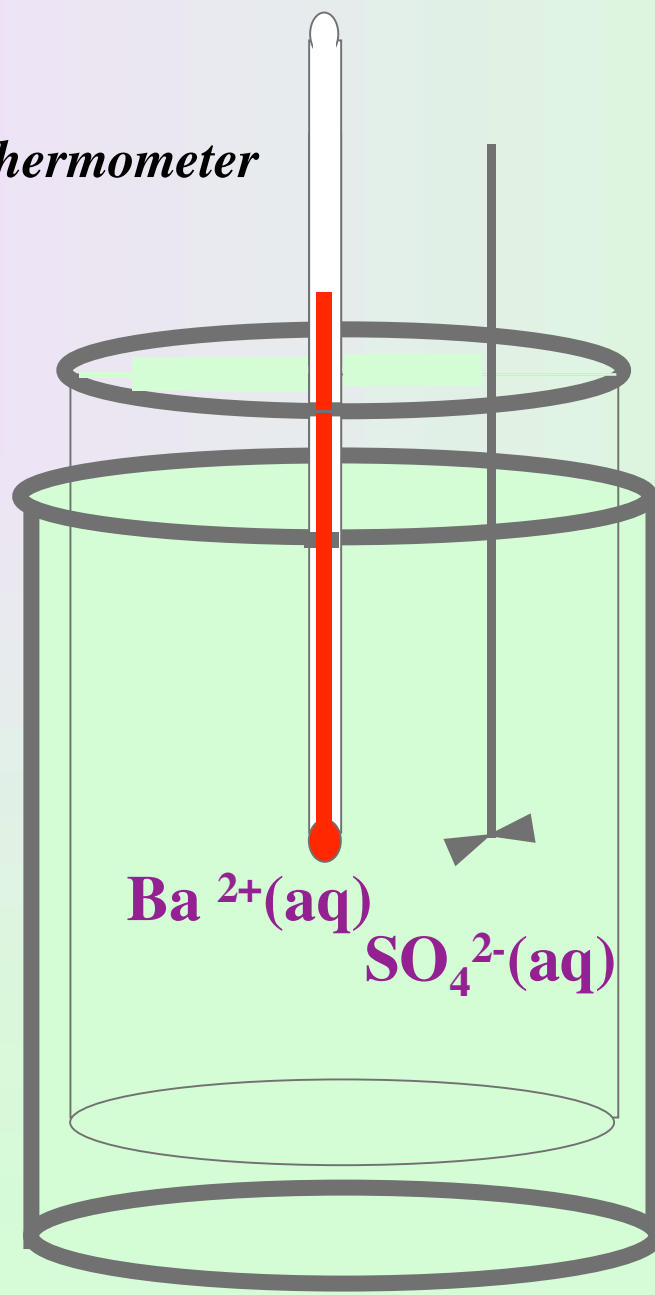
Example:

When 1.0L of 1.0 M $\text{Ba}(\text{NO}_3)_2$ at 25 °C is mixed with 1.0 L of 1.0 M Na_2SO_4 at 25 °C in a calorimeter, the white solid BaSO_4 forms and the temperature increases to 28.1 °C. The specific heat capacity of the solution is $4.18\text{J } ^\circ\text{C}^{-1} \text{g}^{-1}$, and the density of the final solution is 1.0g/ml, calculate the heat change per mole of BaSO_4 .



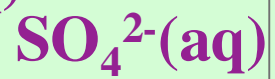
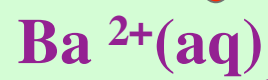
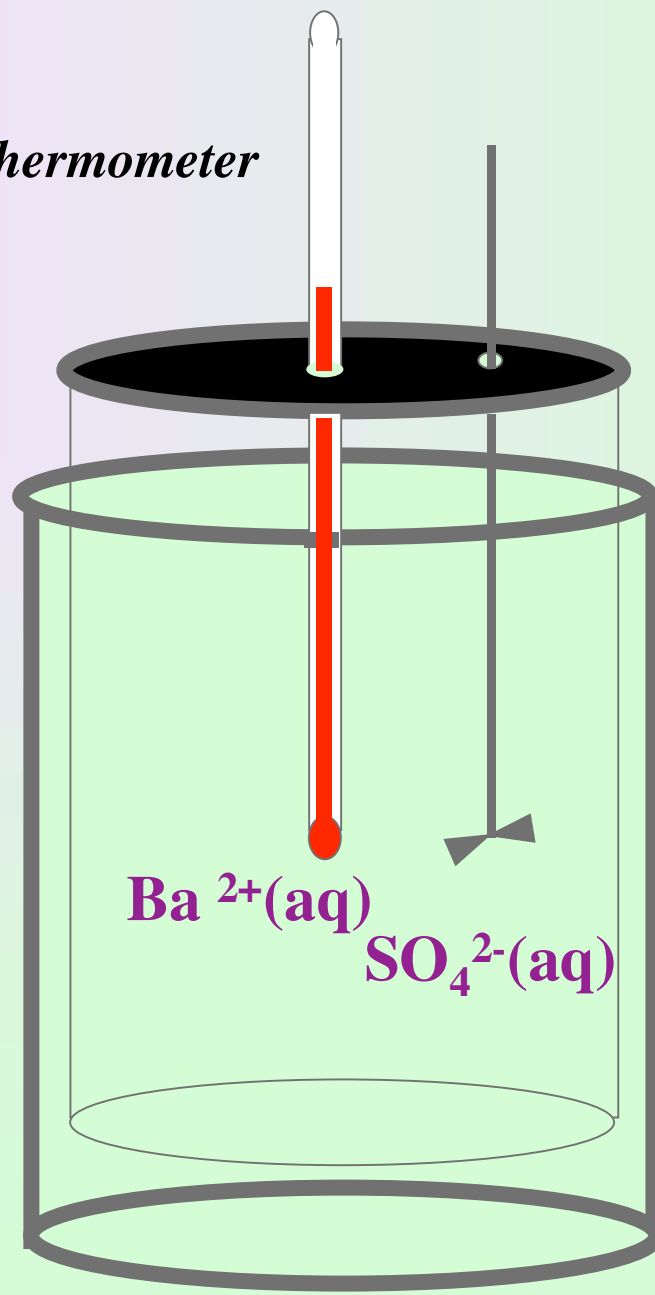
thermometer

stirrer



thermometer

stirrer



ΔT

thermometer

stirrer

$\text{BaSO}_4(\text{s})$

A diagram of a calorimeter setup. It consists of a cylindrical container with a stopper. A thermometer is inserted through the stopper, and a stirrer is also inserted through the stopper. The thermometer is labeled "thermometer" and the stirrer is labeled "stirrer". The temperature change is indicated by the symbol ΔT . The precipitate is labeled $\text{BaSO}_4(\text{s})$.

Example:



**Energy released
by the reaction = Energy absorbed
by the solution**

**= Mass of the
solution x Specific heat
 capacity x Increase in
 temperature**

$$q = nC \Delta T$$

Example:



	Volume solution	Density solution
Mass of the solution	$2.0\text{L} \times \frac{1000 \text{ ml}}{1\text{L}}$	$\times \frac{1.0 \text{ g}}{1\text{ml}} = 2.0 \times 10^3\text{g}$
Increase in temperature	T_{final}	T_{int}
	28.1°C	$25^\circ \text{C} = 3.1^\circ \text{C}$

Example:



$$q = nC \Delta T$$

$$= (2.0 \times 10^3 \text{g}) (4.18 \text{J } ^\circ \text{C}^{-1} \text{g}^{-1}) (3.1 \text{ } ^\circ \text{C})$$

$$= 2.6 \times 10^4 \text{J}$$

Heat absorbed by the solution

Heat released by the system

$$q = -2.6 \times 10^4 \text{J} \times \frac{1 \text{kJ}}{1000 \text{J}} = -26 \text{ kJ}$$

$$1 \text{L Ba}^+ \times \frac{1 \text{mol Ba}^+}{1 \text{L}} \times \frac{1 \text{mol BaSO}_4}{1 \text{mol Ba}^+} = 1 \text{mol BaSO}_4$$

$$\frac{-26 \text{ kJ BaSO}_4}{\text{mol}}$$

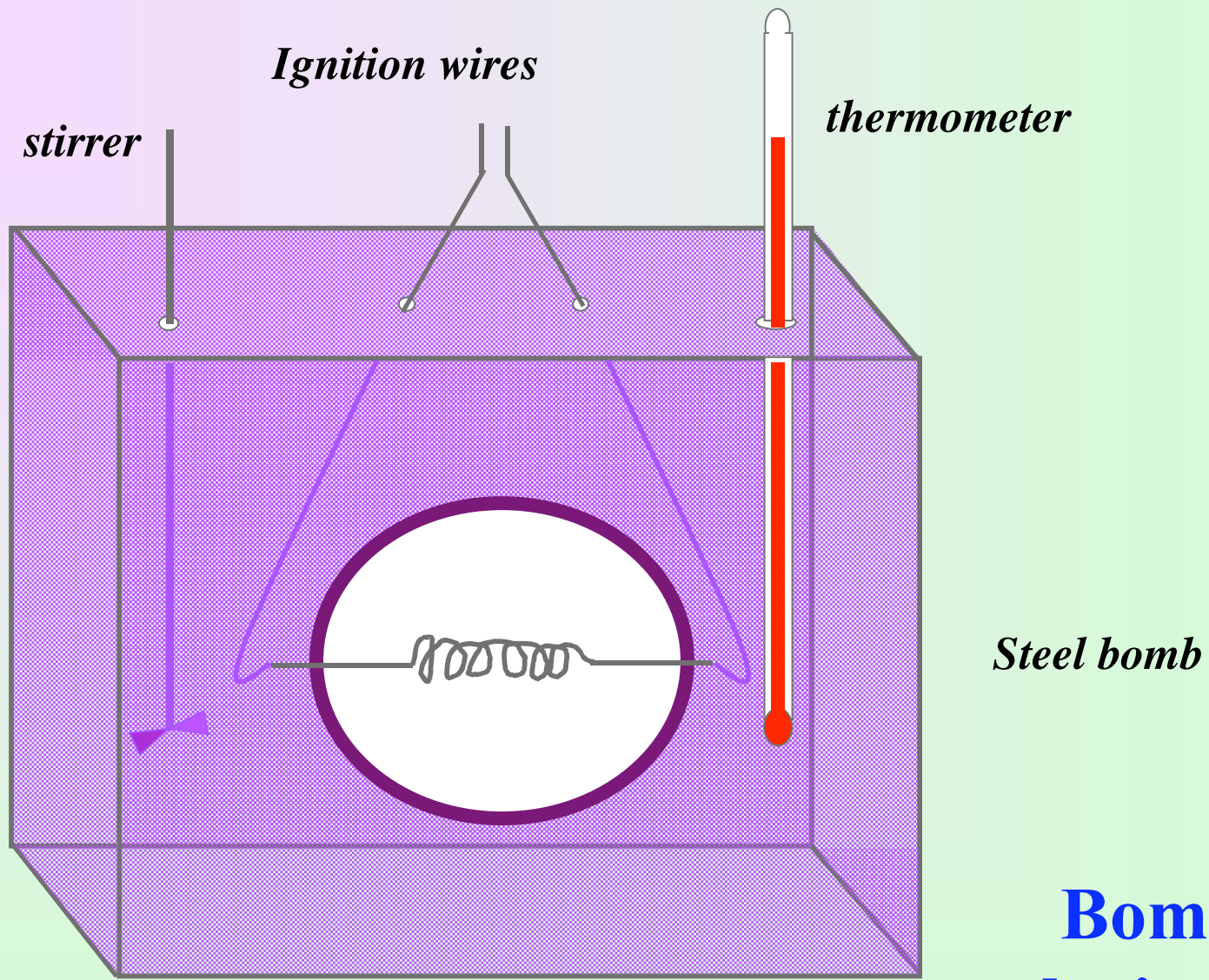
Constant Volume Calorimeter

takes place at constant volume

A bomb calorimeter

Weighed reactants are placed inside a rigid steel container and ignited

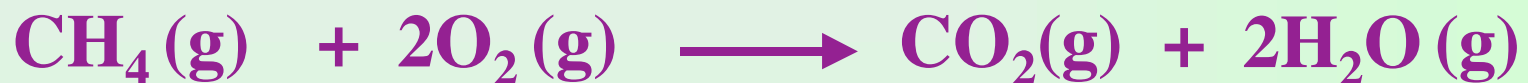
The energy change is determined by measuring the increase in temperature of the calorimeter

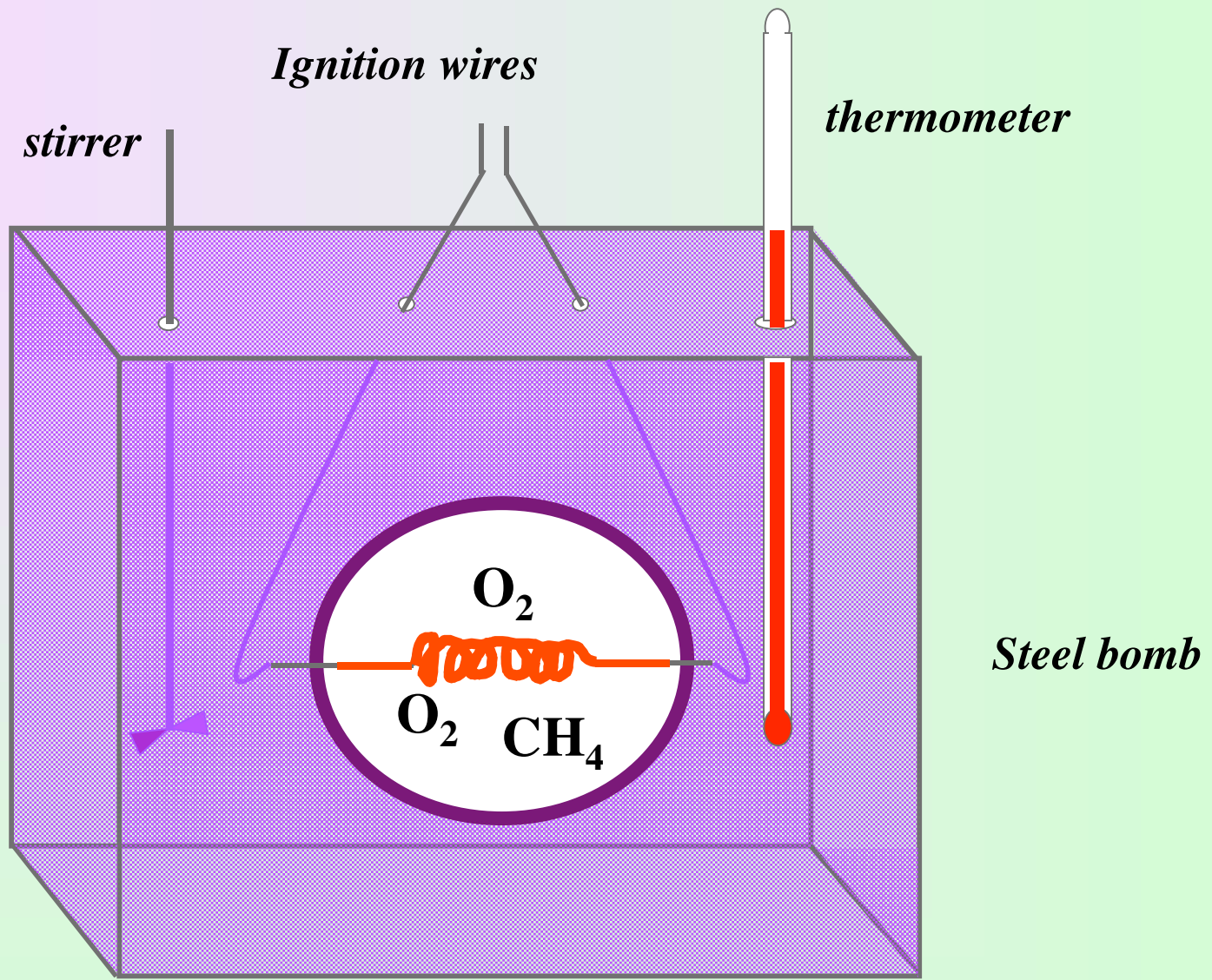


**Bomb
calorimeter**

Example:

1.50g sample of methane gas was burned with excess oxygen in a bomb calorimeter causing a temperature change of 7.3 °C. Calculate the energy of combustion (per gram) if the heat capacity of the calorimeter was 11.3 kJ/ °C.





stirrer

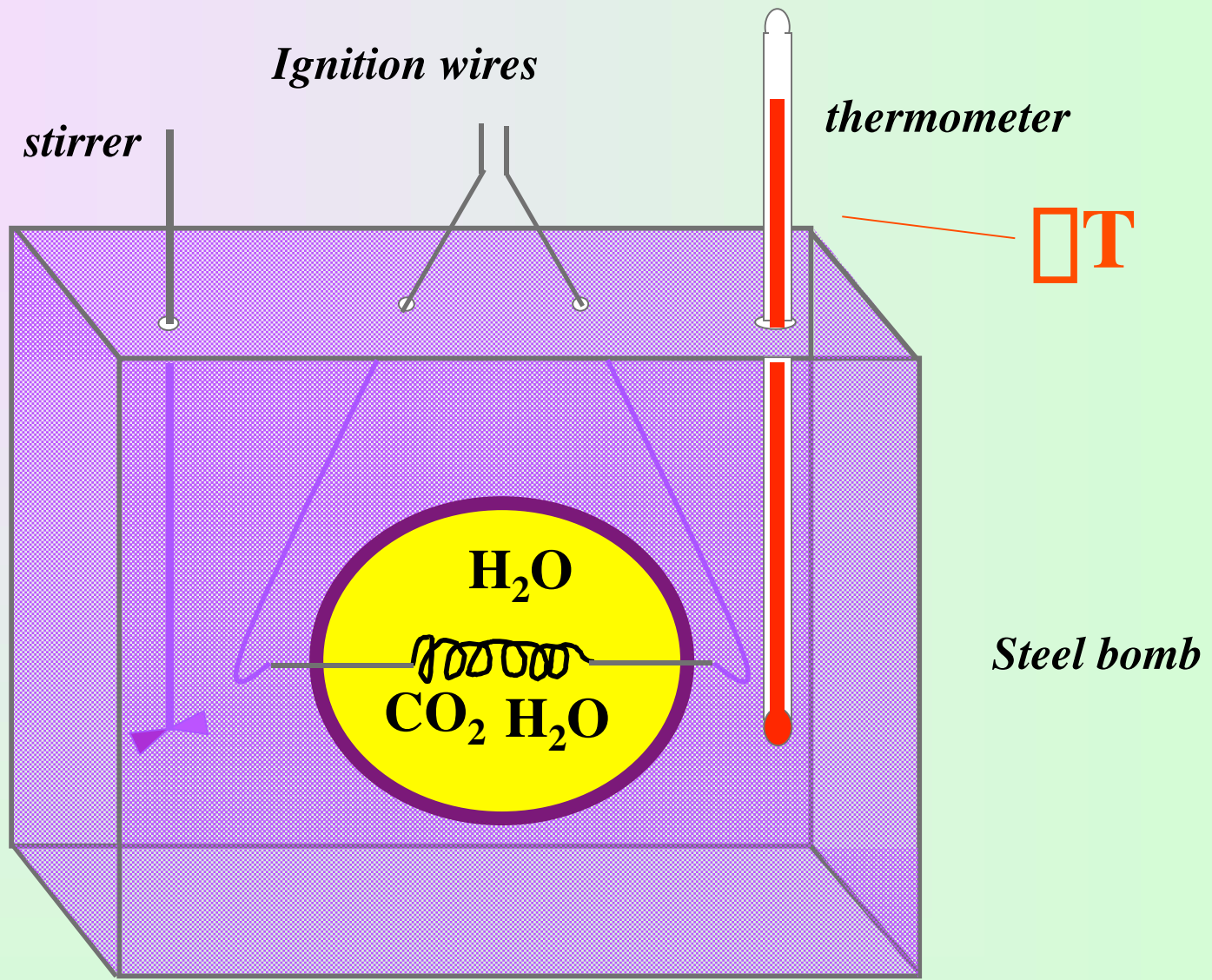
Ignition wires

thermometer

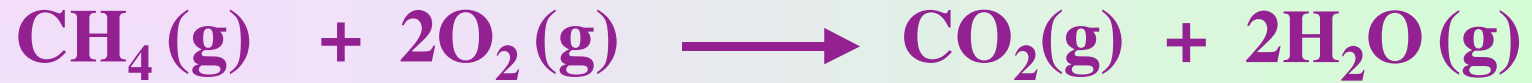
Steel bomb

O_2

O_2 CH_4



Example:



Energy released in the combustion of 1.50g of CH_4 = $(11.3 \text{ kJ/}^\circ\text{C})(7.3^\circ\text{C}) = 83 \text{ kJ}$

$$\frac{83 \text{ kJ}}{1.50\text{g}} = 55 \text{ kJ/g}$$

Example:

50g sample of water at 100 °C is poured into a 50g sample of water at 25 °C . What is the final temperature of the water.

Heat lost by the hot water is = Heat gained by the cold water is

$$nC \Delta T = q = nC \Delta T$$

$$nC (T_{\text{hot}} - T_{\text{f}}) = q = nC (T_{\text{f}} - T_{\text{cold}})$$

$$(50 \text{ g})(4.18 \text{ J } ^\circ \text{ C}^{-1} \text{ g}^{-1})(100 \text{ }^\circ \text{ C} - T_{\text{f}})$$

$$= (50 \text{ g})(4.18 \text{ J } ^\circ \text{ C}^{-1} \text{ g}^{-1})(T_{\text{f}} - 25 \text{ }^\circ \text{ C})$$

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$$209 \text{ J } ^\circ \text{C}^{-1} (100 \text{ } ^\circ \text{C} - T_{\text{f}}) =$$

$$209 \text{ J } ^\circ \text{C}^{-1} (T_{\text{f}} - 25 \text{ } ^\circ \text{C})$$

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$$20900 - 209T_{\text{f}} = 209T_{\text{f}} - 5225$$

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$$26125 = 418T_{\text{f}}$$

$$T_{\text{f}} = 63 \text{ } ^\circ\text{C}$$