

# 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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The diagram illustrates the equation  $q = nC \Delta T$ . The variable  $n$  is associated with the units "moles" and "grams". The variable  $C$  is associated with "Molar heat capacity" and "Specific heat capacity". The variable  $\Delta T$  is associated with "Specific heat capacity".

moles

grams

**Molar heat capacity**

**Specific heat capacity**

# Heat Capacity (C)

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**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

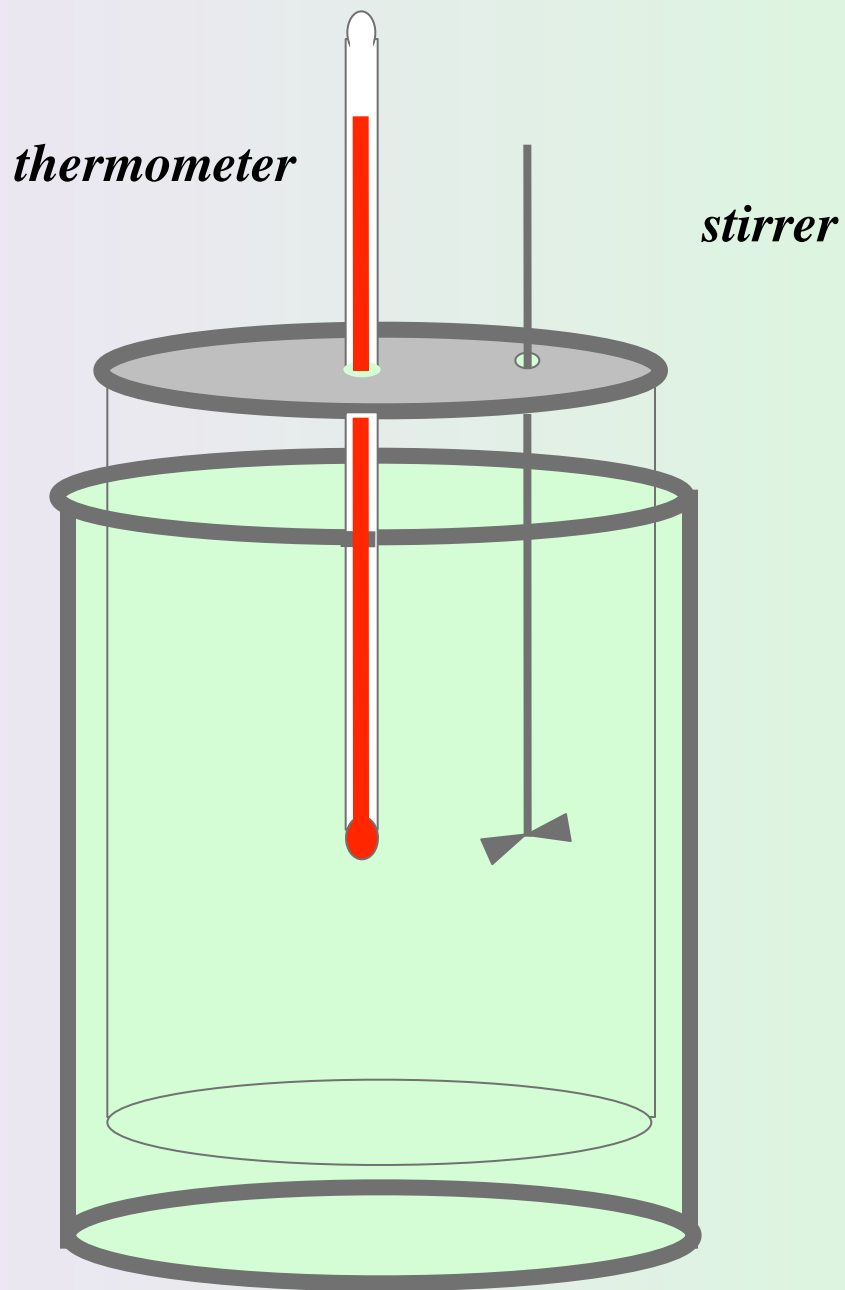
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**takes place at constant pressure**

*(atmospheric pressure )*

**used to determine the changes in enthalpy ( $\Delta H$  )  
occurring in a solution**

# Coffee Cup calorimeter



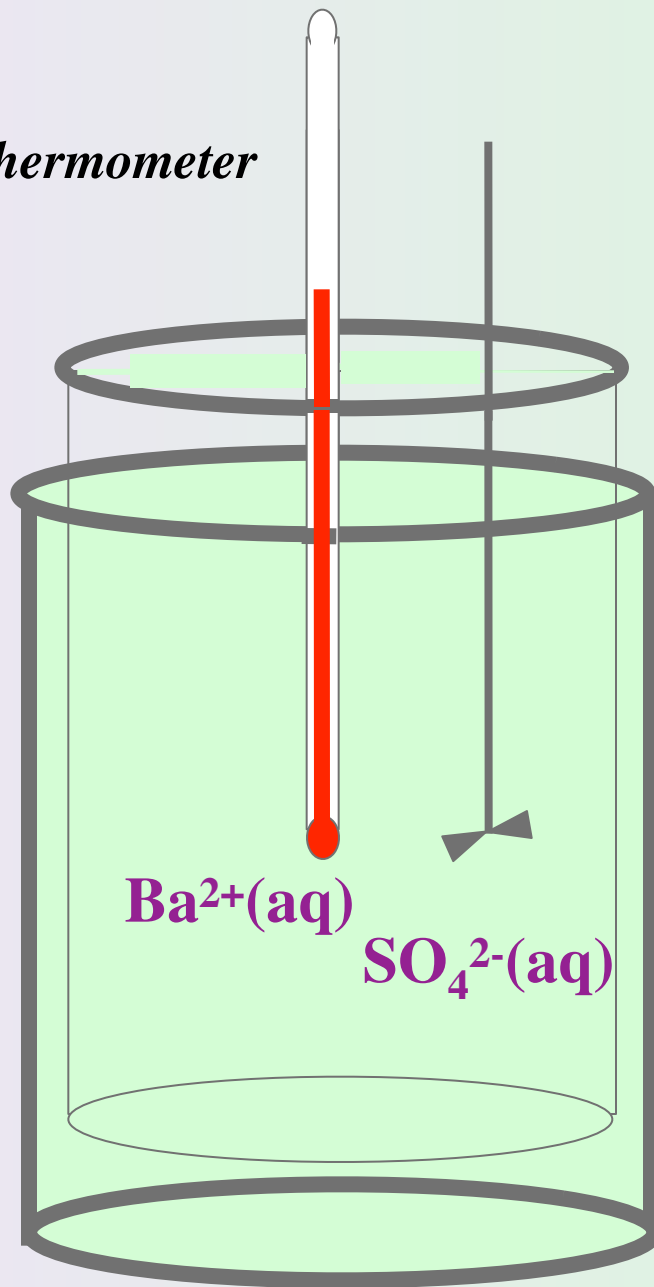
## Example:

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  $\text{Na}_2\text{SO}_4$  at 25 °C in a calorimeter, the white solid  $\text{BaSO}_4$  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 enthalpy ( $\Delta H$ ) change per mole of  $\text{BaSO}_4$ .



*thermometer*

*stirrer*



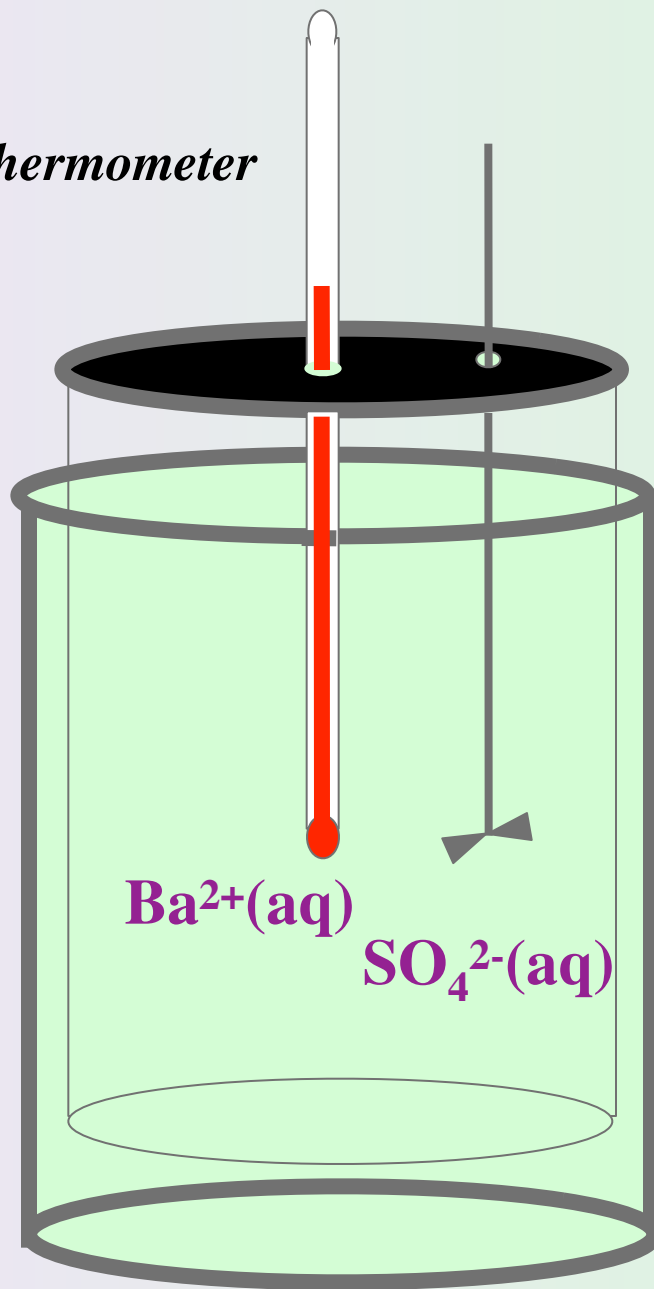
$\text{Ba}^{2+}(\text{aq})$

$\text{SO}_4^{2-}(\text{aq})$



*thermometer*

*stirrer*



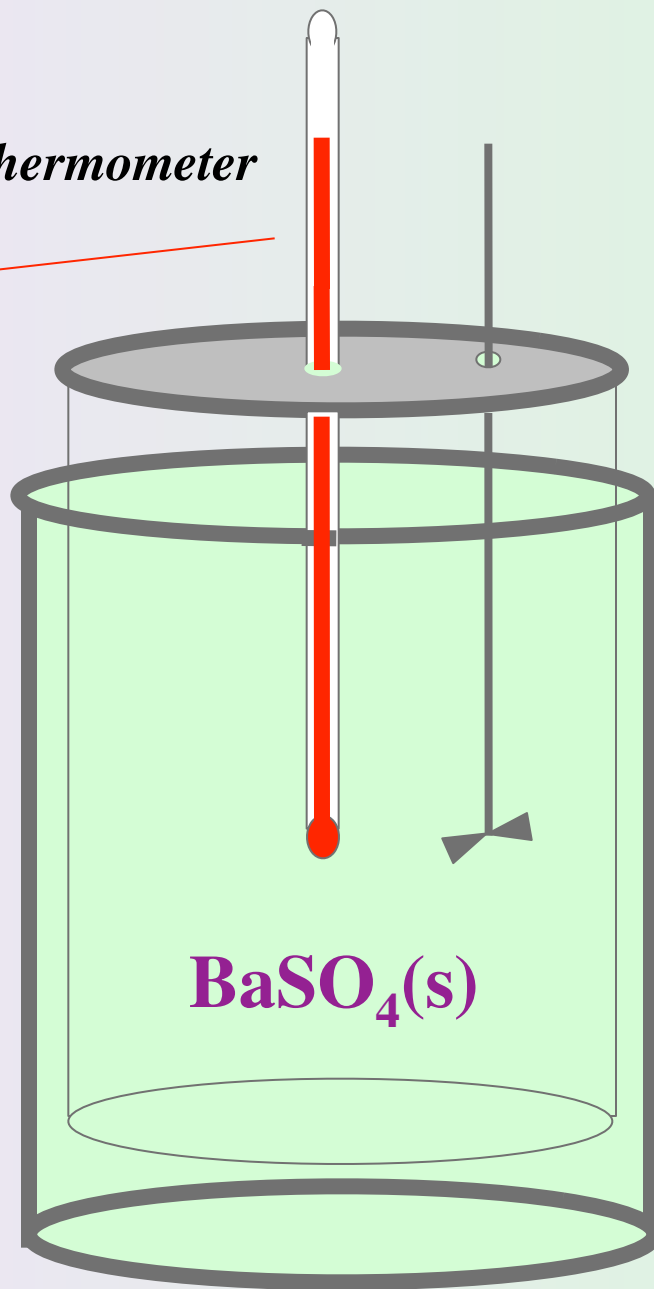
$\text{Ba}^{2+}(\text{aq})$

$\text{SO}_4^{2-}(\text{aq})$

$\Delta T$

*thermometer*

*stirrer*



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

# 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	$2.0\text{L}$	$2.0 \times 10^3\text{g}$
	$\times \frac{1000 \text{ ml}}{1\text{L}}$	$\times \frac{1.0 \text{ g}}{1\text{ml}}$
		$= 2.0 \times 10^3\text{g}$
Increase in temperature	$T_{\text{final}}$	$T_{\text{int}}$
	$28.1 \text{ }^\circ\text{C}$	$25 \text{ }^\circ\text{C}$
	$-$	$= 3.1 \text{ }^\circ\text{C}$

# Example:



$$q = nC \Delta T$$

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

$$= 2.6 \times 10^4 \text{J} \quad \text{Heat absorbed by the solution}$$

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

$$1 \text{L Ba}^{2+} \times \frac{1 \text{mol Ba}^{2+}}{1 \text{L}} \times \frac{1 \text{mol BaSO}_4}{1 \text{mol Ba}^{2+}} = 1 \text{mol BaSO}_4$$

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

# Constant Volume Calorimeter

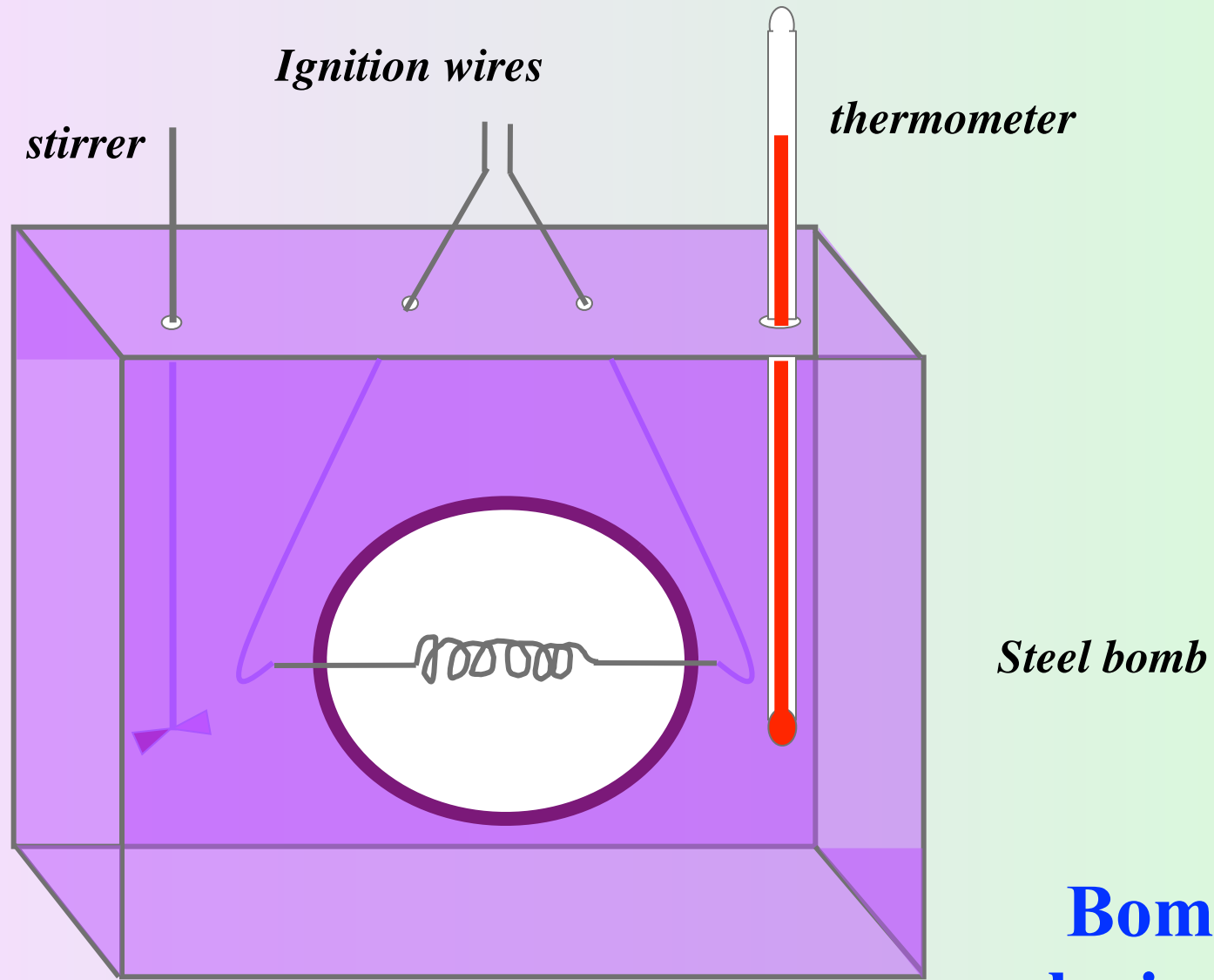
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**takes place at constant volume**

**A bomb calorimeter**

**Weighed reactants are placed inside a rigid steel container and ignited**

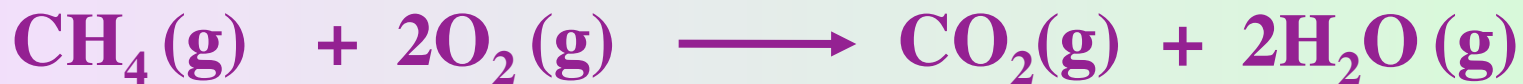
**The energy change is determined by measuring the increase in temperature of the calorimeter**



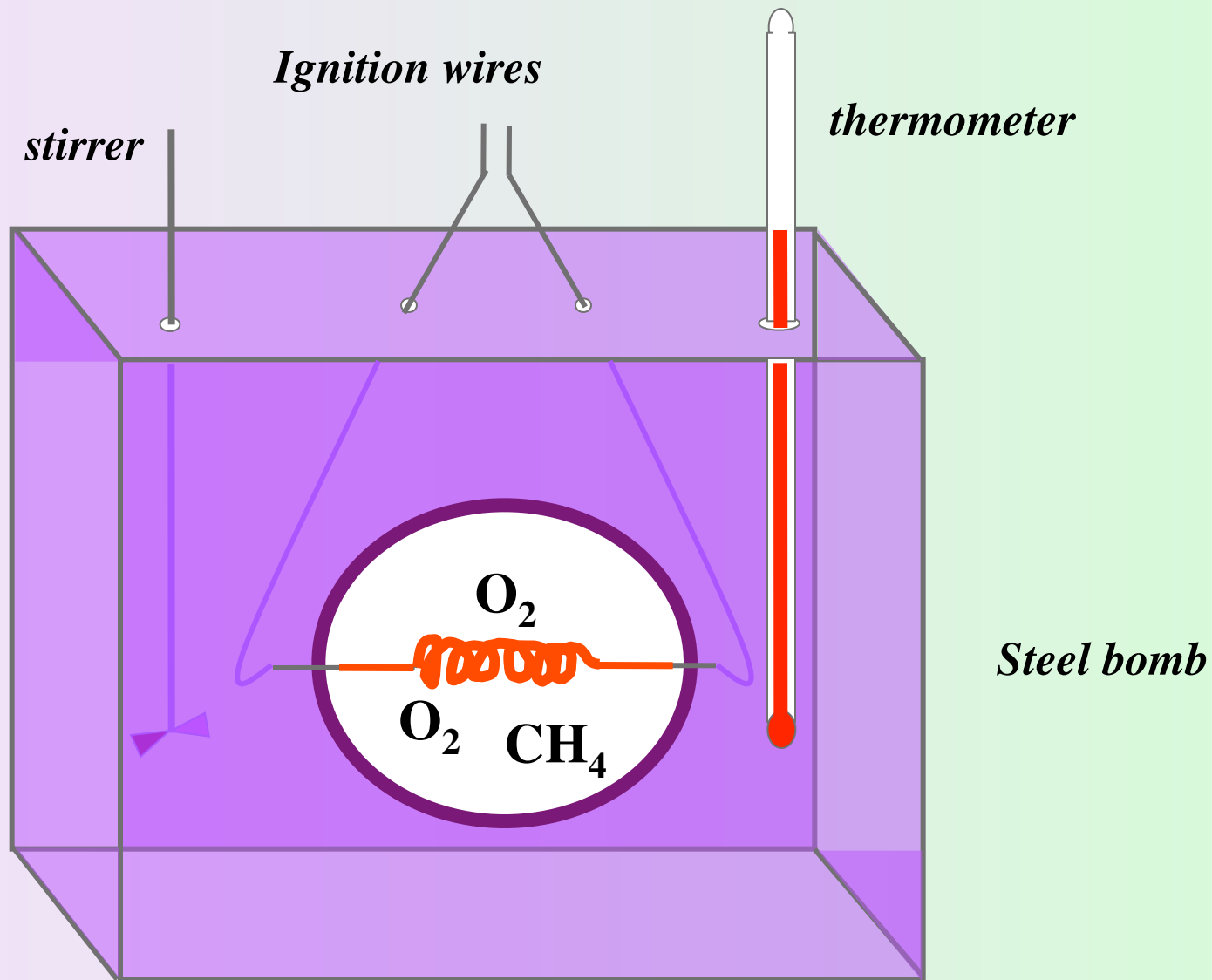
**Bomb  
calorimeter**

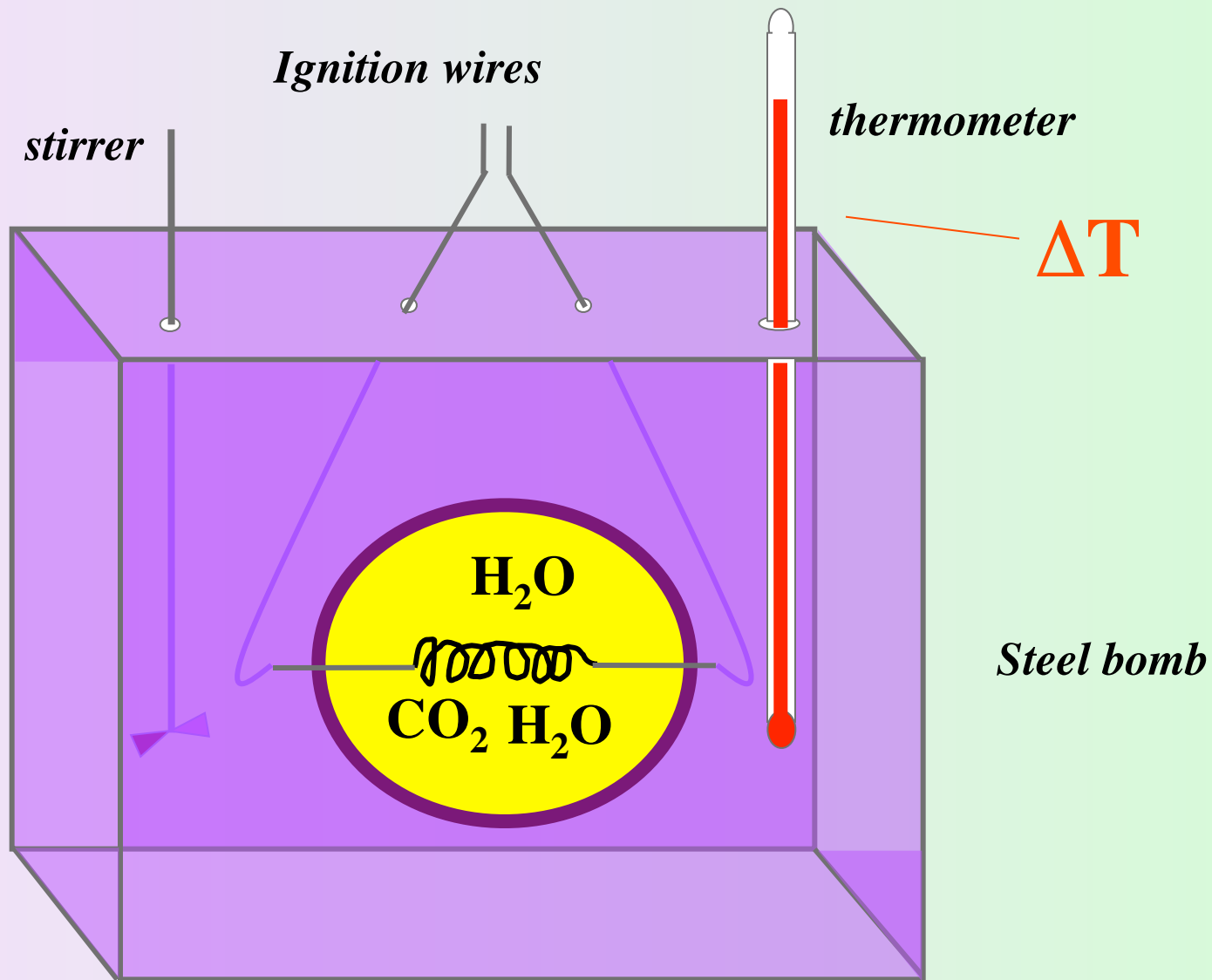
## Example:

**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.**

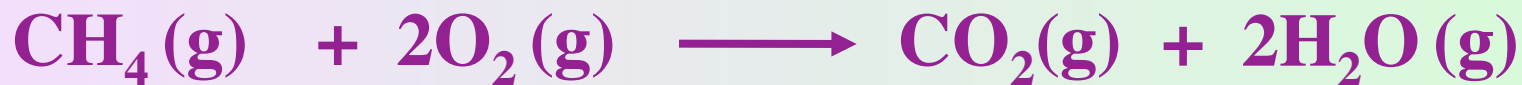








## Example:



Energy released in the combustion of 1.50g of  $\text{CH}_4$  =  $(11.3 \text{ kJ}/^\circ\text{C})(7.3^\circ\text{C}) = 83 \text{ kJ}$

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