

# Thermochemistry

# Chemical reactions

## Exothermic reactions

- All combustion reactions
- Majority of chemical reactions

## Endothermic reactions

- Water + Ammonium chloride

# Heat of reaction

- Is the heat change when the **numbers of moles** of reactants in a balanced equation react completely.
- $\Delta H = -$  is exo
- $\Delta H = +$  is endo

## Heat of combustion

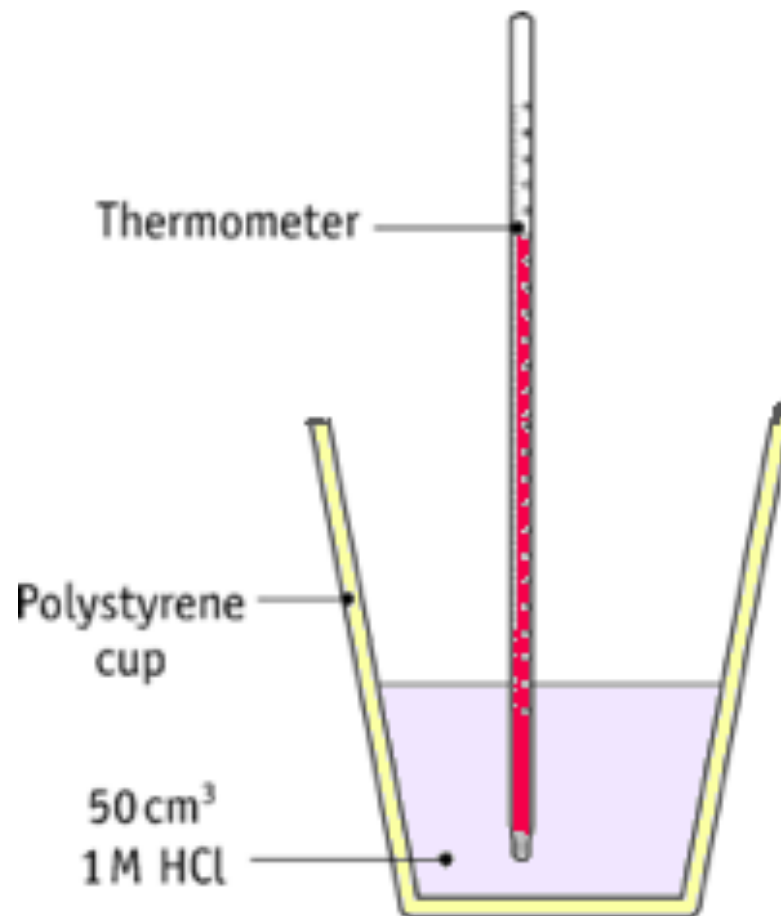
- Heat change when one mole of substance is completely burned in excess oxygen.

# Heat of neutralisation

- Heat change when one mole of  $H^+$  ions from an acid reacts with one mole of  $OH^-$  ions from a base.
- **$\Delta H = \text{mass} \times \text{specific heat capacity} \times \text{rise in temp.}$**
- **$\Delta H = m \times c \times T$**
- **$M = \text{kilograms}$**
- **$C = \text{heat needed to raise temp of 1kg of substance by 1K}$**
- **$C$  always given**
- **Assume density of solution density of water**
- **Answer always negative**

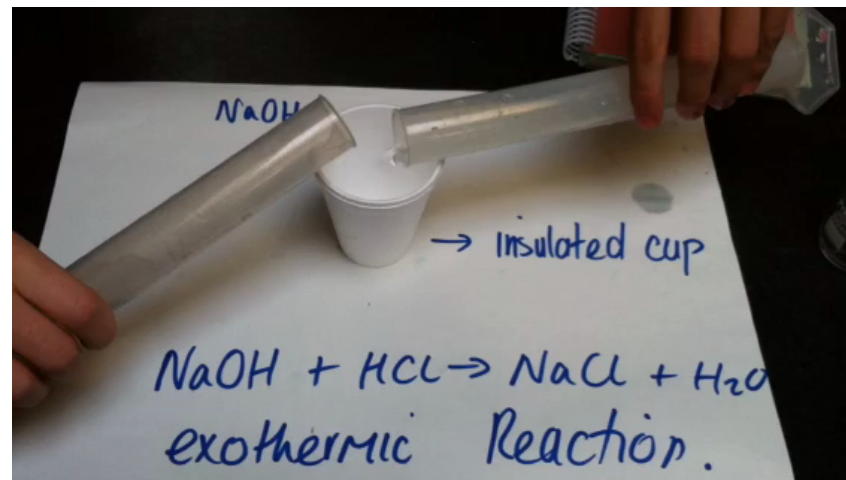
# List of equipment

- 1 M hydrochloric acid
- 1 M sodium hydroxide
- Thermometers (reading to 0.1 °C)
- Polystyrene cups with lids
- Graduated cylinders (100 cm<sup>3</sup>)



# Method

- Using a graduated cylinder, place 50 cm<sup>3</sup> of the 1 M hydrochloric acid solution into one of the polystyrene cups.
- Using a second graduated cylinder, place 50 cm<sup>3</sup> of the 1 M sodium hydroxide solution into the second polystyrene cup.
- Measure the temperature of the hydrochloric acid solution.
- Using a second thermometer, measure the temperature of the sodium hydroxide solution.
- When both solutions are at the same temperature, quickly add the base to the acid, stirring well. Take care to avoid any loss of liquid due to splashing.
- Place a lid on the polystyrene cup and with continuous swirling record the maximum temperature reached.



# $\Delta H$ of neutralisation

$$= m \times c \times T_2 - T_1$$

- Remember the answer to this calculation is always negative
- 1 Molar solution = 1 mole in 1 litre
- $1/1000 = 0.001 \text{ moles/ml}$
- $\times 50$  0.05 moles used
- $\Delta H = m \times c \times T_2 - T_1$
- $m = 0.1 \text{ Kg}$
- $C = 4060$
- $T = 7^\circ\text{C}$
- $= -2842 \text{ J in } 0.05 \text{ moles}$
- $= 1/0.05 = 20$
- $-2842 \times 20 = -56840 \text{ J}$
- $-56.84 \text{ KJ/mol}$

# Another example of calculation

- When  $200\text{cm}^3$  of NaOH solution were added to  $200\text{cm}^3$  of a 0.4M solution of sulphuric acid in a plastic container, a neutral solution was produced and the temp rose by  $5.5^\circ\text{C}$ . The density is presumed to be  $1\text{g/cm}^3$  and specific heat capacity is  $4.2\text{kJ/kg/K}$ .
- Calculate the heat of neutralisation?



# Heat of combustion

- Heat of a substance is the heat change when one mole of substance is completely burned in excess oxygen.
- Heats of combustion are measured accurately using a bomb calorimeter.
- Kilogram Calorific value
- The heat energy produced when 1kg of fuel is completely burned in oxygen.
- A known mass of substance is placed in a crucible inside the bomb.
- The bomb is filled with oxygen under pressure, the oxygen is in excess.
- The bomb is placed in a known quantity of water contained in the calorimeter.
- The substance is ignited electrically using an ignition coil of wire.
- The rise in temp is measured.
- $m \times c \times T_2 - T_1$

# Bond energy

- Is the average energy required to break one of a particular covalent bond and to separate the neutral atoms completely from each other.
- Energy is required to break a bond and energy released when a bond is formed.
- Make a methane molecule and 2 oxygen molecules and make the products using models
- See youtube
- Chemistry 10.4 Energy and Chemical Bonds (Enthalpy)

# Heat of formation

- Heat change that takes place when one mole of a compound is formed from its elements in their standard states.
- Standard state means the state of the chemical at 25<sup>0</sup>C and 101kPa.
- $\text{H}_{2(g)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{H}_2\text{O}_{(l)}$
- $\Delta H = -285.8\text{kJ/mol}$

# Hess's law

- The heat change for reaction depends only on initial and final states of the system, and is independent of the path followed .
- Look at fig 21.44 page 333