Enthalpy change (ΔH_r) of the reaction – amount of chemical heat energy taken in (giving out) in a reaction.

Enthalpy of formation (ΔH_f), when 1 mol of a substance is formed from is constituent elements in their standard state.

Bond enthalpy: energy required to break 1 mole of a bond.

We can use enthalpy change of formation and bond enthalpy to calculate enthalpy change of reactions. Information about enthalpy change of formation for different substances, as well as bond enthalpy for different bonds can be found in text books or internet.

ΔH_r = sum of ΔH_f (products) – sum of ΔH_f (reactants)

ΔH_r = sum of broken bond enthalpies (reactants) – sum of formed bond enthalpies (products)

Answer to problem 3 from HW5:

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

$\Delta H_f^\circ[NH_3(g)] = -46$ $\quad \frac{1}{2}N_2 + \frac{3}{2}H_2 \rightarrow NH_3$

$\Delta H_f^\circ[NO(g)] = 90$ $\quad N + O \rightarrow NO$

$\Delta H_f^\circ[H_2O(g)] = -242$ $\quad H_2 + \frac{1}{2}O_2 \rightarrow H_2O$

$$\Delta H_r^\circ = \sum \Delta H_f^\circ(\text{products}) - \sum \Delta H_f^\circ(\text{reactants})$$

ΔH_f products $= 4 \cdot 90 + 6 \cdot (-242) = -1092$

ΔH_f reactant $= 4 \cdot -46 = -184$

$-1092 - (-184) = -908$ kJ/mol

Specific heat capacity: The energy required to raise the temperature of 1 g of substance by 1 C.
Using calorimetry we can calculate heat flow using this formula:
$Q = mc\Delta T$
Where

- Q – heat
- m – mass
- C – heat capacity
- **Δ**T – temperature change

Note, for exothermic reaction q is negative and enthalpy change is negative, for endothermic reactions the signs are positive. Q = **Δ**H (when pressure is constant)
In the experiment with coffee cup calorimeter we heated peace of cadmium to 100 C and put it in a coffee cup with 100 ml of water at room temperature. We

registered the temperature change of water, the specific heat capacity of water is known. This experiment allowed us to calculate specific heat capacity of cadmium.

	Initial T	Final T	Mass
Water	22C°	25°C	100g
Cd	100C°	25°C	58.953g

specific heat capacity of water $4.18\ Jg^{-1}\cdot C^{-1}$

$Q = mc\Delta T$ Q or q - heat. c - heat capacity, m - mass, g. ΔT - temperature change

1. We can calculate heat flow using information from water. Temperature rised by 3°C, so ΔT = 3

$$Q = 100g \times 4.18\ Jg^{-1}\cdot C^{-1} \times 3\ C = 1254\ J$$

2. Now we know heat, and we know that Cadmium changed temperature from 100 C to 25C. We can calculate heat capacity of Cadmium

$$c = \frac{Q}{m\Delta T} = \frac{1254}{58.953 \times 75} = 0.284\ Jg^{-1}\cdot C^{-1}$$

Question.

1. In a calorimeter, the following exothermic reaction was conducted:

$MgO\ (s) + 2\ HCl\ (l) \rightarrow MgCl_2\ (s) + H_2O\ (l)$

- **Reagents and Observations**:
  - 1 g of magnesium oxide (MgO) was mixed with 100 ml of HCl.
  - The temperature of the solution increased by 6.9 °C.

Assumptions:

- The specific heat capacity of the solution is the same as that of water.
- The mass of the solution (m) is taken as the mass of the liquid alone, with 100 ml = 100 g (we do not count masses of solids).

Tasks:

Calculate the heat change (q): Determine the amount of heat gained or lost by the solution.

Calculate moles of MgO and enthalpy change per mole of used MgO: Using the initial mass of 1 g, find the number of moles of MgO used and recalculate change of enthalpy of the reaction per mole of MgO. Remember for exothermic reaction q is negative and enthalpy change is negative.

2. In another calorimeter experiment, 0.5 g of magnesium (Mg) was reacted with 100 ml of hydrochloric acid (HCl). The reaction is as follows:

$Mg (s) + 2 HCl (l) \rightarrow MgCl_2 (s) + H_2 (g)$

Observation: The temperature of the solution increased by 18.3 °C.

Tasks: **Calculate the Enthalpy Change of the Reaction per Mole of Mg**:

- Calculate the amount of heat (q) released during the reaction, assuming the solution's specific heat capacity is the same as that of water.
- Convert this heat to an enthalpy change per mole of magnesium.

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3. **Enthalpy of Formation for MgO**

Now, we want to calculate the enthalpy of formation for magnesium oxide (MgO) using the reactions provided above.

Formation Reaction of MgO:

$$\mathbf{Mg + \frac{1}{2} O_2 \rightarrow MgO}$$

Additional Data:

- We will use the enthalpy changes from the two reactions above and one more known enthalpy change for the following reaction:

  $H_2 (g) + 1/2 O_2 (g) \rightarrow H_2O (l)$, $\Delta H = -286$ kJ/mol.

Use this information to determine the enthalpy of formation for MgO.