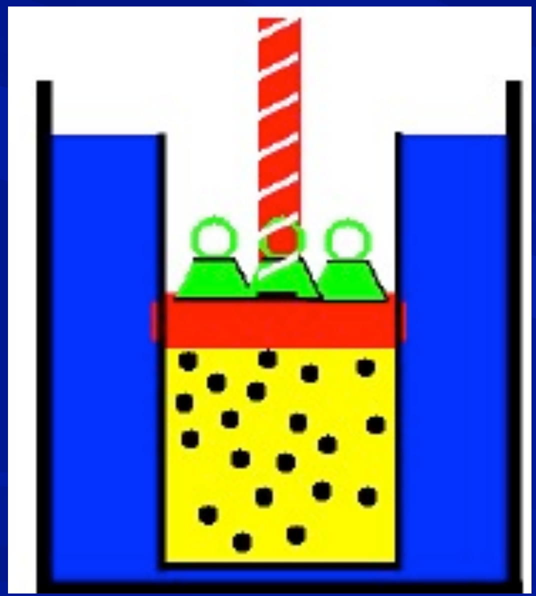
Enthalpy

- Enthalpy
- Endothermic reactions
- Exothermic reactions
- Writing Thermochemical equations

Enthalpy

- **Enthalpy is the heat absorbed or released during a chemical reaction (where the only work done is the expansion of a gas at constant pressure)**



Enthalpy

- Not all energy changes that occur as a result of chemical reactions are expressed as heat
- Energy = Heat + Work
- **Work** is a force applied over a distance.
- Most energy changes resulting from chemical reactions are expressed in a special term known as **enthalpy**

Enthalpy

- It is nearly impossible to set up a chemical reaction where there is no work performed.
- The conditions for a chemical reaction are often set up so that work is minimized.
- Enthalpy and heat are nearly equal under these conditions.

Enthalpy Changes

- Sometimes the symbol for enthalpy (ΔH) is used for heat (ΔQ)
- In many cases where work is minimal heat is a close approximation for enthalpy.
- One must always remember that while they are closely related, heat and enthalpy are NOT identical

Energy and Enthalpy Changes

- It is impractical to measure absolute amounts of energy or enthalpy.
- Hence we measure <u>changes</u> in enthalpy rather than total enthalpy
- Enthalpy is always measured relative to previous conditions.
- Enthalpy is measured relative to the system.

$$\Delta H_{system} = +- |q_{surroundings}|$$

Enthalpy

- The change in enthalpy is designated by the symbol ΔH.
  - If $\Delta H < 0$ the process is **exothermic.**
  - If $\Delta H > 0$ the process is **endothermic.**

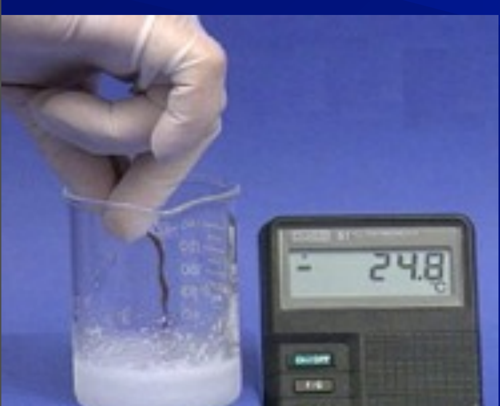
- Breaking chemical bonds requires energy
- Forming new chemical bonds releases energy

Exothermic and Endothermic Processes

- Exothermic processes release energy

  $C_3H_8\ (g) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4H_2O\ (g)$

  + 2043 kJ



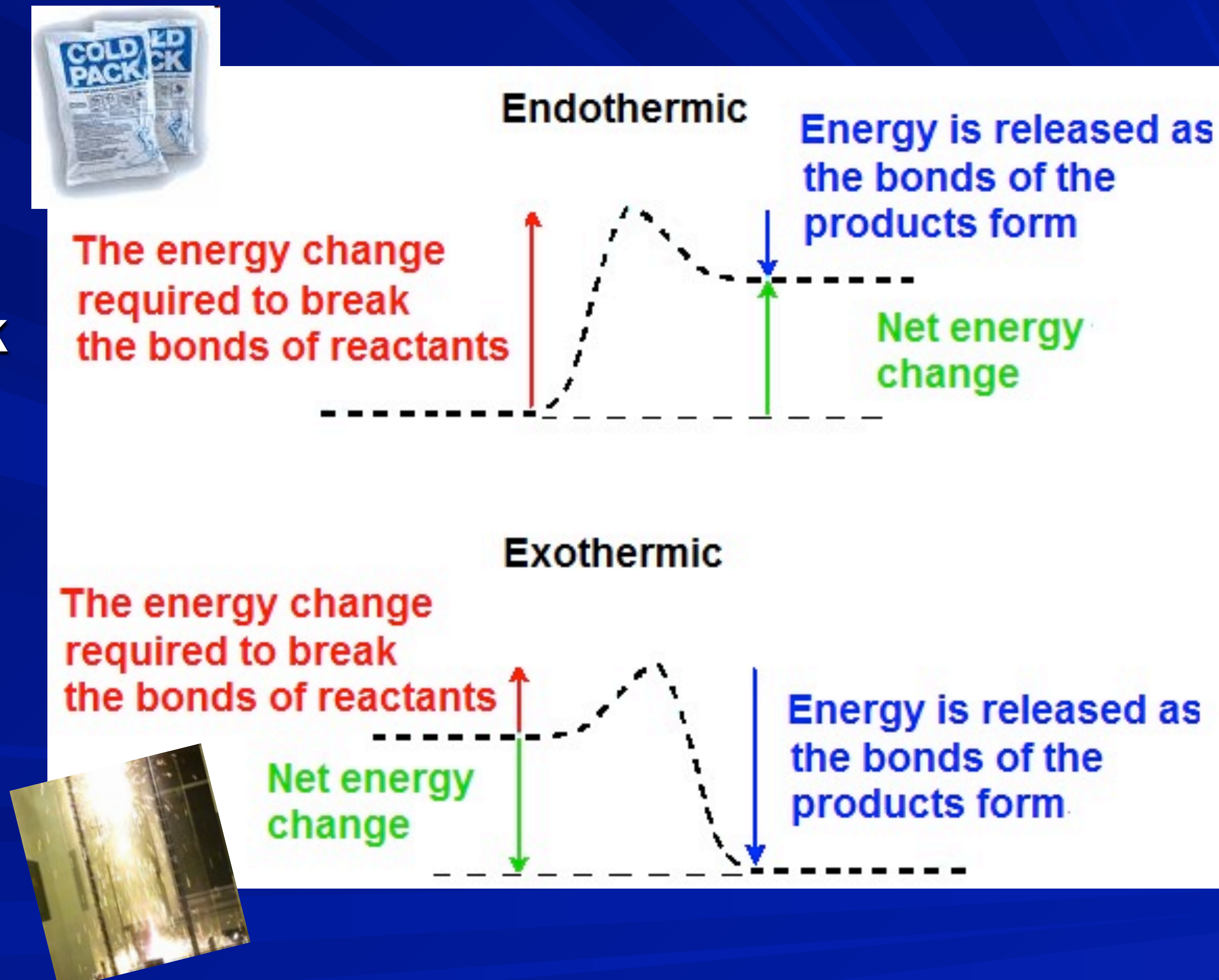
- Endothermic processes absorb energy

  $C(s) + H_2O\ (g)$ **+113 kJ** $\rightarrow CO(g) + H_2\ (g)$

Energy Changes in endothermic and exothermic processes

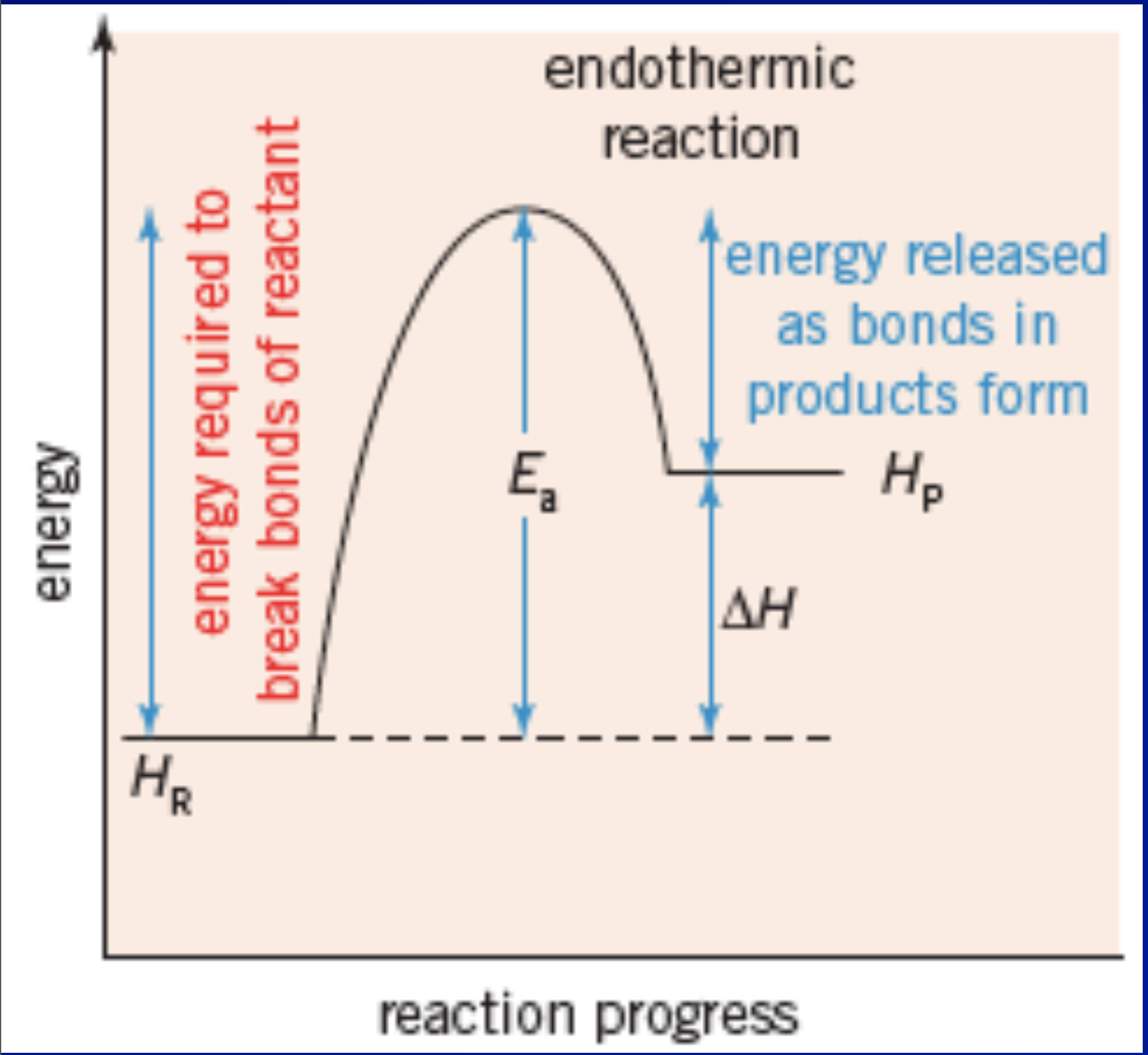
In an endothermic reaction there is more energy required to break bonds than is released when bonds are formed.

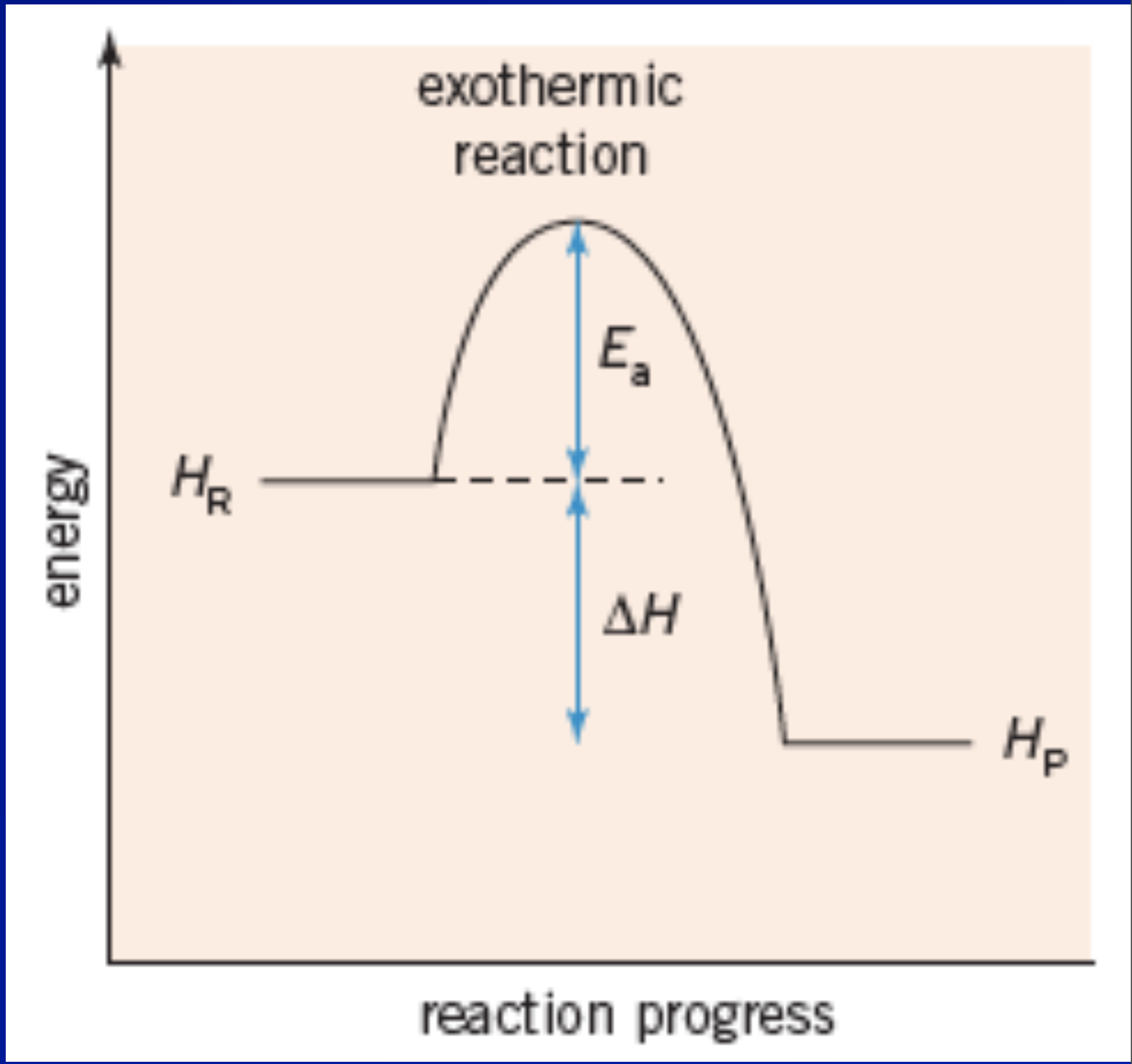
The opposite is true in an exothermic reaction.



Energy Diagrams

- Lower in energy means more stable





Using ΔH

- Classify as endothermic/exothermic
- Rewrite the equation using ΔH
- **Watch your signs!**

$C_3H_8\ (g) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4H_2O\ (g)$ **+2043 kJ**

$C_3H_8\ (g) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4H_2O\ (g)$ **ΔH = -2043 kJ**

$C(s) + H_2O\ (g)$ **+113 kJ** $\rightarrow CO(g) + H_2\ (g)$

$C(s) + H_2O\ (g) \rightarrow CO(g) + H_2\ (g)$ **ΔH = +113 kJ**

Calculate the amount of energy released when 500 cm^3 of methane gas at STP reacts with excess air according to the equation:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H = -890 \text{ kJ mol}^{-1}$$

- 19.9 kJ

What mass of propanol must be burnt in excess air to produce 1.00×10^4 kJ of energy, according to the following equation?

$$2C_3H_7OH(l) + 9O_2(g) \rightarrow 6CO_2(g) + 8H_2O(l) \qquad \Delta H = -4034 \text{ kJ mol}^{-1}$$

- 298 g

1. Consider the following thermochemical equation:

$$2ZnS_{(s)} + 3O_{2(g)} \rightarrow 2ZnO_{(s)} + 2SO_{2(g)} \qquad \Delta H = -878.2 \text{ kJ}$$

(a) How much heat is released when 3.0 mol $ZnS_{(s)}$ reacts in excess oxygen?

(b) How much heat is released when 2.3×10^{-2} mol $ZnS_{(s)}$ reacts in excess oxygen?

(c) What is the enthalpy change when 223.9 g $ZnS_{(s)}$ reacts in excess oxygen?

(d) What is the enthalpy change when 0.96 g $ZnO_{(s)}$ is produced?

2. Slaked lime ($Ca(OH)_{2(s)}$) is produced when lime (calcium oxide, $CaO_{(s)}$) reacts with liquid water. 65.2 kJ of heat is released for each mol of $Ca(OH)_2$ that is produced.

(a) Write a thermochemical equation for the reaction.

(b) What is the enthalpy change when 523.3 kg of lime reacts with excess water?

3. The following reaction represents the complete combustion of hexane, $C_6H_{14(l)}$, at SATP.

$$C_6H_{14(l)} + \frac{19}{2}O_{2(g)} \rightarrow 6CO_{2(g)} + 7H_2O_{(l)} \quad \Delta H = -4163 \text{ kJ}$$

(a) If 0.537 mol of carbon dioxide is produced in the reaction represented by the equation above, how much heat is released by the reaction?

(b) If 25.0 kg of hexane is burned in sufficient oxygen, how much heat will be released?

(c) What mass of hexane is required to produce 1.0×10^5 kJ of heat by complete combustion?