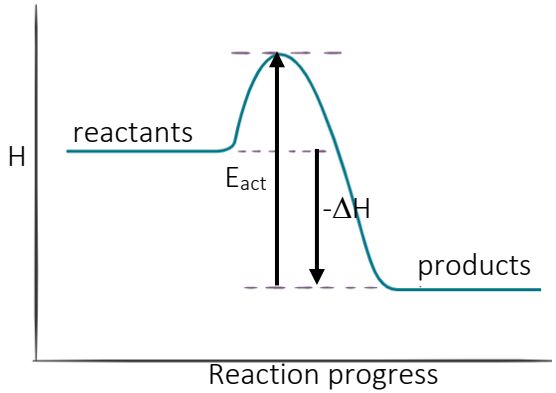
Exothermic or endothermic - and why?

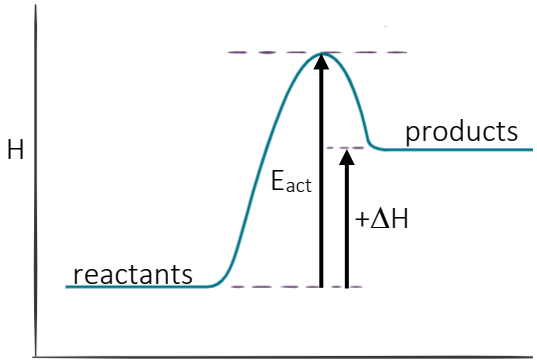
- When solid calcium chloride, $CaCl_2(s)$, reacts with water, the temperature increases.
- When a person sweats, water is lost from the body by evaporation.
- Pentane combustion: $C_5H_{12}(l) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$ $\Delta_rH^o = -3509$ kJ mol^{-1}
- Instant cold packs contain salts such as ammonium nitrate, NH_4NO_3. When activated, the salt dissolves in water, causing the temperature to decrease.
- $H_2O(\ell) \rightarrow H_2O(g)$
- Glucose is made in plants by photosynthesis: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$ $\Delta_rH^o = 2803$ kJ mol^{-1}
- The equation for hydrating anhydrous copper sulfate is: $CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_{4.5}H_2O(s)$ $\Delta_rH^o = -78.2$ kJ mol^{-1}.
- Pentane, C_5H_{12}, is a liquid at room temperature. It evaporates at 36.1°C.
- Hand warmers contain a supersaturated solution of sodium ethanoate which, when activated, crystallises and releases heat.
- When solid sodium hydroxide is added to water, the temperature increases.
- Freezing of water to form ice is represented by the following equation. $H_2O(l) \rightarrow H_2O(s)$
- Dissolving ammonium nitrate in a beaker of water: $NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$ $\Delta_rH^o = 25.1$ kJ mol^{-1}
- Glucose is an important source of energy in our diet. $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$ $\Delta_rH° = -2820$ kJ mol^{-1}.

Exothermic	Endothermic
Energy is given OUT to the surroundings	Energy is taken IN from the surroundings
ΔH is negative	ΔH is positive
Products have LESS energy than the reactants	Products have MORE energy than the reactants
Products are MORE stable than the reactants	Products are LESS stable than the reactants

Exothermic



Endothermic



Bond breaking is endothermic.
Bond making is exothermic.

Calculations:
Bond breaking & making type
E.g. $N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$
How much energy is released by this reaction?
You will be given the average bond enthalpies in kJ mol^{-1} e.g. N-H 391, N-N 158, O=O 498, N≡N 945, O-H 463

Break: 4 x N-H, N-N and O=O
1564 + 158 + 498 = 2220 kJ
Make: N≡N and 4 x O-H (remember bond making is exothermic)
-945 + -1852 = -2797 kJ
Energy released 577 kJ mol^{-1} (as 2220 + -2797 = -577)
Note: do not say -577 kJ released…. The 'released' tells us that it is exothermic.

*You can use "Bond breaking – bond making" BUT don't include the - sign in front of the bond making figure as well! e.g. 2220 – 2797 = -577

From equation type

E.g. $Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(s) + Al_2O_3(s)$ $\Delta_rH^o = -852$ kJ mol^{-1}
How much heat energy is produced when 50.0 g of metal oxide is reacted with (excess) aluminium powder, Al(s).
$M(Fe_2O_3) = 160$ g mol^{-1}.

$n(Fe_2O_3) = 50.0/160 = 0.3125$ mol
1 mol Fe_2O_3 releases 852 kJ of energy, so 0.3125 mol would release 0.3125 x 852 = 226 kJ (3 s.f.)

Note: do not say -226 kJ released…. The 'released' tells us that it is exothermic.

Given on data sheet in 2018 $n = \frac{m}{M}$

n is the amount (in mol), m is the mass (in g) and M is the molar mass (in g mol^{-1}).

Exothermic or endothermic - and why?

- When solid calcium chloride, $CaCl_2(s)$, reacts with water, the temperature increases. Exothermic; there is an increase in temperature.
- When a person sweats, water is lost from the body by evaporation. Endothermic; energy is absorbed from the body to break the bonds between water molecules.
- Pentane combustion: $C_5H_{12}(l) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$ $\Delta_rH^o = -3509$ kJ mol^{-1} Exothermic; the sign of ΔH is negative.
- Instant cold packs contain salts such as ammonium nitrate, NH_4NO_3. When activated, the salt dissolves in water, causing the temperature to decrease. Endothermic; there is an decrease in temperature.
- $H_2O(\ell) \rightarrow H_2O(g)$ Endothermic; energy is absorbed to break the bonds between water molecules in the phase change.
- Glucose is made in plants by photosynthesis: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$ $\Delta_rH^o = 2803$ kJ mol^{-1} Endothermic; the sign of ΔH is positive
- The equation for hydrating anhydrous copper sulfate is: $CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_{4.5}H_2O(s)$ $\Delta_rH^o = -78.2$ kJ mol^{-1}. Exothermic; the sign of ΔH is negative.
- Pentane, C_5H_{12}, is a liquid at room temperature. It evaporates at 36.1°C. Endothermic; energy is absorbed to break the bonds between pentane molecules in the phase change.
- Hand warmers contain a supersaturated solution of sodium ethanoate which, when activated, crystallises and releases heat. Exothermic; there is an increase in temperature / heat energy is released.
- When solid sodium hydroxide is added to water, the temperature increases. Exothermic; there is an increase in temperature.
- Freezing of water to form ice is represented by the following equation. $H_2O(l) \rightarrow H_2O(s)$ Exothermic; energy is released when bonds are being made between water molecules in the phase change.
- Dissolving ammonium nitrate in a beaker of water: $NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$ $\Delta_rH^o = 25.1$ kJ mol^{-1} Endothermic; the sign of ΔH is positive
- Glucose is an important source of energy in our diet. $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$ $\Delta_rH^\circ = -2820$ kJ mol^{-1}. Exothermic; the sign of ΔH is negative.