CIE Chemistry A-Level

Topic 5 - Chemical Energetics

Flashcards

In terms of energy, what happens when a chemical reaction occurs?

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- Energy changes occur, generally in the form of thermal energy.
- The energy change is either endothermic or exothermic.

What is an endothermic reaction?

What is an endothermic reaction?

- Heat energy is absorbed during the reaction.
- Positive enthalpy change.
- More energy is used to break bonds than is released in making bonds.

What is an exothermic reaction?

What is an exothermic reaction?

- Heat energy is released during the reaction.
- Negative enthalpy change.
- More energy is released making bonds than is used to break bonds.

Draw an enthalpy level diagram for an exothermic reaction

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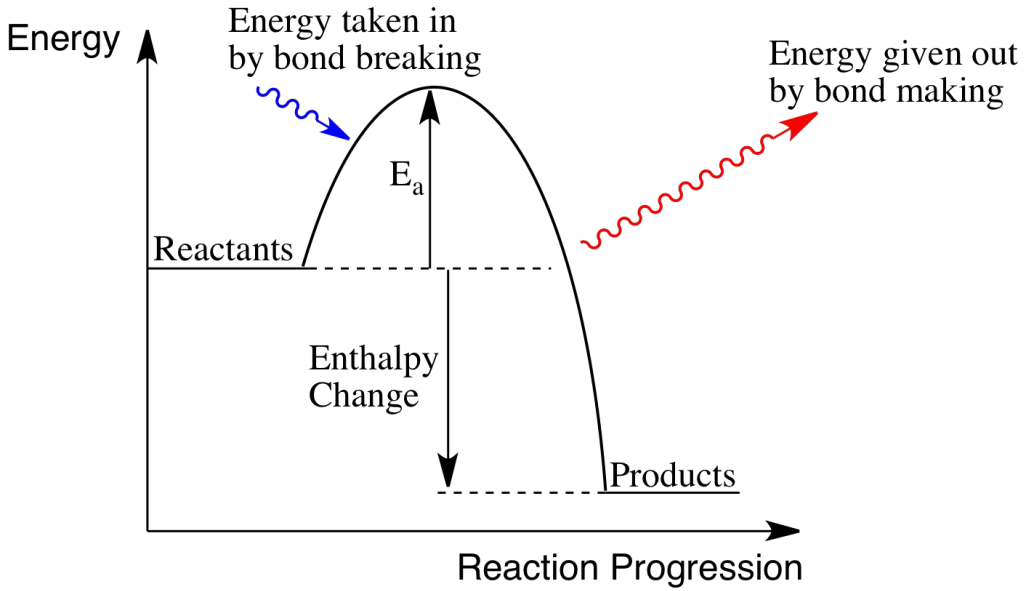

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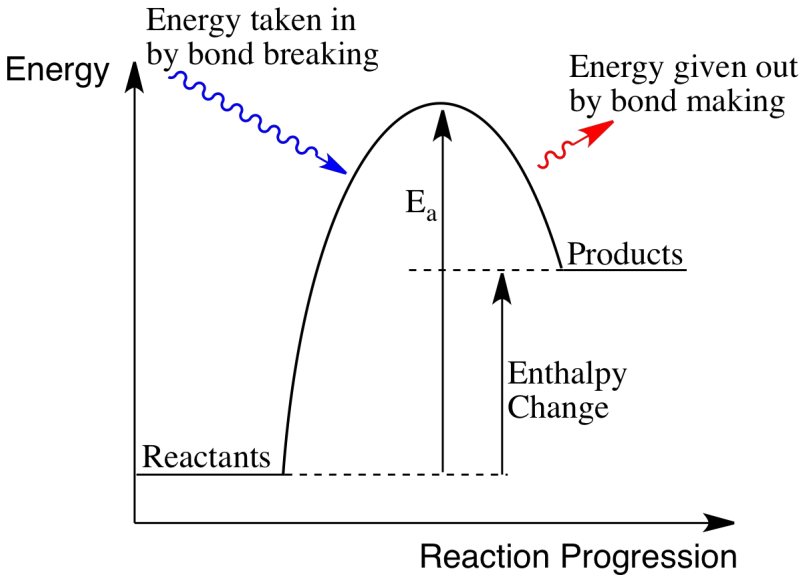

What is activation energy?

What is activation energy?

The minimum amount of energy required to start a reaction.

What are standard conditions?

What are standard conditions?

- Pressure: 101 kPa (or 100 kPa) or 1 atm
- Temperature: 298 K or 25℃
- Solution concentrations: 1 $moldm^{-3}$

Define the standard enthalpy change of reaction, $\Delta_r H^\theta$

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The enthalpy change that accompanies a reaction in the molar quantities expressed in an equation under standard conditions, with all reactants and products in their standard states.

Define the standard enthalpy change of formation, $\Delta_f H^\theta$

Define the standard enthalpy change of formation, $\Delta_f H^\theta$

The enthalpy change that occurs when one mole of product is formed from its constituent elements under standard conditions, with all reactants and products in their standard states.

Define the standard enthalpy change of combustion, $\Delta_c H^{\theta}$

Define the standard enthalpy change of combustion, $\Delta_c H^\theta$

The enthalpy change that occurs when one mole of compound completely reacts with oxygen under standard conditions with all reactants and products in their standard states.

Define the standard enthalpy change of neutralisation, $\Delta_{neut}H^{\theta}$

Define the standard enthalpy change of neutralisation, $\Delta_{neut}H^{\theta}$

The enthalpy change that occurs when one mole of water is formed in a neutralisation reaction under standard conditions.

Define the standard enthalpy change of atomisation, $\Delta_a H^\theta$

Define the standard enthalpy change of atomisation, $\Delta_a H^\theta$

The enthalpy change that occurs when 1 mole of gaseous atoms are formed from an element in its standard state, under standard conditions.

Define the standard enthalpy change of hydration, ΔH_{hyd}^{θ}

Define the standard enthalpy change of hydration, $\Delta H_{hyd}^{\ominus}$

The enthalpy change that occurs when one mole of gaseous ions are completely hydrated by water to form one mole of aqueous ions, under standard conditions.

Define the standard enthalpy change of solution, ΔH_{sol}^{θ}

Define the standard enthalpy change of solution, ΔH_{sol}^{θ}

The enthalpy change that occurs when one mole of ionic compound is completely dissolved in water to form aqueous ions, under standard conditions.

What is bond energy?

What is bond energy?

- The energy in a covalent bond.
- A measure of the strength of a chemical bond.

What is lattice enthalpy?

(A level only)

What is lattice enthalpy? **(A level only)**

The enthalpy change that occurs when 1 mole of a solid ionic compound is formed from its gaseous ions under standard conditions.

How do you directly calculate enthalpy change of a reaction?

How do you directly calculate enthalpy change of a reaction?

- $q = mc\Delta T$
- *m* - mass of the solution that changes temperature ($1g = 1cm^3$)
  c - specific heat capacity (usually of water)
  ΔT - temperature change
  q - heat energy taken in/ released (joules)
- Divide q (in kJ) by the number of moles of the limiting reactant.
- Add a sign to show whether $\Delta H_r^{\ominus}$ is exothermic (-) or endothermic (+).

What are two factors that affect the magnitude of lattice enthalpy?

(A level only)

What are two factors that affect the magnitude of lattice enthalpy? **(A level only)**

- Ionic charge
- Ionic radius

Explain how ionic radius affects lattice enthalpy **(A level only)**

Explain how ionic radius affects lattice enthalpy **(A level only)**

- A smaller ionic radius means the ions are closer together.
- As a result, the positive and negative ions are more strongly attracted together.
- Lattice enthalpy is more exothermic.

Explain how ionic charge affects lattice enthalpy **(A level only)**

Explain how ionic charge affects lattice enthalpy **(A level only)**

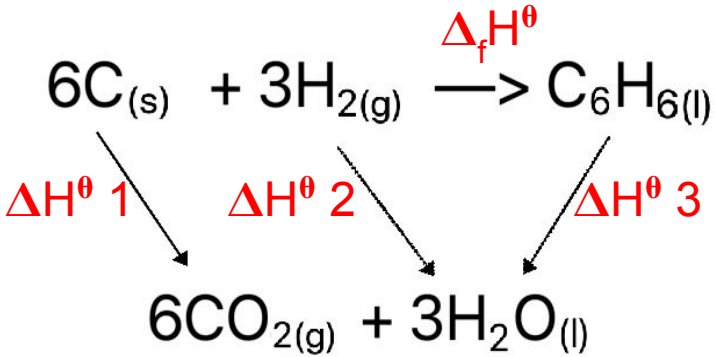
- A greater ionic charge means greater electrostatic attraction between positive and negative ions.
- Lattice enthalpy is more exothermic.

What is Hess' law?

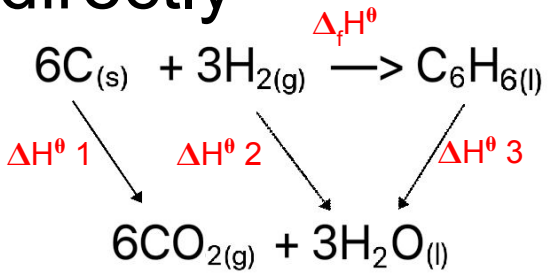
What is Hess' law?

The enthalpy change of a reaction is independent of the route it takes.

How can you use the Hess cycle shown below to indirectly determine an enthalpy change?



How can you use a Hess cycle to indirectly determine an enthalpy change?



- There are two routes shown for this reaction.
- The enthalpy change for $\Delta_f H^\theta$ is equal to $\Delta H^\theta 1 + \Delta H^\theta 2 - \Delta H^\theta 3$.
- Make sure you multiply the enthalpy change by the stoichiometric ratio, i.e. 6 x $\Delta H^\theta 1$.
- Going with the arrow: add the value
  Going against the arrow: subtract the value.

Calculate the enthalpy change of formation of $C_6H_6(l)$ using the table below

	$\Delta_c H^{\theta}$ / kJ mol^{-1}
$C_6H_{6(l)}$	-3267
$C_{(s)}$	-394
$H_{2(g)}$	-286

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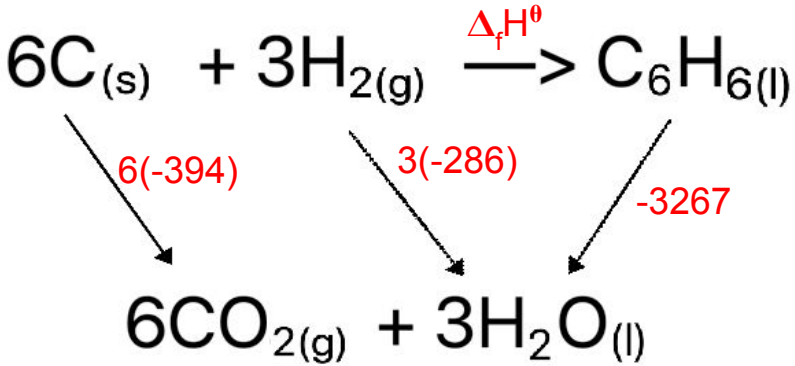

	$\Delta_c H^\theta$ / kJ mol^{-1}
$C_6H_{6(l)}$	-3267
$C_{(s)}$	-394
$H_{2(g)}$	-286

$\Delta_f H^\theta + (-3267) = 6(-394) + 3(-286)$

$\Delta_f H^\theta = 6(-394) + 3(-286) - (-3267)$

$= -2364 - 858 + 3267$

$= +45$ kJ mol^{-1}

Calculate the enthalpy change of reaction for the equation below using the table of bond enthalpies:

$$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$$

Bond	Average bond energy / kJ mol^{-1}
C-O (carbon monoxide)	+1077
C=O	+805

Bond	Average bond energy / kJ mol^{-1}
O-H	+464
H-H	+436

Calculate the enthalpy change of reaction for the equation below using the table of bond enthalpies:

$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$

ΔH = total energy needed to break bonds - total energy made when forming bonds

$\Delta H = +1077 + 2(+464) - (+436) - 2(+805)$

$\Delta H = +2005 - (+2046)$

$\Delta H = -41$ kJ mol^{-1}

(May use a Hess' Cycle instead. Final result should be -41 kJ mol^{-1})

Bond	Average bond energy / kJ mol^{-1}
C-O (carbon monoxide)	+1077
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Draw a diagram using KCl to show how lattice enthalpy, enthalpy change of solution and enthalpy change of hydration are related

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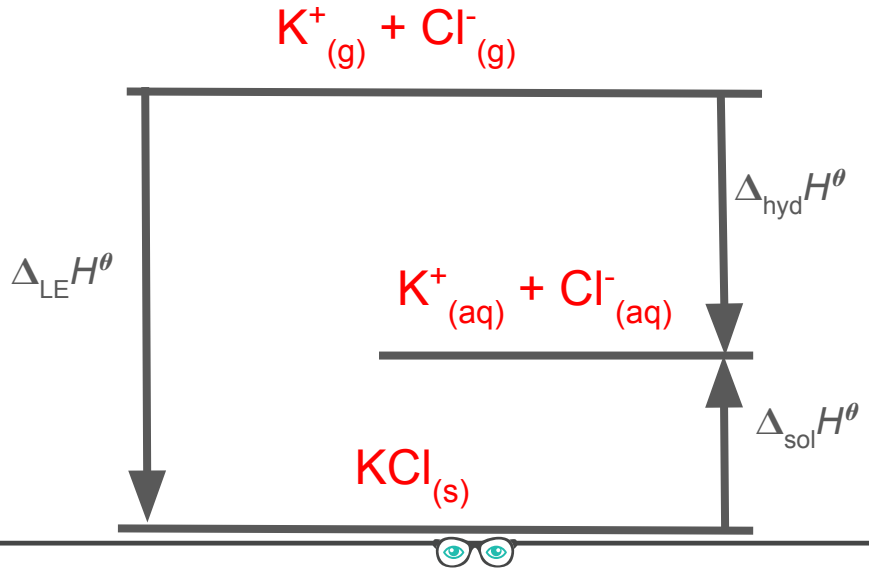


What is first ionisation energy?

(A level only)

What is first ionisation energy? **(A level only)**

The energy required to remove an electron from each atom in one mole of gaseous atoms to form one mole of gaseous 1+ ions under standard conditions.

What is first electron affinity?

(A level only)

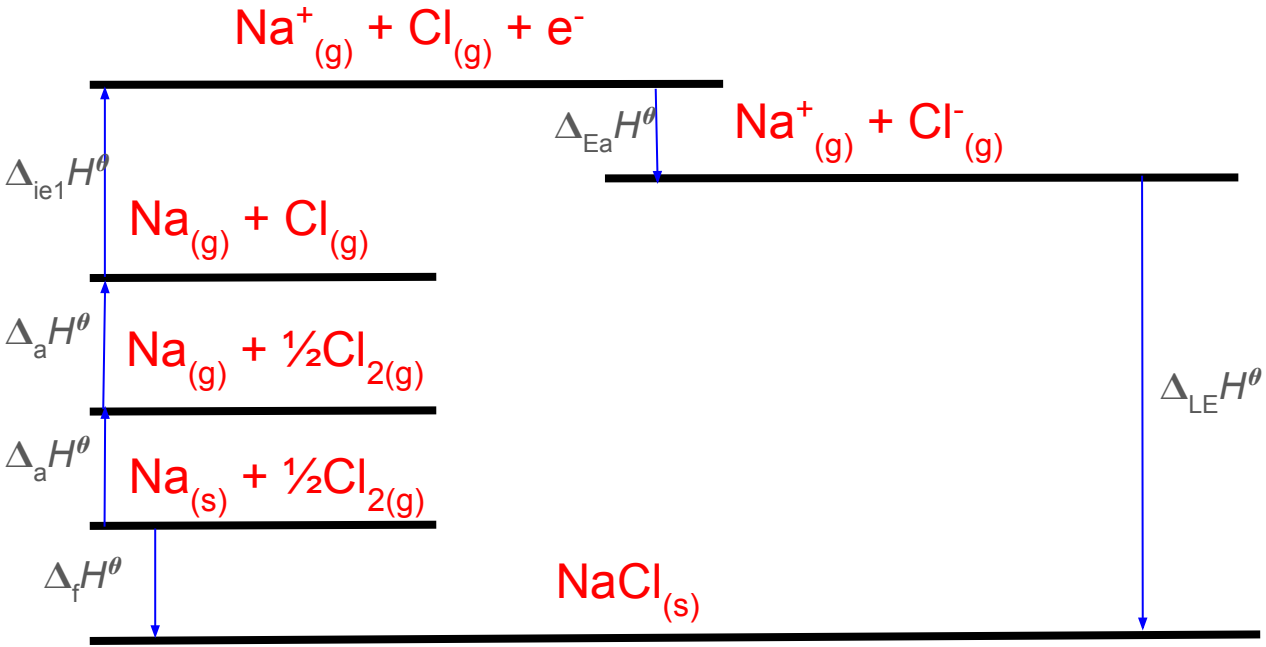
What is first electron affinity? **(A level only)**

The enthalpy change that takes place when each atom in one mole of gaseous atoms gains an electron to form one mole of gaseous 1- ions under standard conditions.

Draw a Born-Haber cycle for NaCl

(A level only)

Draw a Born-Haber cycle for NaCl **(A level only)**



What is average bond enthalpy?

What is average bond enthalpy?

The average enthalpy change that occurs when one mole of gaseous covalent bonds are broken.

What is entropy? **(A level only)**

What is entropy? **(A level only)**

The measure of the disorder of a system.

In terms of entropy, when is a system more stable? **(A level only)**

In terms of entropy, when is a system more stable?
(A level only)

A system is more stable when its energy is spread out/ in a more disordered state. The higher the entropy, the more stable the system.

How does entropy change when a substance changes state? **(A level only)**

How does entropy change when a substance changes state? **(A level only)**

- Entropy increases from Solid → Liquid/Aqueous → Gas.
- This is because the system becomes more disordered.

How does entropy change as temperature changes?

(A level only)

How does entropy change as temperature changes? **(A level only)**

As temperature increases, the particles in a substance gain kinetic energy and become more disordered. As a result, entropy increases.

How does entropy change during a reaction in which the number of gas molecules changes?

(A level only)

How does entropy change during a reaction in which the number of gas molecules changes?

(A level only)

- Entropy increases if the number of gas molecules increases.
- This is because the gaseous state has the highest entropy as there is more disorder in the system.

How do you calculate the entropy change of the system (given the standard entropies of reactants and products)?

(A level only)

How do you calculate the entropy change of the system (given the standard entropies of reactants and products)? **(A level only)**

$$\Delta S = \Sigma S^{\theta}_{products} - \Sigma S^{\theta}_{reactants}$$

When will ΔS be positive? **(A level only)**

When will ΔS be positive? **(A level only)**

When disorder increases

E.g.

- state change from solid to liquid/ liquid to gas
- increase in temperature
- increase in the number of gaseous molecules

What is Gibbs free energy?

(A level only)

What is Gibbs free energy? **(A level only)**

- The overall change in energy during a reaction is Gibbs free energy, ΔG.
- This energy change consists of entropy change (ΔS) and enthalpy change (ΔH) at a given temperature (T).
- $\Delta G = \Delta H - T\Delta S$ (where the units for ΔS have been converted to kJ K^{-1} mol^{-1}).

What does the sign of ΔG say about the feasibility of the reaction?

(A level only)

What does the sign of ΔG say about the feasibility of the reaction? **(A level only)**

- ΔG has to be **negative** for the reaction to be feasible/ spontaneous.
- If ΔG is positive, the reaction is not feasible/ spontaneous at the given temperature.

If ΔH is negative and ΔS is positive, how will changing temperature affect the spontaneity of the reaction?

(A level only)

If ΔH is negative and ΔS is positive, how will changing temperature affect the spontaneity of the reaction? **(A level only)**

ΔG is always negative regardless of temperature so the reaction is spontaneous at all temperatures.

If ΔH is positive and ΔS is negative, how will changing temperature affect the spontaneity of the reaction?

(A level only)

If ΔH is positive and ΔS is negative, how will changing temperature affect the spontaneity of the reaction? **(A level only)**

ΔG is always positive regardless of temperature so the reaction is never spontaneous at any temperatures.

If ΔH and ΔS are positive, how will changing temperature affect the spontaneity of the reaction?

(A level only)

If ΔH and ΔS are positive, how will changing temperature affect the spontaneity of the reaction?

(A level only)

ΔG is only negative at high temperatures so the reaction will not be spontaneous at low temperatures.

If ΔH and ΔS are negative, how will changing temperature affect the spontaneity of the reaction?

(A level only)

If ΔH and ΔS are negative, how will changing temperature affect the spontaneity of the reaction? **(A level only)**

ΔG is only negative at low temperatures so the reaction will not be spontaneous at high temperatures.