The Energy of Reactions

AP Biology

|  |  |  |
| --- | --- | --- |
| **General rule** | **Endergonic** | **Exergonic** |
| Net energy input or energy released? |  |  |
| Anabolic or catabolic? |  |  |
| Increasing complexity or decreasing complexity? |  |  |
| Change in G positive or negative? |  |  |
| Spontaneous or non-spontaneous?  |  |  |
| Molecule complexity greatest in product or reactant? |  |  |
| ADP or ATP produced in the coupled rxn? |  |  |
| Greater energy in the reactants or products?  |  |  |
| Dehydration or hydrolysis? |  |  |
| Photosynthesis or respiration? |  |  |
| Entropy increased or decreased?  |  |  |
| Decomposition or synthesis? |  |  |
|  Energy of reactants and products same or different? |  |  |
| Number of atoms of reactants and products same or different?  |  |  |

Gibbs Free Energy S’math practice

AP Biology

Notes:

• Enthalpy is expressed in kJ (kilojoules)/mol, entropy in J/mol K (joules/moles kelvin), and temperature in K. Cancel the Kelvins, and convert J to kJ using 1000J = 1kJ . Solve for G in kJ/mol.

• Standard temperature is 298K (25C), but some problems use 20C (293K)

• Free energy is calculated using Δ G = Δ H - T ( Δ S) where a negative G value is exergonic (spontaneous) and a positive is endergonic (non-spontanteous)

• Practice Problems:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Rxn*  | *Δ enthalpy (kJ/mol)* | *Δ entropy (J/mol K)* | *Δ Free energy (kJ/mol)* | *Ender- or exergonic?**Spontaneous or not?* |
| A + B -> AB | +12 | -5 |  |  |
| CD -> C + D | -32 | +25 |  |  |
| CH4 + 2O2 -> CO2 + 2H2O | -890 | -243 |  |  |
| N2 + 3H2 -> 2NH3 | -92 | -199 |  |  |
| Hydrolysing ATP ->  ADP + Pi | - | - | -0.31 |  |
| Phosphorylation of Glucose (glucose + Pi) | - | - | +14 |  |
| \* 2COCl2 + H2O ->  CO2 + 2HCl | -223 | +284 |  |  |

\* Phosgene, COCl2, was used as a weaponized gas during World War I. It reacts with moisture in the lungs to produce HCl, which causes the lungs to fill with fluid, leading to death. Use the energy values above, at a **body temp of 37C (310K)** to see if this reaction is spontaneous or not.

More problems (bell ringers? )

1. A rxn occurs at STP (21C). Enthalpy is 12kJ/mol. Entropy is -5kJ/mol K. Solve for free energy.

Change in G = 12 – (293)(-5)

G = 12 + 1465

G = 1477

2. Nitrification is a key step in the nitrogen cycle, as it converts the ammonia produced in N-fixation into nitrates useable by cells for proteins and DNA.

The ammonium ion -> nitrite results in a GFE = --274.88/mol. M

(2NH4+ + O2 -> 2NO2 + 4 H+ + 2 H2O)

Next, the nitrite -> nitrate with an associated GFE = 73.22kJ/mol

(2NO2- + O2 -> 2NO3)