

The Energy of Reactions
 AP Biology

General rule	Endergonic	Exergonic
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?		
ATP coupled process, or ATP produced?		
Greater energy in the reactants or products?		
Dehydration or hydrolysis?		
Photosynthesis or respiration?		
ATP formed, or ADP + P?		
Entropy increased or decreased?		
High energy bonds formed, or broken?		
Decomposition or synthesis?		
Energy of reactants vs products same or different?		
Atoms of reactants vs products same or different?		

Gibbs Free Energy S'math practice
AP Biology

Notes:

- Enthalpy is expressed in kJ (kilojoules)/mol, entropy in J/K (joules/kelvin), and temperature in K. Cancel the Kelvins, and convert J to kJ by dividing by 1000 to find G in kJ.
- Standard temperature is 298K (25C), but some problems use 20C (293K)
- Free energy is calculated using $\Delta G = \Delta H - T (\Delta S)$ where a negative G value is exergonic (spontaneous) and a positive is endergonic (non-spontaneous)

• Practice Problems:

Rxn	Δ enthalpy (kJ/mol)	Δ entropy (J/K)	Δ Free energy (kJ/mol)	Ender- or exergonic? Spontaneous or not?
A + B -> AB	+12	-5		
CD -> C + D	-32	+25		
CH ₄ + 2O ₂ -> CO ₂ + 2H ₂ O	-890	-243		
N ₂ + 3H ₂ -> 2NH ₃	-92	-199		
Hydrolysing ATP -> ADP + Pi	-	-	-0.31	
Phosphorylation of Glucose (glucose + Pi)	-	-	+14	
* 2COCl ₂ + H ₂ O -> CO ₂ + 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.

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General rule	Endergonic	Exergonic
Energy input or energy released?	input	released
Anabolic or catabolic?	anabolic	catabolic
Increasing complexity or decreasing complexity?	increasing	decreasing
Change in G positive or negative?	positive	negative
Spontaneous or non-spontaneous?	non-spont	spontaneous
Molecule complexity greatest in product or reactant?	product	reactant
ATP coupled process, or ATP produced?	coupled	produced
Greater energy in the reactants or products?	products	reactants
Dehydration or hydrolysis?	dehydration	hydrolysis
Photosynthesis or respiration?	psn	cell resp
ATP formed, or ADP + P?	ADP + P	ATP
Entropy increased or decreased?	decreased	increased
High energy bonds formed, or broken?	formed	broken
Decomposition or synthesis?	synthesis	decomposition
Energy of reactants vs products same or different?	same!	diff @ "
Atoms of reactants vs products same or different?	same!	same @ "

under?

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• Practice Problems:

<i>Rxn</i>	Δ enthalpy (kJ/mol)	Δ entropy (J/K)	Δ Free energy (kJ/mol)	<i>Ender- or exergonic?</i> <i>Spontaneous or not?</i>
1 A + B -> AB	+12	-5		
2 CD -> C + D	-32	+25		
3 CH ₄ + 2O ₂ -> CO ₂ + 2H ₂ O	-890	-243		
4 N ₂ + 3H ₂ -> 2NH ₃	-92	-199		
5 Hydrolysing ATP -> ADP + Pi	-	-	-0.31	
6 Phosphorylation of Glucose (glucose + Pi)	-	-	+14	
7 * 2COCl ₂ + H ₂ O -> CO ₂ + 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.

Key

$$\begin{aligned} 1) \Delta G &= \cancel{+12} - (\cancel{298K})(\cancel{-5J/K}) \\ &= +12 \text{ kJ} - (298K)(-5J/K) \\ A+B \rightarrow AB &= +12 \text{ kJ} - \left(\frac{-1490 \text{ J}}{1000 \text{ K}} \right) \\ &= 12 \text{ kJ} + 1.49 \text{ kJ} \end{aligned}$$

$$\Delta G = 13.5 \text{ kJ} \quad \text{endergonic; non-spontaneous}$$

$$\begin{aligned} 2) \Delta G &= -32 \text{ kJ} - (298K)(25J/K) \\ C+D \rightarrow C+D &= -32 \text{ kJ} - \left(\frac{7450 \text{ J}}{1000 \text{ K}} \right) \\ &= -32 \text{ kJ} - 7.45 \text{ kJ} \end{aligned}$$

$$\Delta G = -39.45 \text{ kJ} \quad \text{exergonic; spontaneous}$$

$$\begin{aligned} 3) \Delta G &= -890 - \frac{(298)(-243)}{1000} \\ \text{CH}_4 &= -890 - (-72.4) \end{aligned}$$

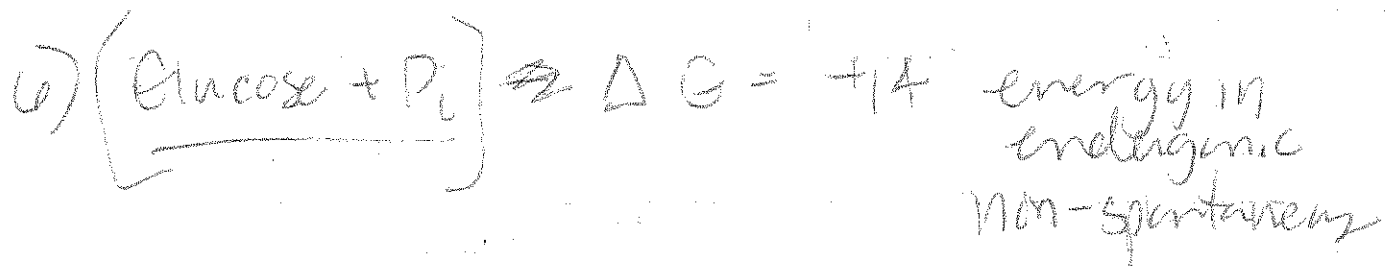
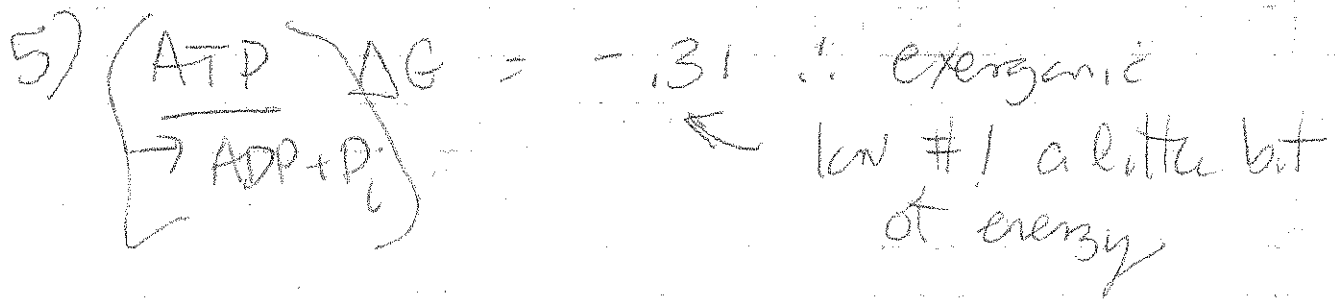
$$\Delta G = -817.6 \quad \text{exergonic}$$

$$4) \Delta G = -92 - \frac{(298)(-199)}{1000}$$

$$\Delta G = -92 - (-59.30)$$

$$\Delta G = -32.7 \quad \text{exergonic}$$





$$\Delta G = -223 - \frac{(310)(284)}{1000}$$

$$= -223 - 88.04$$

$$\Delta G = -311$$

exergonic non
 spontaneous