Eng Gen 140

from
(course book / handouts / past slides)

Mitochondria pump 10^{21} protons (H^+) per second during respiration, which generates a voltage gradient across the 6 nm mitochondrial membrane of 180 mV

Calculate the voltage gradient across the mitochondria in terms of volts/m.

Substance	Energy yield			Form of Activity	Total energy expenditure ($kcal.h^{-1}$)
	$kJ.mol^{-1}$	$kJ.g^{-1}$			
Glucose	2,817	15.6		Lying still, awake	77
Lactate	1,364	15.2		Sitting at rest	100
Palmitic acid	10,040	39.2		Walking, level ground	200
Carbohydrate	-	16		Sexual intercourse	280
Fat	-	37		Biking, level ground	305
Protein	-	23		Walking, uphill	360
Ethyl alcohol	-	29		Jogging	570
Coal	-	28		Rowing	830
Oil	-	48		Maximal activity (untrained)	1440

A calorie is a unit of energy that is often found in older texts and is still common in food science. One calorie = 4.184 J, which is the energy required to increase the temperature of 1 g of H2O from 14.5 C to 15.5 C.

Using Table 8 in your coursebook, calculate the total energy expenditure (in J) following 20 mins of jogging, and compare this to 2 h of walking on level ground.

Estimate how high a ladder could a 70kg person climb, fuelled by a Cadbury Moro bar, which has the following nutritional content: 10g fat, 45g sugar, and 3g protein. Assume muscle is 24% efficient and obtain energy yield from Table 8 below.

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What is the difference between the Gibbs Free Energy of glucose and the change in Enthalpy ΔH, for glucose (Table 7)? What explains this difference?

ΔG = -2880 kJ/mol
ΔH = -2808 kJ/mol

72 kJ/mol

$$G = U + PV - TS$$
$$H = U + PV$$
$$G = H - TS$$

$$\Delta G = \Delta H - T\Delta S$$
$$-2980 = -2808 - 72$$

$$T\Delta S = 72$$

Another important biological reaction is the combination of simple sugars (monosaccharides) to form more complex chains of sugars (e.g. disaccharides, such as sucrose)

$$glucose + fructose \rightarrow sucrose + H_2O$$

$$\Delta G = +23\ kJ.mol^{-1}$$

This is an endergonic, non-spontaneous reaction, meaning that additional energy is required for the reaction to take place

If we reversed the reaction above and hydrolysed the sucrose, what would be ΔG?

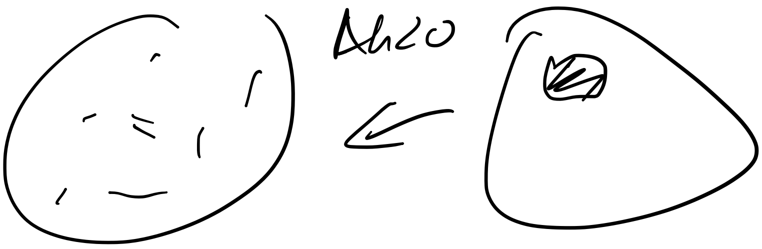
−23 kJ/mol.

Remember, the sign of the change in Enthalpy determines whether a reaction will release heat or absorb heat. Describe the cases below as being exothermic or endothermic.

ΔH > 0:

ΔH < 0:

ΔH<0



Is ΔH sufficient to determine whether a reaction will be spontaneous?

No ΔG

$$\Delta G = \Delta H - T\Delta S$$ (at T, P const)

can make ΔG sign diff. to ΔH.

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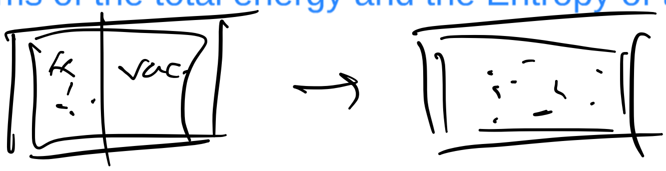
$$G = U + PV - TS$$

$$\Delta G = \Delta U + P\Delta V + \Delta P V - \Delta T \cdot S - T\Delta S$$

Consider a gas released into a vacuum. Describe what happens to the gas, in terms of the total energy and the Entropy of the system



The inevitable increase of Entropy with time, as stated by the Second Law of Thermodynamics seems to contradict the mere existence of biological systems. If entropy is pushing us further and further toward a state of disorganisation, how can it be that biological systems create more order and develop highly structured organs and organ systems?

For example, in the sugar cane plant, the overall reaction in which two monosaccharides are combined to form the disaccharide sucrose is given by:

$$glucose + fructose \rightarrow sucrose + H_2O$$

Which is an endergonic reaction with a $\Delta G = +23$ kJ/mol. Calculate the change in free energy if the reaction is coupled with 2ATP molecules.

(Hydrolysis of)

$$2[ATP + H_2O \rightarrow ADP + P]$$

(1) $2ATP + 2H_2O \rightarrow 2ADP + 2P \quad \} \; 2 \times \left(-29 \frac{kJ}{mol}\right)$

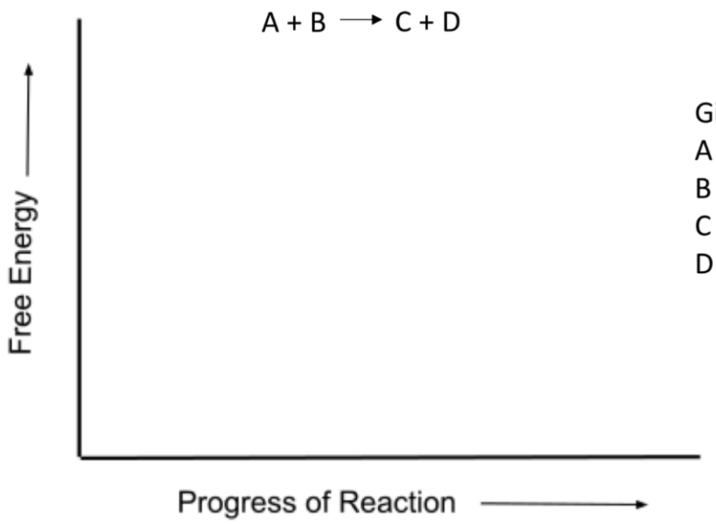
(2) $g + f \rightarrow s + H_2O \quad + 23 \frac{kJ}{mol}$

$$\Delta G^{overall} = 23 \frac{kJ}{mol} + 2 \times \left(-29 \frac{kJ}{mol}\right)$$

$$= -35 \text{ kJ/mol}.$$

from (course book / handouts / past slides)

Calculate the total change ΔG for the reaction, given the Gibbs Free Energies of the reactants and products below. Sketch the reaction in the figure below, indicating the reactants, products, and ΔG. State whether the reaction is exergonic or endergonic.



Gibbs Free Energy
A = 13 kJ/mol
B = 32 kJ/mol
C = -39 kJ/mol
D = 56 kJ/mol

What is the rate of consumption of hydrogen gas in the following reaction when its concentration decreases by 0.2 mol/L in 10 s?

Is the rate the same if expressed in terms of HI?

The average rate of combustion of a candle made of paraffin, $C_{25}H_{52}$, is 8.33×10^{-4} mol/min. The molar mass of paraffin is 352.6 g/mol. You want the candle to burn for 4h. The candle is only sold in four sizes: 25, 50, 75 or 100 g. Which one is the smallest one you could use?

$r = 8.33\times10^{-4}$ mol/min $\left(352.6 \frac{g}{mol}\right)$

required time $= 4h = 4\cancel{h} \times 60 \frac{min}{\cancel{h}} = 240 min$

amount required [=] mol, $= r \times t = 8.33\times10^{-4} \frac{mol}{\cancel{min}} \times 240 \cancel{min}$

≈ 0.2 mol

$= 0.2 \cancel{mol} \times 352.6 \frac{g}{\cancel{mol}} = 70.2$ g

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Predict what might happen to the reaction rate with an increase in temperature. Describe this at a molecular level.

Draw what you might predict the Reaction rate vs substrate concentration curve and Reaction rate vs enzyme concentration curve to look like. Put Reaction rate on the y-axis.

The free energy available from glucose is $\Delta G = -2862$ kJ/mol under standard conditions. In respiration, 38 ATP molecules are synthesised for each glucose molecule:

$$C_6H_{12}O_6 + 6O_2 + 38\ ADP + 38\ P \rightarrow 6CO_2 + 6H_2O + 38\ ATP$$

Under standard conditions, each ATP can contribute $\Delta G = -29$ kJ/mol to drive reactions in the cell

Calculate the efficiency of the cell

Stage 1 of respiration (Glycolysis) does not require oxygen, so can be used to generate ATP from sugar, fat, and protein

Comment on the number of ATP molecules you would produce from just glycolysis and compare this to aerobic respiration

(2017 Exam)

→ see other handout!