Questions and Answers for Lecture 1, redox equations

1) What is the energy source, carbon source and electron donor of a

a) photolithoautotrophic microorganism?

b) chemoorganoheterotrophic microorganism?

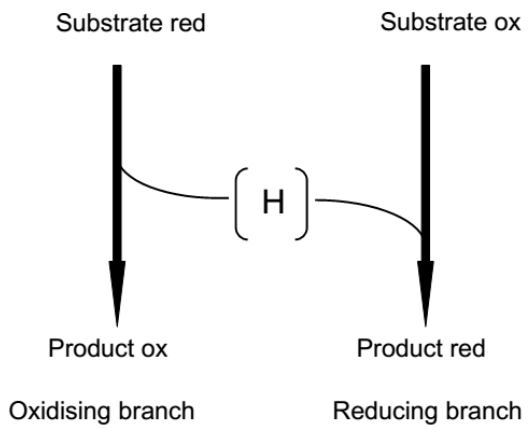
a) light, inorganic compound, inorganic carbon (CO2)

b) chemical energy source, organic compound as electron donor, organic carbon source

2) Give the redox reaction for the denitrification process:

Reduction reaction: $NO_3^- + 5\ e^- + 6\ H^+ \rightarrow 0.5\ N_2 + 3\ H_2O$:

3) In which two parts can the energy-metabolism be divided? What are the respective mechanisms to preserve energy gain?



oxidising branch: substrate level phosphorylation

reducing branch: electron transport phosphorylation

4a) How can microbes be classified (energy source, carbon source, ..)?

b) Difference between fermentation and aerobic respiration?

c) Draft the different ways of energy conservation.

a)

- Energy source chemo - photo
- e- donor organo - litho
- Carbon source hetero - auto

b) respiration yields ATP via electron transport phosphorylation, fermentation via substrate level phosphorylation

c) oxidative branch: substrate level phosphorylation
reductive branch: electron transport phosphorylation

5) What is the difference between substrate level phosphorylation and oxidative phosphorylation? In what cell process are they employed?

Substrate level phosphorylation: reaction where an energy rich organic phosphorylated compound is generated and ATP is produced (or GTP) by an transpherase reaction

oxidative phosphorylation: reaction where electrons are transported along a respiratory chain and protons are pumped across the membrane. ATP is produced via proton motive force.

6) What is the definition of a reduction and an oxidation?

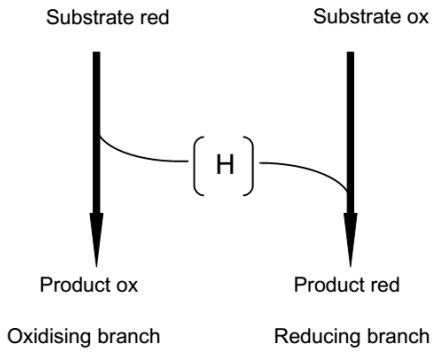
Oxidation: losing of electrons
reduction: receiving electrons

7) Write down the redox equation of the reduction sulfate to hydrogen sulfide and name an organism doing this reaction.

Organism: *Desulfovibrio desulfuricans*

Red.: $SO_4^{2-} + 8\ e^- + 10\ H^+ \rightarrow H_2S + 4\ H_2O$

8) Describe how microorganisms conserve energy. What is the driving force?



oxidative branch: substrate level phosphorylation
reductive branch: electron transport phosphorylation

The driving force for the reaction is the energy difference between the electron donor and acceptor.

1. All catabolic reactions involve e^- transfer which allows energy to be captured in high energy bonds like ATP. There are two major ways of generating this energy.
   Which two ways do you know and what is their difference?

   a) Substrate level phosphorylation → only during oxidation using energy from high energy bonds
   b) e^- transfer phosphorylation → during reduction using energy of proton motive force to generate ATP

2. Write down the balanced equation for denitrification (anaerobic respiration; with NO_3^- to N_2) of glucose.

$$C_6H_{12}O_6 + 6\ H_2O \rightarrow 6\ CO_2 + 24\ e^- + 24\ H^+ \qquad \text{I} *5$$
$$2\ NO_3^- + 12\ H^+ + 10\ e^- \rightarrow N_2 + 6\ H_2O \qquad \text{I} *12$$
$$5\ C_6H_{12}O_6 + 24\ NO_3^- + 24\ H^+ \rightarrow 30\ CO_2 + 12\ N_2 + 42\ H_2O$$

3. a) Write the redox reaction that shows how microorganisms oxidize glucose with oxygen as electron acceptor.

$$C_6H_{12}O_6 + 6\ H_2O \rightarrow 6\ CO_2 + 24\ e^- + 24\ H^+$$
$$O_2 + 4\ H^+ + 4\ e^- \rightarrow 2\ H_2O \qquad \text{I} *6$$
$$C_6H_{12}O_6 + 6\ H_2O \rightarrow 6\ CO_2 + 24\ e^- + 24\ H^+$$
$$6\ O_2 + 24\ H^+ + 24\ e^- \rightarrow 12\ H_2O$$
$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

   b) Which CO_2 concentration do we obtain from the oxidation of 5g/l of glucose?

$$x = \frac{6 * 5\ g/l}{180\ g/mol} = \frac{1}{6}\ mol/l$$

Which is the energy source, carbon source and the electron donor of a chemolithoautotrophic organism? Do you know an organism as an example?

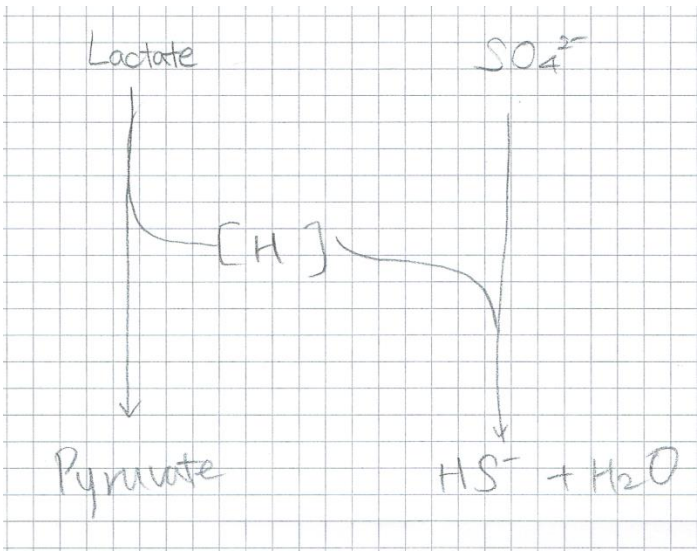
Energy: chemo -> chemical substances

Electron donor: litho -> inorganic substances

Carbon source: auto -> inorganic carbon

Example: Nitrifying bacteria

Show the schematic oxidation and reduction pathway (degradation) of Lactate.



Is the reaction of the ATP synthase reversible? Is it of importance for the cell?

Yes. ATP -> ADP + P_i

Yes, ATP is essential as energy currency.

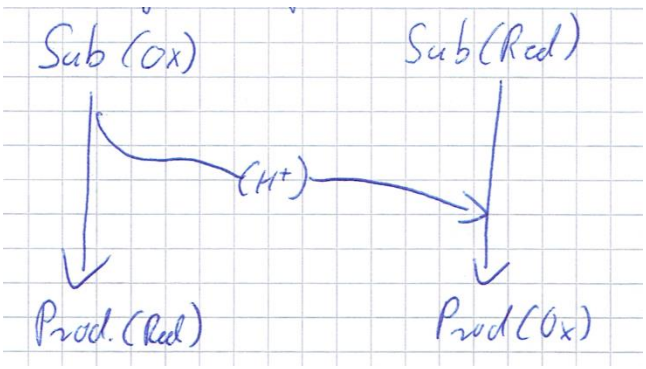
To which order belongs Desulfovibrio desulfuricans? (comment Meckenstock: do you really want to have such questions in an exam? To me this is too specific → I suggest more demanding questions)

Desulfovibrionales

Explain the principle of energy conservation in organisms including the specific characteristic of fermentation. Give one example for energy conservation.

Substrate reduction and substrate oxidation

Electron transport phosphorylation



Fermentation: Resulting product will be used again as electron acceptor

Determine the oxidation number of pyruvate (CH_3COCOO^-).

3 x O → +6

3 X H → -3

1 x (-) → -1

Sum: +2

Write the Redox equation for the oxidation of Glucose with sulfate as electron acceptor.

$C_6H_{12}O_6 + 6\ H_2O \rightarrow CO_2 + 24\ H^+ + 24\ e^-$

$SO_4^{2-} + 10\ H^+ + 8\ e^- \rightarrow H_2S + 4\ H_2O$ | x3

Total: $C_6H_{12}O_6 + H_2O + 3\ SO_4^{2-} + 6\ H^+ \rightarrow CO_2 + 3\ H_2S + 6\ H_2O$