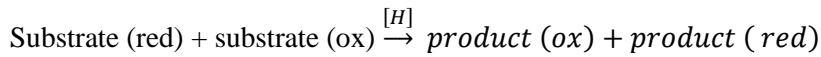


Question

1. What kind of reaction is performed by all organisms in order to conserve energy and which main components are required? **What is the general principle of energy conservation?**

Answer:



Main substances: [H]; [e⁻]; ADP; [P_i]

Energy is conserved by substrate level phosphorylation in the course of oxidation of the substrate and by electron transport phosphorylation in reduction of an electron acceptor (e.g. oxygen reduction). Electron transport phosphorylation also takes place in photosynthesis.

Question:

Write down the equations of four anaerobic respiratory chains

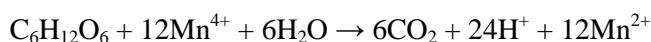
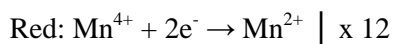
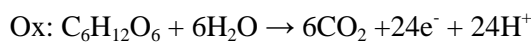
Answer:

- $2[H] + Mn^{4+} \rightarrow Mn^{2+} + 2H^+$
- $[H] + Fe^{3+} \rightarrow Fe^{2+} + H^+$
- $2[H] + S \rightarrow H_2S$
- $8[H] + SO_4^{2-} + 2H^+ \rightarrow H_2S + 4H_2O$

Question:

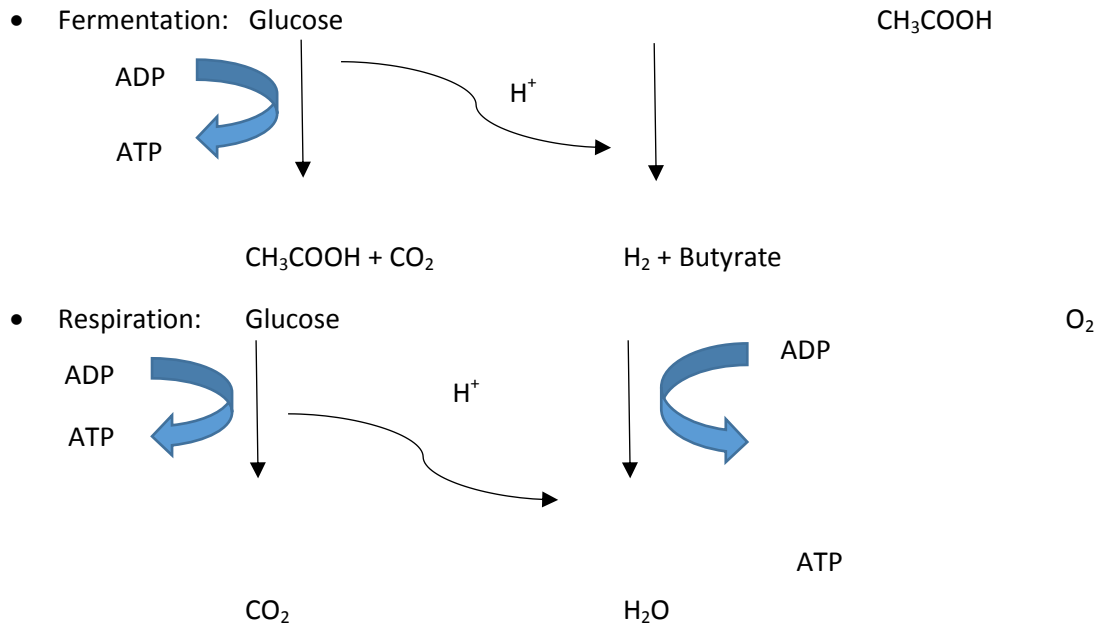
Write the redox equation for the oxidation of glucose with Mn⁴⁺

Answer:



2. **What process is required to oxidise glucose to eg. CO₂?**
 - For example (there are more ways) Glycolysis, tri-carbonic acid cycle
 - Glucose is oxidized to $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

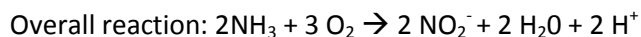
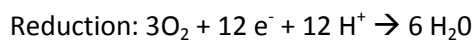
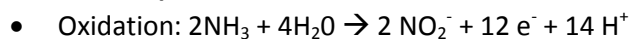
3. Give an example of ATP-conservation in a fermentation and respiration process.



4. Can you determine the phenotype from the genotype?

- No. If one finds a gene sequence in the genome there is a potential that this function is expressed → phenotype. If there are no other options for this function, it might be true that this gene is expressed to a predicted phenotype. However, the gene sequence is not a prove, it's a hint.

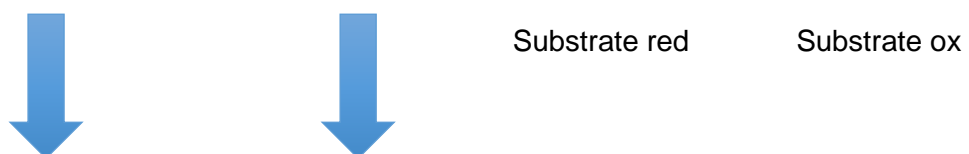
5. Some bacteria aid the destruction of historical monuments by nitrification. These bacteria, for example *Nitrosomonas* use elemental oxygen for the oxidation of ammonia. Show the redox equation for this reaction.



However hidden behind the equation is the important step of the ammonia monooxygenase to activate ammonia to hydroxylamine. This need of molecular oxygen is not reflected in the overall stoichiometry.

Question: How do microbes conserve energy? Give one example. What is the driving force?

Answer: There are two substrates. One gets oxidized and one reduced.





Product ox product red

Oxidizing branch reducing branch

Example: $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$

Question: What is the difference between respiration and fermentation?

Answer: Fermentation does only lead to ATP-production by substrate level phosphorylation in the oxidative branch. Respiration leads to electron transport phosphorylation.

Question: Find a method to remove dissolved Iron Fe^{2+} from water!

Answer: $4 Fe^{2+} + O_2 \rightarrow 4 Fe^{3+}$

$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3 \downarrow + 3H^+$

$4 Fe^{2+} + O_2 + 12 H_2O \rightarrow 4 Fe(OH)_3 \downarrow + 12 H^+$

O_2 oxidize ferrous iron (Fe^{2+}) to ferric iron (Fe^{3+}) which precipitates as ironhydroxid at (pH 7)

Question: In glucose fermentation:

- i. O_2 can be used as electron acceptor
- ii. ATP can be produced from both, oxidative and reductive branches
- iii. The amount of energy conserved is less than with respiration
- iv. Glucose can be oxidised to form lactate

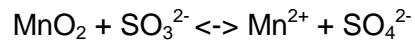
Tick the right answer!

Answer: The answer is iii. and iv.

Question: What does chemo-organo-hetero-troph mean and which microbe is part of this category?

Answer: The energy they utilize is from chemical compounds. The electron source is from an organic compounds and they utilize organic compounds as a carbon source. *Desulfovibrio desulfuricans* is chemo-organo-heterotroph.

Question: Fill in the chemical equation!



Answer: $\text{MnO}_2 + \text{SO}_3^{2-} + 2\text{H}^+ \leftrightarrow \text{Mn}^{2+} + \text{SO}_4^{2-} + \text{H}_2\text{O}$

Question: Some microorganisms can oxidize ammonia anaerobically with nitrite. Write down the redox equation. How is that process called?

Answer: Anamox: $\text{NH}_4^+ + \text{NO}_2^- \rightarrow \text{N}_2 + 2\text{H}_2\text{O}$

Question: What are the differences in energy sources, electron donors and carbon sources in microbial metabolism?

Answer:

energy source:	chemotroph or phototroph
Electron donor:	organotroph or lithotroph
Carbon sources:	autotroph or heterotroph

Question: Give the overall reaction of denitrification and name the enzymes which are involved!

Answer: $2\text{NO}_3^- + 12\text{H}^+ + 10\text{e}^- \rightarrow \text{N}_2 + 6\text{H}_2\text{O}$

Nitrate reductase, Nitrite reductase, NO reductase, and nitrous oxide reductase