Sek. II

Photo-Blue-Bottle

A model experiment for energy conversion and energy storage in a light-driven concentration cell

required previous knowledge: galvanic cell | concentration cell | photosynthesis (biology; lower secondary classes) | NERNST equation (only necessary for **E3**)

P(hoto)-B(lue)-B(ottle) base experiment

PBB – Tutorial analysis

T1

The German tutorial 'Photosynthese – ein Fall für Zwei: Teil 1' contains a comparison between the natural processes within the photosynthesis/cellular respiration-cycles, and PBB model experiment. First, identify the corresponding cycle parts and the corresponding substances in the two cycles. Then mark low-energy and high-energy substances (draft a legend!).

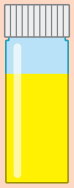
T2 Following the tutorial, create a labelled sketch of the experimental set-up for the photoelectrochemical concentration cell. Give the redox-reactions for the sub-strate.

T3 Describe the two processes of energy conversion and energy storage taking place in the PBB-experiment.

T4 Explain the correlation between photosynthesis and the galvanic cell in the tutorial.

Finished? An assignment for the quick ones:
T5|E5 Point out the limits to the model experiment.

B1 Using the provided material (hot plate, torch with different light colours, UV torch), explore how to drive a chemical reaction in the vial. This becomes evident when a blue substance generated in the reaction becomes visible *within the yellow solution*.



Contents:
3 chemicals (EV^{2+}, PF^{+}, EDTA*)
+ water
+ air

Hint: colours within the visible light spectrum

high in energy — low in energy

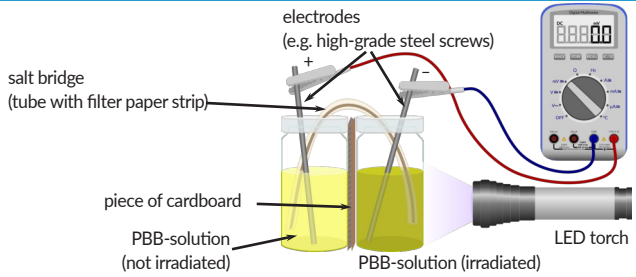
B2 Is the statement T rue or F alse?
Test your decision either by conducting or by suggesting an appropriate experiment.

- ☐ The chemical reaction YELLOW → BLUE requires warmth as a source of energy.
- ☐ The reaction BLUE → YELLOW requires light energy.
- ☐ The reaction cycle YELLOW → BLUE → YELLOW runs only two times.
- ☐ The reaction BLUE → YELLOW will not take place if there is no air above the solution.
- ☐ The reaction BLUE → YELLOW requires oxygen.
- ☐ The PBB-experiment is a model for the natural cycle of photosynthesis and cellular respiration.
- ☐ The blue solution is richer in energy than the yellow one.

PBB – Energy conversion and energy storage

E1 Photoelectrochemical concentration cell

Fig. 1



Following figure 1, set up the experiment and switch on the LED torch. Observe voltage and colour for three minutes. Switch off the light and observe another three minutes. Name all forms of energy which are involved in the experiment.

E2 The following reduction is responsible for the build-up of voltage: $\mathbf{EV^{2+}} + \mathbf{e^-} \xrightarrow{\text{Light}} \mathbf{EV^{+}}$. However, the ratio $\frac{c(\mathbf{EV^{2+}})}{c(\mathbf{EV^{+}})}$ plays a decisive role. By using chemical equations, explain the chemical processes which take place at the two electrodes.

E3 The concentration cell shows a voltage of 200 mV. Calculate the ratio $\frac{c(\mathbf{EV^{2+}})}{c(\mathbf{EV^{+}})}$ in the irradiated half-cell ($E^0(\mathbf{EV^{2+}}/\mathbf{EV^{+}}) = -0{,}45$ V). Assume that the ratio in the other, not irradiated half-cell is $\frac{c(\mathbf{EV^{2+}})}{c(\mathbf{EV^{+}})} = 10^{10}$.
Afterwards, compare the ratio $\frac{c(\text{Ox})}{c(\text{Red})}$ in the two half-cells and give reasons for the differences.

E4 Experiment E1 works with sunlight, too. Assess the suggested name 'solar accumulator' for the concentration cell. Then discuss why the production and storage of electrical energy from sun light is of utmost importance for our society.