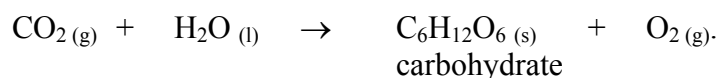


Challenge Problem on Photosynthesis

The following series of problems could be assigned in three sets (1+2, 3+4 and 5+6) over a period of several weeks.

Photosynthesis uses solar energy to reduce (“fix”) carbon from carbon dioxide to carbohydrate. The overall process is described by the following unbalanced equation:



1. An average rate of solar energy incidence on the Earth’s surface is $4.0 \text{ kJ min}^{-1}\text{ft}^2$. How much solar energy will be available to plants in an area of 1 hectare ($1.00 \times 10^4 \text{ m}^2$) per hour?
2. Calculate the standard free energy change (standard enthalpy change) for photosynthesis (a) per mol of carbon dioxide and (b) per gram of carbohydrate.
3. Assuming that absorption of incident solar energy and utilization in photosynthesis are 100% efficient, calculate mol of carbohydrate that can be produced by a hectare of crops in 1 hour.
4. Under optimal conditions a hectare of crops yields about 21 kg of carbohydrate per hour. How efficient is the harnessing of solar energy for photosynthesis?
5. Given the efficiency calculated in #4, how many liters of carbon dioxide are taken up per hectare per day, assuming 12 hours of sunlight, a temperature of 28°C , and a barometric pressure of 756 mm Hg?
6. It is estimated that an area of tropical rain forest equal to the state of Pennsylvania is destroyed each year. The environmental consequences include a decrease in the Earth’s capacity to absorb atmospheric carbon dioxide, which has been greatly increased by industrial activity and development. Assuming the conditions in #5, calculate how many fewer liters of carbon dioxide per 12-hour daylight period can be absorbed worldwide, due to one year’s rain forest depletion.