

Problem 5.6. A muscle can be thought of as a fuel cell, producing work from the metabolism of glucose:



- (a) Use the data at the back of this book to determine the values of ΔH and ΔG for this reaction, for one mole of glucose. Assume that the reaction takes place at room temperature and atmospheric pressure.
 - (b) What is the maximum amount of work that a muscle can perform, for each mole of glucose consumed, assuming ideal operation?
 - (c) Still assuming ideal operation, how much heat is absorbed or expelled by the chemicals during the metabolism of a mole of glucose?
 - (d) Use the concept of entropy to explain why the heat flows in the direction it does.
 - (e) How would your answers to parts (b) and (c) change, if the operation of the muscle is not ideal?
- (a)

Problem 5.18. Imagine that you drop a brick on the ground and it lands with a thud. Apparently the energy of this system tends to spontaneously decrease. Explain why.

Response.

Problem 5.32. The density of ice is 917 kg m^{-3} .

- (a) Use the Clausius-Clapeyron relation to explain why the slope of the phase boundary between water and ice is negative.
- (b) How much pressure would need to be put on an ice cube to make it melt at -1°C ?
- (c) Approximately how deep under a glacier would one need to be before the weight of the ice above gives the pressure found in part (b)?
- (d) Make a rough estimate of the pressure under the blade of an ice skate, and calculate the melting temperature of ice at this pressure. Some authors have claimed that skaters glide with very little friction because the increased pressure under the blade melts the ice to create a thin layer of water. Is this claim plausible?

(a)

Problem 5.33. An inventor proposes to make a heat engine using water/ice as the working substance, taking advantage of the fact that water expands as it freezes. A weight to be lifted is placed on top of a piston over a cylinder of water at 1°C . The system is then placed in thermal contact with a low-temperature reservoir at -1°C until the water freezes into ice, lifting the weight. The weight is then removed and the ice is melted by putting it in contact with a high-temperature reservoir at 1°C . The inventor is pleased with this device because it can seemingly perform an unlimited amount of work while absorbing only a finite amount of heat. Explain the flaw in the inventor's reasoning, and use the Clausius-Clapeyron relation to prove that the maximum efficiency of this engine is still given by the Carnot formula, $1 - T_c/T_h$.

Response.