The Physical Basis of Biochemistry

Contents

Q.5.10 What is the

(a) work performed by a 50 kg gymnast who performs a lift on the rings and is elevated 1.2 m in the air?
(b) How many joules and how many calories must be supplied to the muscles?
(c) Assuming 100% efficiency in energy extraction from sugar and given that there are 4 kcal/gram of sugar and 5 g in a teaspoon, how many teaspoons of sugar should be consumed at lunch to make the lift?

5.2 Answers

A.5.1 A conservative system is one in which the energy of a point in state space is related to its position. Gravity and electrical potential are both examples of conservative forces.

A.5.2 (a) The total energy of a system is fixed and equal to the sum of the kinetic and potential energy in the system. (b) Because energy is conserved, the frictionless pendulum will have 4 J of energy at the bottom of its swing, where all of the energy will be kinetic.

A.5.3 $10^{21}/10^{10} = 100,000,000,000$ lifespans. N.B., the stability of the electron can be approximated as being stable for the period of time of interest to human survival in our solar system.

A.5.4 Mass and energy, linear momentum, and angular momentum. If experimental results depended on space-time location, reproducing experiments would be uncertain.

A.5.5 As shown in Equation 6.3 and its associated text, the force acting on an object is proportional to its mass and acceleration. Its momentum is proportional to its mass and velocity. a) $F = ma; F = 1000\ \text{kg} \times 5\ \text{m/s}^2 = 5000\ \text{N}$, (b) $5\ \text{s} \times 5\ \text{m/s}^2 = 25\ \text{m/s}$, (c) Momentum $= mv = 1000\ \text{kg} \times 25\ \text{m/s} = 25,000\ \text{kg} \cdot \text{m/s}$

A.5.6 As shown in Equation 6.3 and its associated text, the force acting on an object is proportional to mass and acceleration, and its momentum is proportional to its mass and velocity. (a) $F = ma; F/m = a; 5000\text{N}/100\text{kg} = 50\ \text{m/s}^2$, (b) $1\ \text{s} \times 50\ \text{m/s}^2 = 50\ \text{m/s}$, (c) Momentum $= mv = 50\ \text{m/s} \times 100\ \text{kg} = 5000\ \text{kg} \cdot \text{m/s}$

A.5.7 As shown in Equation 6.14 and its associated text, work done on an object in a gravitational field is proportional to its mass, the acceleration due to gravity, and the change in its height. Personal experience tells you that it requires work to raise an object, while falling objects can be used to do work. This is why when the change in height is positive, the work done on the object is also positive. (a) $w = mg\Delta h$ can be rearranged to $w/mg = \Delta h$. $4\ \text{J}/(9.8\ \text{m/s}^2 \times 0.1\ \text{kg}) = 4.08\ \text{m}$; (b) $\text{w} = mg\Delta h = 1.6\ \text{m/s}^2 \times 0.1\ \text{kg} \times 4.08\ \text{m} = 0.65\ \text{J}$.

Chapter 26
Separation and Characterization of Biomolecules Based on Macroscopic Properties

26.1 Questions

Q.26.1 Calculate the work performed by a battery delivering 100 milliamps at 9 volts for 2 hours. Express the answer in (a) joules, (b) calories and (c) watt-hours.

Q.26.2 What is the work performed by a 50 kg gymnast who performs a lift on the rings and is elevated 1.2 m in the air?

(a) How many calories must be supplied to the muscles?
(b) Assuming 100% efficiency in energy extraction from sugar and given that there are 4 kcal/gram of sugar (5 g in a teaspoon, how many teaspoons of sugar should be consumed at lunch to make the lift?

Q.26.3 The difference between normal hemoglobin A and the sickle-cell hemoglobin mutant protein is a single amino acid replacement of glutamate with valine in the β chains. (Each hemoglobin molecule is composed of 2α and 2β chains). The mobility of these two proteins can be measured as $+0.3 \times 10^{-9} m^2/s$ - V and $-0.2 \times 10^{-9} m^2/s$ - V.

(a) Match the mutant versus native protein with its respective mobility.
(b) On an isoelectric focusing gel which protein will be found at the more acidic position in the pH gradient?

Q.26.4 On average, the addition of SDS[H_3C - $(CH_2)_{10}$ - CH_2O - $SO_3^-Na^+$] to a denatured protein leads to a stoichiometry of 2 amino acids/1 SDS molecule. Estimate the SDS associated charge on the following proteins following denaturation. [A reasonable rule of thumb is to assign each amino acid a weight of 100 daltons.]

(a) Albumin (67.5 kD)
(b) Ribonuclease A (12.4 kD)

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