Admission Test

Applied Physics - Biomolecular Physics

Second Semester 2018

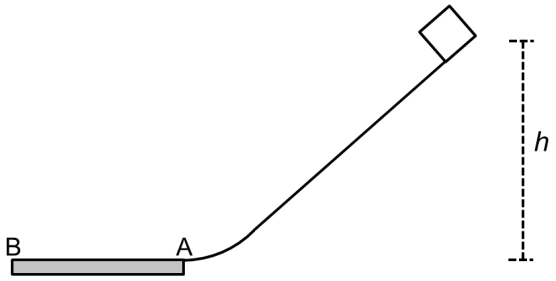
Candidate's Code:

QUESTIONS OF PHYSICS

Question 1:

A block of mass m is at the top of a hill of height h. It then slides from rest with negligible friction to point A. Arriving at point A, it is braked by a sand-covered surface AB for a time T until it reaches rest.

a) What is the speed of the block at the bottom of the ramp?
b) What is the coefficient of kinetic friction between the block and the sand while the block is in surface AB?



Question 2:

A student fires a bullet of mass m_b into a hanging wooden box of mass m_c, hung by a wire of negligible mass. The bullet strikes the box and passes through it completely. A laser device indicates that the bullet has emerged at half its initial velocity. The wooden box swings upward to a certain height h. Neglecting air resistance, determine h.

Question 3:

A student decides to test a new wire for possible use in a piano. The wire specifications tell that the 3m-long wire has a linear mass density of 0,0025kg/m. The student finds two adjacent resonant frequencies at 252Hz and at 336Hz, respectively.

a) Determine the fundamental frequency of the wire.
b) Determine whether the wire is safe to keep in the piano, considering that safety issues start to arise if the tension in the wire gets above 700N.

Question 4:

An object oscillates in x direction with angular frequency ω . At $t=0\,s$ the object is at x_0 with an initial velocity v_0 .

a) Find the phase constant for the motion

b) Find the oscillation amplitude.

Question 5:

Two liters of water are left in a jar in the sunlight all day, reaching the temperature of $40°C$. In a Styrofoam cup, 250g of this water is poured and two ice cubes (each with a mass of 25g at a temperature of $0°C$) are added. Consider the specific heat of the water as $1 cal/g°C$ and the latent heat of fusion of the ice as $80 cal/g$.

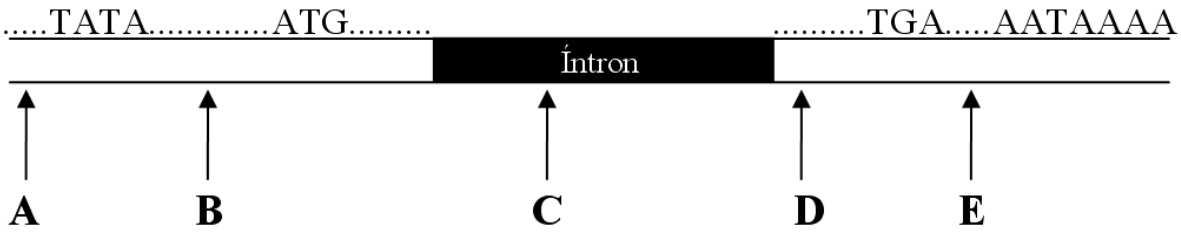
a) Assuming no heat is released to the surroundings (not even to the cup), what is the final equilibrium temperature of the water in the cup?

b) A new amount of 250g of water is poured in another cup. What is the largest number of ice cubes (each with a mass of 25g at a temperature of $0°C$) that could be added so that no ice remains without melting?

QUESTIONS OF BIOLOGICAL SCIENCE AND BIOCHEMISTRY

Question 1:

The figure below represents a eukaryotic gene. Circle the position(s) (A-E) in which the insertion of a single base pair would induce a frameshift mutation. Justify your answer.



Question 2:

Indicate the main functions of the proteins: myosin, immunoglobulin, reverse transcriptase, hemoglobin, and insulin.

Question 3:

Mixtures of peptides are analyzed by first separating the mixture into its components through ion-exchange chromatography. Peptides placed on a cation-exchange resin containing sulfonate ($-SO_3^-$) groups flow down the column at different rates because of two factors that influence their movement: (1) ionic attraction between the $-SO_3^-$ on the column and positively charged functional groups on the peptides, and (2) hydrophobic interactions between amino acid side chains and the strongly hydrophobic backbone of the polystyrene resin.

Considering the following dipeptides:

Asp–Glu

Asp–Lys

Arg–Gly

Glu–Gly

Arg–Lys

a) Indicate the protonation state and the net charge of each dipeptide at a pH 7.0 buffer.

b) Determine the order of elution of each dipeptide from a cation-exchange column using a pH 7.0 buffer.

Questão 4:

Sucrose, a major product of photosynthesis in green leaves, is synthesized by a battery of enzymes. The substrates for sucrose synthesis, D-glucose and D-fructose, are a mixture of α and β anomers as well as acyclic compounds in solution. Nonetheless, sucrose consists of α-D-glucose linked by its carbon-1 atom to the carbon-2 atom of β-D-fructose.

a) Draw the structures of α-D-glucose and β-D-fructose
b) How can the specificity of sucrose be explained in light of the potential substrates?

Question 5:

Unsaturated fatty acids are typically biosynthesized by a unique dehydrogenation reaction called desaturation.

a) Why are most unsaturated fatty acids found in phospholipids in the *cis* rather than the *trans* conformation?

b) Draw the structure of a 16-carbon fatty acid as saturated, *trans* monounsaturated, and *cis* monounsaturated.