SECTION A

1. Which device transforms mechanical energy into electrical energy?

a. generator
b. motor
c. transformer
d. mass spectrometer

2. The use of biodiesel contributes to a reduction in carbon emissions because

a. the biodiesel manufacturing process uses electricity
b. biodiesel produces no CO_2 upon combustion
c. the plants from which biodiesel is made absorb CO_2
d. diesel engines are more efficient than petrol engines

3. Which organ in the human body helps us sense acceleration?

a. The eyes
b. The ears
c. The skin
d. None. We cannot directly sense acceleration.

4. We wear special glasses when watching 3-D movies at a theatre because

a. 3-D movies use special colors which cannot be sensed by the human eye
b. 3-D movies are brighter than ordinary movies and can hurt our eyes if seen directly
c. the glasses allow our left and right eyes to see different images
d. none of the above

5. Fossils of sea creatures are sometimes found on high mountain tops. The most likely explanation for this is:

a. sea levels were much higher in the past
b. land that once formed the sea floor was slowly pushed upwards to form the mountain
c. intermittent ‘great floods’ moved sea creatures onto mountain tops
d. the fossils are actually of land animals that resemble sea creatures

6. A sundial meant to be used in Mumbai cannot be used in Stockholm because

a. the two cities are in different time zones
b. the two cities are at different altitudes
c. there isn't enough sunlight in Stockholm
d. the two cities are at different latitudes

7. The sum of all integral numbers from 1 to 10,000,000 is

a. 20,000,000,000,000
b. 23,456,787,654,320
c. 50,000,005,000,000
d. 200,000,000

8. A ball point pen and an ink-pen have the same amount of their respective inks in them. Which one can be used to write more on paper?

a. Ball point pen
b. Ink-pen
c. Both can be used to write to the same extent
d. It depends upon the paper and ink color

9. Which of the following statements is true?

a. $\sqrt{2} < \sqrt[3]{2} \wedge \sqrt{1/2} < \sqrt[3]{1/2}$
b. $\sqrt{2} < \sqrt[3]{2} \wedge \sqrt{1/2} > \sqrt[3]{1/2}$
c. $\sqrt{2} > \sqrt[3]{2} \wedge \sqrt{1/2} < \sqrt[3]{1/2}$
d. $\sqrt{2} > \sqrt[3]{2} \wedge \sqrt{1/2} > \sqrt[3]{1/2}$

10. In a family in Tindivanam, the parents and all four children lack eyebrows. It can be concluded that the underlying cause is

a. genetic
b. cultural
c. a contagious disease
d. any of the above

11. Which of the following spheres will roll down an inclined plain slowest?

a. A solid copper ball
b. A hollow copper sphere of the same diameter as above with mercury to compensate for weight
c. A hollow copper ball filled with a lead ball inside to compensate for weight
d. A hollow copper ball without weight compensation

12. We only see one side of the moon because

a. we live in the northern hemisphere
b. the earth's gravity attracts one side of the moon more strongly
c. the moon rates of rotation and orbital revolution happen to be equal
d. it is an optical illusion

13. A square has a side of 1 cm. An equilateral triangle with the same area has a base of

a. $\sqrt{\sqrt{4}/3}$ cm
b. $\sqrt{\sqrt{3}/4}$ cm
c. $\sqrt{3/\sqrt{4}}$ cm
d. $\sqrt{4/\sqrt{3}}$ cm

14. Two identical containers A and B hold equal amounts of water. Initially, the water in container A is at 70ºC, and the water in container B is at 30ºC. Now we cool both containers in the same room. Which of the following is true?

a. The water in container A cools slower than in container B
b. The water in container A cools faster than in container B
c. The water in container A cools at same rate as in container B
d. None of the above

15. A monkey experiences fear the first time it sees a snake. This is because:

a. the monkey has learned to beware of snakes from its parents
b. the monkey is frightened by any novel experiences
c. natural selection has lead to monkeys having an instinctive fear of snakes
d. the monkey logically deduces that the snake must be dangerous

SECTION B

1. A stone is tied to a thread of constant length and rotated in a horizontal plane. Which of the following quantities is not constant in time?

a. Kinetic energy of the stone
b. Potential energy of the stone
c. Momentum of the stone
d. Total energy of the stone

2. A cube shaped object made of a certain material has sides of 2 m. The object weighs 6 kg. It is slowly lowered into a certain liquid. What will happen?

a. The object will sink
b. The object will float
c. It depends on the properties of the liquid
d. It depends on whether the object is hollow or solid

3. A ball is thrown up with a velocity of 20 m/s. How long will it be before the ball returns to the ground? Assume gravitational acceleration = 10 m/s^2. You can ignore air friction.

a. 0.5 s
b. 1 s
c. 2 s
d. 4 s

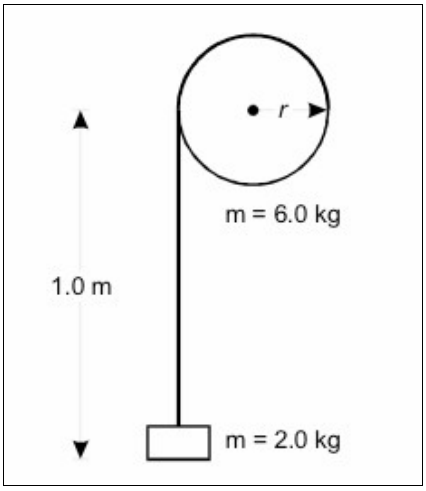
4. What is the expected pressure of air in the lungs of a diver at 4 meters below sea level?

a. 140 Kpa
b. 14 Kpa
c. 40 KPa
d. 4 KPa

5. Two balls on a frictionless surface collide and stick. Which of the following is not conserved?

a. momemtum
b. angular momemtum
c. kinetic energy
d. mass

6. The diagram below shows a frictionless wheel with a weightless cable wrapped around it and a block attached to the end of the cable. The wheel has a mass of 6.0 kg and the block has a mass of 2.0 kg. The block is released from rest and drops as the cable unwinds. When the block has dropped 1.0 m, its velocity is 2.8 m/s. What is the kinetic energy of the wheel?



a. 0 J
b. 8.4 J
c. 12 J
d. 20 J

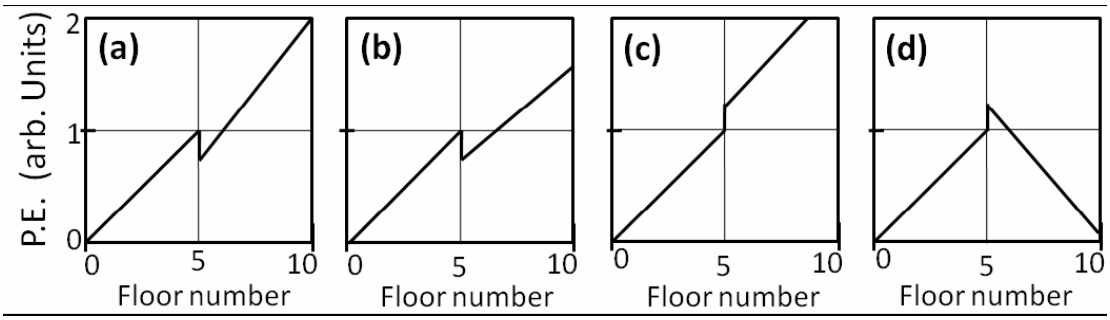
7. Scientists make an insulated container to hold 4.0 moles of nitrogen at a pressure of 10^5 Pa and a temperature of 200 K. What is the approximate size of the container? (1 atm = 101 kPa)

a. 4 litres
b. 8 litres
c. 17 litres
d. 67 litres

8. The radius of the nucleus of an atom of gold is $R = 6.2 \times 10^{-15}$ m. Which of the following expressions represent the variation of the magnitude of the electric field from the centre of the nucleus to the outside? (Assume that the nucleus is spherical and that the charge is distributed uniformly throughout that volume). r is the distance from the centre of the nucleus and q is the total charge of the nucleus.

a. $E \propto qr/R^3$ outside the nucleus;
$E \propto q/r^2$ inside the nucleus
b. $E \propto q/r^2$ both inside and outside the nucleus
c. $E \propto q/r^2$ outside the nucleus; $E \propto qr/R^3$ inside the nucleus
d. $E \propto qr^2$ inside the nucleus; $E \propto qr$ outside the nucleus

9. An elevator starts at the ground floor with two persons, each weighing 100 Kg. One person gets down on the fifth floor. The elevator then continues with the second person to the 10th floor. Which of the following plots best represents the variation in potential energy (P.E.) of the elevator and its contents from the start to the instant the elevator reaches the 10th floor.



a. (a)
b. (b)
c. (c)
d. (a & d)

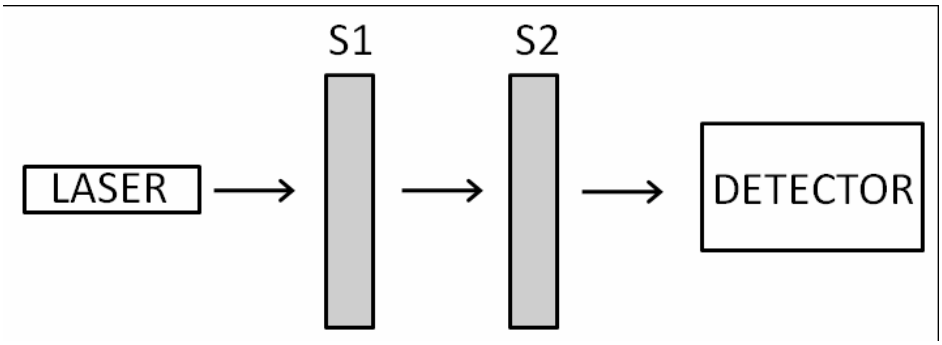
10. If the cross sectional area of the aorta of a normal person is 3 cm^2 and the speed of blood is 30 cm/s. In contrast, the typical cross sectional area of a blood capillary is 3 X 10 -7 cm^2 and the flow speed in capillary is 0.05 cm/s. How many capillaries does the person have?

a. 6 million
b. 6 billion
c. 600 thousand
d. 600 million

11. Find the electric field at a distance z above the mid-point of a straight line of length 2L with a uniform charge density ρ.

a. $E \propto 2\rho/L^2$
b. $E \propto 2\rho/z^2$
c. $E \propto 2\rho L/z^2$
d. $E \propto 2\rho L/(z*sqrt(z^2+L^2))$

12. Two identical glass slabs S1 and S2 are placed between a laser light source and a detector as shown in the figure below. Each slab transmits 50% of incident light, and reflects the remaining 50% light. What fraction of the emitted laser light reaches the detector?



a. 0 % (no light reaches the detector)
b. Greater than 25%
c. Exactly 25%
d. Less than 25%

13. A lens has focal length +10 cm. An object is placed at a distance 20 cm to the left of the lens. The image is:

a. real and 20 cm right of the lens
b. virtual and 20 cm left of the lens
c. real and 10 cm right of the lens
d. virtual and 10 cm left of the lens

14. The xylem system in plants transports water through the stem. Assuming that xylem tubes are composed of thin, uniform cylindrical tubes that carry sap entirely due to capillary action with a contact angle of 450 and surface tension of 0.05 N/m, what is the maximum radius of the tubes for a 20 m tall tree?

a. 1.2 X 10-4 m
b. 4.3 X 10-2 m
c. 3.6 X 10-7 m
d. 2.5 X 10-6 m

15. What is the maximum sustained horizontal acceleration possible on a flat track in a motorcycle whose wheels are 2 m apart centre to centre, centre of mass symmetrically between the wheels and 0.5 m from the ground? Assume friction with the road is not limiting.

a. 0.5 g
b. 1 g
c. 2 g
d. Insufficient information provided.

SECTION C

1. In case of a unimolecular nucleophilic substitution reaction

    a. The leaving group departs first before the attack of the nucleophilic reagent
    b. Departure of the leaving group and attack of the nucleophilic reagent happens simultaneously
    c. First the nucleophilic reagent attacks before the leaving group departs
    d. None of the above

2. Two unstable elements A and B have atomic numbers 40 and 56, respectively. When A emits alpha rays and B emits beta rays their atomic numbers will change to:

    a. 38 and 57
    b. 42 and 54
    c. 42 and 55
    d. None of the above

3, Hydrogen bonds are unique among non-covalent interactions because of their

    a. directional character
    b. they are formed from protons
    c. the strength of these bonds is equal to that of covalent bonds
    d. none of the above

4. A planar ring can have aromatic properties if the number of its pi electrons equals

    a. 14
    b. 16
    c. 12
    d. None of the above

5. Due to the common-ion effect, the solubility of one salt (S1)

    a. Decreases on addition of another salt (S2) because there is an ion common to both S1 and S2
    b. Increases on addition of another salt (S2) because there is an ion common to both S1 and S2
    c. Increases and then decreases on addition of another salt (S2) because there is an ion common to both S1 and S2
    d. None of the above

6. The lattice energy of a compound increases as

a. the distance between the ions decreases
b. the charge on the ions increases
c. all of the above
d. none of the above

7. For the reaction A⇌ B+C, at equilibrium, the concentration of A is $1x10^{-3}$ M, B is 0.15 M and C is 0.05M. The $\Delta G^{o'}$ for the hydrolysis of A at 27°C will be

a. -5.0 kJ/mol
b. -17.3 kJ/ml
c. -11.2 kJ/mol
d. None of the above

8. The half life of radioactive P32 is 14.3 days. In how many weeks will the radioactivity fall to $1/16^{th}$ of the original value

a. 8.2 weeks
b. 9.7 weeks
c. 7.6 weeks
d. None of the above

9. Molar absorptivity of potassium chromate at a wavelength of 373 nm is 8305 M-1 cm-1. The absorbance (A1) of a solution of this compound (concentration =0.5M) was measured using a cuvette of path length =2 cm. Absorbance was also measured (A2) of another solution of this compound (concentration=1.0M) using a cuvette of path length=1 cm. The relation between A1 and A2 can be described as follows

a. A1= 2x A2
b. A1= 0.5x A2
c. A1=A2
d. None of the above

10. Which of these is the closest to the value of 1kcal/mole?

a. $2/3 \times 10^{-20}$ Joules
b. 2/3 Joules
c. 2×10^{-20} Joules
d. 3×10^{-10} Joules

11. What is the hybridization of oxygen in CH_3 CO CH_3

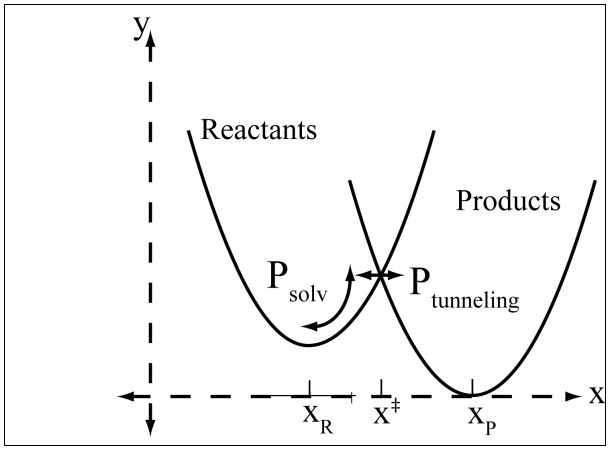
a. sp^3
b. sp^2
c. sp
d. All of the above.

12. The peptide bond is planar because of:

a. Hydrogen bonding
b. π backbonding
c. π ↔ lone pair interaction
d. The hydrophobic effect

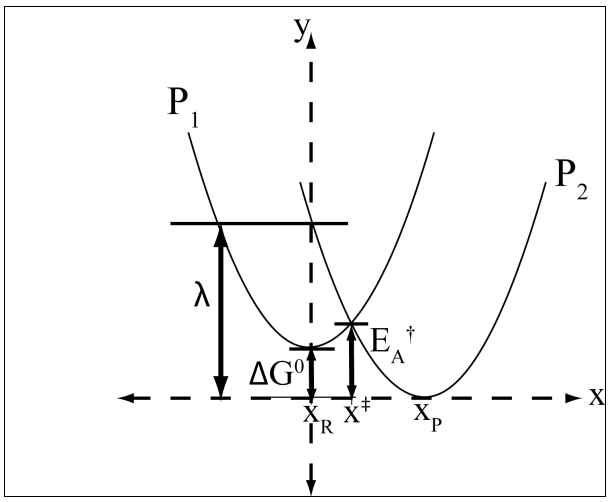
13. An electron transfer reaction proceeds by diffusion along a solvent coordinate, followed by an electron tunneling event (see figure). If P_{solv} is the probability of the system diffusing from x^R to $x^{\ddagger}$ and $P_{tunneling}$ is the probability of the electron tunneling then the rate constant for electron transfer is proportional to:

a. $P_{solv} + P_{tunneling}$
b. P_{solv} x $P_{tunneling}$
c. $P_{solv} - P_{tunneling}$
d. $P_{solv} / P_{tunneling}$



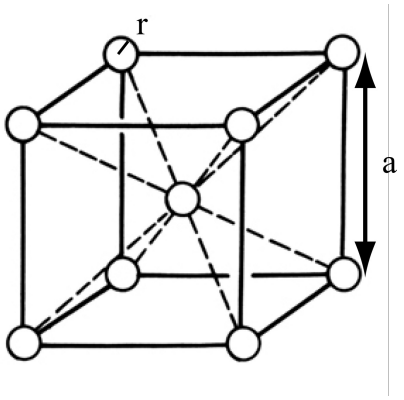
14. Assuming completely equivalent parabolas (the equations of P_1 and P_2 are same except for a shift in coordinates), calculate the value of $E_A^{\dagger}$ in terms of λ and ΔG^0.

a. $E_A^{\dagger} = \lambda^2 / 4$
b. $E_A^{\dagger} = (\lambda - \Delta G^0)^2 / (4 \Delta G^0)$
c. $E_A^{\dagger} = (\lambda + \Delta G^0)^2 / (4 \lambda)$
d. $E_A^{\dagger} = (\Delta G^0)^2 / \lambda$



15. The unit cell in a body centered cubic lattice is given in the figure. Each sphere has a radius, **r**, and the cube has a side, **a**. What fraction of the total cube volume is empty?

a. $1 - 8/3\ \pi\ r^3 / a^3$
b. $4/3\ \pi\ r^3 / a^3$
c. r/a
d. $2 - 4/3\ \pi\ r^3 / a^3$



SECTION D

1. A couple want to have two children who are genetically identical. Short of having identical twins engineered, which of the following statements best describes the number of offspring they should have to allow this?

   a. 23,000
   b. 23^2
   c. 2^{23000}
   d. Aleast a billion

2. I have a sequence of DNA that is 24 bp long (starts with a start codon and ends with a stop codon) that codes for a protein called MFP. Which of the following statements about the amino acid composition of the protein are false?

   a. Adding a 25^h base pair has no effect.
   b. Substituting the 6th base may have an effect.
   c. Adding a base after the 6^{th} base and deleting the 10^{th} base has a smaller effect than each mutation alone.
   d. Adding a base after the 6^{th} base and deleting the 10^{th} base has greater effect than each mutation alone.

3. An alcohol molecule with a five-carbon ring can be chemically modified at positions 3, 4 and 5 ONLY to generate biologically active second messengers. The modification can occur either at a single position or in more than one position in combination. How many distinct second messenger species can be generated in this manner?

   a. Three
   b. Five
   c. Seven
   d. Two

4. I set up a cross between two genetically identical parents heterozygous for a recessive mutation that causes the progeny to die as embryos. Which of the following is false?

   a. A quarter of the embryos show the mutant phenotype.
   b. Three quarters of the adult progeny show no phenotype.
   c. A third of the adults do not pass on the mutation to the next generation.
   d. All of the adults are phenotypically indistinguishable.

5. A signalling pathway I have identified has three proteins A, B, C that work to allow function X, When A is absent, X does not happen. The absence of C or B

individually does not substantially affect function X. When C and B are both defective function X fails but can be restored if excess A is provided. Which of the following statements is false?

a. Protein A functions after proteins C and B.
b. Protein A requires proteins C and B.
c. Protein A requires protein C or B to function.
d. Proteins C and B do not influence each others' function.

6. When bacteria are transformed with DNA, the effectiveness with which they take up DNA is quantified as the transformation efficiency. If the operational definition of transformation efficiency is the number of bacterial colonies obtained when bacteria are incubated with 1 microgram of DNA. A new student prepared bacterial cells suitable for transformation. On testing his preparation, he obtained 8000 colonies when he incubated the cells with 8 picograms of DNA. His transformation efficiency is:

a. $1x10^9$
b. $8x10^6$
c. $8x10^9$
d. None of the above

7. At the plasma membrane of a cell the transduction of light is mediated by three proteins A, B and C. A is the sensor and C is the effector. The efficiency of this sensory transduction system is limited by the probability of interaction of A with B and B with C. If the probability of A interacting with B is 0.2 and the probability of B interacting with C is 0.1, what is the probability of the signal passing from A to C?

a. 0.2
b. 0.02
c. 0.1
d. 0.003

8. A species of bacteria found at the bottom of a shallow pond has a hard cell wall and a semi-permeable membrane. Which of the following statements is true?

a. The cell wall prevents the cell from being crushed by external forces
b. The cell wall prevents the cell from exploding due to internal pressure
c. The internal and external pressure are equal, hence the cell wall determines shape
d. None of the above

9. Pigment colour in guppies is determined genetically. Of the progeny obtained from a guppy pair 25% exhibit red pigment, 25% yellow pigment, 25% white and 25% exhibit orange pigment. Based on these observations, which of the following statements is correct.

a. Alleles for Red and Yellow are dominant over white allele
b. Red and Yellow are co-dominant alleles
c. One of the parent must have the red pigment
d. All of the above

10. An accidental exposure of a mouse embryo to the UV light results in a green pigment patch in the skin. However, none of the F1 and F2 progeny exhibit green patches in the skin. The most probable explanation for this phenomenon is:

a. The mutation is repaired in the germ cells
b. This is a somatic mutation and does not get transmitted to the next generation
c. The mutant gene is imprinted and hence is not expressed in the progeny
d. All of the above

11. A species of a flightless bird found on an island is 10 times bigger than it's nearest known mainland relatives. This could be because

a. The food on the island is more nutritious
b. Larger size enables more efficient heat dissipation
c. Predators are absent on the island
d. They need to survive extended periods without food

12. Injection of an extract from the lotus leaves in a rabbit induces immune response. The characterization reveals that some of the antibodies can selectively recognize a protozoan antigen. Also the infection assays reveal that the rabbit becomes immune to the protozoan infection. Based on these observations, it is claimed that lotus leaves have an alkaloid that induces production of anti parasitic antibodies. Which of the following observations will weaken this claim substantially?

a. The pond water- from where the lotus leaves were taken- shows very high parasitic count.
b. Lotus leaves do not have alkaloids that have been previously reported to have anti parasitic activity
c. When the lotus leaves samples from 50 different ponds were screened, only 10 % showed increased antibody production when injected in rabbits
d. When the un-injected rabbits -grown in the laboratories were screened, 0.5% showed antibodies against the parasites.

13. Tight junctions are apically placed junctions in the epithelial cells. These junctions are selectively permeable and regulate the water and electrolyte transport across the epithelium. The Trans-epithelial Electrical Resistance (TER) measurement reflects how permeable an epithelium is. The TER is inversely correlated with the epithelial permeability. Thus lower TER values are indicative of leakiness of the tight junctions. It is known that one of the cholera toxins called Zot increases the leakiness of the tight junctions, contributing to symptoms of cholera. A pharmaceutical company is screening for bacterial toxins, which can enhance the epithelial permeability. Their aim is to use the best of these toxins as an agent to enhance the transport of an anticancer drug across the intestinal epithelium. It is known that the transport of the drug increases when TER is below 5000 ohms. The effects of these 4 toxins (Figure A) and toxin+drug (Figure B) on TER were tested on cultured epithelial cells. The treatment started after 3 hours and the toxins and drugs were washed out after 4 hours of incubation.

Figure A

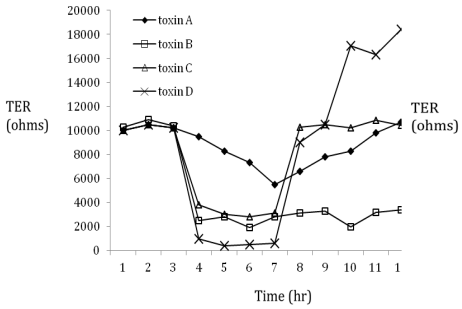
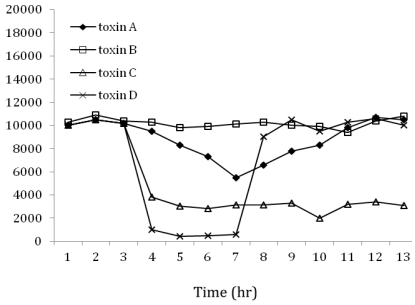


Figure B



Which of these would you recommend for use in combination with the drug for clinical trials?

a. Toxin B
b. Toxin A
c. Toxin C
d. Toxin D

Q14 & 15

A graduate student is attempting to purify an enzyme from the brain of a blowfly. He grinds up the heads of 500 blowflies in a buffer solution and filters to obtain a crude extract. He then employs two steps of purification to end up with a moderately pure protein. He estimates enzyme activity at each stage of purification:

Stage of Purification	Total protein in sample (mg)	Specific Enzyme activity (µmoles substrate hydrolyzed/mg protein/minute)	Total Enzyme activity (µmoles substrate hydrolyzed/ minute)
Crude extract	200	2.5	500
After Step 1 of Purification	40	25	1000
After step 2 of purification	5	160	800

14. Which of the following statements about Step 1 of purification is TRUE?

a. The data reflect the normally expected pattern of a protein purification project
b. The increase in total enzyme activity is unexpected
c. The decrease in total protein is unexpected
d. The increase in Specific Enzyme activity is unexpected

15. Which of the following statements about the data are plausible?

a. The enzyme being purified constitutes a large fraction of the total extracted protein
b. Only a small fraction of the enzyme was recovered in this project
c. The tissue contains a substance that inhibits the activity of the enzyme
d. There is considerable degradation of protein during Step 2 of the purification