Joint Graduate Entrance Exam in Biology and Interdisciplinary Life Sciences

Section A: General

1. Migrating birds often fly in a V-shaped formation. Why?

      a. To increase their visual range to aid navigation
      b. To deter predatory birds
      c. So that related individuals can fly together
      d. To conserve energy due to aerodynamic effects ✔

2. Elephants sometimes use infrasound in the 5 – 20 Hz range to communicate, rather than sounds in the human audible range of 20 – 20,000 Hz. This is probably because

      a. The large elephant ear cannot detect high frequencies
      b. There is too much competing sound in the 20 – 20,000 Hz range
      c. Infrasound has a longer distance range than higher frequency sound ✔
      d. This keeps elephant herds hidden from predators

3. People with anaemia are most likely to be comfortable in

      a. Leh
      b. Lhasa
      c. Lucknow ✔
      d. La Paz, Bolivia

4. Fifty rabbits from an isolated forest patch were captured, marked with special tags, and released. The next day, sixty rabbits were captured and ten of these were found to have tags. What assumptions do you need to make to estimate the number of rabbits in the forest from these data?

      a. All rabbits are equally likely to get captured ✔
      b. The number of rabbits in the forest is very high
      c. All captured rabbits are approximately the same age and healthy
      d. Rabbits are equally active at all times of day

5. A medical test for some condition has a false positive rate of 0.1% and false negative rate of 0.1%. The condition is present in 0.1% of the population. What is the probability that a randomly tested individual who tests positive actually has the disease?

      a. 0.1
      b. 0.5 ✔
      c. 0.9
      d. 0.999

6. We are given a random sample of 5000 diastolic blood pressure measurements. Suppose the 99% confidence interval for the blood pressure is found to be 68 to 73 mm Hg. How is this related to the 95% confidence interval?

    a. The 95% interval will be wider than the 99% interval
    b. The 95% interval will be narrower than the 99% interval ✔
    c. The 95% and 99% intervals will be the same
    d. This cannot be determined from the given information

7. As you increase the n (number of measurements) in an experiment, which quantity do you expect to decrease?

    a. mean
    b. standard deviation
    c. standard error of the mean ✔
    d. Both (b) and (c)

8. The next term in the series: 3, 0, 3, 3, 6, 9, 15,… is

    a. 18
    b. 21
    c. 24 ✔
    d. 27

9. The height of a cylinder is increased by a certain percentage, and the radius is decreased by the same percentage. How will the volume of the new cylinder be related to that of the original?

    a. The same
    b. Larger
    c. Smaller ✔
    d. Cannot be determined

10. A cube and a cylinder have the same volume. Which has the larger surface area?

    a. The cube
    b. The cylinder
    c. Both are equal
    d. Cannot be determined ✔

11. You are given three bricks each measuring 5" x 4.5" x 3". How many differing heights can you build up using all three of them?
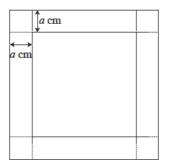
    a. 14
    b. 7
    c. 10 ✔
    d. 13

12. In a recent election, two parties fielded one candidate each in all the districts of a state. On election day, party A was victorious, with many more winning candidates than party B. However, both parties had received an identical number of total votes across the state. The most likely explation for this is:

    a. Some voters supported a third party C
    b. Many party B supporters did not cast a vote at all
    c. The proportion of A and B supporters varies between districts ✔
    d. The result was a statistical fluke based on the binomial distribution

13. Vessel A has liquids X and Y in the ratio X:Y = 8:7. Vessel B holds a mixture of X and Y in the ratio X:Y = 5:9. What ratio should you mix the liquids in both vessels if you need the mixture to be X:Y = 1:1?

    a. 4:3
    b. 30:7 ✔
    c. 17:25
    d. 7:30

14. A square sheet measuring 10cm x 10cm is taken. Squares with side a cm are cut from the four corners. The resulting sheet is bent into a box. Find the value of a that maximizes the volume of the box so formed.

    a. 5 cm
    b. 3/5 cm
    c. 5/3 cm ✔
    d. 4 cm

15. What is the limit of the expression $(2x^2 - 18x + 28) / (x^2 - 10x + 21)$ when x→7 ?

    a. 5/2 ✔
    b. 7/3
    c. 0
    d. Infinity

Section B: Physics

1. It is possible to detect cosmic rays using which of the following household items?

    a. Digital camera ✔
    b. Thermometer
    c. Stethoscope
    d. Binoculars

2. The fluorescence of a molecule is due to transitions between

    a. Electronic states
    b. Rotational states
    c. Vibrational states
    d. All of the above ✔

3. When monochromatic light passes from air into water, which statement is true?

    a. Its speed and frequency decrease
    b. Its frequency stays the same and its wavelength decreases ✔
    c. Its speed decreases and its wavelength increases
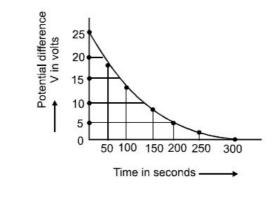   d. Its speed increases and its frequency stays the same

4. Which of the following parameters, if increased, would in theory improve the resolution of an electron microscope?

    a. The electron mass
    b. The acceleration voltage
    c. The electron charge
    d. All of the above ✔

5. One solid and one hollow ball, of the same radius and same material, are released from rest at some height h above the surface of the earth. Assume air resistance is negligible. When each has fallen 1 m, they both have the same

    a. speed ✔
    b. momentum
    c. kinetic energy
    d. inertia

6. The following figure shows experimental plot of discharging of a capacitor in an RC circuit. The time constant of this circuit lies between:
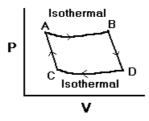

a. 0 and 50 sec
b. 50 sec and 100 sec
c. 100 sec and 150 sec ✔
d. 150 sec and 200 sec

7. I have a mixture of N_2 and O_2 at equilibrium. Treating these as ideal gases, which of the following quantities, on average, will be equal for both molecular species?

a. Squared velocity
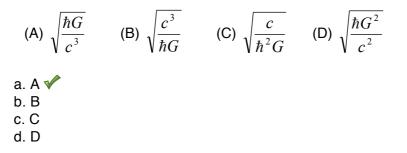b. Momentum
c. Kinetic energy
d. Both (b) and (c) ✔

8. The following figure represents an ideal gas taken through a Carnot cycle. The net change in entropy of the gas over the cycle is

a. Positive
b. Negative
c. Zero ✔
d. Indeterminable

9. Which of the following correctly expresses the Planck length (l) in terms of other fundamental constants (the gravitational constant G, velocity of light c and Planck's constant ħ)?

(A) $\sqrt{\dfrac{\hbar G}{c^3}}$ (B) $\sqrt{\dfrac{c^3}{\hbar G}}$ (C) $\sqrt{\dfrac{c}{\hbar^2 G}}$ (D) $\sqrt{\dfrac{\hbar G^2}{c^2}}$
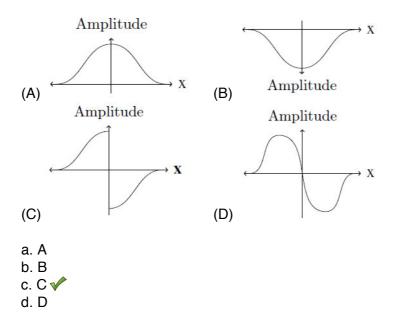
a. A ✓
b. B
c. C
d. D

10. On any given day, I find that I am much more likely to oversleep than to wake up on time. Consider this as a random process with two possible outcomes. What is the entropy of this distribution, in bits?

a. Less than 1 bit ✓
b. 1 bit
c. Greater than 1 bit
d. Cannot be determined.

11. Which of the following functions is an eigenfunction of the operator d/dx?

a. x
b. sin(x)
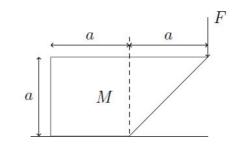c. exp(ax^2)
d. exp(bx) ✓

12. Consider a particle in a parabolic potential with a Dirac delta potential at the middle. The ground state wavefunction of the particle could be depicted as

(A)   (B)   (C)   (D)

a. A
b. B
c. C ✓
d. D

13. A positive point charge of magnitude q and mass m is dropped from a great height h onto another similar charge fixed on the ground. The minimum distance between the charges in CGS units is:
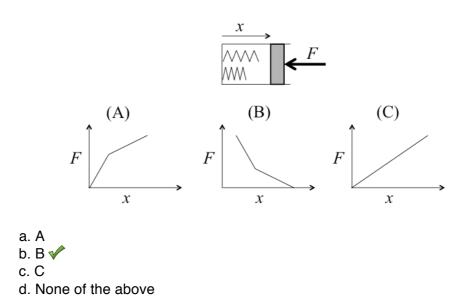
    a. $q^2/(mgh)$ ✔
    b. $q^2/(2mgh)$
    c. $h - q^2/(mgh)$
    d. $h - q^2/(2mgh)$

14. An inverted trapezoidal block of mass M is pushed downward as shown in the figure. The minimum force required to tip the block is

    a. 4Mg/9
    b. Mg/9
    c. 2Mg/9 ✔
    d. Mg/3

15. Two springs with the same spring constant but different resting lengths are attached to the base of a cylinder within which a piston is moved. Which of the graphs below is the force vs. position curve of the piston?

    a. A
    b. B ✔
    c. C
    d. None of the above

Section C: Chemistry

1. In which of these reactions is there an increase in entropy?

     a. Condensation of water
     b. Polymerization of an agarose gel
     c. Combustion of paper ✔
     d. Compression of Hydrogen

2. Two molecules of the same molecular weight, size, shape and charge can be separated by:

     a. Gel filtration chromatography
     b. Ion-exchange chromatography
     c. Affinity chromatography ✔
     d. Thin layer chromatography

3. Which of the following cannot diffuse freely through a phospholipid bilayer?

     a. Small uncharged molecules
     b. Non-polar molecules
     c. Charged molecules ✔
     d. Cholesterol

4. What is the only macromolecule whose formation does not involve dehydration reactions?

     a. Proteins
     b. Carbohydrates
     c. Lipids ✔
     d. Nucleic Acids

5. How many ml of a 0.2 M NaOH solution are required to bring the pH of 20 ml of a 0.4 M HCl solution to 7.0?

     a. 4
     b. 40 ✔
     c. 10
     d. 20

6. In a redox reaction involving two molecules:

     a. both lose electrons
     b. one loses electrons and is reduced, the other gains electrons
     c. one loses electrons and is oxidized, the other gains electrons ✔
     d. one gains electrons and is oxidized, the other loses electrons

7. You want to analyze the waxy surface volatiles of leaves using gas chromatography. For this purpose you would select:

a. A polar column
b. A nonpolar column ✔
c. A semipolar column
d. A chiral column

8. Which of the following compounds would you expect to be most soluble in water?

a. CH3-CH2-OH ✔
b. CH3-CH2-CH2-CH2-OH
c. CH3-CH2-CH2-CH2-CH2-CH2-OH
d. CH3-CH2-CH2-CH2-CH2-CH2-CH2-CH2-CH2-CH2-OH

9. The oxidation state of Cr & NO in the compound K3[Cr(CN)5(NO)] is

a. +3 & -1
b. +1 & +1 ✔
c. +2 & 0
d. +1 & -1

10. The following rates were determined for a reaction in which A and B combine to give a product. What is the overall rate law for this reaction?

[A]	[B]	Initial Rate
0.5 M	0.5 M	10 M s^{1}
0.5 M	1.0 M	20 M s^{1}
0.25 M	0.5 M	5 M s^{1}
1.0 M	1.0 M	40 M s^{1}

a. Rate = k $[A]^2[B]^2$
b. Rate = k $[A]^2[B]$
c. Rate = k $[A][B]^2$
d. Rate = k $[A][B]$ ✔

11. A levorotatory optically active compound is not pure, and gives 60 % of the expected optical rotation signal. If the contaminant is the corresponding dextrorotatory component, to what percentage is it present?

a. 40%
b. 20% ✔
c. 10%
d. 5%

12. The enzyme succinic dehydrogenase catalyses the conversion of succinate to fumarate as given below. Which one of the following compounds would be a likely competitive inhibitor of this reaction?

$$(COOH)H_2C-CH_2(COOH) \rightarrow (COOH)HC=CH(COOH)$$

a. $(COOH)HC=CH(COOH)$
b. $(COOH)C\equiv C(COOH)$
c. $CH_3CH_2CH_2NH_2$
d. $(COOH)-CH_2-(COOH)$ ✔

13. Treatment of a polypeptide by 2-mercaptoethanol yields two polypeptides that have the following amino acid sequences:

    X: Ala-Phe-Cys-Met-Tyr-Cys-Leu-Trp-Cys-Asn
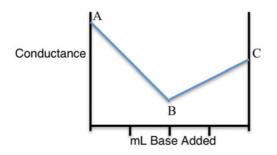   Y: Val-Cys-Trp-Val-Ile-Phe-Gly-Cys-Lys

Chymotrypsin-catalyzed hydrolysis of the intact polypeptide yields polypeptide fragments with the following amino acid compositions:

(Ala, Phe) (Asn, Cys2, Met,Tyr) (Cys, Gly, Lys) (Cys2, Leu,Trp2,Val) (Ile, Phe,Val)

Indicate the positions of the disulfide bonds in the original polypeptide. Cysteines are numbered in order (C1, C2, C3 in X; and C4, C5 in Y).

a. C1-C2 and C4-C5
b. C2-C3 and C1-C4
c. C1-C3 and C2-C4 ✔
d. C2-C3 and C1-C5

14. A sample of HCl is titrated with a standard solution of NaOH and the reaction followed by monitoring the conductance of the solution. Which of the following statements based on this data is NOT TRUE:

a. The measured conductance increases after B because the overall concentration of ions increases as NaOH is added after this point
b. Point B is the End Point of the titration
c. H_3O has a lower conductance than Na+ ✔
d. | slope AB | > | slope BC |

15. When investigating enzyme/substrate interaction, which of the following would be expected to show a linear relationship under constant conditions?

I. Rate of reaction against enzyme concentration in the presence of excess substrate.
II. Rate of reaction against enzyme concentration with the amount of substrate limited
III. Amount of product against time, with the amount of substrate limited
IV. Rate of reaction against substrate concentration

    a. I only ✔
    b. I & II
    c. III only
    d. II & IV

Section D: Biology

1. If the ratio of (A + G)/(T + C) in one strand of DNA is 0.70, what is the same ratio in the complementary strand?

    a. 0.70
    b. 1.43 ✔
    c. 0.35
    d. 0.30

2. DNA was isolated from wild type (W) and mutant (M) E.coli cells and separated by density gradient centrifugation technique. DNA from M strain acquired a lower position. This indicates that the mutation is caused by:

    a. Deletion
    b. Insertion ✔
    c. Missense mutation
    d. Point mutation

3. Cotransformation between two genes is more likely if they are:

    a. close to one another ✔
    b. far apart from one another
    c. both next to the F factor
    d. both oriented in the same direction

4. How is it possible for ions to be at equilibrium across a plasma membrane and yet not be at the same concentration on both sides?

    a. Because the mobility of ions is restricted across the plasma membrane
    b. Because there is a charge difference across the plasma membrane ✔
    c. Because of voltage-gated ion channels in the plasma membrane
    d. Because of the presence of leak ion channels in the plasma membrane

5. One of the most accurate methods for placing an individual at the scene of a crime is DNA finger printing. This involves the following steps:

(1)   Denaturation of DNA
(2)   Recognition of repetitive sequences
(3)   Gel electrophoresis
(4)   Digestion of DNA with restriction endonucleases
(5)   Use of a radio-labeled DNA probe
(6)   Transfer of DNA to nitrocellulose
(7)   Extraction of DNA

The correct order of these steps is:

a.   (7, 1, 3, 6, 4, 5, 2)
b.   (6, 7, 1, 3, 4, 5, 2)
c.   (7, 4, 3, 1, 6, 5, 2) ✔
d.   (7, 3, 6, 4, 2, 5, 1)

6. Animal cells are labeled with radioactive amino acids. In which of the following molecules would you detect radioactivity:

I. Proteins   II. RNA   III. Ribosomes   IV. Glycolipids

a. I
b. I & III ✔
c. II
d. I & IV

7. Protein gels (SDS-PAGE) are usually run vertically whereas DNA gels (agarose) are usually run horizontally. A student desires to run a protein gel horizontally and a DNA gel vertically. Which of the following statements will best explain his results?

a. The protein gel experiment will not work because the proteins need gravity to move. The DNA gel will be fine.
b. Both the protein and the DNA gel experiments will not work. Protein gels have to be run vertically and DNA gels have to be run horizontally.
c. Both the protein and the DNA gel experiments will work as the principles ✔ behind their functioning do not depend upon gravity.
d. The protein gel experiment will work but the DNA gel experiment will not.

8. The molar absorption coefficient (extinction coefficient) of NADH at 340nm is 6220 l/mol/cm, whereas that of NAD at the same wavelength is 0. What absorbance will be observed when 340nm light passes through a 1 cm cuvette containing 10 micromolar NADH and 10 micromolar NAD?

a. 0.031
b. 0.062 ✔
c. 0.31
d. 0.62

9. The different beak morphologies of Darwin's Finches on the Galapagos Islands is best explained by

    a. Genetic variation
    b. Dietary differences
    c. Different habitats
    d. All of the above ✓

10. Because of widespread pollution in England during the industrial revolution, areas near factories became darkened with soot. During this period, a darker form of the peppered moth (*Biston betularia*) found to be more predominant over the lighter form This was because:

    a. The darker pigments allowed the moths to resist the effects of soot
    b. The pollutants caused toxicity, resulting in darker wings
    c. The darker form was better camouflaged from predators ✓
    d. The food source of the lighter form was wiped out

11. Let us consider three independently assorting autosomal genes in Drosophila: A, B and C. What is the probability that a female of genotype AaBBCc when crossed to a male of AAbbCc will produce an offspring of genotype AABbcc?

    a. 1/2
    b. 1/4
    c. 1/8 ✓
    d. 1/16

12. Insectivorous bats can hunt at night by using echolocation (biosonar). Which of the following aspects of the target insect does not affect the loudness of the echo?
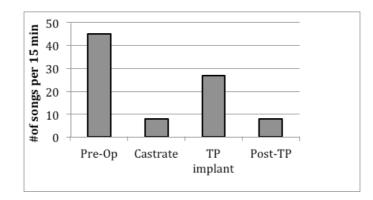
    a. distance
    b. size
    c. position of wings ✓
    d. rate of approach

13. Two students independently isolated lactate dehydrogenase from chicken heart and measured its activity as a function of substrate concentration, each determining Vmax and Km of their own preparation. They both got the same Km but different Vmax. One student said they had isolated different forms of the same enzyme, the other said they had isolated the same form. To resolve their argument they must

    a. Measure the molecular weight of the enzyme
    b. Measure enzyme activity as a function of time after addition of substrate
    c. Determine the turnover number of each preparation ✓
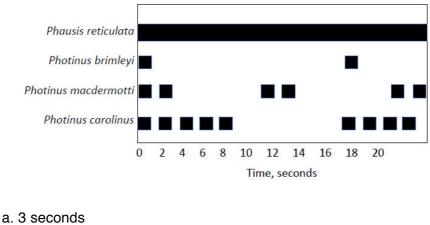   d. All of the above

14. Male zebrafinches sing during the breeding season to attract females. A.P. Arnold investigated the relationship between circulating testosterone and song production by castrating male birds and then inserting an implant that releases testosterone propionate. His results are shown in the bar graph below.

Based on these data, which of the following conclusions CANNOT be drawn:

   a. A male zebrafinch typically sings about 3 songs per minute
   b. The effect of castration can be partially reversed by added testosterone
   c. The continued presence of testosterone is not required for normal singing ✔
   d. The male zebrafinch testes secretes substances other than testosterone that regulate singing

15. The light-flashing pattern of four species of fireflies is shown in the image below. Each black bar represents one light flash. Assuming that observations begin at a random time, what is the shortest duration in which I can distinguish P. macdermotti from the other species with certainty?

   a. 3 seconds
   b. 9 seconds
   c. 13 seconds
   d. 15 seconds ✔