Section A: General

1. Which of the following contribute to climate change?

a. The ozone hole
b. Lead additives in petrol
c. Natural-gas-based power
d. All of the above

2. At night, if a torch is pointed at a cat's eyes they reflect light back to the source. Why does this phenomenon occur?

a. To scare away predators
b. To attract mates
c. To increase sensitivity to low light
d. It is just a side-effect of photoreceptor function

3. A person throws a ball across a field. When the ball is at the highest point of its trajectory, the direction of its velocity and acceleration are

a. parallel to each other
b. anti-parallel to each other
c. inclined to each other at an angle of 45°
d. 90° to each other

4. If the radius and height of a cone are both increased by 100%, then its volume is increased by

a. 400%
b. 300%
c. 200%
d. 100%

5. If the average of X, 2X+5, X+6 and 45 is 29, what's X?

a. 15
b. 20
c. 24
d. 32

6. The Doppler effect causes a change in the perceived frequency of a moving source of sound. Suppose an ambulance is moving with constant speed down a road, and a listener is standing next to the road on a footpath. Why does the frequency of the ambulance siren appear to change most abruptly when it passes closest to the listener?

a. Because this is where the greatest change of relative velocity occurs
b. Because the Doppler effect acts most strongly at short distances
c. Because human hearing is more sensitive to the frequency of louder sounds
d. All of the above

7. A goat consumes 2 kg of grass per day, and a cow consumes 4 kg of grass per day. Two pairs of goats and one pair of cattle are released in a sanctuary with a total biomass of 16,000 kg of grass at the time of release. The growth rate of grass accounts for an increase of 1000 kg every 100 days. How much grass stands after 1000 days?

a. 100 kg
b. 500 kg
c. 1,000 kg
d. 10,000 kg

8. You have caught 100 flies, marked them, and released them back in a greenhouse of area 100 m^2. Assume the fly population doubles every 4 days; assume no flies die. After 12 days, you catch 400 flies and find that 10 out of them are marked. What is your estimate of the number of flies in the greenhouse at the start of your experiment?

a. 500
b. 800
c. 1,000
d. 4,000

9. In his 2001 book "What Evolution Is" Ernst Mayr has said that behavior is the pacemaker of evolution. The most appropriate way to refer to this and avoid plagiarism is to note:

a. Behaviour is the timekeeper of evolutionary processes.
b. "Behaviour is the pacemaker" for evolutionary processes (Mayr, 2001).
c. Behaviour is the pacemaker of evolution (Mayr, 2001).
d. Any of the above

10. A large cube is formed from the material obtained by melting three smaller cubes with sides 3, 4 and 5 cm respectively. What is the ratio of the total surface areas of the smaller cubes and the large cube?

a. 2:1
b. 25:18
c. 3:2
d. 27:20

11. Consider the graphs of the two linear equations $ax + by = c$ and $bx - ay = c$, where a, b and c are all greater than zero. These graphs

a. are perpendicular
b. are parallel
c. intersect at an acute angle
d. intersect at more than one point

12. If you roll three fair six-sided dice, what is the probability that you get two sixes and one odd number, in any order?

a. 1/36
b. 1/72
c. 1/24
d. 5/9

13. In a football tournament of repeated games between two teams, team A scored more goals while team B won more games. What can you conclude?

a. Team B won more games in the first half of the tournament
b. Team B scored more goals first half of the tournament
c. Team A had larger goal victory margins in the games they won
d. Team B had larger goal victory margins in the games they won

14. A quantity x is drawn from a normal distribution $P(x)$, with mean 1 and variance 4. Consider the quantity $X=x_1+x_2\ldots+x_N$ obtained by adding values of x from N independent samples drawn from this distribution. The distribution of X has a standard deviation of

a. $\sqrt{2N}$
b. $2\sqrt{N}$
c. $2N$
d. $4N$

15. This graph shows how hearing ability varies with the frequency of sound in three groups of airport inspectors. The solid line represents inspectors who had worked at the airport for 16-20 years and had been exposed to aircraft noise. The broken line represents inspectors who had worked for the same period but were not exposed to aircraft noise. The dotted line is for inspectors who had worked from 1-5 years without being exposed to aircraft noise.
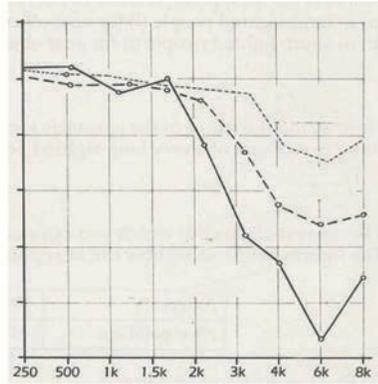

Which of the following conclusions CANNOT be drawn based on the data shown above?

a. Exposure to aircraft noise does not affect hearing of sounds up to 1500Hz.
b. Humans are more sensitive to sounds at 500Hz than they are to sounds at 5000Hz.
c. Exposure to aircraft noise affects hearing ability.
d. Hearing declines with age.

Section B: Physics

1. A sample of a pure solid substance is heated at a constant rate and its temperature recorded as a function of time. This graph has a long flat portion because
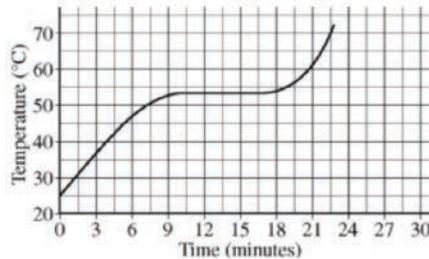
a. heat is rapidly absorbed by the substance between 9 and 18 minutes
b. the substance starts to melt at 9 minutes and is fully melted by 18 minutes
c. the substance rapidly cools at the 9 minute point by radiating away absorbed heat
d. the temperature becomes difficult to measure beyond 50° C

2. Two forces of 7 Newtons each acting at 45 degrees to each other will have a resultant of approximately

a. 6 Newtons
b. 8 Newtons
c. 10 Newtons
d. 13 Newtons

3. Two particles X and Y have the same mass but their charges differ. If X has charge $+q$ and Y has charge $+9q$ and they accelerate in vacuum from rest through the same electric potential difference, then their speeds $v_X:v_Y$ will be in the ratio:

a. 1:9
b. 9:1
c. 1:3
d. 3:1

4. A wire has resistance 12 ohms. It is bent and its two ends are connected to form a circle. The effective resistance between the two points on any diameter of the circle is

a. 3 ohms
b. 6 ohms
c. 12 ohms
d. 24 ohms

5. An object with a mass of 70 kilograms hits a stationary air bag, with velocity 25 m/s at the instant of impact. After 0.25 seconds the object has come to a stop and the air bag has deflated. The average force on object during this interval is most nearly,

a. 70,000 N
b. 7,000 N
c. 700 N
d. 70 N

6. Inside a uniformly charged solid sphere of radius R, at a distance r from the centre, the electric field is proportional to:

a. $1/r^2$
b. $1/r$
c. r
d. r^2

7. The drag force on a particle moving at a speed v in a medium is of the form $F=\zeta v$, where the drag coefficient ζ depends on the particle's shape and size and on properties of the medium. If length is measured in cm, mass in g, and time in s, then ζ has units:

a. g
b. g/(cm s)
c. g/s
d. g cm^2/s

8. A small metabolite on average diffuses about 1 nanometre (10^{-9} m) in a nanosecond (10^{-9} s). How far from its starting point will this metabolite reach on average in 10 s?

a. 10^{-6} m
b. 10^{-4} m
c. 10^{-1} m
d. 10 m

9. A motor protein moves cargo in cells by taking forward steps along linear tracks called microtubules. Assume each step has size 8nm and consumes 30 kJ mol^{-1} of energy by burning ATP. If this energy is converted to work, what is the force exerted at each step?

a. 3.75 x 10^{+12} N
b. 6.25 x 10^{+12} N
c. 3.75 x 10^{-12} N
d. 6.25 x 10^{-12} N

10. What is the effective capacitance of this circuit?
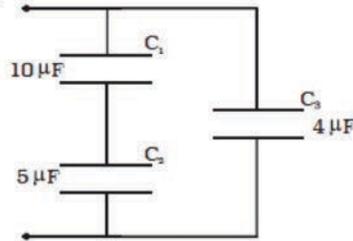
a. 1.54 μF
b. 4.5 μF
c. 7.33 μF
d. 19 μF

11. Consider a simple pendulum consisting of a light rod of length l, pivoted at one end with a mass m attached at the other, swinging with an amplitude A (which may be large). Which of the following statements is the most accurate?

a. Its time period depends on m, l, and A
b. Its time period depends on l and A but not m
c. Its time period depends on m and l but not A
d. Its time period depends only on l, not m or A

12. I place a finger 1/3rd of the way down a guitar string to dampen it, and pluck it. Then I move my finger to 3/4ths of the way down, and pluck the string again. What is the frequency ratio of the first note to the second note:

a. 1:1
b. 1:4
c. 1:3
d. 3:4

13. Two spherical liquid droplets coalesce to form one large spherical droplet. The initial radius of each droplet is r, the surface tension the liquid is s, and its density is d. The energy released in this process depends on

a. only s
b. s and r
c. s and d
d. s, r and d

14. A system consists of molecules that can be in one of two energy levels, E_1 and $E_2 > E_1$. At a temperature T, what fraction of the molecules are in energy level E_2?

a. $E_2/(E_1+E_2)$
b. $\exp(-E_2/kT)/\exp(-(E_1+E_2)/kT)$
c. $\exp(-(E_2-E_1)/kT)$
d. $\exp(-E_2/kT)/(\exp(-E_1/kT)+\exp(-E_2/kT))$

15. A random walker steps by a unit to the right with probability p, by a unit to the left with probability q, and stays at the same site with probability r at each time step. Of course, $p + q + r = 1$. After N time steps the net displacement (number of right steps - number of left steps) of the random walker has an average value of:

a. 0
b. Np
c. $N(1-r)(p - q)$
d. Npq

Section C: Chemistry

1. What is the relationship between the following pair of chemical entities?
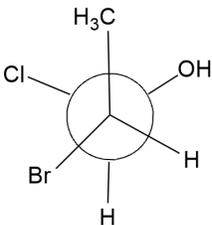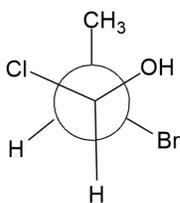
a. diastereomer
b. enantiomer
c. tautomer
d. conformer

2. When 1 litre of 1 M NaCl solution in water is mixed with 1 litre of 1M $CaCl_2$ solution in water, what is the total concentration of chloride ions in the resulting solution?

a. 2 M
b. 1 M
c. 3 M
d. 1.5 M

3. The IR stretching frequency for C=O stretching in carboxylic acid chlorides, esters amides, and acid anhydrides generally ranks as:

a. Acid chlorides> esters> acid anhydrides> amides
b. Amides> esters> acid anhydrides> acid chlorides
c. Acid chlorides> acid anhydrides > esters> amides
d. Acid anhydrides> esters> acid chlorides> amides

4. What type of impurity atoms are used to increase the number of conduction band electrons in intrinsic silicon?

a. bivalent
b. trivalent
c. tetravalent
d. pentavalent

5. In an enzyme-catalysed reaction, if [S] = 10 K_M the velocity of the reaction is about:

a. 0.9 V_{max}
b. 0.7 V_{max}
c. 0.5 V_{max}
d. 0.1 V_{max}

6. The correct shape of the $[TeF_5]^-$ ion on the basis of VSEPR theory is

a. trigonal bipyramidal
b. square pyramidal
c. pentagonal planar
d. see-saw

7. Nucleophilic attack will be most facile on

a. $CH_2=CF_2$
b. $CH_2=CCl_2$
c. $CF_2=CF_2$
d. $CH_2=CH_2$

8. Which conformation of cyclohexane has a C_3 axis of symmetry?

a. Boat
b. Twist boat
c. Chair
d. Envelope

9. Proton NMR of ethyl acetate will show

a. Three peaks, singlet-doublet-triplet in 3:2:3 intensity ratio
b. Three peaks, singlet-quartet-triplet in 3:2:3 intensity ratio
c. Three peaks, doublet-quartet-triplet in 2:2:3 intensity ratio
d. Four peaks, singlet-quartet-triplet-doublet in 3:2:3:2 intensity ratio

10. A dye that is non-fluorescent in water becomes fluorescent with an emission maximum at 430 nm when bound to a globular protein. Its absorption maximum is 400 nm. Given this information, you can conclude that the dye binding to the protein causes:

a. an increase in Stokes shift
b. a decrease in intersystem crossing efficiency
c. a decrease in excited state radiative rate
d. a decrease in excited state non-radiative rate

11. A transition is spectroscopically allowed if it obeys:

a. Wien's displacement law
b. The law of conservation of energy only
c. The law of conservation of angular momentum only
d. Both the laws of conservation of angular momentum and energy

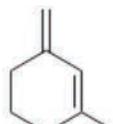12. Which of the following dienes does not react with the dienophile in the Diels-Alder reaction?
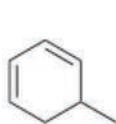
A   B   C   D

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

13. Which of the following nitrogen oxides do not contain N−N bonds?

a. N_2O_5
b. N_2O_4
c. N_2O
d. all of the above

14. What is the order of acidity of the labeled protons?
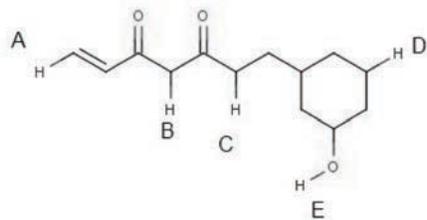
a. A>B>C>D>E
b. C>E>D>A>B
c. E>B>C>A>D
d. D>E>B>A>C

15. In a polypeptide chain, a cis-to-trans rearrangement of two consecutive proline residues can be achieved by rotating the:

a. ϕ angle to 10°
b. ω angle to 180°
c. ψ angle to 0°
d. χ^1 angle to 60°

Section D: Biology

1. Which one of the following changes will not alter the sequence of the encoded protein?

a. Codon optimization
b. Gene methylation
c. Synonymous mutation
d. All of the above

2. Which of the following best indicates that a segment of DNA is a gene?

a. multiple expressed sequence tags (ESTs) of the DNA sequence
b. 50% identity with a known promoter
c. the DNA sequence is able to form hairpin loop
d. multiple short repeats

3. Which of the following is not an oncovirus?

a. Hepatitis B Virus (HBV)
b. Hepatitis C Virus (HCV)
c. Epstein Barr Virus (EBV)
d. Dengue Virus (DENV)

4. Which of these events contributes the most in proper folding of a polypeptide to its native state in an aqueous solvent?

a. loss of hydrogen bonding between the polar amino acids and water
b. hydrophobic effect which sequesters the non-polar residues away from water
c. formation of new inter-molecular hydrogen bonding between polar amino acids
d. formation of di-sulphide linkages between free cysteine residues located at a distance along the primary sequence

5. In the evolutionary history of life, identify the most likely order in which the following entities arose:

a. plasma membrane < RNA < chloroplasts < nucleus
b. nucleus < plasma membrane < RNA < chloroplasts
c. RNA < plasma membrane < nucleus < chloroplasts
d. chloroplasts < RNA < plasma membrane < nucleus

6. Microorganisms that produce antibiotics are unaffected by the same antibiotic. One mechanism to explain this is:

a. Microorganisms export the antibiotic using efflux pumps as soon as it exceeds a certain intracellular concentration
b. Antibiotics are made in parts and are assembled after being transported to the extracellular environment.
c. Antibiotics are always produced in inactive forms and get activated by the enzymatic action of the target cell
d. The active pharmacophore of the bactericidal antibiotic remains bound to antibodies while they are intracellular

7. You transcribe mRNA from a DNA sample and purify it. You then separate the two strands of the DNA and analyse the base composition of each strand and of the mRNA. You obtain the data shown in the table below. Which strand of the DNA is serving as a template for mRNA synthesis?

	A	G	C	T	U
DNA strand 1	19.1	26.0	31.0	23.9	0
DNA strand 2	24.2	30.8	25.7	19.3	0
mRNA	19.0	25.9	30.8	0	24.3

a. Strand 1
b. Strand 2
c. Both strands
d. Neither strand

8. The Asian mongoose and the American skunk evolved independently of each other, but show similar structures and features, for e.g., ability to spray their attacker with musk. The similarities between the two organisms are most likely the result of:

a. genetic drift
b. divergent evolution
c. allopatric speciation
d. convergent evolution

9. Mitochondria isolated and placed in a buffered solution with a low pH start to produce ATP. This is likely due to:

a. lower pH inside mitochondria
b. increased OH- concentration in the mitochondrial matrix
c. increased movement of H+ from the inter-membrane space to the matrix
d. decreased H+ in the inter-membrane space

10. N-linked glycosylation in proteins of eukaryotes is initiated in the:

a. lumen of the endoplasmic reticulum
b. lumen of the Golgi apparatus
c. inside the nucleus
d. within endosomes

11. When HeLa cells were treated with the growth factor TGF-β for 30 minutes, levels of E-Cadherin protein were reduced. mRNA levels of the E-Cadherin gene (CDH1) did not show any reduction. What could be the potential mechanism behind this observation?

a. Inhibition of translation of CDH1 mRNA
b. Degradation of E-Cadherin protein
c. Increased stability of CDH1 mRNA
d. Both 'a' and 'b'

12. Which of the following mRNA molecules would form the most stable stem-loop structure?

a. 5'...GGCUU......UUCGG...3'
b. 5'...GGCUU......AAGCC...3'
c. 5'...GGCUU......GGCUU...3'
d. 5'...GGCUU......CCGAA...3'

13. Rifampicin, an inhibitor of RNA polymerase, is added to a bacterial culture. The culture is immediately divided into three fractions, to which radioactive thymine or uracil or methionine are added, respectively. Five minutes later the cells are lysed and the radioactive label in all macromolecules is monitored. What will you observe?

a. The labels will be equally incorporated
b. Uracil incorporated is similar to methionine but less than thymine
c. Uracil incorporated will be greater than methionine but less than thymine
d. Thymine and methionine incorporated will be greater than uracil

14. Despite humans having a highly evolved immune system, pathogens are able to evade the immune system using various strategies. Which of the following immune evasion strategies cannot be employed by a virus?

a. Antigenic shift
b. Antigenic switching
c. Antigenic drift
d. All of the above

15. Rank the following ideas/discoveries from oldest to most recent.

(I) DNA is the molecule responsible for heredity
(II) Living things best suited to their environment are more likely to survive, reproduce and pass their characteristics to future generations
(III) The molecular structure of DNA corresponds to a double helix
(IV) Different pairs of alleles are passed onto the offspring independently of each other

a. I, II, III, IV
b. IV, II, I, III
c. II, IV, I, III
d. II, I, III, IV

Answer Keys - Biology

Question #	Answer
Section # : 1	
Total questions : 15	
Q 1	c
Q 2	c
Q 3	d
Q 4	b
Q 5	a
Q 6	a
Q 7	d
Q 8	a
Q 9	b
Q 10	b
Q 11	a
Q 12	c
Q 13	c
Q 14	b
Q 15	d
Section # : 2	
Total questions : 15	
Q 1	b
Q 2	d
Q 3	c
Q 4	a
Q 5	b
Q 6	c
Q 7	c
Q 8	b
Q 9	d
Q 10	c
Q 11	b
Q 12	d
Q 13	b
Q 14	d
Q 15	c

Section # : 3	
Total questions : 15	
Q 1	a
Q 2	d
Q 3	c
Q 4	d
Q 5	a
Q 6	b
Q 7	a
Q 8	c
Q 9	b
Q 10	d
Q 11	d
Q 12	c
Q 13	a
Q 14	c
Q 15	b
Section # : 4	
Total questions : 15	
Q 1	d
Q 2	a
Q 3	d
Q 4	b
Q 5	c
Q 6	a
Q 7	b
Q 8	d
Q 9	c
Q 10	a
Q 11	d
Q 12	b
Q 13	d
Q 14	b
Q 15	c