JGEEBILS GS2020

Section A: General

1.

Who among the following has been leading a campaign on climate change?

a.   Greta Thunberg

b.   P. V. Sindhu

c.   Michelle Obama

d.   Malala Yousafzai

2.

Pick the odd one out:

a.   Speed of light in vacuum

b.   Charge of the electron

c.   Diameter of the Earth

d.   Gravitational constant

3.

The Earth's diameter measured across the equatorial plane is about 40 km more than that measured between the poles. This is because of:

a.   excess ocean water at the equator

b.   the rotation of the Earth

c.   freezing of water at the Earth's poles

d.   the Moon's gravitational pull

4.

We are given two plant species. Species A has large white colored flowers with copious amounts of nectar, while Species B has dull green colored flowers with no nectar. Which of the following is true?

a.   Species A is more fit than Species B.

b.   Species B is more fit than Species A.

c.   Both species are equally fit.

d.   We cannot conclude anything about fitness from the given data.

5.

In bacteria, glucose absorbed via the cell surface is used to synthesize ATP. The ATP, in turn, powers processes throughout the cell volume. Based on this alone, which of the following types of cells would you expect to have the slowest growth rate?

a.   Short rods (cylinder: length = 2µm, diameter = 1 µm)

b.   Long rods (cylinder: length = 4µm, diameter = 1 µm)

c.   Small cocci (sphere: diameter = 1µm)

d.   Large cocci (sphere: diameter = 4µm)

6.

Giant squid have the largest eyes of any animal. This suggests:

a.   Giant squid use binocular vision

b.   Giant squid spend time in low-light environments

c.   Giant squid can focus on very distant objects

d.   All of the above

7.

50 leaves were clipped from a plant. Priya and Gautam separately measured the areas and distances from the apical tip, of all the leaves. The students plotted their values on separate graphs, with the y-axis showed the distance and the x-axis showed the leaf area. After fitting these graphs to straight lines, they found the following:

Priya's graph: Slope 0.8   correlation coefficient 0.99
Gautam's graph: Slope 1.0   correlation coefficient 0.90

You are now provided the distance of a leaf from the apical tip of the same plant, and asked to predict the area of the leaf using this information. Whose graph should you use?

a.   Priya's

b.   Gautam's

c.   Either would be equally good

d.   Neither, since the leaf area is the independent variable

8.

With which of the following do you associate the term "qubits"?

a.   Black holes

b.   Quantum computers

c.   Whole genome sequencing

d.   Sea level rise

9.

Many species of ants lay chemical trails when they search for food. Once one ant discovers food and returns to the colony, other ants follow its trail back to the food source. Once the food runs out, ants abandon the trail and begin to search for new food sources. For this process, ants should use signal molecules with which of the following properties?

a.   Species-specific chemical, half-life of one day

b.   Common chemical, half-life of one day

c.   Species-specific chemical, half-life of one hour

d.   Common chemical, half-life of one hour

10.

Which of the following statements about the function $f(x) = x^2 - 3x + 4$ is true?

a.   The function does not intersect the x-axis

b.   The function does not intersect the y-axis

c.   The function has two real roots

d.   The function has one real and one imaginary root

11.

Which of the following is FALSE:

a.   Neanderthals and Homo sapiens coexisted

b.   Neanderthals and Homo sapiens mated

c.   Some living humans have Neanderthal ancestors

d.   All living humans have Neanderthal ancestors

12.

I drove my car over a bunch of nails. I estimate there's a 10% chance that any given tyre is punctured. I have only one spare tyre. The probability that I'll be able to drive on safely (after changing a tyre if necessary) is:

a.   95%

b.   90%

c.   66%

d.   60%

13.

I am given a three-digit digital display, where the decimal point can be placed at one of three possible positions as shown below. How many different numerical values can I represent using this display? Remember to ignore any leading zeros: "08.9" represents the same value as "8.90".


a.   1000

b.   2700

c.   2800

d.   3000

14.

I am given a function $f(x)$ and told that $f(-1) > 0$, $f(+10) < 0$. Which of the following properties of the function is necessary and sufficient to conclude that the function has a root $f(x_0) = 0$ for some value x_0 in the interval $-1 < x_0 < +10$?

a.   Monotonic

b.   Continuous

c.   Differentiable

d.   Quadratic

15.

A 2005 report from the World Health Organization shows the effect of malnutrition on the mortality of children admitted to hospitals for various diseases. Which of the following conclusions is supported by data in the graph?
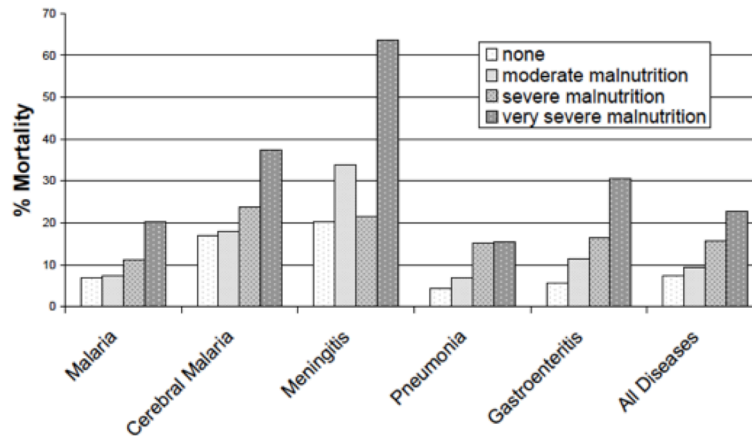
a.   Meningitis is the most common illness among this group.

b.   Malnourishment correlates with increased mortality among this group.

c.   Most children admitted to hospitals were malnourished.

d.   Most children admitted to hospitals suffered from multiple diseases.

Section B: Physics

1.

For a spherical water droplet at sea level, which one of the following is true about the internal pressure:

a.   lower than atmospheric pressure, and depends on surface tension

b.   lower than atmospheric pressure, and independent of surface tension

c.   higher than atmospheric pressure, and depends on surface tension

d.   higher than atmospheric pressure, and independent of surface tension

2.

A box of mass m slides along a wooden floor. The contact area between the box and the floor is A. Which of these statements is true about the frictional force?

a.   It doubles if A doubles while m is kept the same

b.   It doubles if m doubles while A is kept the same

c.   It does not change if A doubles and m decreases by half

d.   It does not change if both A and m doubles

3.

A ball is falling through a viscous fluid at its terminal velocity. The magnitudes of the forces acting on the ball are: gravitational force F_G, drag force F_D and buoyant force F_B. Which of the following conditions is true?

a. $F_G + F_B + F_D = 0$

b. $F_G + F_B = F_D$

c. $F_G - F_B = F_D$

d. $F_G + F_B = 2F_D$

4.

The probability distribution function P(x) of a continuous random variable x is shown in the left figure. Which of the curves in the right figure best represents the cumulative distribution function C(x) corresponding to P(x)?
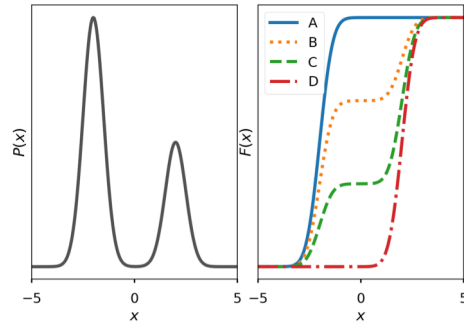
a.   A

b.   B

c.   C

d.   D

5.

A protein can exist in two conformational states A and B with energies -E and +E respectively. Assume the system (single protein) is in thermal equilibrium with a heat bath at temperature T. The average energy in the infinite temperature case and zero temperature case are respectively given by

a.   E, -E

b. ∞, 0

c.   E, -2E

d.   0, -E

6.

Four discharged capacitors C_1, C_2, C_3 and C_4 are connected as shown in the figure. A potential difference is applied between the points X and Y and the system is allowed to reach steady state. What should the relation between the capacitances of the capacitors be so that the potential difference between the points x and y is zero?
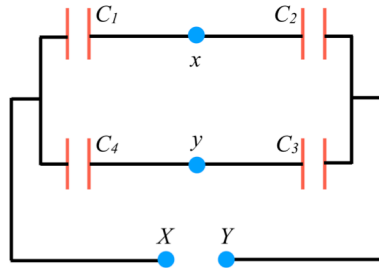
a. $C_1/C_4 = C_2/C_3$

b. $C_1/C_2 = C_3/C_4$

c. $C_1 + C_4 = C_3 + C_2$

d. $1/C_1 + 1/C_2 = 1/C_3 + 1/C_4$

7.

Which one of the geometries of the same mass and radius has the maximum moment of inertia?

a.   a thin circular disk

b.   a thin circular ring

c.   a thin spherical shell

d.   a solid sphere

8.

A sound wave propagating in a solid block can have the following modes:

a.   One transverse only

b.   One longitudinal only

c.   Two transverse and one longitudinal only

d.   One transverse and one longitudinal only

9.

Light is incident from a medium with refractive index n = 1.72 onto vacuum. The smallest angle of incidence (measured with respect to the normal) for which light is not transmitted into vacuum is (approximately):

a.   30°

b.   45°

c.   60°

d.   90°

10.

A multimeter has an internal resistance of 0.5 Ohms while another has an internal resistance of 5×10^6 Ohms. What use can the two multimeters be best put to?

a.   The first as an ammeter and the second as a voltmeter

b.   The second as an ammeter and the first as a voltmeter

c.   Both can be used as ammeters but not as voltmeters

d.   Both can be used as voltmeters but not as ammeters

11.

The number of molecules dN with speeds lying between v and $v+dv$ of a classical gas is given by dN = $\rho(v)$ dv. The distribution $\rho(v)$ is shown for two systems in the figure. You are told that $\rho(v)$ for system 2 is twice that of system 1 for all v. What can we say about the two systems?
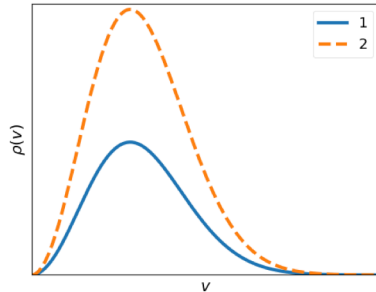
a.   System 1 is twice as hot as System 2

b.   The molecules of System 2 are twice as heavy as those of System 1

c.   The molecules in System 2 are moving twice as fast as those in System 1

d.   System 2 has twice the number of molecules as System 1

12.

The minimum number of NAND gates required to construct an OR gate is

a.   1

b.   2

c.   3

d.   4

13.

Two reference frames S and S' are moving towards each other with relative velocity 3c/4, where c is the speed of light. Now an object in S frame is moving with velocity 3c/4 towards the same direction that S frame is moving. What will be the velocity of that object as measured from S' frame ?

a.   c

b.   3c/4

c.   3c/2

d.   24c/25

14.

A circuit consists of a battery, a resistor and a reverse-biased Zener diode in series. The battery voltage is greater than the barrier voltage of the diode. Which of the following statements is correct?

a.   Increasing the resistance will increase the voltage drop across the diode

b.   Increasing the resistance will decrease the voltage drop across the diode

c.   Changing the resistance does not change the circuit current

d.   Changing the resistance does not change the voltage drop across the diode

15.

A 1-D infinite potential well of width L has a ground-state energy of E_1. If the width is doubled to 2L, it now has a ground-state energy E_2. Which of the following is true?

a. $E_2 = 1.41 \times E_1$

b. $E_2 = 4 \times E_1$

c. $E_2 = E_1 / 2$

d. $E_2 = E_1$

Section C: Chemistry

1.

The types of bonds present in NH4Cl are:

a.   ionic, covalent and coordinate

b.   only ionic

c.   ionic and covalent

d.   covalent and coordinate

2.

The product formed is an isobar if there is

a.   1 α emission

b.   1 β emission

c.   1 α and 1 β emission

d.   2 α and 1 β emission

3.

Which element has the greater difference between the first ionization energy and the second ionization energy, among Potassium, Calcium and Gallium?

a.   Potassium

b.   Calcium

c.   Gallium

d.   All have the same difference as they are in the same row of the periodic table

4.

Which of the following can chelate metals, among salicylaldehyde, salicylic acid, and o-nitrophenol?

a.   salicylaldehyde

b.   salicylic acid
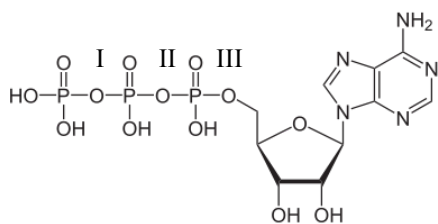
c.   o-nitrophenol

d.   all of these

5.

Two solutions of the same molecule, with concentrations of 10^{-3} M and 5×10^{-4} M, are kept in two different cuvettes with path lengths 1 cm and 2 cm, respectively. If the absorbance for 1st sample is 1.2, what will be the absorbance for the second sample?

a.   1.0

b.   1.2

c.   2.4

d.   6.0

6.

In the following structure

The ease of breaking phosphate bonds follows the order

a.   I > II > III

b.   III > II > I

c.   II > III > I

d.   I = II = III

7.

Among the following salts which has the highest water solubility?

a. $NaClO_4$

b. $CsClO_4$

c. $LiClO_4$

d. $KClO_4$

8.

What is the hybridisation of triplet carbene?

a.   sp3

b.   sp2

c.   sp2 and sp

d.   sp

9.

Choose the molecule that has polar bonds but does NOT orient within an electric field.

a.   HCl

b. Cl_2

c. CCl_4

d. NH_3

10.

A monobasic acid has pKa = 5.2. Calculate the pH at which the ratio between the acid and the anion (A^-) will be 1:50.

a.   3.5

b.   5.7

c.   6.9

d.   7.4

11.

Arrange the following compounds in increasing order of acid strength:
I: Phenol, II: o-nitrophenol, III: m-nitrophenol, IV: 2,4-dinitrophenol, V: 2,4,6-trinitrophenol

a.   I < V < IV < II < III

b.   V < IV < III < II < I

c.   I < III < II < IV < V

d.   I < II < III < IV < V

12.

Between metal carbonyl complexes A = $M(CO)_4(PEt_3)$ and B = $M(CO)_4(PPh_3)$, the ability to act as a catalyst for nucleophilic addition to olefin is

a.   similar for both

b.   higher for A

c.   higher for B
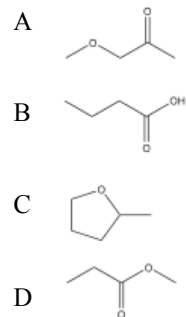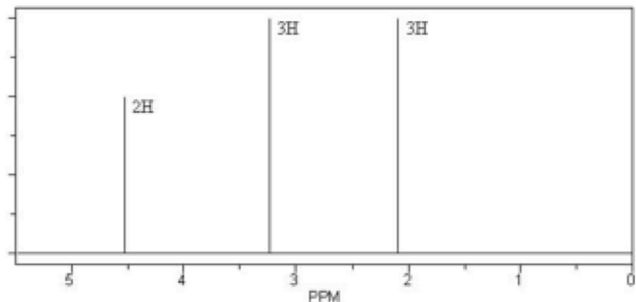
d.   indeterminate based on the given information alone

13.

An acidic solution containing 0.01 M La^{3+} is treated with NaOH until $La(OH)_3$ precipitates. At what pH does this occur? ($K_{sp}=2x10^{-21}$)

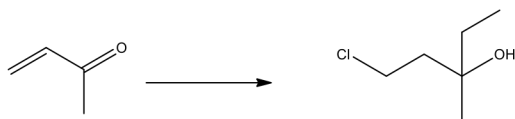a.   6.8

b.   7

c.   7.8

d.   8

14.

A molecule has formula $C_4H_8O_2$. Based on the following proton NMR spectrum, what is the structure?

a.   A

b.   B

c.   C

d.   D

15.

Which of the options listed below show the most appropriate set of reagents to carry out the following reaction?

a.   i. EtMgBr, ii. HCl

b.   i. HCl, ii. EtMgBr

c.   i. C_2H_5Li, ii. HCl

d.   i. $(C_2H_5)2CuLi$, ii. HCl

Section D: Biology

1.

Ocean acidification has multiple consequences on marine life, including reducing availability of carbonate for skeletal formation of ocean organisms, increasing coral bleaching, and other impacts. The main driver of the increasing acidity of our oceans is:

a.   Increased ozone that reacts with water to release hydrogen atoms

b.   Increased plastic pollution which breaks down in the water

c.   Increased CO_2 that reacts with water to form carbonic acid and then bicarbonate

d.   Reduction in marine life which decreases the amount of ammonia waste

2.

Which one of the following would produce the highest variability of gametes if the alleles assorted independently?

a.   Yy PP Tt Rr

b.   Yy Pp Tt Rr

c.   YY Pp Tt Rr

d.   Yy PP TT RR

3.

In PCR, annealing temperature of the primer does not depend on:

a.   Primer length

b.   dNTP concentration

c.   The secondary structure of the primer

d.   The GC content of the primer

4.

In a new species of bacteria, tRNA anticodons are recognized by two nucleotide bases instead of three. What would be the number of amino acids and the number of peptide bonds, respectively, of a polypeptide encoded by a 120 nucleotide long coding DNA sequence which includes a two-base stop codon?

a.   58, 58

b.   59, 58

c.   60, 59

d.   61, 60

5.

Which of the following statements is incorrect about meiosis?

a.   Two rounds of DNA replication occur

b.   The chromosome number is reduced to half

c.   Four daughter cells are formed

d.   Homologous chromosomes are paired

6.

The recent all India tiger census counted all individuals above the age of 1 year as adults. An earlier estimate four years ago included only individuals above the age of 1.5 years. Given this information alone, can these two estimates be compared?

a.   Yes, because the age of first reproduction in tigers has decreased due to pollution

b.   No, because they are comparing different sets of tigers in the population

c.   Yes, because these are random samples of the whole population

d.   No, because many tigers die specifically between 1 and 1.5 years

7.

Dogs are genetically very close to wolves. Yet all wolves look similar while the breeds of dogs look very different from one another. This is best explained by which of the following:

a.   Wolves have very little genetic variation as a species

b.   Wolves are selected for camouflage

c.   Different dog breeds have been created by artificial selection and inbreeding

d.   Dogs evolved more recently than wolves

8.

A student was asked to clone a DNA fragment flanked by BamHI (GGATCC) sites into a vector cut with BglII (AGATCT). The cloning was successful, as these two restriction enzymes are known to create compatible sites. Based on this, what will be the restriction site configurations of these two enzymes (/ indicates the point of enzymatic cleavage)?

a.   G/GATCC and AGATC/T

b.   G/GATCC and A/GATCT

c.   GGATC/C and A/GATCT

d.   GGATC/C and AGA/TCT

9.

A student has a mixture of different proteins (molecular weight of Protein A = 30.0 KDa; Protein B = 35.0 KDa; Protein C = 40.0 KDa; Protein D = 50.0 KDa). The protein mixture was purified using FPLC, size-exclusion (gel filtration) chromatography. What size fraction will elute first?

a.   Protein A = 30.0 KDa

b.   Protein B = 35.0 KDa

c.   Protein C = 40.0 KDa

d.   Protein D = 50.0 KDa

10.

A hydrilla plant is growing in a beaker with water. What will happen to the rate of photosynthesis if you add sodium bicarbonate to the water?

a.   It will remain unchanged

b.   It will decrease

c.   It will stop

**d.**   It will increase

11.

You decide to improve your western blotting by customizing the buffer used for incubation and washing and hear from friends that they routinely use reducing agents to purify proteins. So you incorporate DTT into the western blotting procedures and realize that it only makes it worse. You do not get any signals. The reason for this is:

a.   DTT inhibits horse radish peroxidase conjugated to your secondary antibody

b.   DTT prevents the binding of secondary antibodies to primary antibodies

c.   DTT specifically blocks the interaction of primary antibody with antigens

d.   DTT destroys the structural integrity of the antibody

12.

In the following pedigree, what will be the genotype of the parent indicated by the dark square? Dark symbols indicate individuals with a specific phenotype, controlled by the locus with alleles A or a.
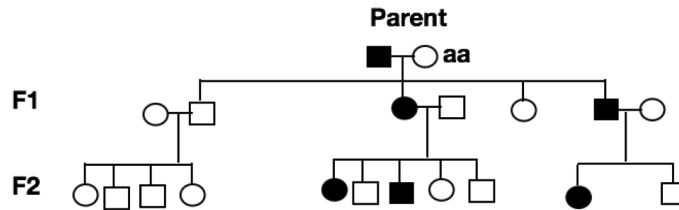
a.   AA

b.   Aa

c.   aa

d.   It could be either AA or aa

13.

A bacterial gene has two alleles, A and B. A scientist measured bacteria grown under two different treatments in the laboratory, and she measured proportion of the population that had allele A, repeating the experiment six times in each case. The results are shown below. Which of the following statements could you make about the alleles?
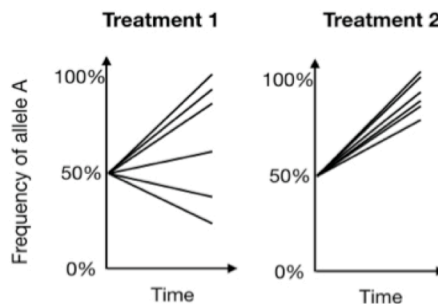
a.   Allele B is beneficial in treatment 1

b.   Allele A is beneficial in treatment 2

c.   Allele B is beneficial in both treatments

d.   The fate of allele A is more variable than that of allele B

14.

A protein coding gene in the mouse was mutated such that the resultant protein was non-functional. The phenotypic effect of the mutation was observed in homozygous mutant mice, in heterozygous mice that inherited the mutation from the mother, and in heterozygous mice that inherited the mutation from the father. This suggests that:

a.   The gene is imprinted

b.   The mutation acts as a dominant negative

c.   The gene possibly has more than two alleles

d.   The gene is X-linked

15.

A single-stranded RNA virus was grown in cell culture, either in absence of or in presence of chemicals X/Y. The intracellular genome copy number of the virus, and titer in the cell culture supernatant (plaque forming units) were estimated over several hours. Based on the data presented below, choose the most correct option.
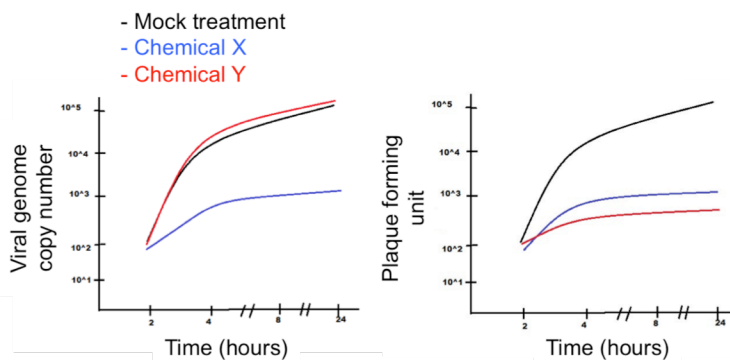
a.   X inhibits viral entry and Y inhibits viral genome replication.

b.   X inhibits viral genome replication and Y inhibits viral entry.

c.   X inhibits viral release and Y inhibits viral entry.

d.   X inhibits viral entry and Y inhibits viral release.