

GENERAL QUESTIONS:

In a population of a remote Pacific island, the frequency of people with green eyes is 3%. In that same population, the frequency of people having dimples is 0.5%. Assuming independent assortment, what is the expected number of people who will have both dimples and green eyes, given that the population of the island is 3400 individuals?

~~51~~

~~102~~ *This question has not been taken into account for the purpose of evaluation*

~~119~~

~~150~~

In a skewed distribution with a long right tail like the distribution of annual incomes in most developing countries, which of the following statements is true?

mean < mode < median

mean < median < mode

mode < mean < median

mode < median < mean

A bat echolocates and receives an echo 10 milliseconds later. Assuming a speed of sound in air of 340 m/s, how far away is the object?

3.4 m

1.7 m

6.8 m

5.1 m

A badminton tournament has 128 participants and needs to produce just one winner. In each match, only the winner goes to the next round and plays with one of the other winners. This proceeds till ultimately there is only one winner. How many matches will a person need to reach the semi-finals?

8

7

6

5

Kleiber's law states that for a number of animal species, the metabolic rate, scales as the $3/4$ th power of its mass. Thus, a cat that weighs about 80 times more than a mouse:

consumes about 27 times the energy of the mouse.

consumes about $1/27$ times the energy of the mouse.

consumes as much energy as the mouse.

consumes about 60 times the energy of the mouse.

Where would the graph of $y=x^2$ and $y=x^3$ intersect?

At $x = -1$

At all $x > 1$

At $x=0$ and $x=1$

At all points between $x=0$ and $x=1$

Avni has 8 favorite paintings but only 2 wall hooks where she can hang them. In how many different ways can she hang the paintings?

32

56

16

64

Consider the following data as a sample.

15, 15, 33, 17, 30, 30, 20, 60, 45, 15

If each data value is increased by 5, what is the effect on the mean and standard deviation?

Both the mean and the standard deviation increase by 5.

The mean remains the same, but the standard deviation increases by 5.

The standard deviation remains the same, but the mean increases by 5.

Both the mean and the standard deviation remain the same

Electric cars are considered more eco-friendly because:

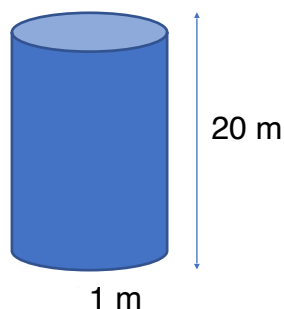
They do not cause air pollution

They are built from bio-degradable parts

They can carry more people

They are cheaper

A large sealed drum with a radius of 1 m and a height of 20 m, needs to be painted all over. Assuming 1 litre of paint covers 6 square meters, how many litres of paint will be required to paint the drum?



132 litres

22 litres

20 litres

125 litres

Garima started a business with a personal investment of INR 3000. After 3 months Ridhima joined the same business and invested INR 2000. After some more time Badima joined the business with INR 1500. At the end of the year, the profit was 16000 and the share of Badima was INR 1600. How many months did Badima invest in the business?

3

5

4

7

If a cat's pupils are circular, it is likely that

It is looking at a fire

It is walking in darkness

It is pleading for food

It is about to sleep

The Arctic tern is one of the fastest long-distance migratory birds with them migrating from the Arctic to the Antarctic pole and back every single year,

which is about 90000 km in total. On average, these birds fly at the rate of about 40 km/hr, which of the following is true?

I. The birds take ~45 days to complete one-half of the journey.

II. The birds complete ~65% of one-half of the journey in a month.

III. This is equivalent to Usain Bolt completing one-half of the Arctic-Antarctic journey in ~50 days at his 100-metre world record pace, which he completed in 9.58 seconds.

I and II only

II and III only

I and III only

All three statements are correct.

The Malabar carnation has red and white flowers. You suspect that sunbirds, which are diurnal, pollinate the red flowers, whereas the nocturnal hawkmoth pollinates the white ones. To show this you cover the red flowers at night and white ones during the day. All flowers become pollinated. What additional experiment can you do to support your claim?

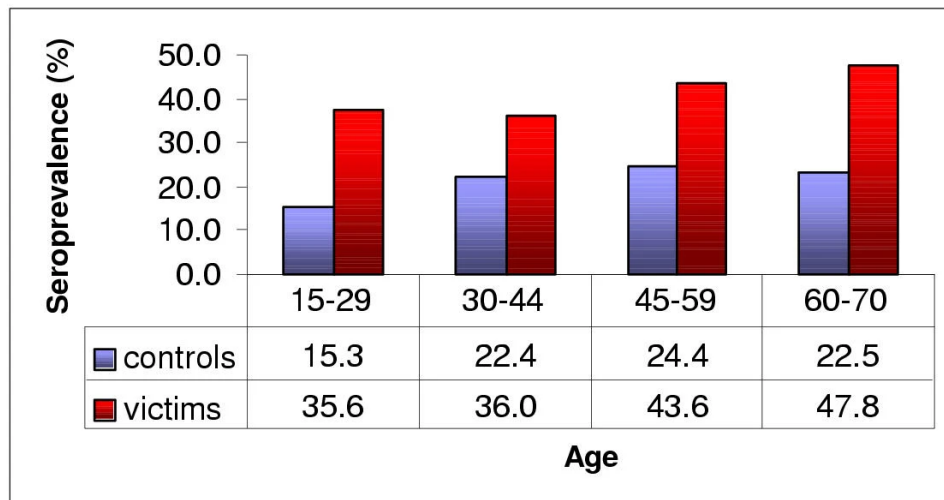
Set up a red and white Malabar carnation at opposite ends of a darkened flight arena to determine the flower preference of a sunbird

Set up a red and white Malabar carnation at opposite ends of a well-lit flight arena to determine the preference of a sunbird

Cover red flowers during the day and white flowers during the night and determine pollination

Cover only white flowers and determine the colour of the resulting progeny.

Toxoplasma is a parasite known to induce behavioural changes in mice, such as making them less fearful of cats. About 30-70% of humans are thought to be infected by Toxoplasma. A study was conducted to determine if reckless driving leading to motor accidents could be due to toxoplasma infection (Flegr et al 2002) and the following data were obtained:



Seroprevalence indicates the presence of antibodies to Toxoplasma in the blood sample taken from the subjects. Controls were healthy individuals not involved in traffic accidents. Based on the above data, which of the following statements can be made?

- I. Toxoplasma infection causes humans to get into accidents
- II. There is no relationship between toxoplasma infection and accidents
- III. Toxoplasma infection is correlated with an increased risk of accidents

I only

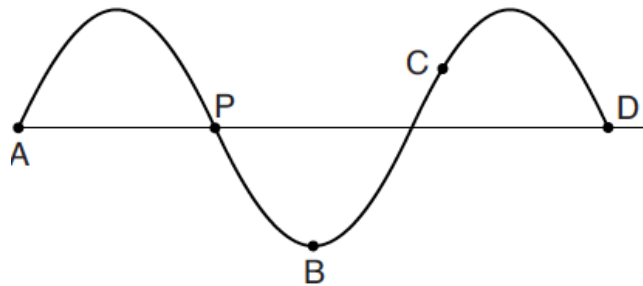
II only

III only

I and III only

PHYSICS

The diagram below represents a periodic wave. Which point on the wave is 90° out of phase with point P?



- A
- B**
- C
- D

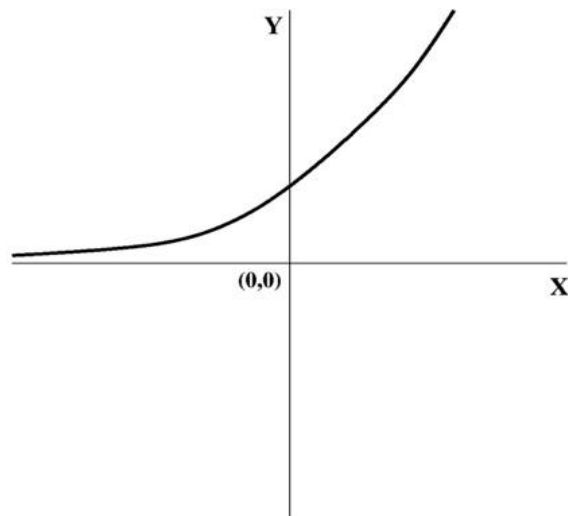
An electric circuit has two parallel plate capacitors (C1 and C2) in series. Both capacitors have the same dielectric and inter-plate distance, but the plates in C1 have a higher surface area compared to those in C2. Once fully charged, which of the two capacitors will have a higher voltage drop?

- C1
- C2**

The capacitor which is closer to the power supply

The capacitor which is further from the power supply

Which of the following equations best represents the graph shown below?



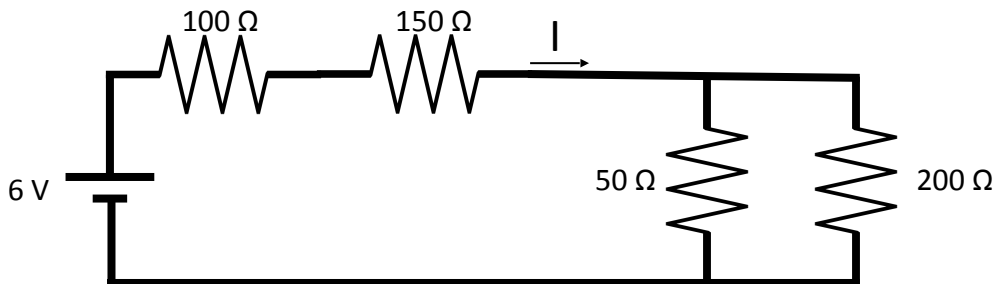
$Y = X^2$

$Y = e^x$

$Y = \log X$

$Y = X^{1/2}$

What is the value of the current I given below?



0.01 A

0.03 A

0.02 A

0.04 A

A decibel is a measure of

The ratio of sound amplitude to sound frequency

The ratio of a pure tone to the background noise

The frequency of sound

The amplitude of sound

A bullet with the same density as water is shot straight down into a very deep water tank. What happens after sufficient time?

The bullet eventually comes to a halt at an intermediate depth.

The bullet eventually falls to the bottom of the tank

The bullet initially moves down but eventually floats to the surface.

The bullet eventually oscillates between two depths.

Reaction P has $\Delta H < 0$ and $\Delta S > 0$ while reaction Q has $\Delta H > 0$ and $\Delta S > 0$. Which of the following is true?

Both P and Q are spontaneous at all temperatures because entropy increases.

P is spontaneous at all temperatures but Q is spontaneous only at high temperatures.

P is spontaneous only at high temperatures but Q is spontaneous at all temperatures.

Both P and Q are spontaneous only at high temperatures.

Evidence for the expansion of the universe comes from the observation of light from distant galaxies. What is this observation?

Light from distant objects is red shifted

More distant pulsars have a lower orbital frequency

Light from other galaxies is focused by gravitational lensing

The number of stars per volume drops at greater distances

The wheels on a drag racing car have a higher diameter at the end of a race than at the beginning. Which of the following is the least important factor contributing to this?

The weight of the car is reduced due to fuel consumption.

The tires heat up so the air inside expands.

The tires rotate rapidly so the centrifugal force stretches them.

Due to rubber fatigue the stiffness of the rubber decreases.

11 balls have radii X cm, $X+1$ cm, ..., $X+10$ cm. Which of the following is true about the volumes of these balls?

The mean is equal to the median.

The mean is greater than the median.

The mean is less than the median.

The relative order of mean and median depends on the value of X.

A seagull flying 30 metres above the ocean spots a fish swimming 6 metres below the surface. The seagull folds its wings and falls to catch the fish. What is the velocity of the seagull when it hits the surface of the water? Assume no air resistance.

27.5 m/s

24.25 m/s

11 m/s

588 m/s

A bacterium is swimming in an isotonic medium. I now add NaCl to a concentration of 100 mM. Which of the following is true?

The osmotic pressure points inward but the water flows outward

The osmotic pressure points outward so the water flows outward

The osmotic pressure points inward so the water flows inward

The osmotic pressure points outward but the water flows inward

I have two identical glass beakers, X and Y, full of water. I introduce a concentrated drop of ink into each beaker. I stir beaker Y until the ink concentration is uniform. What can you say about the diffusive motion of the ink molecule?

The molecule diffuses with the same diffusion coefficient in both X and Y.

The molecule diffuses in X but not in Y.

The molecule diffuses in Y but not in X.

The molecule diffuses at the site of the original droplet but not close to the boundary.

Elon Musk goes cycling on the moon, where there is no air resistance. He finds a hill which has a nice smooth slope on one side, and a cliff on the other. If he jumps off the cliff his speed is greater than when he rides to the bottom of the slope, even though the starting height, and therefore potential energy is the same. His cycle has no friction. What is the explanation?

The conversion of potential energy is more efficient if the resulting kinetic energy is along the same vector as the force due to gravity.

The distance travelled down the slope is greater, so it takes longer, so the final speed is slower.

The gas in his space suit applies friction even though the cycle has none.

The wheels of the bicycle acquire kinetic energy when he rides down the cliff.

The Pauli spin matrices are defined as

$$\begin{aligned}\sigma_1 = \sigma_x &= \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \\ \sigma_2 = \sigma_y &= \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix} \\ \sigma_3 = \sigma_z &= \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\end{aligned}$$

Which of these matrices has an eigenvector $[1 \ -1]^T$?

σ_x

σ_y

σ_z

None have real eigenvectors.

CHEMISTRY

The structure of nitrous oxide (N₂O) can best be described by a resonance of two structures. The hybridization of nitrogen atoms in the two resonance structures are:

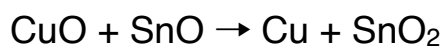
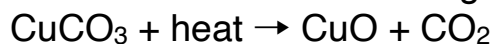
both sp

one sp another sp³

both sp²

one sp another sp²

Which statement is true for the following chemical reactions?



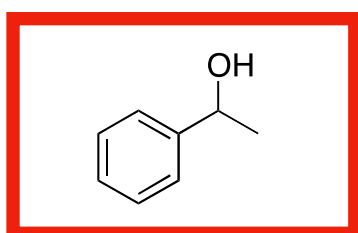
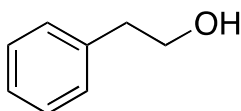
CO₂ is oxidised and SnO₂ is reduced

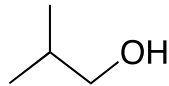
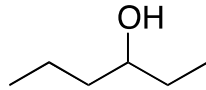
CuCO₃ is oxidised and CuO is reduced

CuO is oxidised and SnO is reduced

SnO is oxidised and CuO is reduced

Among the following, the one that gives a positive Iodoform test upon reaction with I₂ and NaOH is:





Correct Answer is B

Dinitrogen tetroxide (N_2O_4) breaks down into nitrogen dioxide (NO_2). If the reaction is reversible and endothermic, which condition will give the largest yield of NO_2 ?

High temperature and high pressure.

High temperature and low pressure.

Low temperature and high pressure.

Low temperature and low pressure.

The melting temperature of a human protein is $33\text{ }^\circ\text{C}$ in 100 mM sodium phosphate buffer at pH 6.5. What should the predominant conformation of the protein in the same buffer at physiological temperature conditions be?

disordered

α helical

β sheet

Mixture of alpha helix and beta sheet.

20 μl of a 10 mg/ml solution of protein A (molecular weight 10 kDa) is added to 20 μl of a 10 mg/ml solution of protein B of molecular weight 20 kDa. What is the molar ratio of the two proteins (A:B) in the mixture?

1:1

2:1

1:2

2:2

When the velocity of enzyme activity is plotted against substrate concentration, which of the following is obtained?

Hyperbolic curve

Parabola

Straight line with positive slope

Straight line with negative slope

Phosphoric acid is tribasic with three pKa values of 2.14, 6.86, and 12.4, respectively. The ionic form of the acid that predominates at pH 3.2 is:

PO_4^{3-}

HPO_4^{2-}

H_2PO_4^-

H_3PO_4

If you have a polypeptide of size 11 kilo Daltons, what would be the mass of the open reading frame that codes for the polypeptide? The average mass of an amino acid and a nucleotide is considered to be 110 Daltons and 330 Daltons, respectively.

99990

99000

90900

99900

When the velocity of enzyme activity is plotted against substrate concentration, which of the following is obtained?

Hyperbolic curve

Parabola

Straight line with positive slope

Straight line with negative slope

Select one of the below sets in which all the molecules show a microwave rotational spectrum?

H₂, CH₄, SF₆

HCl, CH₃Cl, CH₂Cl₂, H₂O

H₂, HCl, CH₄, CH₃Cl

CH₂Cl₂, H₂O, SF₆

A tyrosine-to-histidine mutation in the active site of an enzyme significantly affects its activity. The reaction is likely to be

Acid-catalysed

Base-catalysed

Free radical-catalysed

None of the above

If a branched polysaccharide (e.g. amylopectin) has 7 branch points, how many free -OH ends are available for reduction?

7

1

6

0

The Michaelis-Menten equation can be represented as follows:

$$v = V_{max} \frac{[S]}{1 + [S]/K_m}$$

For an intracellular enzyme to function optimally, which of the following statements regarding intracellular substrate concentration is true?

The intracellular substrate concentration should be greater than the K_m of the enzyme.

The intracellular substrate concentration should be significantly lower than the K_m of the enzyme.

The intracellular substrate concentration is independent of the Michaelis constant K_m .

The intracellular substrate concentration should be approximately the same as that of the K_m .

BIOLOGY

In a human family, the father and the mother are carriers for an autosomal recessive disease. One of their sons is phenotypically normal. What is the probability that this son is also a carrier?

1/2

1/3

1/4

2/3

Which of the following techniques can be used to identify a post-translational modification such as phosphorylation or methylation of a protein, and the residue where it is modified?

2-D gel electrophoresis

Size exclusion chromatography

Mass spectrometry

UV-Visible spectroscopy

Amino acids have different chemical properties that determine whether they are found on the surface of globular proteins. Which of the following series of amino acids is ordered according to how likely it will be found on the surface of a protein:

Arginine > Leucine > Aspartic acid > Phenylalanine

Threonine > Arginine > Phenylalanine > Asparagine

Arginine > Phenylalanine > Threonine > Glycine

Aspartic acid > Threonine > Leucine > Phenylalanine

~~Repolarisation of membrane potential in neurons is caused by the movement of:~~

~~potassium into the cell and sodium into the cell~~

~~**potassium out of the cell and sodium out of the cell**~~

~~potassium into the cell and sodium out of the cell~~

~~potassium out of the cell and sodium into the cell~~

You synthesise a short peptide [AMxVFxGNxM], where x is any amino acid with a charged side chain. How many possible peptides can be synthesised?

15

243

125

27

Human DNA contains 18% C on a molar basis. What is the mole percentage of A, G, and T respectively?

32, 18, 32

18, 32, 32

32, 32, 18

Insufficient information to calculate

Which of the following statements explains why net primary productivity is higher near the tropics?

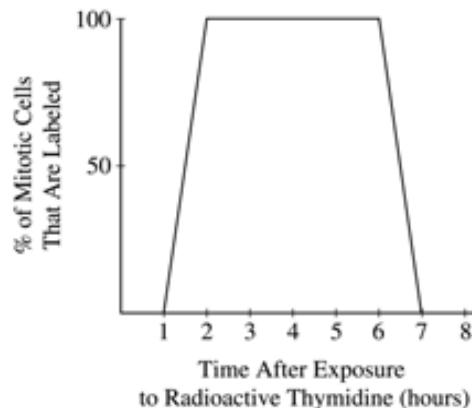
More predators in the tropics kill herbivores, increasing plant growth in the tropics

Increased species diversity results in increased plant growth

Availability of newly weathered inorganic nutrients

Water and warm temperatures in the tropics promote photosynthesis

The stages of the cell cycle for a cultured mammalian cell line require the following periods of time: G1 = 8 hr, S = 5 hr, G2 = 1 hr, M = 1 hr. An asynchronous culture of these cells is exposed to radioactive thymidine for five minutes and then allowed to continue to grow in nonradioactive medium. The figure below shows the results.



If the length of G2 were increased by one hour, which of the following statements would be true regarding the slope of the line from the first appearance of labelled mitotic cells until all cells are labelled?

It would increase.

It would decrease.

It would stay the same.

It would switch from a positive to a negative slope

X-linked recessive disorders are most commonly exhibited by ---- because-----

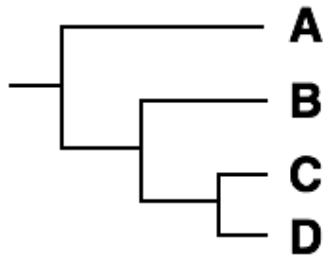
females, because they have two X-chromosomes and are therefore more likely to inherit one with a disease

males, because they have only one X-chromosome

females, because one of their X-chromosomes is deactivated

both males and females, because of equal penetrance

Which of the following statement is correct, given this phylogeny of four species?



A has gone extinct

A is more closely related to C than D

D evolved from C

B, C and D shared a common ancestor

A trihybrid test cross (order of loci unknown) produced progeny classes as follows: 35 AbC/abc, 37 aBc/abc, 8 ABc/abc, 10 abC/abc, 3 ABC/abc, 5 abc/abc, 1 Abc/abc, 1 aBC/abc. The gene order is

CBA

BAC

BCA

CAB

A newly discovered extra-terrestrial organism was found to contain proteins that are made up of 75 different amino acids. Assuming that one codon codes for a unique amino acid, which of the following is possibly correct about its DNA and codons?

The DNA could be composed of 4 bases and the organism has a triplet codon.

The DNA could be composed of 3 bases and the organism has a triplet codon.

The DNA could be composed of 3 bases and the organism has a quartet codon.

The DNA could be composed of 2 bases and the organism has a quartet codon.

You unearth a fossilised skull. Your initial investigation suggests a reptile, likely a dinosaur, that had strong jaw muscles. What feature led to you that conclusion?

The presence of a sagittal crest at the top of the skull

The length of the maxilla

The shape and number of molars

Evidence of torsional strain on the tripus bone

The mutation rates due to replication error in strains A and B of *Escherichia coli* are 10^{-8} and 10^{-9} per genome per generation respectively. Starting from 10 cells of each strain, the bacteria were cultured for varying amounts of time as given below. Both strains divide once in 20 minutes. In which of these cases would both cultures have at least one mutant bacterium?

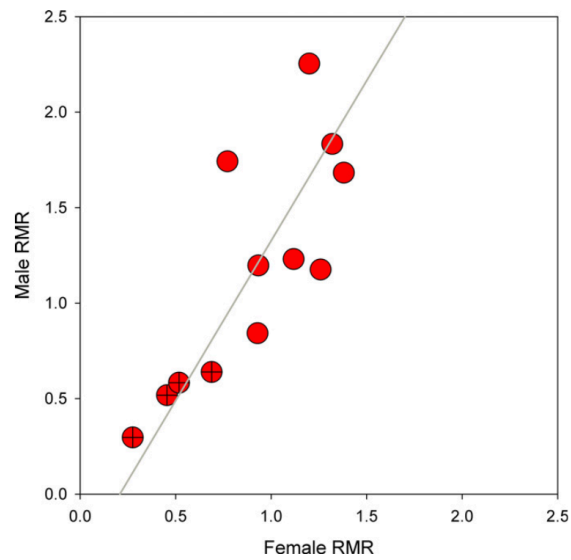
Strain A- 520 minutes Strain B- 400 minutes

Strain A- 120 minutes Strain B- 240 minutes

Strain A- 560 minutes Strain B- 360 minutes

Strain A- 500 minutes Strain B- 560 minutes

Scientists measured the resting metabolic rate (RMR) of males and females from 12 different insect species. Given the results shown in the figure, which statement is correct? Circles with a cross inside indicate species that eat plants.



In each species, males and females have similar RMR

Plant-eating insects have higher RMR than other insects

Male and female RMR is not correlated

Males generally have higher RMR than females