

NLSO

Sample Questions

Level 4

- Biology
- Chemistry
- Physics
- Mathematics

Level 2 and 3

- AI

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BIOLOGY

Question: 2- Biology

A population of a plant species is found to be resistant to a particular herbicide. However, when the herbicide is applied to the population for several years, the proportion of resistant plants decreases. This suggests that the herbicide is selecting for a particular genotype in the population.

Which of the following best explains why the proportion of resistant plants decreases over time?

- (A) The herbicide is causing the resistant plants to mutate into susceptible plants.
- (B) The herbicide is selecting for a different genotype that is more competitive than the resistant genotype.
- (C) The herbicide is causing the resistant plants to die, leaving only susceptible plants to reproduce.
- (D) The herbicide is causing the resistant plants to mate with susceptible plants, producing offspring that are not resistant to the herbicide.

Answer: 1- Biology

The correct answer is (D). The electron transport chain and oxidative phosphorylation are the final steps in the ATP production pathway. By blocking these steps, the inhibitor prevents the production of ATP.

Explanation:

Here is a brief overview of the ATP production pathway:

- Glycolysis: Glucose is broken down into pyruvate in the cytoplasm.
- Pyruvate dehydrogenase complex: Pyruvate is converted into acetyl-CoA in the mitochondrial matrix.
- Krebs cycle: Acetyl-CoA is broken down into carbon dioxide, water, and NADH.
- Electron transport chain: NADH and FADH₂ transfer their electrons to O₂, producing H₂O. The energy released from this process is used to pump protons across the inner mitochondrial membrane.
- Oxidative phosphorylation: The protons pumped across the inner mitochondrial membrane flow back down, driving the production of ATP.

The inhibitor that the scientist used in the experiment most likely blocks the electron transport chain and oxidative phosphorylation. By blocking these steps, the inhibitor prevents the production of ATP.

BIOLOGY

Case Study

A scientist is studying the role of mitochondria in cell metabolism. The scientist observes that mitochondria are responsible for the production of ATP, which is the energy currency of the cell. The scientist hypothesizes that the mitochondria use a series of chemical reactions to convert glucose into ATP. To test their hypothesis, the scientist designs an experiment in which they use a specific type of inhibitor to block one of the chemical reactions in the ATP production pathway.

Question: 1- Biology

The scientist observes that the production of ATP is blocked when they use the inhibitor. What is the most likely role of the inhibitor in the ATP production pathway?

- (A) It blocks the breakdown of glucose into pyruvate.
- (B) It blocks the conversion of pyruvate into acetyl-CoA.
- (C) It blocks the Krebs cycle.
- (D) It blocks the electron transport chain and oxidative phosphorylation.

Answer: 2- Biology

The correct answer is (D). The herbicide is causing the resistant plants to mate with susceptible plants, producing offspring that are not resistant to the herbicide.

Explanation:

Option A is not possible because mutations are random events, and there is no reason to believe that the herbicide would be causing the resistant plants to mutate into susceptible plants any more than the other way around.

Option B is possible, but it is not the best explanation for the data. The fact that the proportion of resistant plants decreases over time suggests that the herbicide is selecting for a particular genotype, but it does not necessarily mean that this genotype is more competitive than the resistant genotype.

Option C is possible, but it is not the most likely explanation. If the herbicide were causing the resistant plants to die, then we would expect the proportion of resistant plants to decrease more quickly than it does.

Option D is the best explanation for the data. When resistant plants mate with susceptible plants, the offspring are heterozygous for the resistance gene. These heterozygous plants are still resistant to the herbicide, but they can also produce offspring that are homozygous for the susceptible gene. These homozygous offspring are not resistant to the herbicide, and they will be killed by the herbicide. Over time, this will lead to a decrease in the proportion of resistant plants in the population.

Therefore, the answer is D. The herbicide is causing the resistant plants to mate with susceptible plants, producing offspring that are not resistant to the herbicide.

NATIONAL LEVEL SCIENCE X OLYMPIADS (NLSO) 2023

CHEMISTRY

Question: 1- Chemistry

A standard hydrogen electrode is dipped in a solution of HCl at 25°C. The potential of this electrode is measured as -0.277 V. The pH of the solution is:

- (A) 7.00
- (B) 4.00
- (C) 1.00
- (D) 0.00



NATIONAL LEVEL SCIENCE X OLYMPIADS (NLSO) 2023
CHEMISTRY

Answer: 03- Chemistry

The Nernst equation for the hydrogen electrode is:

$$E^\circ = E - 2.303RT/nF \log[H^+]$$

where:

E° is the standard electrode potential (0.00 V for the hydrogen electrode)

E is the measured electrode potential (-0.277 V)

R is the gas constant ($8.314 \text{ J mol}^{-1} \text{ K}^{-1}$)

T is the temperature in Kelvin (298 K for 25°C)

n is the number of electrons transferred (1 for the hydrogen electrode)

F is the Faraday constant ($96,485 \text{ C mol}^{-1}$)

$[H^+]$ is the concentration of protons in the solution

Substituting the known values into the Nernst equation, we get:

$$0.00 = -0.277 - 2.303 \times 8.314 \times 298 / 1 \times 96,485 \times \log[H^+]$$

Solving for $\log[H^+]$, we get:

$$\log[H^+] = 1.20$$

Taking the antilog of both sides, we get:

$$[H^+] = 10^{1.20} = 15.85 \text{ M}$$

The pH of the solution is:

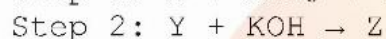
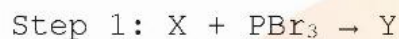
$$\text{pH} = -\log[H^+] = -\log(15.85) = 1.00$$

Therefore, the answer is (C) 1.00.

CHEMISTRY

Question: 2- Chemistry

Consider the following reaction sequence involving an organic compound (X):



The product Z obtained in Step 2 is then treated with methyl iodide (CH₃I) in the presence of a suitable solvent. Which of the following statements is true regarding the final product obtained in this reaction?

- (A) It undergoes nucleophilic aromatic substitution (S_NAr).
- (B) It undergoes electrophilic aromatic substitution (S_EAr).
- (C) It undergoes nucleophilic substitution with retention of configuration (S_N1).
- (D) It undergoes nucleophilic substitution with inversion of configuration (S_N2).
- (E) It undergoes a concerted reaction involving both nucleophilic and electrophilic substitution.

Answer: 2- Chemistry

The correct answer is (A).

Explanation:

In Step 1, X reacts with PBr_3 to form Y. This is an example of a nucleophilic substitution reaction, where the bromide ion (Br^-) acts as a nucleophile and attacks the phosphorus atom (P) in PBr_3 . This results in the formation of a phosphorus-bromine bond and the release of X-Br.

In Step 2, Y reacts with KOH to form Z. This is an example of a hydrolysis reaction, where the hydroxide ion (OH^-) acts as a nucleophile and attacks the carbon atom (C) in the carbonyl group ($\text{C}=\text{O}$) of Y. This results in the formation of a carbon-oxygen bond and the release of X-OH.

The final product obtained in the reaction is Z, which is an alkyl iodide (RI). Alkyl iodides can undergo nucleophilic substitution reactions, where the iodide ion (I^-) acts as a leaving group and is replaced by a nucleophile. In this case, the nucleophile is the methyl group (CH_3^-), which comes from the methyl iodide (CH_3I). The reaction is an example of a nucleophilic aromatic substitution ($\text{S}_{\text{N}}\text{Ar}$) reaction, where the methyl group attacks the aromatic ring of Z.

Therefore, the correct answer is (A).

NATIONAL LEVEL SCIENCE X OLYMPIADS (NLSO) 2023

PHYSICS

Question: 1- Physics

When a light wave is incident at the interface between two media, the reflection coefficient is given by $\frac{(n-1)^2}{(n+1)^2}$ where n is the refractive index of the denser medium with respect to the rarer medium. Two stretched strings whose linear densities are 25 g/m and 9 g/m are joined together. Assuming the law of optics holds good here also, the reflection coefficient for the pulse along the strings is

- (A) $\frac{9}{16}$
- (B) $\frac{3}{4}$
- (C) $\frac{1}{16}$
- (D) $\frac{1}{9}$

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Physics

Answer: 06- Physics

Speed of the wave is given by

$$v = \sqrt{\frac{T}{\mu}}$$

μ = Mass/Unit length

$$\mu_1 = 25\text{g/m}$$

$$\mu_2 = 9\text{g/m}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{\mu_2}{\mu_1}} = \sqrt{\frac{9}{25}} = \frac{3}{5}$$

$$\Rightarrow \text{Refractive Index} \propto \frac{1}{v}$$

$$\Rightarrow \frac{n_2}{n_1} = \frac{5}{3} = n$$

$$\Rightarrow \text{Ref. Coeff.} = \frac{(n-1)^2}{(n+1)^2} = \frac{4}{64} = \frac{1}{16}$$

Therefore, the answer is (C) 1/16.

NATIONAL LEVEL SCIENCE X OLYMPIADS (NLSO) 2023**Physics | Level 4****Question: 1- Physics**

A long, straight wire carrying a current of 5 A is placed parallel to a solenoid with 100 turns and a length of 20 cm. The current in the solenoid is 2 A. The magnetic field strength at a point 10 cm away from the wire is 5×10^{-5} T. What is the magnetic field strength at a point 20 cm away from the wire?

- (A) 2.5×10^{-5} T
- (B) 1.25×10^{-5} T
- (C) 6.25×10^{-5} T
- (D) 3.125×10^{-5} T

Answer: 1- Physics

The correct answer is (B).

Explanation:

The coefficient of thermal expansion of a liquid is given by the following equation:

$$\text{Coefficient of thermal expansion} = \frac{(\text{Change in volume} / \text{Original volume})}{(\text{Change in temperature})}$$

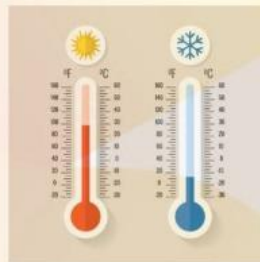
Substituting the given values into the equation, we get:

$$\text{Coefficient of thermal expansion} = (2\% / 100\%) / (20^\circ\text{C} - 40^\circ\text{C}) = 0.05 \text{ K}^{-1}$$

Therefore, the coefficient of thermal expansion of the liquid is 0.05 K^{-1} .

PHYSICS

Case Study



A scientist is studying the thermal expansion of a liquid. The scientist observes that the volume of the liquid increases as the temperature increases. The scientist hypothesizes that the liquid molecules are expanding as they absorb heat. To test their hypothesis, the scientist designs an experiment in which they measure the volume of a liquid at different temperatures.

Question: 1- Physics

The scientist observes that the volume of the liquid increases by 2% when the temperature is increased from 20°C to 40°C. What is the coefficient of thermal expansion of the liquid?

- (A) 0.02 K^{-1}
- (B) 0.05 K^{-1}
- (C) 0.1 K^{-1}
- (D) 0.2 K^{-1}

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Physics | Level 4

Answer: 01- Physics

(C) $6.25 \times 10^{-5} \text{ T}$

Explanation:

The magnetic field strength due to a long, straight wire is given by the formula:

$$B = \mu_0 I / 2\pi d$$

where:

B is the magnetic field strength in tesla (T)

μ_0 is the permeability of free space ($4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$)

I is the current in amperes (A)

d is the distance from the wire in meters (m)

The magnetic field strength due to a solenoid is given by the formula:

$$B = \mu_0 \mu N I / 2\pi L$$

where:

μ is the relative permeability of the core material (1 for air)

N is the number of turns in the solenoid

L is the length of the solenoid in meters (m)

At a point 10 cm away from the wire, the magnetic field strength due to the wire is:

$$B = (4\pi \times 10^{-7} \text{ T}\cdot\text{m/A})(5 \text{ A}) / (2\pi)(0.1 \text{ m})$$

$$B = 2.5 \times 10^{-5} \text{ T}$$

SCIENCE X PHYSICS OLYMPIADS (SPO)

LAST DATE: 30 NOVEMBER 2023

EXAM DATE: Sunday, 17 December 2023

EXAM TIME: Level 4 - 09:00 AM TO 10: 30 AM

<https://sciencex.org.in>

MATHEMATICS

Question: 1- Mathematics

A circle with centre $(2,3)$ and radius 5 is given. A line passes through the point $(0,0)$ and intersects the circle at two distinct points. Find the equation of the line that maximizes the area of the triangle formed by the two points of intersection and the centre of the circle.

(a) $y = x + 3$

(b) $y = 2x + 3$

(c) $y = -x + 3$

(d) $y = -\frac{1}{2}x + 3$

Answer: 1- Mathematics

The correct answer is (c).

Let the equation of the line be $y = mx + b$. Substituting this into the equation of the circle, we get:

$$(x - 2)^2 + (y - 3)^2 = 5^2$$

Substituting $y = mx + b$ for y , we get:

$$(x - 2)^2 + (mx + b - 3)^2 = 5^2$$

Expanding the square, we get:

$$x^2 - 4x + 4 + m^2x^2 + 2mbx + b^2 - 6mx - 6b + 9 = 25$$

Combining like terms, we get:

$$(1 + m^2)x^2 + (2mb - 4)x + (b^2 - 6mb + 16) = 0$$

Since the line intersects the circle at two distinct points, the quadratic equation above must have two distinct real roots. This means that the discriminant of the quadratic must be greater than zero. Therefore, we have:

$$(2mb - 4)^2 - 4(1 + m^2)(b^2 - 6mb + 16) > 0$$

Expanding this inequality, we get:

$$4m^2b^2 - 16mb^2 - 16b^2 + 16m^4 - 64m^3 + 256 > 0$$

Factoring out $4b^2$, we get:

$$4b^2(m^2 - 4m + 64) > 0$$

Since $b^2 \geq 0$, we have:

$$m^2 - 4m + 64 > 0$$

Solving this quadratic, we get:

$$m < 0 \text{ or } m > 4$$

Therefore, the equation of the line must be of the form $y = mx + 3$ where $m < 0$ or $m > 4$.

To maximize the area of the triangle, we want the line to be as far away from the center of the circle as possible. This means that we want the slope of the line to be as steep as possible. Therefore, we want the value of m to be as far away from 0 as possible. Since $m < 0$, the line with the steepest negative slope is $y = -x + 3$.

Therefore, the equation of the line that maximizes the area of the triangle is $y = -x + 3$.

NATIONAL LEVEL SCIENCE X OLYMPIADS (NLSO) 2023

AI

Question: 1- AI

Question:

In the AI project cycle, which of the following phases involves evaluating the performance of the AI model and making necessary adjustments to improve its accuracy and effectiveness?

- (A) Data Collection**
- (B) Model Training**
- (C) Model Evaluation**
- (D) Model Deployment**

SCIENCE X AI OLYMPIADS (SAIO)

LAST DATE: 30 NOVEMBER 2023

EXAM DATE: Saturday, 09 December 2023

EXAM TIME: Level 2 – 10:00am | Level 3 – 12:30pm

NATIONAL LEVEL SCIENCE X OLYMPIADS (NLSO) 2023

AI

Answer: 01- AI

(C) Model Evaluation

Explanation:

The AI project cycle is a structured approach to developing and implementing AI solutions, encompassing a series of well-defined phases that guide the project from inception to completion. One of the crucial phases in this cycle is Model Evaluation, which occurs after the model has been trained on a dataset.

Model evaluation involves assessing the performance of the trained AI model using various metrics, such as accuracy, precision, recall, and F1-score. These metrics provide insights into how well the model can identify patterns, make predictions, or perform the intended task.

During model evaluation, the AI team analyzes the model's performance on a held-out dataset, which is a separate dataset that was not used for training. This helps to ensure that the model generalizes well and performs accurately on unseen data.

Based on the evaluation results, the AI team may need to make adjustments to the model's architecture, training parameters, or hyperparameters. This process of refinement and optimization ensures that the AI model produces the desired results and meets the project's objectives.

Therefore, Model Evaluation is the phase in the AI project cycle that focuses on assessing and improving the performance of the AI model.

Therefore, the answer is (C) Model Evaluation.