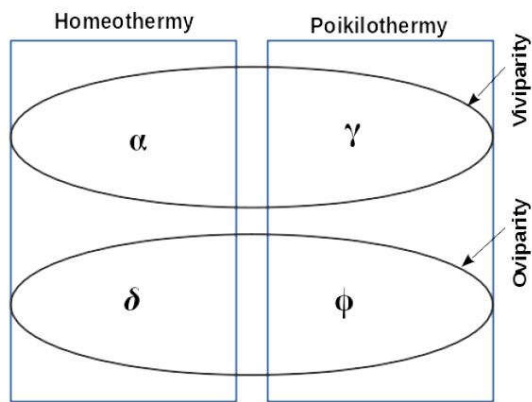




Participant ID	
Participant Name	
Test Center Name	
Test Date	29/09/2020
Test Time	2:30 PM - 6:00 PM
Subject	NEST 2020
Marks Obtained	22.00000

Section : General

Q.1 The greek symbols (α , γ , etc.) denote individual entities belonging to the classifications in the following diagram:



Choose the correct option which identifies the correct entities.

Ans

- 1. monkey - α ; pigeon - γ ; frog - ϕ .
- 2. cat - α ; shark - γ ; snail - ϕ .
- 3. hen - α ; frog - δ ; snail - ϕ .
- 4. shark - α ; snake - δ ; pigeon - ϕ .

Question Type : MCQ
Question ID : 414664581
Status : Answered
Chosen Option : 2
Marks : 3

Q.2

Consider the following set of four cards lying on a table, the other side of the card not visible until you turn them. Each card has an image of an animal on one side and a weather pattern on the other side.



You need to choose the minimum number of cards to turn to test whether the following hypothesis is true:

If there is an aquatic animal on one side of the card, then there will be an image of rain / snow on the other side of the card.

Choose among the following options which cards need to be turned.

Ans

- 1. Card F and Card S.
- 2. Card L and Card F.
- 3. Card F only.
- 4. Card F and Card R.

Question Type : **MCQ**
Question ID : **414664579**
Status : **Answered**
Chosen Option : **4**
Marks : **0**

Q.3

A 'dendrochronologist' is an expert who may be able to

Ans

- 1. study the environment of the past by analysing an ice core and its layers.
- 2. study the evolution of earth's crust from a rock using its mineral contents.
- 3. determine the age of a tree by counting its annular rings.
- 4. diagnose the disease of a person by studying his/her hairs.

Question Type : **MCQ**
Question ID : **414664577**
Status : **Answered**
Chosen Option : **1**
Marks : **0**

Q.4 Choose the option that will make the following statement **INCORRECT**.
An athlete runs one complete lap around a circular ground. For this athlete, no net work will be done by

- Ans**
- 1. non-zero frictional force.
 - 2. non-zero normal force.
 - 3. non-zero gravitational force.
 - 4. non-zero centrifugal force.

Question Type : **MCQ**
Question ID : **414664578**
Status : **Answered**
Chosen Option : **2**
Marks : **0**

Q.5 Mary was carrying a few marbles (M_i) in her pocket. When Neelam told Mary that she is also carrying some marbles in her pocket (N_i), Mary felt greedy and snatched all the marbles from Neelam's pocket and put them in her own pocket. Neelam complained to the teacher, who counted the number of marbles in Mary's pockets and gave Neelam as many marbles from the store as the total number of marbles in Mary's pockets. Neelam loved the marbles, but returned to the store as many marbles as she originally had. She had N_f marbles left with her. On seeing this, Mary returned to the store as many marbles as she saw still remaining in Neelam's pocket. Mary was left with M_f marbles.

Which of the following conditions are always true?

- Ans**
- 1. $N_f = M_i$ AND $N_i = M_f$.
 - 2. $M_f > N_i > N_f$.
 - 3. $N_f > M_i > M_f$.
 - 4. $N_f = N_i$ AND $M_i = M_f$.

Question Type : **MCQ**
Question ID : **414664580**
Status : **Answered**
Chosen Option : **1**
Marks : **3**

Comprehension:

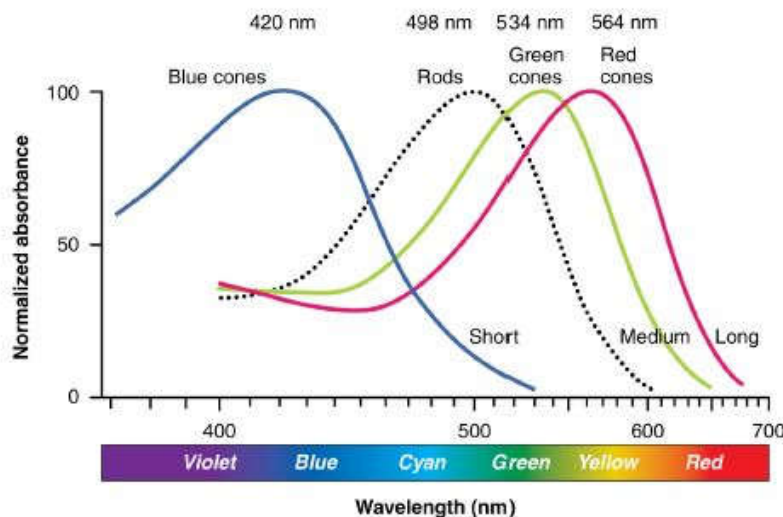
Eye is a sense organ for vision. The retina is a light-sensitive layer at the back of the eye that covers about 65 percent of its interior surface and consists of cells arranged in layers. The two types of light sensitive photoreceptor cells, rods and cones, are present just beneath the pigment epithelium. The bipolar cells receive inputs from photoreceptor cells and transmit their signal to the ganglion cells. The ganglion cells serve as the final output neurons in the retina which conveys information from retinal cells to the brain via the optic nerve.

The total number of rods in the human retina far exceeds the number of cones and therefore the density of rods is much higher than cones in most of the retinal parts. Further the cones are larger in size as compared to rods. The rods and cones are intermingled nonuniformly over the retina. Rods dominates the periphery with a few cones. The ensemble of rods forms an exceedingly sensitive detector, which provides vision in dim light that cones cannot detect and respond to. Rods are unable to distinguish color, and the images it relays are not well defined/sharp. In contrast to rods, the cones are separate, and can be imagined as overlapping, low-speed color film. They perform mostly in bright light, giving detailed colored views. The relative distribution of rods and cones is dramatically different in a region in the middle of the retina known as fovea, which literally means pit. This region is the center of the sharpest vision (acuity) and location of color perception. The cells overlying the photoreceptors are displaced around the fovea, which also contributes to the superior acuity of vision. In addition, compared to other retinal regions, fovea contain a higher ratio of ganglion and bipolar cells which makes nearly a 1:1 mapping of photoreceptors to these cells, permitting high acuity. The blind spot in the eye does not produce any vision and image falling on this spot will not be seen.

Rods contain only one type of photosensitive pigment (rhodopsin) with a peak sensitivity to wavelength of about 500 nm. Humans have trichromatic colour vision and have three types of cone cells (red-, green-, and blue-sensitive). The relative distribution of these cones and their peak sensitivity to light is given in the table below.

Type of cones	Wavelength (nm) of peak sensitivity	Relative distribution (%)
S (short wavelength / absorbs blue)	420	2
M (medium wavelength / absorbs green)	534	32
L (long wavelength / absorbs red)	564	64


The response of rods (R) and cone cells (S, M, and L) to different light wavelengths is shown in the following figure.



SubQuestion No : 6


Q.6 Under normal lighting conditions, the human eyes are most sensitive to which one of the following colour/s:

Ans

 1. violet-blue.

 2. yellow-red.

 3. blue-cyan.

 4. green-yellow.

Question Type : **MCQ**
Question ID : **414664583**
Status : **Answered**
Chosen Option : **2**
Marks : **0**

Comprehension:

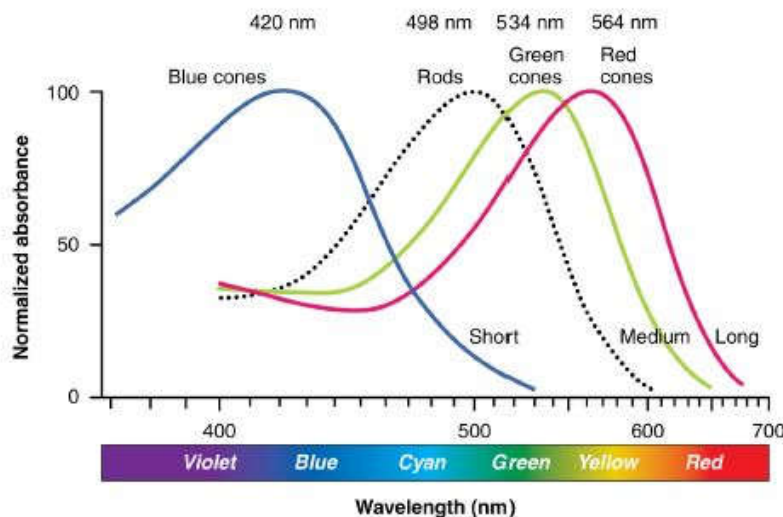
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The response of rods (R) and cone cells (S, M, and L) to different light wavelengths is shown in the following figure.



SubQuestion No : 7

Q.7

Choose the **INCORRECT** statement about fovea.

Ans  1.

It has a higher number of photoreceptors compared to ganglion and bipolar cells.

 2.

It is a region in the retina for daylight vision.

 3.

It is recognized as a point in the retina with maximum acuity and color sensitivity.

 4.

For visual clarity, humans keep moving their eyes/ heads around to direct the foveas of the two eyes to objects of interest.

Question Type : **MCQ**

Question ID : **414664585**

Status : **Answered**

Chosen Option : **4**

Marks : **0**

Comprehension:

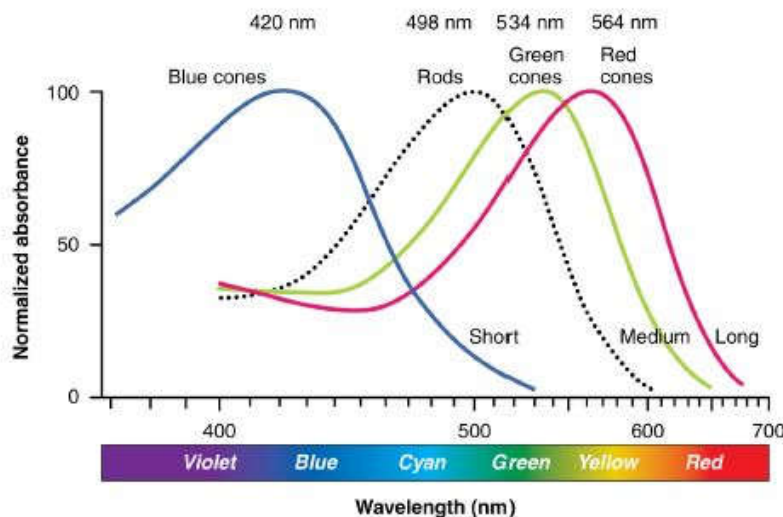
Eye is a sense organ for vision. The retina is a light-sensitive layer at the back of the eye that covers about 65 percent of its interior surface and consists of cells arranged in layers. The two types of light sensitive photoreceptor cells, rods and cones, are present just beneath the pigment epithelium. The bipolar cells receive inputs from photoreceptor cells and transmit their signal to the ganglion cells. The ganglion cells serve as the final output neurons in the retina which conveys information from retinal cells to the brain via the optic nerve.

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The response of rods (R) and cone cells (S, M, and L) to different light wavelengths is shown in the following figure.



SubQuestion No : 8

Q.8

Night blindness arises due to defect in the

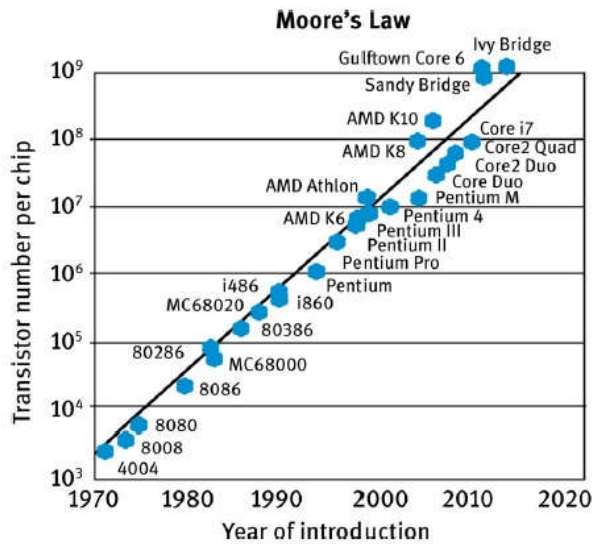
Ans

- ✓ 1. rod cells.
- ✗ 2. cone cells.
- ✗ 3. ganglion cells.
- ✗ 4. bipolar cells.

Question Type : **MCQ**
Question ID : **414664584**
Status : **Answered**
Chosen Option : **1**
Marks : **3**

Comprehension:

Gordon Moore, former CEO of Intel corporation, made an interesting prediction in 1965 regarding development of computers. This prediction was about how many transistors can be fitted on the leading microchip of any era. The number of transistors on a microchip determines the computational power of that chip. Thus, Moore's Law also gives us insight about the increase of computational power. The graph below shows the number of transistors (y-axis) in various microchips versus the year in which they first appeared in the market (x-axis). The solid black line shows the linear best fit for the data. (Note: 4004, 8008, 8080, 8086, 80286 and 80386 denote the name of the microprocessors)



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SubQuestion No : 9

Q.9 As per the graph, the number of transistors on an IC are doubled approximately every

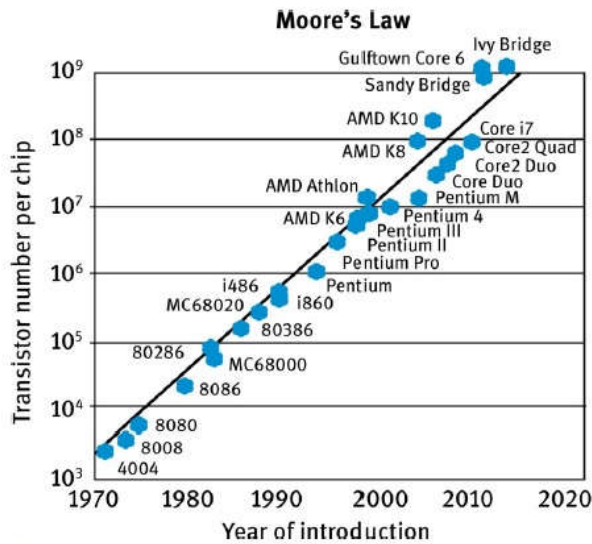
Ans

- 1. four years.
- 2. two years.
- 3. three years.
- 4. one year.

Question Type : **MCQ**
Question ID : **414664588**
Status : **Answered**
Chosen Option : **3**
Marks : **0**

Comprehension:

Gordon Moore, former CEO of Intel corporation, made an interesting prediction in 1965 regarding development of computers. This prediction was about how many transistors can be fitted on the leading microchip of any era. The number of transistors on a microchip determines the computational power of that chip. Thus, Moore's Law also gives us insight about the increase of computational power. The graph below shows the number of transistors (y-axis) in various microchips versus the year in which they first appeared in the market (x-axis). The solid black line shows the linear best fit for the data. (Note: 4004, 8008, 8080, 8086, 80286 and 80386 denote the name of the microprocessors)



SubQuestion No : 10

Q.10 If we express number of transistors (T) as function of number of years (y) since 1970, and take a , b and c as some constants, then the mathematical form of this function will be

- Ans**
- 1. $T = a \times \log_{10}(y + b)$.
 - 2. $T = a \times \log_{10}(y) + b$.
 - 3. $T = a \times y^b$.
 - 4. $T = a \times b^y$.

Question Type : **MCQ**
Question ID : **414664587**
Status : **Answered**
Chosen Option : **1**
Marks : **0**

Section : **Biology**

Q.1 A selenium-activated protein **P** catalyses a metabolic reaction that results in release of two H^+ ions. Expression of **P** is induced by lactose. In an experiment, cells were grown for 1 hour in selenium and lactose containing media resulting in a net concentration of 10^6 M H^+ per cell. Selenium and lactose were removed from the media and cells were grown for another 10 generations. Assuming that all other proteins are expressed at a constant level, the net change in pH inside the cell at the end will be _____.

- Ans**
- 1. 1
 - 2. 3
 - 3. 11
 - 4. 6

Question Type : **MCQ**
Question ID : **414664594**
Status : **Answered**
Chosen Option : **1**
Marks : **-1**

Q.2 A drug **P** inhibits DNA replication in the bacterium *E. coli* by specifically blocking the catalytic site of DNA polymerase activity. That the same drug **P** can be used to treat cancers in humans can be explained from the fact that _____.

- Ans**
- 1. mechanism of DNA polymerase is majorly conserved
 - 2. both DNA polymerases require RNA as a primer
 - 3. both cancer and bacterial cells divide rapidly into large numbers
 - 4. DNA replication is bi-directional in both the organisms

Question Type : **MCQ**
Question ID : **414664595**
Status : **Answered**
Chosen Option : **2**
Marks : **-1**


Q.3 Endoplasmic reticulum is tubular, golgi apparatus is stacked flat cisternae, mitochondria are oval-shaped. However, lysosomes are spherical in shape. This is fundamentally a result of _____.


Ans  1.

the propensity to minimize surface tension

 2.

an increased surface area of signalling molecules

 3. genes that regulate shape

 4. highly acidic pH of the lysosome

Question Type : **MCQ**

Question ID : **414664593**

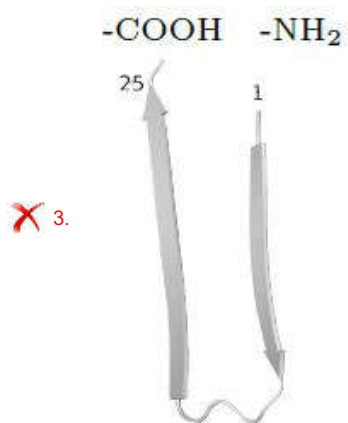
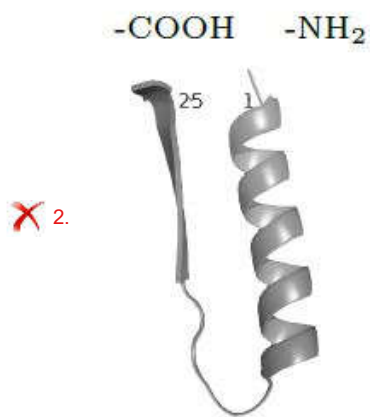
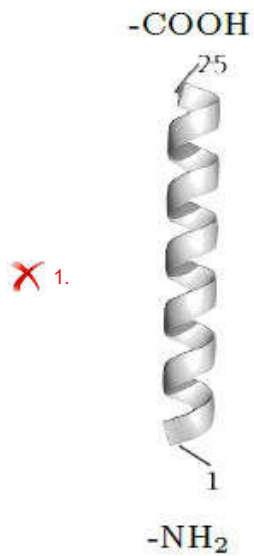
Status : **Answered**

Chosen Option : **2**

Marks : **-1**

Q.4 Proteins in biological systems are polypeptides that are exclusively made from L-amino acids. A peptide, P, with L-amino acids of a particular sequence always adopts a right-handed alpha helical structure. Under identical conditions, if all the amino acids of the peptide P are changed to D-amino acids, then the expected conformation from the options given below would be _____.

Ans





✓ 4.

Question Type : **MCQ**
 Question ID : **414664592**
 Status : **Not Answered**
 Chosen Option : --
 Marks : **0**

Q.5 A polymerase chain reaction (PCR) for amplification of DNA fragments involves multiple cycles of thermal denaturation, annealing and extension steps in each cycle. Because of the heat denaturation step, a thermostable polymerase is required for performing PCR. An experimenter had all the resources except the thermostable DNA polymerase to perform a PCR. The experimenter can use _____ to substitute for thermostable DNA polymerase.

Ans ✗ 1.

Escherichia coli DNA polymerase added before denaturation step of every PCR cycle

✗ 2.

Escherichia coli DNA polymerase, added after extension step of every PCR cycle

✗ 3.

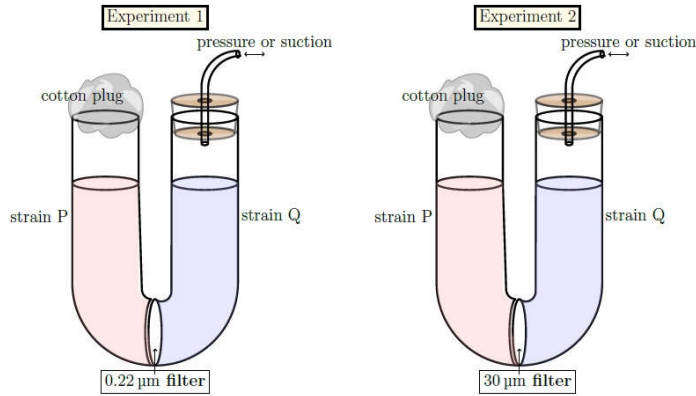
excess amount of *Escherichia coli* DNA polymerase added once at the beginning of the reaction

✓ 4.

Escherichia coli DNA polymerase, added after annealing step of every PCR cycle

Question Type : **MCQ**
 Question ID : **414664596**
 Status : **Answered**
 Chosen Option : **1**
 Marks : **-1**

Q.6 Conjugation in *E. coli* is a microbial process wherein conjugative plasmids are transferred from one bacterium to another that does not possess it. This requires physical contact between the cells involved in the transfer. In an experiment performed in a sterilized U-tube, strains P (resistance to ampicillin encoded in its plasmid) and Q (resistance to tetracycline encoded in its genome) were grown in an appropriate medium without an antibiotic. A 0.22 μm pore size nitrocellulose membrane placed in between the two arms serves as a partition. In a parallel identical experiment the 0.22 μm membrane was replaced by a 30 μm nitrocellulose membrane. After allowing enough time for the conjugation process to occur, an aliquot from each arm is plated on either ampicillin or tetracycline antibiotic containing plate. Choose the correct statement about the outcome of the experiment.



Ans 1.

Strain Q would be ampicillin resistant in experiment 1.

2.

Strain P would be tetracycline resistant in experiment 2.

3.

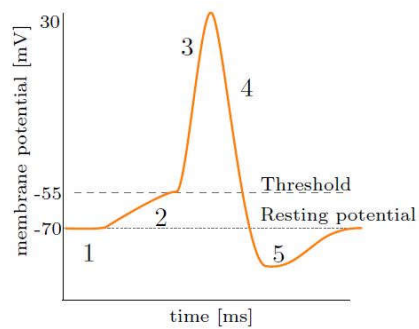
Strain Q would be ampicillin resistant in experiment 2.

4.

Strain P would be tetracycline resistant in experiment 1.

Question Type : **MCQ**
 Question ID : **414664591**
 Status : **Not Answered**
 Chosen Option : --
 Marks : **0**

Q.7 Graphical representation of action potential across the membrane of a neuron is shown below. The different stages of the action potential are shown with numbers 1 to 5. Choose the correct statement about the Na^+ and K^+ ion concentration across the membrane in stage 4.



Ans ✓ 1.

Opening of K^+ ion channels, leading to K^+ efflux.

✗ 2.

Equilibrium is reached between Na^+ and K^+ across the membrane.

✗ 3.

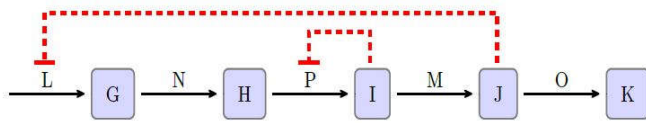
Both K^+ and Na^+ ion channels are open leading to more K^+ influx than that of Na^+ .

✗ 4.

Opening of Na^+ ion channels, leading to Na^+ efflux.

Question Type : **MCQ**
Question ID : **414664598**
Status : **Answered**
Chosen Option : **4**
Marks : **-1**

Q.8 Height of a plant is positively determined by the amount of final product, **K**, of a metabolic pathway catalyzed by five enzymes **L**, **N**, **P**, **M** and **O** (as depicted below). The intermediate product, **I**, blocks the activity of the enzyme **P**, whereas intermediate **J** blocks the enzyme **L**. Conversion of **I** to **J** is the rate limiting step. Based on this information, choose the correct statement from below.



Ans 1.

Silencing the gene **M** will result in tall phenotype.

2.

Silencing of the gene **N** will result in a tall phenotype.

3.

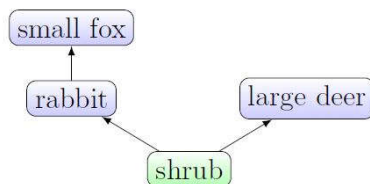
Overexpression of the gene **P** will have no effect on height of the plant.

4.

Overexpression of the gene **O** can lead to plants with tall phenotype.

Question Type : **MCQ**
 Question ID : **414664590**
 Status : **Answered**
 Chosen Option : **4**
 Marks : **-1**

Q.9 On an oceanic island, long isolated away from any continent, there are only four co-existing species: flowering shrub, rabbit, large deer and small fox. The food web for the island ecosystem is depicted below.



Deer and rabbit eat precisely the same parts of the flowering shrub, depleting the shrub vegetation at precisely the same rates. If predation is NOT the reason that the four species coexist, choose the statement that best explains their coexistence.

Ans

1. Deer population is large in number.

2.

The population of small fox is larger than that of rabbit.

3.

Interspecific competition is stronger than intraspecific competition.

4.

Intraspecific competition is stronger than interspecific competition.

Question Type : **MCQ**
 Question ID : **414664597**
 Status : **Answered**
 Chosen Option : **4**
 Marks : **3**

Q.10 Choose the correct statement(s) from the following regarding light reactions taking place in the chloroplast.

- (i) The H^+ ion concentration of thylakoid lumen is higher than stroma.
- (ii) Flow of H^+ ions through ATP synthase drives phosphorylation of adenosine diphosphate.
- (iii) The electrons from the photolysis reaction of H_2O are passed to the photosystem II.

Ans

1. Only (i)

2. Only (ii) and (iii)

3. Only (i) and (ii)

4. (i), (ii) and (iii)

Question Type : **MCQ**

Question ID : **414664589**

Status : **Answered**

Chosen Option : **4**

Marks : **3**

Q.11 A crop variety was developed at a research station in Dehradun (located in a temperate zone) and this variety produces round (*RR*, or *Rr*) or wrinkled seeds (*rr*) with green (*GG* or *Gg*) or yellow seed (*gg*) colour. A field test was performed with seeds from a cross between *RRGG* (round and green) and *rrgg* (wrinkled and yellow) parents. Seeds obtained from this test were planted at the same research station and compared to three new tropical locations with different levels of microbial infection and salinity challenges.

	Temperate region	Tropical region	Tropical region with microbial infection	Tropical region with microbial infection and high salinity
Number of seeds sown	800	800	800	800
Number of seeds germinated	795	355	210	190
Number of plants reached flowering	775	350	208	48
Number of plants produced seeds	766	345	204	47
Total yield	8.2 Kg (6.2 Kg Green + 2.0 Kg Yellow)	3.6 Kg (1.5 Kg Green + 2.1 Kg Yellow)	2.1 Kg (0.05 Kg Green + 2.05 Kg Yellow)	0.51 Kg (0.01 Kg Green + 0.5 Kg Yellow)

Based on the information provided and assuming that the genes follow Mendelian inheritance (with no other factors affecting the yield), choose the correct statement(s) from the options given below.

Ans  1.

It is better to sow three parts of green seeds and four parts of yellow seeds in tropical region.

 2.

Wrinkled character is better suited for tropical region than round character.

 3.

Tropical region does not support the growth of round seed plants.

 4.

Only yellow seeds are better to sow in tropical region carrying high microbial infection load.

Question Type : **MSQ**
 Question ID : **414664599**
 Status : **Answered**
 Chosen Option : **1,4**
 Marks : **0**

Q.12 In order to understand immune responses to COVID-19 viral infection, a researcher took five individuals of an animal model of the disease. One of these animals was infected, in controlled lab conditions, by nasal spray of the viral suspension. The animal developed pneumonia-like symptoms (fever and difficulty in breathing) ten days later. Blood plasma was collected at two time points from the infected animal: i. when symptoms were still there (draw 1), ii. seven days after the animal completely recovered from the illness (draw 2). The remaining four animals were given different treatments with the plasma (either draw 1 or draw 2), and then challenged with viral infection. Symptom development was monitored and results are tabulated. (assume the plasma is made hypoallergenic by chemical treatment)

Treatment (M, N, O or P)	Result
(M). Injection of draw1, followed by mock spray (no virus)	only fever developed
(N). Injection of draw 1, followed by the viral challenge	mild disease symptoms
(O). Injection of draw 2, followed by the viral challenge	no disease symptoms
(P). No plasma treatment before the viral challenge	severe disease symptoms

Based on these results, the correct inference(s) would be.

Ans  1.

In treatment (O), the viral antigen from the plasma generated a humoral immune response (antibody response) in the animal and thus protected it.

 2.

In treatment (M) fever was because of cytokines such as interferons that are in the plasma.

 3.

In treatment (O) antibodies against COVID-19 gave passive immunity to the animal.

 4.

In treatment (N) symptoms were mild, because interferons from the plasma set a general innate immune state in the animal.

Question Type : **MSQ**
 Question ID : **414664602**
 Status : **Answered**
 Chosen Option : **3,4**
 Marks : **0**

Q.13 Hydra has a receptor **Q** in certain cell/s that respond to a specific neurotransmitter **P1**, isolated from brains of higher mammals. An experimenter finds that many species have neurotransmitters that are structurally related to **P1** and have functional homologs of receptor **Q**. Binding of **P** to **Q** elicits neuronal response. A summary of this study is given below.

species	number of Q genes	response to P group (P1 to P4) of molecules
Hydra	1	Yes (only to P1)
Worms	1	Yes (only to P1)
Insects	0	No response to P1, P2, P3, P4
Fishes	1	Yes (only to P1)
Amphibians	2	Yes (only to P1 and P3)
Reptiles	3	Yes (only to P3 and P4)
Birds	4	Yes (only to P3 and P4)
Mammals	5	Yes (only to P1, P2, P4)

Based on this information choose the statement(s) that is(are) likely to be correct.

Ans  1.

In mammals, **P3** can compete with **P1**, **P2**, **P4** for eliciting the response.

 2.

Insects might have lost the gene **Q** due to the loss of endogenous production of **P** group of neurotransmitters.

 3.

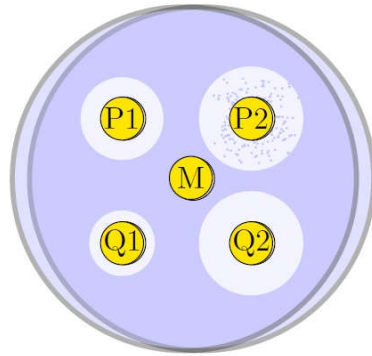
Insects have lost the gene **Q** after fish have evolved.

 4.

In mammals, the **Q** gene multiplication occurred as a result of diversification of the neurotransmitter **P**.

Question Type : **MSQ**
Question ID : **414664603**
Status : **Answered**
Chosen Option : **2,4**
Marks : **0**

Q.14 Antibiotics **P1**, **P2** (cell wall synthesis inhibitors), and **Q1**, **Q2** (protein synthesis inhibitors) are equally hydrophilic and moderately toxic to humans. *Staphylococcus* is known to develop resistance to all these antibiotics. An experimenter tested these antibiotics against a recent pathogenic strain of *Bacillus*. A high density of *Bacillus* culture was spread on a nutrient agar plate. Filter paper discs, each soaked in **P1**, **P2**, **Q1** and **Q2** individually (of same concentration), were placed on the bacterial lawn (purple background in the schematic). **M** is mock control without any antibiotic. Following an overnight incubation, a zone of inhibition is seen around each disc, except for **M**. Additionally, few individual colonies were observed in zone of inhibition for **P2**. Based on these observations select the correct statement(s).



Ans ✓ 1.

Q2 would be the preferred antibiotic for therapy against this *Bacillus* infection.

✗ 2.

If **P2** is a new generation antibiotic derived from **P1**, then long term use of **P2** is likely to remain highly effective against this *Bacillus* infection.

✗ 3.

The combination of **P1** and **P2** will not lead to antibiotic resistance in the *Bacillus*.

✓ 4.

The combination of **P1** and **Q2** is least likely to lead to antibiotic resistance in the *Bacillus*.

Question Type : **MSQ**

Question ID : **414664600**

Status : **Answered**

Chosen Option : **4**

Marks : **0**

Q.15 Barbara McClintock observed non-Mendelian pigmentation patterns in maize (figure 1) mediated by transposons, as also observed in *Petunia* (figure 2 and 3). These somatic changes were inheritable as evident from the clonal patterns of pigmentation observed both in seeds and flowers.



figure 1



figure 2



figure 3

As leaves grow, 'jumping genes' get activated and insert themselves into chlorophyll producing genes, thereby disrupting and inactivating them. This is typically seen as leaf pigment variegation (P and Q). Sometimes, the transposon jumps out from where it was inserted, restoring the chlorophyll gene function. Observing the leaf variegation patterns in P and Q, choose the correct statement(s).



P



Q

Ans 1.

Only Q shows clonal propagation of the variegated phenotype.

2.

Only P largely indicates that the transposon can jump out of chlorophyll gene, restoring its function.

3.

Tissue culture propagated plants from green tissue of leaf Q will show no variegation.

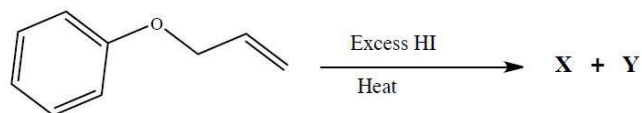
4.

Both P and Q show sporadic events of transposon-mediated variegation.

Question Type : **MSQ**
Question ID : **414664601**
Status : **Answered**
Chosen Option : **2,4**
Marks : **4**

Section : **Chemistry**

Q.1



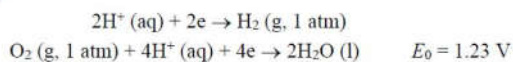
The products X and Y in the above reaction are:

Ans

- 1. Ph-I and $\text{CH}_2=\text{CH}-\text{CH}_2-\text{OH}$
- 2. Ph-I and $\text{I}-\text{CH}_2-\text{CH}(\text{I})-\text{CH}_3$
- 3. Ph-OH and $\text{I}-\text{CH}_2-\text{CH}(\text{I})-\text{CH}_3$
- 4. Ph-OH and $\text{CH}_2=\text{CH}-\text{CH}_2-\text{I}$

Question Type : MCQ
Question ID : 414664611
Status : Answered
Chosen Option : 4
Marks : -1

Q.2 In nature, many electron transfer reactions take place which are catalyzed by enzymes. Two such half-cell reactions are



The reduction potentials for the two half-cell reactions respectively at the physiological pH 7 are:

Ans

- 1. 0.0 V and +0.82 V
- 2. -0.41 V and +0.82 V
- 3. 0.0 V and +1.23 V
- 4. -0.41 V and +1.23 V

Question Type : MCQ
Question ID : 414664605
Status : Answered
Chosen Option : 3
Marks : -1

Q.3 Consider the bonding (Φ_b) and antibonding (Φ_a) molecular orbitals of the H_2^+ molecule formed by the linear combination of the atomic orbitals Ψ_X and Ψ_Y centered on the two H atoms X and Y. The correct statement is:

Ans 1.

As the internuclear distance is increased from the equilibrium bond distance, the energy of Φ_b is increased and that of Φ_a is lowered.

2.

For Φ_a , the probability density between the nuclei is increased by $c\Psi_X\Psi_Y$, where c is a positive real number.

3.

For the function Φ_a , the probability density at any point on a plane midway between the nuclei and perpendicular to the internuclear axis is 0.5.

4.

An electron present in the Φ_a orbital feels more electron-nuclei attraction compared to the one present in the Φ_b orbital.

Question Type : **MCQ**
Question ID : **414664604**
Status : **Answered**
Chosen Option : 1
Marks : 3

Q.4 The set of metal halides in which all the members form hydrates is:

Ans 1. KCl, MgCl₂, SrCl₂

2. KCl, LiCl, SrCl₂

3. LiCl, MgCl₂, SrCl₂

4. LiCl, KCl, MgCl₂

Question Type : **MCQ**
Question ID : **414664608**
Status : **Answered**
Chosen Option : 4
Marks : -1

Q.5 Among the complexes given below, the compound(s) that exhibit(s) optical isomerism is(are):

(i) *cis*-[Fe(NH₃)₂(CN)₄]⁻; (ii) *trans*-[Fe(NH₃)₂(CN)₄]⁻; (iii) *cis*-[CrCl₂(C₂O₄)₂]³⁻; (iv) *trans*-[CrCl₂(C₂O₄)₂]³⁻

Ans 1. Only (i).

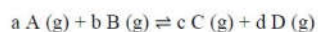
2. Both (ii) and (iv).

3. Only (iii).

4. Both (i) and (iii)

Question Type : **MCQ**
Question ID : **414664610**
Status : **Answered**
Chosen Option : 4
Marks : -1

Q.6 Consider a chemical reaction



with the equilibrium constants K_p and K_c defined in terms of pressure and concentration respectively.

Considering their inter-relation $K_p = K_c (RT)^{\Delta n}$, the correct statement (for $\Delta n = 1$) is:

Ans  1.

The value of K_p is always greater than that of K_c

 2.

The intercept of the plot of $\ln (K_p/K_c)$ vs $\ln T$ is $\ln 12.2$

 3.

The value of T at which $K_p = K_c$, is $1/0.082$

 4.

The value of T at which $K_p = K_c$, is $1/8.314$

Question Type : **MCQ**

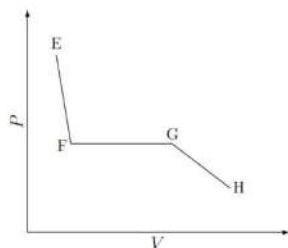
Question ID : **414664606**

Status : **Answered**

Chosen Option : **1**

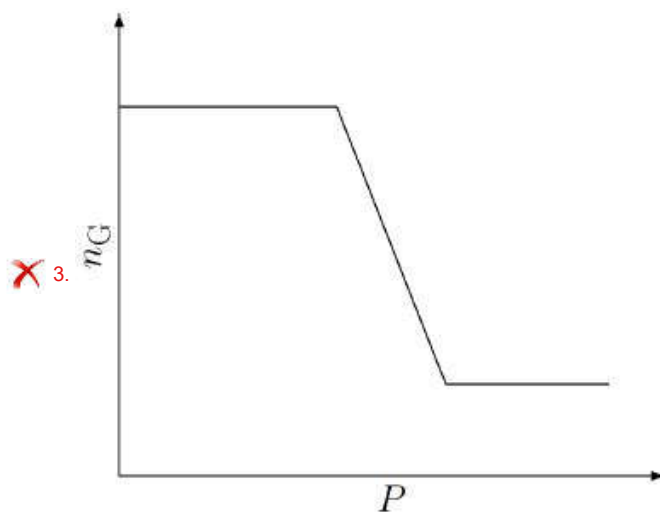
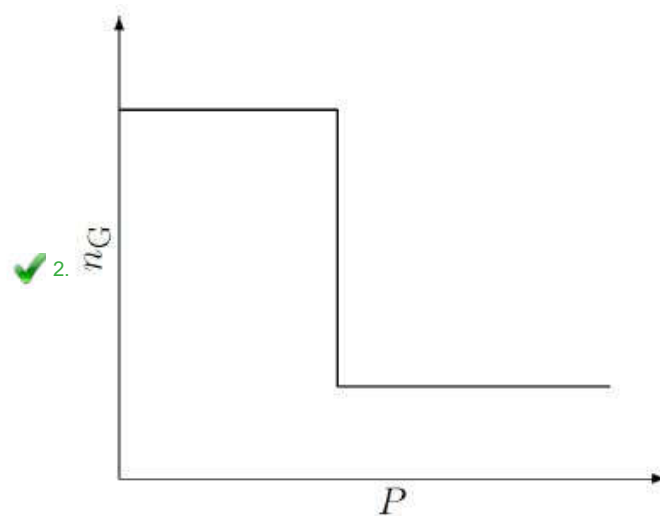
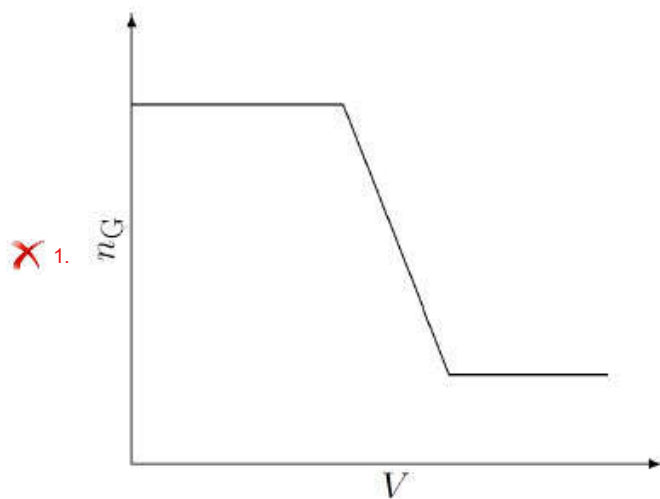
Marks : **-1**

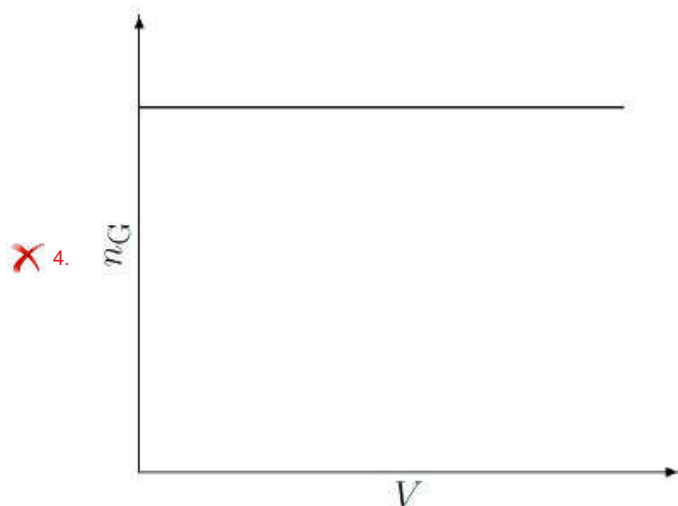
Q.7 Consider one mole of a gas in a closed vessel fitted with a movable piston. At constant temperature (T), the pressure of the gas (P) is increased gradually and the volume (V) is noted. The resulting P - V isotherm (not drawn to scale) is given below.



The correct plot (not drawn to scale) of the number of moles of the substance in gas phase (n_G) against V or P is:

Ans





Question Type : **MCQ**
 Question ID : **414664607**
 Status : **Not Answered**
 Chosen Option : --
 Marks : **0**

Q.8 The reactivity of an organometallic compound depends on the metal and the reactivity of the compound with which it is reacting. The compound that gives 2-butanone on reaction with an excess with propanoyl chloride is

- Ans
- 1. CH_3MgCl
 - 2. $(\text{CH}_3)_2\text{Cd}$
 - 3. $(\text{C}_2\text{H}_5)_2\text{Cd}$
 - 4. CH_3ONa

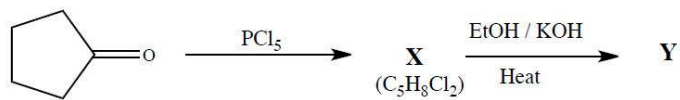
Question Type : **MCQ**
 Question ID : **414664612**
 Status : **Answered**
 Chosen Option : 2
 Marks : **3**

Q.9 The correct order of ionic radius is:

- Ans
- 1. $\text{Na}^+ < \text{Mg}^{2+} < \text{F}^- < \text{O}^{2-} < \text{N}^{3-}$
 - 2. $\text{Mg}^{2+} < \text{Na}^+ < \text{F}^- < \text{O}^{2-} < \text{N}^{3-}$
 - 3. $\text{F}^- < \text{O}^{2-} < \text{N}^{3-} < \text{Na}^+ < \text{Mg}^{2+}$
 - 4. $\text{N}^{3-} < \text{O}^{2-} < \text{F}^- < \text{Na}^+ < \text{Mg}^{2+}$


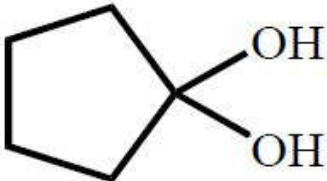
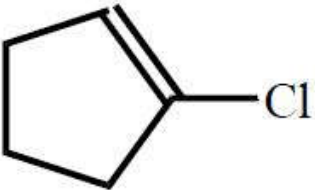

Question Type : **MCQ**
 Question ID : **414664609**
 Status : **Answered**
 Chosen Option : 1
 Marks : **-1**

Q.10



The product **Y** in the above reaction sequence is

Ans

- 1. 
- 2. 
- 3. 
- 4. 

Question Type : **MCQ**

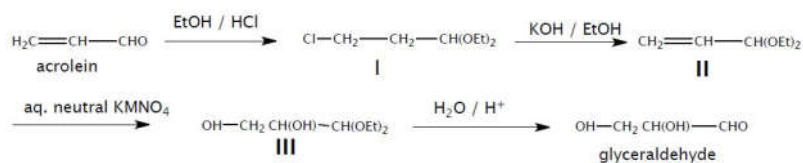
Question ID : **414664613**

Status : **Answered**

Chosen Option : **2**

Marks : **-1**

Q.11 Glyceraldehyde is an important intermediate in organic reactions. It can be prepared from readily available acrolein as given below.



The correct statement(s) with respect to the above synthesis is(are):

Ans 1.

The oxidation of compound **II** to compound **III** can also be carried using alkaline KMnO_4 .

2.

The addition of HCl to acrolein is *anti* to Markovnikov rule.

3.

Compound **I** can also be prepared by reacting acrolein with HCl in Et_2O .

4.

The conversion of compound **I** to compound **II** involves β -elimination reaction.

Question Type : **MSQ**

Question ID : **414664617**

Status : **Answered**

Chosen Option : **1,4**

Marks : **0**

Q.12 The CFSE (in Dq) and the spin only magnetic moment (S) of metal ions in an octahedral environment is plotted below as a function of number of electrons

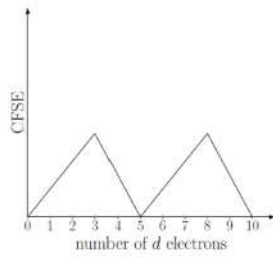


Fig. 1

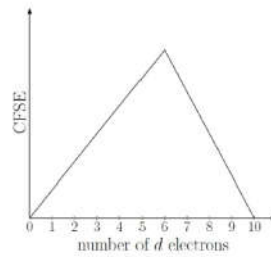


Fig. 2

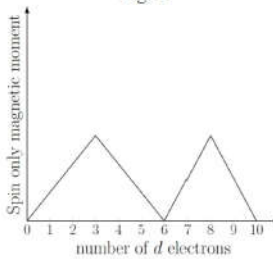


Fig. 3

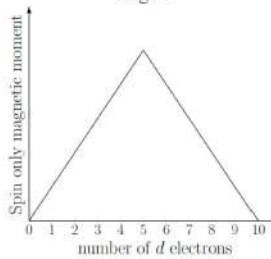


Fig. 4

The correct statement(s) is(are):

Ans 1.

Figs 2 and 4 represent strong field complexes

2.

Figs 1 and 4 represent weak field complexes

3.

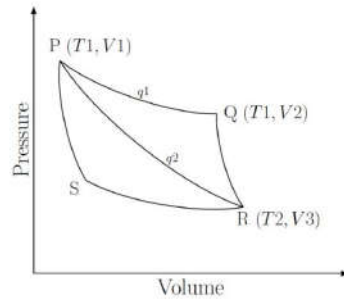
Figs 2 and 3 represent strong field complexes

4.

Figs 1 and 3 represent weak field complexes

Question Type : **MSQ**
 Question ID : **414664616**
 Status : **Answered**
 Chosen Option : **2,3**
 Marks : **4**

Q.13 The pressure-volume diagrams for some processes involving 1 mole of an ideal gas are indicated below



The process **P → Q** is isothermal and irreversible, while **Q → R** is adiabatic and reversible. The correct statement(s) is(are):

Ans ✓ 1.

The relation $q_1/T_1 + q_2/T_2 = 0$ is not valid.

✗ 2.

The magnitude of q_1 and q_2 should be the same since energy is conserved.

✓ 3.

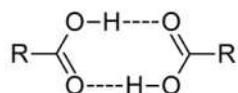
The entropy changes in the process **R → P** is given by $R \ln (V_1/V_2)$.

✓ 4.

The cyclic process **P → Q → R → P** is possible and $\Delta S < 0$ for **R → P**.

Question Type : **MSQ**
Question ID : **414664615**
Status : **Answered**
Chosen Option : **2**
Marks : **0**

Q.14 Carboxylic acids are known to form hydrogen bonded dimers of the type given below.



The equilibrium constants (K_{eq}) of the dissociation of certain dimers determined experimentally for different temperatures are given below. The plot of $\log_{10} K_{eq}$ vs $(1/T)$ is linear and the variation of the K_{eq} can be expressed in the form $\log_{10} K_{eq} = A - (B/T)$. The values of A and B are also given below.

Acid	T (K)	K_{eq}	A	B
Benzoic acid	353	13.0×10^{-4}	2.090	1700
	338	8.04×10^{-4}		
	327	5.19×10^{-4}		
p-Toluic acid	353	4.03×10^{-4}	2.202	2000
	338	2.30×10^{-4}		
	327	1.42×10^{-4}		

The correct statement(s) is(are):

Ans

✓ 1.

The ΔH for the dissociation of p-toluic acid dimer is approximately 9000 cal/mol.

✓ 2.

The average hydrogen bond strength for benzoic acid dimer is approximately 4 kcal/mol.

✗ 3.

The ΔS for the dissociation of benzoic acid dimer is negative.

✓ 4.

The hydrogen bond strength in p-toluic acid dimer is stronger than that in benzoic acid dimer.

Question Type : **MSQ**

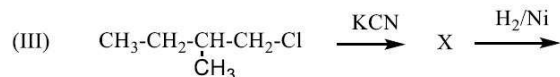
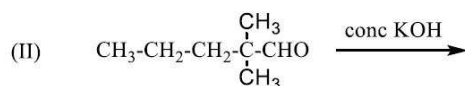
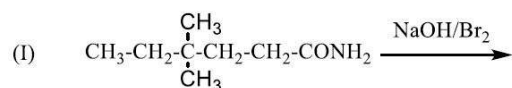
Question ID : **414664614**

Status : **Answered**

Chosen Option : **3,4**

Marks : **0**

Q.15 The correct statement(s) pertaining to the following reactions is(are):



Ans 1.

The reaction in which the product has the same number of carbon atom as that in the reactant is II.

2.

The reactions in which optically active reactant gives optically active product are III and IV.

3.

The reaction in which one of the products has one carbon atom less than the reactant is I.

4.

The reaction in which the product has one carbon atom more than the reactant is III.

Question Type : **MSQ**
 Question ID : **414664618**
 Status : **Answered**
 Chosen Option : **1,4**
 Marks : **0**

Section : **Mathematics**

Q.1

If $x \geq 10^{100}$, then

Ans

1. $\frac{x}{e^x} < \frac{\ln \ln x}{\ln x} < \frac{\ln x}{x}$

2. $\frac{x}{e^x} > \frac{\ln x}{x} > \frac{\ln \ln x}{\ln x}$

3. $\frac{x}{e^x} < \frac{\ln x}{x} < \frac{\ln \ln x}{\ln x}$

4. $\frac{\ln x}{x} > \frac{x}{e^x} > \frac{\ln \ln x}{\ln x}$

Question Type : **MCQ**
 Question ID : **414664626**
 Status : **Not Answered**
 Chosen Option : **--**
 Marks : **0**

Q.2 Let n be a randomly chosen integer from the set $\{100, 101, \dots, 999\}$. The probability that the sum of the digits of n is equal to 24 is

Ans

1. $\frac{11}{89}$

2. $\frac{1}{90}$

3. $\frac{3}{89}$

4. $\frac{1}{87}$

Question Type : **MCQ**
Question ID : **414664621**
Status : **Not Answered**
Chosen Option : --
Marks : **0**

Q.3 Let A be a 3×3 nonsingular matrix with real entries. Suppose the determinant of A is k . Then $\text{adj}(\text{adj } A)$ is equal to

Ans

1. $\frac{1}{k}A^{-1}$

2. $\frac{1}{k}A$

3. kA

4. kA^{-1}

Question Type : **MCQ**
Question ID : **414664623**
Status : **Not Answered**
Chosen Option : --
Marks : **0**

Q.4 The number of positive divisors of the number 79200 which are not divisible by 4 is

Ans

1. 4

2. 36

3. 18

4. 72

Question Type : **MCQ**
Question ID : **414664619**
Status : **Not Answered**
Chosen Option : --
Marks : **0**

Q.5 Consider the equations

$$y = x^3 - x^2 + 3x - 4$$

and

$$y = \alpha x^2 - x - 4, \quad \alpha \in \mathbb{R}.$$

The number of values of α for which the above two equations intersect at exactly two points is

Ans

1. 0

2. 2

3. 1

4. 3

Question Type : MCQ

Question ID : 414664627

Status : Not Answered

Chosen Option : --

Marks : 0

Q.6 Let \mathcal{R} be a relation on \mathbb{Z} given by

$$\mathcal{R} = \{(a, b) \in \mathbb{Z} \times \mathbb{Z} : 3|(a - b) \text{ or } 2|(a + b)\}.$$

Then \mathcal{R} is

Ans

1.

symmetric and transitive but not reflexive

2.

reflexive and symmetric but not transitive

3.

reflexive and transitive but not symmetric

4. an equivalence relation

Question Type : MCQ

Question ID : 414664620

Status : Not Answered

Chosen Option : --

Marks : 0

Q.7 Let ABCD be a trapezium where $AB \parallel CD$ and $AB \perp BC$. Suppose the length of the sides AB and CD are 3 and 5 units respectively and the coordinate of B and C are (2, 5) and (3, 7) respectively. If E is a point on the side BC and $AE + DE$ is minimum, then the coordinate of E is

Ans

1. $(\frac{5}{2}, 6)$

2. $(3, 7)$

3. $(\frac{19}{8}, \frac{46}{8})$

4. $(\frac{21}{8}, \frac{50}{8})$

Question Type : **MCQ**

Question ID : **414664628**

Status : **Not Answered**

Chosen Option : --

Marks : **0**

Q.8 Let $f: \mathbb{R} \rightarrow \mathbb{R}$ be a function defined by $f(x) = |x| + 2x$ for $x \in \mathbb{R}$. Then f is

Ans

1. one-to-one but not onto

2.

invertible and $f^{-1}(x) = -|x| + \frac{x}{2}$ for $x \in \mathbb{R}$

3. onto but not one-to-one

4.

invertible and $f^{-1}(x) = -\frac{|x|}{3} + \frac{2x}{3}$ for $x \in \mathbb{R}$

Question Type : **MCQ**

Question ID : **414664625**

Status : **Not Answered**

Chosen Option : --

Marks : **0**

Q.9 Suppose p, q, r, s are distinct integers chosen from $\{1, 2, 3, 4\}$. Let

$$x = \frac{1}{p + \frac{1}{q + \frac{1}{r + \frac{1}{s}}}}$$

The value of s for which x takes maximum value is

Ans

1. 2

2. 1

3. 3

4. 4

Question Type : **MCQ**
Question ID : **414664622**
Status : **Not Answered**
Chosen Option : --
Marks : **0**

Q.10 Let $f : \mathbb{R} \rightarrow \mathbb{R}$ be a continuous function. For an $\alpha \in \mathbb{R}$, suppose that

$$\lim_{h \rightarrow 0} \frac{f(\alpha + h) - f(\alpha - h)}{h} = p,$$

where $p \in \mathbb{R}$. Then

Ans 1.

f is differentiable at α if the left hand and right hand derivatives at α exist

2. f is differentiable at α and $f'(\alpha) = p$

3. f is differentiable at α and $f'(\alpha) = \frac{p}{2}$

4. f may not be differentiable at α

Question Type : **MCQ**
Question ID : **414664624**
Status : **Not Answered**
Chosen Option : --
Marks : **0**

Q.11 If the roots of the equation $x^3 + bx^2 + cx - 1 = 0$ are real, positive, distinct and in geometric progression then

Ans

✓ 1. $b \in (-\infty, -3)$

✓ 2. one of the roots is 1

✓ 3.

one of the roots is smaller than 1 and one of the roots is bigger than 1

✓ 4. $b + c = 0$

Question Type : **MSQ**
Question ID : **414664629**
Status : **Answered**
Chosen Option : **2,3,4**
Marks : **0**

Q.12

Let $f : \mathbb{R} \rightarrow \mathbb{R}$ be a differentiable function such that $\lim_{x \rightarrow \infty} \frac{f(x)}{x} = 0$. Then

Ans ✗ 1.

there exists a real number m such that $|f'(x)| < m$ for all $x \in [0, \infty)$

✓ 2.

$\lim_{x \rightarrow \infty} \frac{|F(x)|}{x^2} = 0$ where $F(x)$ is an antiderivative of $f(x)$

✗ 3. $\lim_{x \rightarrow \infty} f'(x) = \infty$

✓ 4.

$\lim_{x \rightarrow \infty} f'(x) = 0$ whenever $\lim_{x \rightarrow \infty} f'(x)$ exists

Question Type : **MSQ**
Question ID : **414664633**
Status : **Answered**
Chosen Option : **1,2**
Marks : **0**

Q.13 For a finite sequence $a = (a_1, \dots, a_n)$ of n integers (where $n \geq 2$), define

$$S(a) = \sum_{\substack{i,j \in \{1,2,\dots,n\} \\ i < j}} a_i a_j.$$

Ans 1.

For $a = (a_1, \dots, a_n)$ and $b = (b_1, \dots, b_m)$, define $a \star b = (a_1, \dots, a_n, b_1, \dots, b_m)$.
Then $S(a \star b) = S(a) + S(b)$.

2.

If a is a sequence of $m + k$ integers with m many 1's and k many -1 's then

$$S(a) = \frac{m(m-1)}{2} + \frac{k(k-1)}{2} - mk.$$

3.

Then there is an integer x such that for the finite sequence $a = (2, 3, x, 2x)$,
 $S(a) = -7$.

4.

If a is a sequence of 100 integers consisting of 2's and -1 's only then the minimum possible value of $S(a)$ is less than -100 .

Question Type : **MSQ**
Question ID : **414664630**
Status : **Answered**
Chosen Option : **2,4**
Marks : **0**

Q.14 Let $f : \mathbb{R} \mapsto \mathbb{R}$ be defined by $f(x) = [x] + \sqrt{x - [x]}$. Here, $[x]$ is the greatest integer function for $x \in \mathbb{R}$ and \sqrt{y} is the positive square root of y for $y \in \mathbb{R}^+$. Then

Ans 1. f is differentiable everywhere

2. f is continuous everywhere

3. f is bijective

4. f is discontinuous only at integer points

Question Type : **MSQ**
Question ID : **414664631**
Status : **Answered**
Chosen Option : **1,4**
Marks : **0**

Q.15

Let \vec{a} , \vec{b} and \vec{c} be any three vectors. Then

Ans 1.

$\vec{a} \cdot \vec{b} + \vec{b} \cdot \vec{c} + \vec{c} \cdot \vec{a} = 0$ if \vec{a} , \vec{b} and \vec{c} are unit vectors with $\vec{a} + \vec{b} + \vec{c} = 0$

2.

$\vec{a} + \vec{b}$, $\vec{b} + \vec{c}$ and $\vec{c} + \vec{a}$ are coplanar if \vec{a} , \vec{b} and \vec{c} are coplanar

3. $|\vec{a}| = |\vec{b}|$ if $(\vec{a} + \vec{b}) \cdot (\vec{a} - \vec{b}) = 0$

4. $\vec{a} = \vec{b}$ if $|\vec{a}| = |\vec{b}|$ and $\vec{a} \cdot \vec{b} = 0$

Question Type : **MSQ**
Question ID : **414664632**
Status : **Answered**
Chosen Option : **1,2,3**
Marks : **0**

Section : **Physics**

Q.1 A beam of laser light is incident on an analyzer which is rotated on a spectrometer stage. If the intensity of the transmitted light changes from maximum to minimum (not zero), the nature of the incident beam is

Ans 1. circular polarized

2. plane polarized

3. unpolarized

4. partially polarized

Question Type : **MCQ**
Question ID : **414664641**
Status : **Answered**
Chosen Option : **2**
Marks : **-1**

Q.2 In a certain experiment, liquid helium at an initial temperature of 1 K is to be further cooled by bringing it into contact with a paramagnetic salt which is initially at temperature T_0 . The heat capacity of liquid helium is expressed as $C_h = aT^3$ ($a = 128 \times 10^{-4} \text{ J} \cdot \text{K}^{-4}$) and that of salt is expressed as $C_s = bT^{-2}$ ($b = 15 \times 10^{-4} \text{ J} \cdot \text{K}$). Assume that the mixture is thermally and mechanically isolated and no work is done during the process. If the final temperature of the system is 0.5 K, the initial temperature T_0 of the salt is

Ans

1. 0.5 K

2. 0.25 K

3. 0.01 K

4. 0.1 K

Question Type : **MCQ**

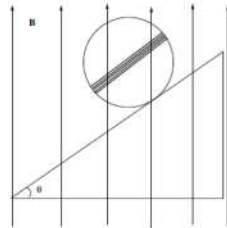
Question ID : **414664637**

Status : **Not Answered**

Chosen Option : --

Marks : **0**

Q.3 A nonconducting sphere has mass 8.0 kg and radius 0.2 m. A flat compact coil of wire with 50 turns is wrapped tightly around it, with each turn concentric with the sphere. As shown in the figure, the sphere is placed on an inclined plane that slopes downward to the left, making an angle θ with the horizontal, so that the coil is parallel to the inclined plane. A uniform magnetic field of 0.35 T vertically upward exists in the region of the sphere. If the sphere rests in equilibrium on the inclined plane, the current through the coil is closest to



Ans

1. 3.64 A

2. 1.52 A

3. 7.28 A

4. 0.59 A

Question Type : **MCQ**
 Question ID : **414664643**
 Status : **Not Answered**
 Chosen Option : --
 Marks : **0**

Q.4 Assume that the mass density of the Sun is uniform and treat solar radiation as blackbody radiation. It's given that the surface temperature of the Sun is 6000 K and assume that the Sun continues giving energy at the same rate in future. If the source of Sun's radiated energy was its gravitational potential energy instead of the nuclear fusion then the Sun will cease to exist in a time of the order of

Ans

- 1. 10 years
- 2. 10 million years
- 3. 1 billion years
- 4. 1000 years

Question Type : **MCQ**
 Question ID : **414664634**
 Status : **Not Answered**
 Chosen Option : --
 Marks : **0**

Q.5 The potential for a point charge $+q$ placed at a distance d from a grounded infinite conducting plate is

$$V(x, y, z) = kq \left(\frac{1}{\sqrt{x^2 + y^2 + (z - d)^2}} - \frac{1}{\sqrt{x^2 + y^2 + (z + d)^2}} \right)$$

Here $k = 1/4\pi\epsilon_0$ is a constant. The maximum value of induced charge density on the conducting plate is

Ans

- 1. $-2k\epsilon_0q/d^2$
- 2. $-k\epsilon_0q/d^2$
- 3. 0
- 4. $-k\epsilon_0q/2d^2$

Question Type : **MCQ**
 Question ID : **414664642**
 Status : **Not Answered**
 Chosen Option : --
 Marks : **0**

Q.6 The remote control of a TV emits infra-red light of wavelength 900 nm. The TV detector is made of a semiconductor whose band gap is x eV. The detector is shielded by a semiconductor optical filter whose band gap is y eV. From the four options below, select the best option for the TV to function.

Ans

✓^{1.} $x = 1.2$ and $y = 1.4$

✗^{2.} $x = 1.1$ and $y = 1.8$

✗^{3.} $x = 2.2$ and $y = 1.0$

✗^{4.} $x = 2.0$ and $y = 1.2$

Question Type : **MCQ**
Question ID : **414664635**
Status : **Not Answered**
Chosen Option : --
Marks : **0**

Q.7 A radioactive dye of 4 grams is injected into the bloodstream of a patient. The half life of the dye is 6 hours. At the same time the dye is filtered and removed by the body with a half life of 12 hours. One gram of the radioactive dye will be found in the blood after

Ans

✓^{1.} 8 hours

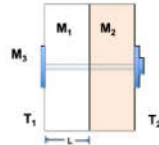
✗^{2.} 6 hours

✗^{3.} 9 hours

✗^{4.} 12 hours

Question Type : **MCQ**
Question ID : **414664636**
Status : **Not Answered**
Chosen Option : --
Marks : **0**

Q.8 Two different materials M_1, M_2 of equal dimensions (length L and uniform cross-sectional area A) having thermal conductivities k_1 and k_2 respectively are connected together through a bolt M_3 . The bolt (length = $2L$, area = A/n) is of another material with thermal conductivity k_3 such that $n \gg 1$. The left sides of the material M_1 and M_3 are kept at the temperature T_1 whereas the right sides of the material M_2 and M_3 are kept at the temperature T_2 as shown in the figure below such that $T_1 > T_2$. Assume that the bolt (M_3) is thermally insulated from materials M_1 and M_2 . The equivalent thermal resistance of this system is



Ans

✗ 1. $\frac{L(k_1+k_2)}{Ak_1k_2}$

✗ 2. $\frac{L}{(k_1+k_2)A}$

✗ 3. $\frac{L(k_3+2n(k_1+k_2))}{A(k_1+k_2)nk_3}$

✓ 4. $\frac{2nL(k_1+k_2)}{A(2nk_1k_2+k_2k_3+k_3k_1)}$

Question Type : **MCQ**

Question ID : **414664639**

Status : **Not Answered**

Chosen Option : --

Marks : **0**

Q.9 An explosion releasing energy E occurs in a medium of density ρ . This results in a spherical blast wave of radius r . One can express the radius of the blast wave at time t after the explosion in a form $r = kt^\alpha E^\beta \rho^\gamma$ where k is a dimensionless constant. Then the radial speed of the blast wave can be written as $v \propto t^n$. The value of n is

Ans

1. -3

2. $1/5$

3. $-3/5$

4. 2

Question Type : **MCQ**
Question ID : **414664638**
Status : **Answered**
Chosen Option : **2**
Marks : **-1**

Q.10 A disk shaped coin is tossed up in the air with '*Head*' side on the top. The initial centre of mass velocity of the coin is $6.8 \text{ m}\cdot\text{s}^{-1}$ in the vertical direction. In addition, the disk is rotating about the horizontal axis with angular velocity $6\pi \text{ rad}\cdot\text{s}^{-1}$. Assume the motion in air is torque-free. Find the number of completed flips the disk will perform before it hits the ground under the action of gravity.

Ans

1.

5 completed flips with '*Tail*' side on the top.

2.

4 completed flips with '*Tail*' side on the top.

3.

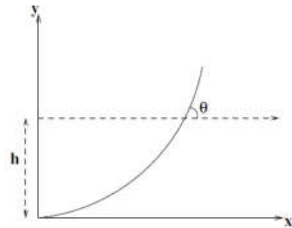
5 completed flips with '*Head*' side on the top.

4.

4 completed flips with '*Head*' side on the top.

Question Type : **MCQ**
Question ID : **414664640**
Status : **Not Answered**
Chosen Option : **--**
Marks : **0**

Q.11 Consider an optical medium where refractive index varies linearly with height i.e. $n(y) = n(0) + ky$ where k is a positive constant and y is the height above the ground level. Here positive number $n(0)$ is the refractive index at the ground level. The refractive index at height y varies with temperature at that point as $(n(y) - 1)T(y) = \text{constant}$. Consider a ray propagating (in a plane) in the medium which is horizontal at the ground level (i.e. at grazing angle) and makes an angle θ with horizontal at height h as shown in the figure. Use small angle approximation i.e. keep only terms upto and including quadratic order in all trigonometric functions. Select the correct option(s).



Ans 1.

The temperature at height h is greater than the temperature at ground level.

2. Angle $\theta = \sqrt{2\left(1 - \frac{n(0)}{n(h)}\right)}$.

3.

For $n(0) = 1.001$ and $k = 1 \times 10^{-4} \text{m}^{-1}$, angle θ at height 1 meter above the ground level is equal to $\sqrt{1/5}$

4.

Angle $\theta = \sqrt{2\left(1 - \frac{1}{n(h)}\right)\left(1 - \frac{T(h)}{T(0)}\right)}$

Question Type : **MSQ**
 Question ID : **414664645**
 Status : **Answered**
 Chosen Option : **1,4**
 Marks : **0**

Q.12 Thermal de Broglie wavelength is the de Broglie wavelength of the gas particles in an ideal gas at temperature T with average kinetic energy given by the equipartition theorem and usual relation between kinetic energy and momentum. Consider an ideal monoatomic gas A of N_a atoms, each of mass m_a and another ideal monoatomic gas B of N_b atoms, each of mass $m_b = 4m_a$. Both gases are uniformly distributed in boxes of volume V at temperature T . Select the correct statement(s).

Ans  1.

If a photon has wavelength equal to thermal de Broglie wavelength of atoms of gas A then the ratio of photon momentum and average momentum of atoms in gas A i.e. p_{photon}/p_A is $2/3$.

 2.

If total mass of gas A is same as total mass of gas B then their pressures are related as $P_B = 4P_A$.

 3.

Thermal de Broglie wavelengths of gases A and B are in ratio $\lambda_A/\lambda_B = 2$.

 4.

If volume and temperature are such that, for both gases A and B , the average inter-particle spacing in each direction is equal to thermal de Broglie wavelength of respective atoms λ_A and λ_B then $N_b = 8N_a$.

Question Type : **MSQ**
Question ID : **414664648**
Status : **Answered**
Chosen Option : **2,3,4**
Marks : **0**

Q.13 Two point charges q and λq in vacuum are located at the points $A(a, 0)$ and $B(\mu a, 0)$ in the xy plane. Assume that $a > 0$ and $q > 0$. Select the correct statement(s).

Ans 1.

If the midpoint between the charges is fixed, then the maximum force of attraction is $\frac{1}{4\pi\epsilon_0}\lambda\left[\frac{q}{2a}\right]^2$.

2.

If the sum of the charges is fixed, then the maximum force of repulsion between the charges is $\frac{1}{4\pi\epsilon_0}\left[\frac{q}{a(1-\mu)}\right]^2$.

3.

If the mid point between the charges is fixed, then the maximum force (attractive or repulsive) happens when the charges are placed symmetrically about the origin.

4.

If the sum of the charges is fixed, then the maximum force of attraction happens when λ is -2 .

Question Type : **MSQ**
Question ID : **414664646**
Status : **Answered**
Chosen Option : **2,4**
Marks : **0**

Q.14 A spherical raindrop of initial mass M_0 and initial radius R falls freely from rest. Let ρ be the constant density and r the radius at time t . Assume that the drop maintains its spherical shape. The drop loses mass at the rate $dm/dt = -4\pi k\rho r^2$, where k is a constant. Define $t_c = \frac{R}{k}$. Select the correct statement(s)

Ans 1.

The speed of the drop at time $t_c/2$ is $15gR/8k$

2.

The rate of mass loss goes to zero as time $t \rightarrow t_c$

3.

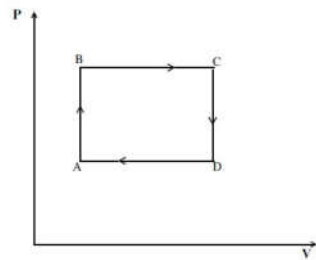
The drop loses all its mass in time t_c

4.

The momentum approaches $M_0gR/4k$ as $t \rightarrow t_c$

Question Type : **MSQ**
Question ID : **414664644**
Status : **Answered**
Chosen Option : **1,2,3,4**
Marks : **4**

Q.15 A heat engine uses one mole of ideal gas as its working substance which performs the following cyclic process, as shown in the figure below. Given $P_C = 2P_A$, $V_C = 2V_A$, select the correct statement(s).



Ans ✓ 1.

Heat released by the heat engine during one cycle is given by $\frac{11}{2}P_A V_A$.

✓ 2.

The efficiency of the heat engine is 15.4 %.

✓ 3.

The change in entropy of the gas during one cycle is zero.

✗ 4.

The minimum temperature occurs at D.

Question Type : **MSQ**
 Question ID : **414664647**
 Status : **Answered**
 Chosen Option : **1,2,3**
 Marks : **4**