

Biology

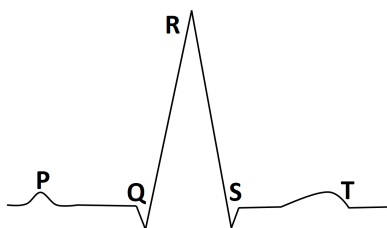
- Which of the following produces a dikaryotic phase in Basidiomycetes?
 - Karyogamy
 - Plasmogamy
 - Apogamy
 - Karyokinesis
- In the standard nomenclature used for depicting floral formula, which type of flower is represented by $K_{(5)}$?
 - Polysepalous
 - Syncarpous
 - Gamosepalous
 - Gamopetalous
- Which one of the following statements is TRUE?
 - Blood is a connective tissue which does not secrete collagen
 - Tendons are a type of dense, irregular connective tissue
 - Adipose tissue is an example of a fluid connective tissue
 - Saliva is secreted by an endocrine gland
- Match the entries in column I and column II. Which one of the following choices is correct?

Column I	Column II
(a) Haem	(1) Cofactor
(b) NAD	(2) Vitamin
(c) Zinc	(3) Coenzyme
(d) Niacin	(4) Prosthetic group

 - a-3, b-1, c-4, d-2
 - a-4, b-3, c-1, d-2
 - a-2, b-1, c-3, d-4
 - a-4, b-1, c-3, d-2
- Which one of the following helps in bacterial motility?
 - Centrioles
 - Fimbriae
 - Microtubules
 - Flagella

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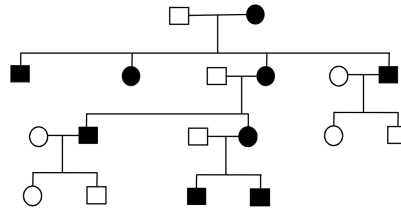
6. During light reaction in chloroplasts of tobacco plants, where is the proton gradient generated?
- Between stroma and intermembrane space of chloroplasts
 - Between thylakoid lumen and intermembrane space of chloroplasts
 - Between stroma and thylakoid lumen
 - Between inner and outer chloroplast membranes
7. Which of the following will NOT be triggered by the release of acetyl choline in the synapse at the neuromuscular junction during muscle contraction?
- Generation of an action potential in the muscles
 - Release of Ca^{2+} from the sarcoplasmic reticulum
 - Binding of ATP molecules to the myosin head
 - Shifting of tropomyosin to expose the myosin binding sites on actin filaments
8. The diagram below shows a typical ECG.



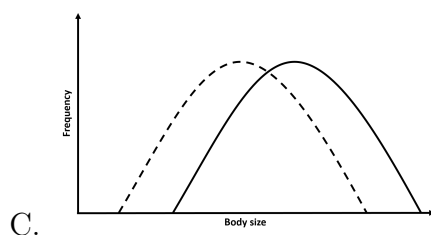
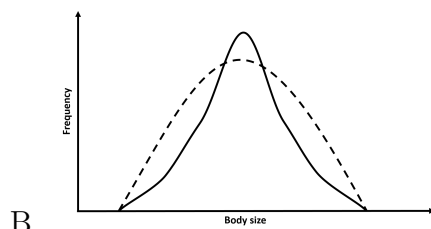
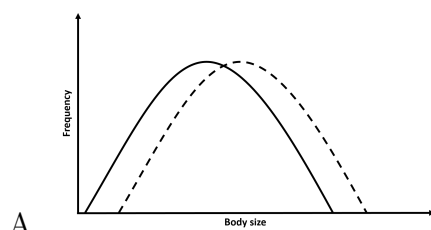
- If the AV node is not functional, which of the following options correctly represents the changes seen in the ECG?
- P wave will sustain longer with smaller amplitude
 - The QRS complex will be absent
 - The T wave will sustain longer with smaller amplitude
 - The distance between the P wave and the QRS complex will be smaller
9. Listed below are different plant reproductive strategies.
- Parthenocarpy
 - Syngamy
 - Apomixis
 - Polyembryony
- Which of them can give rise to a clonal progeny having the same genotype as that of the mother plant?
- III and IV
 - I and II
 - II and III
 - I and IV

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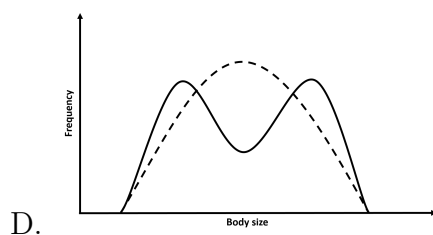
10. The diagram below represents the pedigree of a certain genetic disease (affected individuals are shaded). What is the mode of inheritance of the gene responsible for this disease?



- A. X-linked recessive
 B. Y-linked
 C. X-linked dominant
 D. Mitochondrial
11. An *E. coli* whose DNA is fully labeled by ^{15}N is grown in a medium containing $^{14}\text{NH}_4\text{Cl}$. What will be the percentage of hybrid ($^{15}\text{N}/^{14}\text{N}$) and light ($^{14}\text{N}/^{14}\text{N}$) DNA molecules at the end of 80 minutes (assume that doubling time of *E. coli* is 20 minutes)?
- A. 25% hybrid and 75% light
 B. 50% hybrid and 50% light
 C. 0% hybrid and 100% light
 D. 12.5% hybrid and 87.5% light
12. The following plots represent the body size distributions of a fruit fly population. Dashed lines represent the ancestral distributions and continuous lines represent the distributions after a few generations. If the larger individuals have better survival as well as higher reproductive rates, which diagram below best represents the expected change in the distribution of body size (X-axis represents body size while Y-axis represents frequency)?



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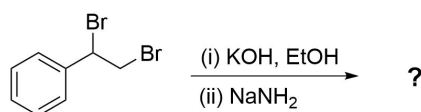
13. What are the types of immunity acquired by i) transfer of antibodies to the foetus via the placenta and ii) vaccination of an infant?
- A. Both are active immunity
 - B. Both are passive immunity
 - C. Active and passive immunity, respectively
 - D. Passive and active immunity, respectively
14. Which among the following correctly represents the sequence of events for a normal polymerase chain reaction?
- A. Denaturation, annealing, extension
 - B. Annealing, denaturation, extension
 - C. Extension, annealing, denaturation
 - D. Denaturation, extension, annealing
15. Loss of biodiversity occurs due to the growth of carrot grass (*Parthenium* sp.). This is an example of?
- A. Alien-species invasion
 - B. Co-extinction
 - C. Over-exploitation
 - D. Habitat loss and fragmentation

Chemistry

16. What are the correct orders of bond lengths d_{X-X} and bond dissociation enthalpies BDE_{X-X} for F_2 and Cl_2 ? (where $X = F$ or Cl)
- $d_{F-F} < d_{Cl-Cl}$ and $BDE_{F-F} < BDE_{Cl-Cl}$
 - $d_{F-F} > d_{Cl-Cl}$ and $BDE_{F-F} > BDE_{Cl-Cl}$
 - $d_{F-F} < d_{Cl-Cl}$ and $BDE_{F-F} > BDE_{Cl-Cl}$
 - $d_{F-F} > d_{Cl-Cl}$ and $BDE_{F-F} < BDE_{Cl-Cl}$
17. Which is the appropriate combination of spin configuration and colour for the anionic complex $[Co(L)_6]^{3-}$ (L is a monodentate and monoanionic ligand)?
- high-spin and green
 - low-spin and green
 - low-spin and blue
 - high-spin and yellow
18. Which of the following combination of elements forms interstitial hydrides?
- Na and Mg
 - Yb and Ti
 - Fe and Mn
 - B and Al
19. How many geometrical isomers are possible for the square planar complex $[Pd(py)(Cl)(Br)(NH_3)]$ (py = pyridine)?
- 2
 - 4
 - 5
 - 3
20. A molecular adduct is formed between BF_3 and Et_2O . Which of the following values describe the coordination number (CN), valency (V) and oxidation state (OS) of B atom in this adduct?
- CN = 4, V = 4 and OS = +3
 - CN = 4, V = 3 and OS = +4
 - CN = 4, V = 3 and OS = +3
 - CN = 3, V = 3 and OS = +4

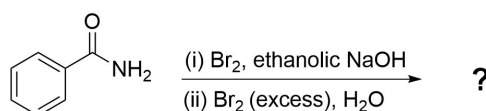
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21. While making paneer (cottage cheese) from milk by adding dilute acetic acid, the milk proteins undergo
- solubilization
 - degradation
 - denaturation
 - polymerization
22. What is the final major product of the following reaction?



-
-
-
-

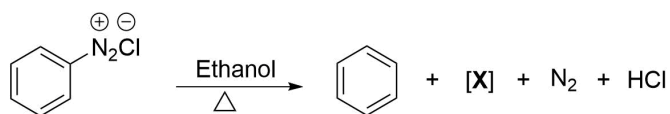
23. Identify the final major product in the following reaction sequence.



-
-
-
-

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24. Identify the compound [X] in the following reaction.



- A. CH_3COOH
- B. OHC-CHO
- C. $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_2\text{Cl}$
- D. CH_3CHO

25. Which one among the following compounds is aromatic?

- A.
- B.
- C.
- D.

26. Using the Arrhenius equation, find out the value of k at $T \rightarrow \infty$?

- A. A
- B. $-A$
- C. e^A
- D. e^{-A}

27. Which one of the following is **NOT** an example of heterogeneous equilibrium?

- A. Equilibrium between water vapour and liquid water in a closed container
- B. Equilibrium attained during acid catalysed hydrolysis of ethyl acetate
- C. Equilibrium between solid Ca(OH)_2 and its saturated solution
- D. Equilibrium attained on heating solid CaCO_3 in a closed container

28. At 60°C , 50% of N_2O_4 (g) is dissociated to NO_2 (g). What is the standard Gibbs free energy change at 60°C and 1 atm pressure for this process? ($R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$)

- A. 763 Jmol^{-1}
- B. -790 Jmol^{-1}
- C. -863 Jmol^{-1}
- D. 500 Jmol^{-1}

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29. For a cell $\text{Ag}|\text{Ag}^+, \text{Cl}^-|\text{AgCl(s)}|\text{Ag}$, E_{Red}° for the half cells are given as: $E_{\text{Ag}^+|\text{Ag}}^\circ = 0.79 \text{ V}$, $E_{\text{Cl}^-|\text{AgCl(s)}|\text{Ag}}^\circ = 0.22 \text{ V}$ at 25°C . What is the value of $\ln K$, where K is the equilibrium constant for the reaction $\text{AgCl(s)} \rightleftharpoons \text{Ag}^+ + \text{Cl}^-$? Given, $1 \text{ F} = 96485 \text{ C}$.
- A. -22.2
B. -18.5
C. -29.3
D. -26.8
30. Match the following:
- | | |
|---------------------|-------------------------|
| i) Ge doped with In | 1. n-type semiconductor |
| ii) Si doped with N | 2. Schottky defect |
| iii) ZnS | 3. p-type semiconductor |
| iv) CsCl | 4. Frenkel defect |
- A. i-1, ii-3, iii-2, iv-4
B. i-1, ii-3, iii-4, iv-2
C. i-3, ii-1, iii-2, iv-4
D. i-3, ii-1, iii-4, iv-2

Mathematics

31. Let $1, \zeta_2, \zeta_3, \dots, \zeta_n$ be the roots of the equation $x^n = 1$, for $n \geq 3$. Then, the sum

$$\frac{1}{2 - \zeta_2} + \frac{1}{2 - \zeta_3} + \dots + \frac{1}{2 - \zeta_n}$$

equals to

- A. $\frac{1+(n-2)2^n}{2^n-1}$.
- B. $\frac{1+n2^{n-1}-2^n}{2^n-1}$.
- C. $\frac{1+n2^{n-1}-2^n}{2^{n-1}+1}$.
- D. $\frac{1+(n-1)2^n-2^{n-1}}{2^{n-1}+1}$.

32. How many solutions does the equation

$$\sin^2 x - 15 \sin x \cos x + 50 \cos^2 x = 0$$

have in the interval $[0, 2\pi]$?

- A. 4.
- B. 0.
- C. 1.
- D. 2.

33. Let A be a 4×4 matrix with real entries. Consider the sets

$$K = \left\{ \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} : A \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \right\},$$

$$J = \left\{ \begin{pmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \end{pmatrix} : \begin{pmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \end{pmatrix} = A \begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{pmatrix}, \text{ for some } y_1, y_2, y_3, y_4 \in \mathbf{R} \right\}.$$

Suppose $K = J$. Then, which one of the following statements is necessarily true?

- A. $A^2 = 0$.
- B. A is symmetric.
- C. A is skew symmetric.
- D. $A^2 = A$.

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34. Consider 5 straight lines in a plane such that no two of them are parallel and no three of them intersect at a point. Then, the number of disjoint regions into which the plane is divided by these lines equals to
- 17.
 - 18.
 - 16.
 - 20.

35. Consider the circle C that passes through the points $(1, 0)$ and $(0, 1)$ having the smallest area. Then, the equation of the tangent to the circle C at $(0, 1)$ is
- $y = -x + 1$.
 - $y = x - 1$.
 - $y = x$.
 - $y = x + 1$.

36. Let $f : [-1, 1] \rightarrow \mathbf{R}$ be a continuous function. Consider the region

$$S = \{(x, y) : -1 \leq x \leq 1 \text{ and } 0 \leq y \leq f(x)\}.$$

For which one of the following functions f , the area of the region S is the largest?

- $f(x) = \pi^x |\sin \pi x|$.
 - $f(x) = \pi^x |\cos \pi x|$.
 - $f(x) = \pi^x \left(1 + \left|\tan \frac{\pi x}{10}\right|\right)$.
 - $f(x) = \frac{\pi^x}{|x|+1}$.
37. Let $f : \mathbf{R} \rightarrow \mathbf{R}$ be a continuous function. Then, f is surjective if
- $\lim_{x \rightarrow \infty} f(x) = \infty$ and $\lim_{x \rightarrow -\infty} f(x) = \infty$.
 - $\lim_{x \rightarrow \infty} f(x) = 0$ and $\lim_{x \rightarrow -\infty} f(x) = \infty$.
 - $\lim_{x \rightarrow \infty} f(x) = 0$ and $\lim_{x \rightarrow -\infty} f(x) = -\infty$.
 - $\lim_{x \rightarrow \infty} f(x) = -\infty$ and $\lim_{x \rightarrow -\infty} f(x) = \infty$.
38. The limit $\lim_{n \rightarrow \infty} \frac{1}{n^{2020}} \sum_{k=1}^n k^{2019}$
- is $\frac{1}{2018}$.
 - is $\frac{1}{2020}$.
 - is $\frac{1}{2019}$.
 - does not exist.

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39. The sum of n consecutive terms of an arithmetic progression consisting of integers is 161. Then, a possible value of n is

- A. 5.
- B. 7.
- C. 6.
- D. 8.

40. Let $f : \mathbf{R} \rightarrow \mathbf{R}$ be a non-zero even function such that

$$\int_{-1}^1 f(x) dx = \alpha.$$

Then, the value of the integral

$$\int_{-1}^1 \frac{f(x)}{1 + e^x} dx$$

is

- A. α .
- B. $\alpha e^{-\alpha}$.
- C. $\frac{\alpha}{2}$.
- D. $\frac{e^{-\alpha}}{2}$.

41. What is the mean deviation about the mean for the following data?

x_i	1	2	3	4
f_i	5	10	15	20

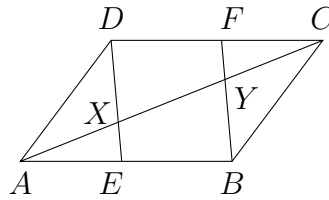
- A. $\frac{4}{5}$.
- B. $\frac{3}{5}$.
- C. $\frac{2}{5}$.
- D. 1.

42. Let S be a non-empty set such that the total number of subsets of S containing at most two elements is equal to 16. Then, the number of elements in S equals to

- A. 5.
- B. 6.
- C. 16.
- D. 7.

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43. Consider the parallelogram $ABCD$ as shown in the figure, where $\frac{AE}{AB} = \frac{CF}{CD} = \frac{1}{n}$, for some positive integer n .



Suppose the length of AC is a , then the length of XY is

- A. $\frac{a}{n}$.
 B. $\frac{na}{n+1}$.
 C. $\frac{(n-1)a}{n+1}$.
 D. $\frac{(n-1)a}{n}$.
44. Let $\hat{i}$, $\hat{j}$ and $\hat{k}$ denote the standard unit vectors in $\mathbf{R}^3$ along the x -axis, y -axis and z -axis, respectively. Consider the sets

$$X = \{a\hat{i} + b\hat{j} + c\hat{k} : a, b, c \in \{-1, 0, 1\}\} \text{ and}$$

$$Y = \{(\vec{v}_1, \vec{v}_2, \vec{v}_3) : \vec{v}_1, \vec{v}_2, \vec{v}_3 \in X \text{ and } \vec{v}_1, \vec{v}_2, \vec{v}_3 \text{ are mutually perpendicular unit vectors}\}.$$

Then, the number of elements in Y is

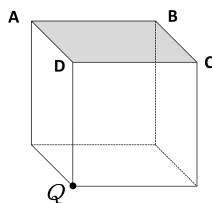
- A. 27.
 B. 24.
 C. 36.
 D. 48.
45. What is the probability that 3 randomly chosen elements x, y, z from the set $\{1, 2, \dots, 10\}$ satisfy $x + y + z = 5$?
- A. $\frac{3}{1000}$.
 B. $\frac{1}{200}$.
 C. $\frac{1}{1000}$.
 D. $\frac{3}{500}$.

Physics

46. A particle of mass m is rotating in a circular orbit of radius r under the action of gravity in the presence of another stationary particle of very large mass M ($M \gg m$). Consider that the gravitational potential energy is zero at infinite separation. If the total energy of the rotating particle is E , then, which of the following expressions correctly represents the angular momentum of the particle?

- A. $r\sqrt{2Em}$
- B. $r\sqrt{-2Em}$
- C. $r\sqrt{-Em/2}$
- D. $r\sqrt{Em/2}$

47. A point electric charge Q is placed at a corner of a cube as shown in the figure. What is the electric flux passing through the shaded surface ABCD of the cube? (ϵ_0 is permittivity of free space)



- A. $\frac{Q}{18\epsilon_0}$
- B. $\frac{Q}{12\epsilon_0}$
- C. $\frac{Q}{6\epsilon_0}$
- D. $\frac{Q}{24\epsilon_0}$

48. Neutral gas molecules, each of mass m , are at a temperature T in a container at zero gravity. How does the average de Broglie wavelength λ of a molecule depend on T ?

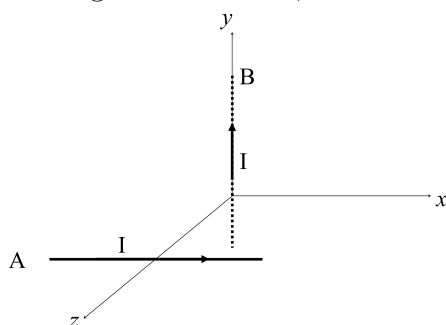
- A. $\lambda \propto \sqrt{T}$
- B. $\lambda \propto 1/T^{\frac{3}{2}}$
- C. $\lambda \propto 1/\sqrt{T}$
- D. $\lambda \propto T^{\frac{3}{2}}$

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49. Consider a particle of unit mass being thrown with an initial velocity v_0 making an angle ϕ with the horizontal ground. What is the magnitude of the angular momentum of the particle about the point of projection at a time t after its projection while it is in flight?

A. $2gt^2v_0 \cos \phi$
 B. $\frac{1}{2}gt^2v_0 \cos \phi$
 C. $2gt^2v_0 \sin \phi$
 D. $\frac{1}{2}gt^2v_0 \sin \phi$

50. Consider two long thin conductors A and B each carrying current I as shown in the figure. Considering A to be fixed, which of the following statements is correct?



A. B experiences a net force along $+x$ axis.
 B. B experiences a net anticlockwise torque.
 C. B experiences a net force along $-x$ axis.
 D. B experiences a net clockwise torque.

51. What is the average kinetic energy of molecules of an ideal gas leaking freely through an orifice of a container which has N molecules at pressure P in volume V ?

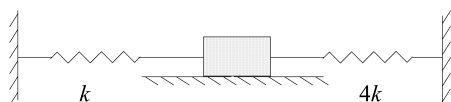
A. $\frac{3PV}{2N}$
 B. $\frac{PV}{2N}$
 C. $\frac{3PV}{N}$
 D. $\frac{2PV}{3N}$

52. Which of the following is an expression for energy in terms of the Planck's constant h , the velocity of light c and the Gravitational constant G ?

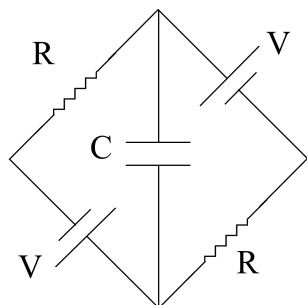
A. $\sqrt{\frac{hG}{c^3}}$
 B. $\sqrt{\frac{hc^5}{G}}$
 C. $\frac{hc^5}{G}$
 D. $\sqrt{\frac{G}{hc^5}}$

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53. A solid block on a frictionless surface is connected to two rigid supports on the left and right side by springs of spring constants k and $4k$ respectively as shown in the figure. The time spent by the block in a complete cycle of oscillation on the left and the right side of the equilibrium position are t_L and t_R , respectively. Which of the following is correct?



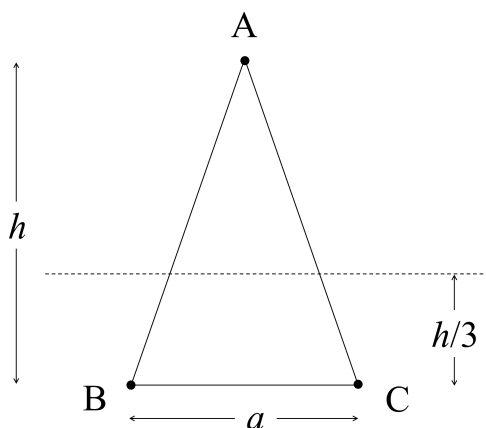
- A. $t_L = 2t_R$
 B. $t_L = t_R/2$
 C. $t_L = t_R$
 D. $t_L = 4t_R$
54. A capacitor with capacitance C_o consists of two concentric spherical conductors. If the radii of the inner and the outer spherical conductors are halved, what is the new capacitance?
- A. $C_o/2$
 B. $4C_o$
 C. C_o
 D. $C_o/\sqrt{2}$
55. What is the time t taken by the capacitor in the given circuit to charge to $1/\sqrt{2\pi}$ of its full capacity?



- A. $t \rightarrow \infty$
 B. $t = 1/RC$
 C. $t = 2\pi RC$
 D. $t = RC$
56. The allowed energy levels of electrons in a Hydrogen atom are given by $E_n = -13.6/n^2$ eV. For electronic transition in Hydrogen atom, what is the maximum frequency of the emitted photon? ($h = 6.62 \times 10^{-34}$ Js; $e = 1.6 \times 10^{-19}$ C)
- A. 2.1×10^6 GHz
 B. 5.5×10^6 GHz
 C. 3.3×10^6 GHz
 D. 1.7×10^6 GHz

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57. Which of the following statements about the P-V diagram of an ideal gas of fixed number of particles is incorrect?
- A. Two distinct adiabats never cross each other.
 - B. Two distinct isotherms never cross each other.
 - C. An isotherm and an adiabat intersect at one point.
 - D. An isotherm and an adiabat intersect at more than one point.
58. A cube, a cylinder (of height equal to its diameter) and a sphere, all solid, are made of a metal and are of identical mass. If all the three shapes having initial temperature 50°C are put in a large reservoir of water at 10°C . Which of the above three shapes cools the fastest?
- A. The cylinder.
 - B. The sphere.
 - C. The cube.
 - D. All three at the same rate.
59. An LED display consists of 100 pixels per cm^2 . Consider that the diameter of the pupil of the eye is 5 mm and the average wavelength of the display is 575 nm. What is the nearest distance from the display one can be at, such that the display does not appear pixelated?
- A. 30.23 m
 - B. 7.12 m
 - C. 4.52 m
 - D. 20.32 m
60. Two equal positive charges (q) are placed at the vertices B and C of an isosceles triangle of base a and height $h = 3\sqrt{3}a/2$, as shown in the adjacent figure. When a charge q' is placed at A , it is found that at a point inside the triangle, the net electric field due to the three charges vanishes. If this point is at a height $h/3$, then what is q' ?



- A. $q' = -3\sqrt{3}q$
- B. $q' = +3\sqrt{3}q$
- C. $q' = +\sqrt{3}q$
- D. $q' = -\sqrt{3}q$