

## Biology

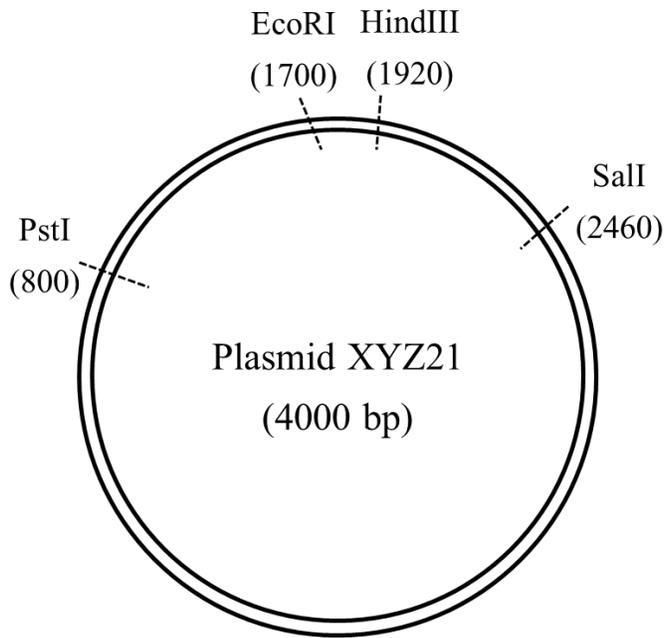
1. Which one of the following epithelial cell types is commonly found in the inner surface of the fallopian tubes?
  - A. Ciliated
  - B. Columnar
  - C. Squamous
  - D. Cuboidal
2. Which of the following is not an asexual reproductive structure?
  - A. Isogametes of *Cladophora*
  - B. Conidia of *Penicillium*
  - C. Zoospores of *Chlamydomonas*
  - D. Gemmules in a sponge
3. Which one of the following is an example of palindromic DNA sequence?
  - A. 5' GAATTC 3'  
3' CTTAAG 5'
  - B. 5' GACTTC 3'  
3' CTGAAG 5'
  - C. 5' GAAGTC 3'  
3' CTTCAG 5'
  - D. 5' GACCAG 3'  
3' CTGGTC 5'
4. Some individuals start sneezing when the pollen content is high in the air. Primarily which Ig isotype will these individuals produce as an immune response?
  - A. IgE
  - B. IgA
  - C. IgM
  - D. IgG1
5. Which of these factors is least likely to cause deviation from the Hardy-Weinberg equilibrium?
  - A. Reduction in population size
  - B. Mutation
  - C. Gene flow
  - D. Genetic drift

6. Motivated by the classic experiment by Frederick Griffith and the work of Avery, Macleod and McCarty to identify the transforming principle, a scientist redesigned and performed the experiment with S-strain and R-strain of *Streptococcus pneumoniae* as summarized in the table below.

Treatment	Experimental Condition
T1	S-strain (heat-killed) injected into mice
T2	S-strain (heat-killed) + R-strain (live) together injected into mice
T3	Nucleic acids isolated from S-strain (heat-killed) + R-strain (live), incubated with RNase, and injected into mice
T4	Nucleic acids isolated from S-strain (heat-killed) + R-strain (live), incubated with DNase, and injected into mice
T5	S-strain (live) injected into mice
T6	R-strain (live) injected into mice

From the options below, identify the outcomes of the treatments (T1 to T6) on the viability of the mice.

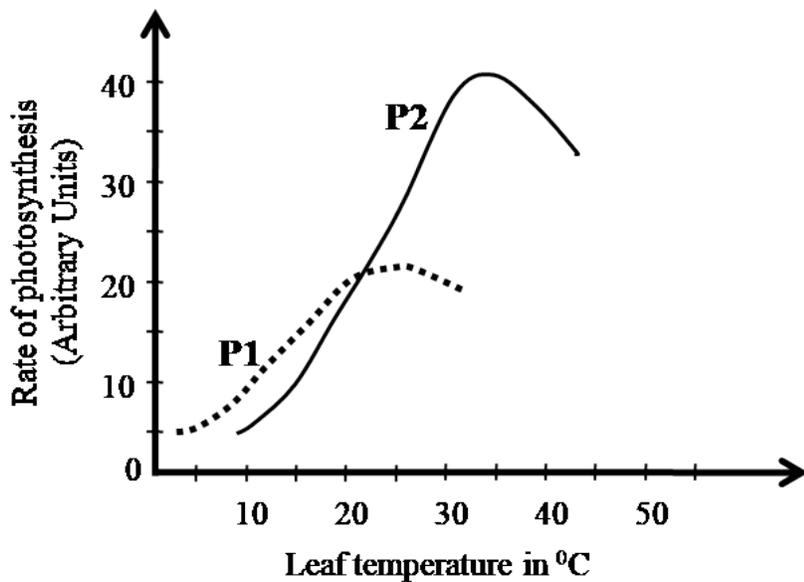
- A. T1: live, T2: die, T3: die, T4: live, T5: die, T6: live
  - B. T1: live, T2: live, T3: die, T4: live, T5: live, T6: live
  - C. T1: live, T2: die, T3: die, T4: die, T5: live, T6: die
  - D. T1: live, T2: die, T3: live, T4: die, T5: die, T6: live
7. Which of the following is/are produced by a plant during photosynthesis with far-red light?
- A. Only ATP
  - B. ATP, NADPH and H<sup>+</sup>
  - C. NADPH and H<sup>+</sup>
  - D. Only NADPH
8. The map of a 4000 base pair (bp) plasmid DNA marking the locations of different restriction enzyme cut sites is shown in the figure below. The numbers in brackets indicate the base pair positions where the enzymes cut. This plasmid is completely digested first with the combination of restriction enzymes PstI and HindIII, and then with EcoRI and SalI. The final digested plasmid is analyzed by agarose gel electrophoresis.



Which one of the following options correctly represents the bands sizes (in bp) obtained on the gel?

- A. 220, 540, 900 and 2340
- B. 220, 540, 1200 and 2040
- C. 540, 760, 1200 and 1500
- D. 320, 540, 800 and 2340

9. The following plot represents the change in the rate of photosynthesis with leaf temperature for two plants, P1 and P2.

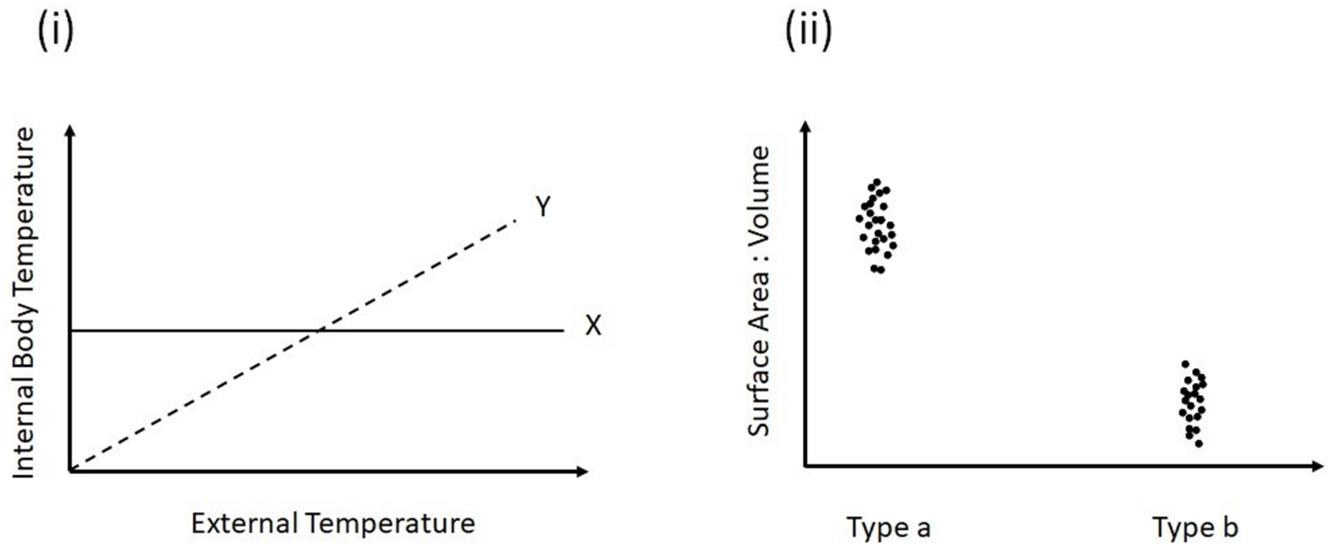


Which one of the following statements correctly describes the characteristics of P1 and P2 plants?

- A. Plant P1 is a C<sub>3</sub> plant having temperate adaptation whereas Plant P2 is a C<sub>4</sub> plant with tropical adaptation

- B. Plant P1 is a  $C_4$  plant having temperate adaptation whereas Plant P2 is a  $C_3$  plant with tropical adaptation
- C. Plant P1 is a  $C_4$  plant having tropical adaptation whereas Plant P2 is a  $C_3$  plant with temperate adaptation
- D. Plant P1 is a  $C_3$  plant having tropical adaptation whereas Plant P2 is a  $C_4$  plant with temperate adaptation

10. The figure (i) represents two categories of animals (X and Y) with respect to their response to the external environment. The figure (ii) represents two broad categories of animals (Type a and Type b) with respect to their body surface area to volume ratio.



Which combination most suitably represents the following animals in the order: humming bird; crocodile; frog; polar bear?

- A. Xa; Yb; Ya; Xb
  - B. Xb; Ya; Yb; Xa
  - C. Ya; Yb; Xa; Xb
  - D. Yb; Xb; Xa; Ya
11. In plants, ammonium ions are produced by protonation of ammonia. Which enzyme uses these ammonium ions to convert an alpha-keto acid into an amino acid?
- A. Glutamate dehydrogenase
  - B. Nitrogenase
  - C. Transacetylase
  - D. Lactate dehydrogenase
12. Which one of the following physiological functions is common between the small intestine and the renal tubules?

- A. Absorption of glucose
- B. Excretion of waste materials
- C. Excretion of water
- D. Absorption of proteins

13. Match the following pairs of interacting species to the corresponding names of the interactions.

	Name of interacting species		Name of interaction
i	Herbivores and Plants	a	Mutualism
ii	Cuckoo and Crow	b	Predation
iii	Sea anemone and Clown fish	c	Parasitism
iv	Fungus and Cyanobacteria (Lichens)	d	Commensalism

Pick the correct option from below.

- A. i and b; ii and c; iii and d; iv and a
- B. i and c; ii and b; iii and d; iv and a
- C. i and b; ii and d; iii and c; iv and a
- D. i and b; ii and a; iii and c; iv and d

14. The following events are associated with meiosis:

- i) appearance of recombinant nodules
- ii) formation of meiotic spindle
- iii) formation of chiasmata
- iv) formation of synaptonemal complex

Which of the following is the correct sequence of these events during meiosis?

- A. iv → i → iii → ii
- B. iii → iv → ii → i
- C. iv → iii → i → ii
- D. i → iii → iv → ii

15. Which of the following floral formulae represents a zygomorphic flower with diadelphous androecium and superior ovary?

$$\% \text{♀} \mathbf{K}_{(5)} \mathbf{C}_{1+2+(2)} \mathbf{A}_{(9)+1} \underline{\mathbf{G}}_1$$

A.

$$\oplus \text{♀} \mathbf{K}_{(5)} \mathbf{C}_{(5+5)} \mathbf{A}_{(\infty)} \underline{\mathbf{G}}_1$$

B.

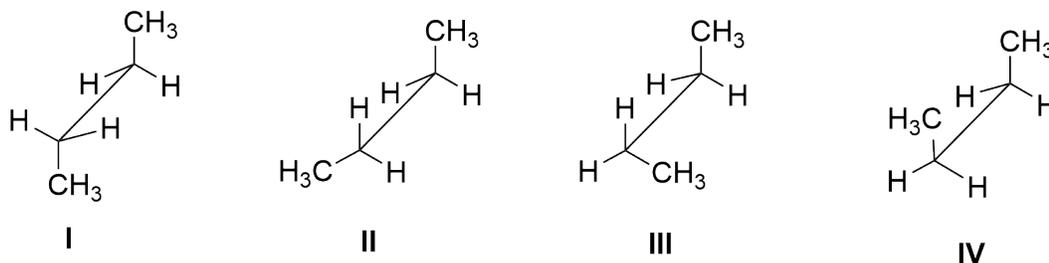
C.  $\% \varphi K_{(5)} C_{(5+5)} A_{(\infty)} \underline{G}_1$

D.  $\% \varphi K_{(5)} C_{(5)} A_2 \underline{G}_1$

## Chemistry

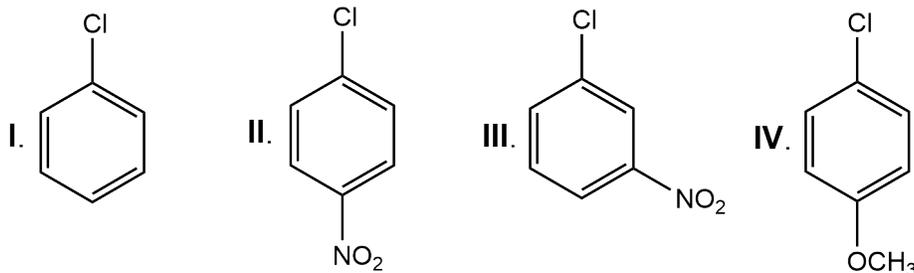
16. The F-P-Cl bond angles in the most stable structure of  $\text{PF}_3\text{Cl}_2$  are close to
- $90^\circ$  and  $120^\circ$ .
  - $90^\circ$ ,  $120^\circ$ , and  $180^\circ$ .
  - $90^\circ$  only.
  - $90^\circ$  and  $180^\circ$ .
17. The correct statement about the bond angles and bond lengths in  $\text{Al}_2\text{Cl}_6$  is ( $\text{Cl}_t$  = terminal Cl;  $\text{Cl}_b$  = bridging Cl)
- $\angle\text{Cl}_t\text{-Al-Cl}_t > \angle\text{Cl}_b\text{-Al-Cl}_b$  and  $\text{Al-Cl}_b > \text{Al-Cl}_t$ .
  - $\angle\text{Cl}_t\text{-Al-Cl}_t > \angle\text{Cl}_b\text{-Al-Cl}_b$  and  $\text{Al-Cl}_t > \text{Al-Cl}_b$ .
  - $\angle\text{Cl}_t\text{-Al-Cl}_t = \angle\text{Cl}_b\text{-Al-Cl}_b$  and  $\text{Al-Cl}_t > \text{Al-Cl}_b$ .
  - $\angle\text{Cl}_b\text{-Al-Cl}_b > \angle\text{Cl}_t\text{-Al-Cl}_t$  and  $\text{Al-Cl}_b > \text{Al-Cl}_t$ .
18. Among  $\text{CH}_3\text{SiCl}_3$ ,  $(\text{CH}_3)_2\text{SiCl}_2$  and  $(\text{CH}_3)_3\text{SiCl}$ , which one is used to synthesize straight chain (linear) and which one is used to prepare branched chain (cross-linked) silicone polymer, respectively?
- $(\text{CH}_3)_2\text{SiCl}_2$  and  $(\text{CH}_3)\text{SiCl}_3$
  - $(\text{CH}_3)\text{SiCl}_3$  and  $(\text{CH}_3)_2\text{SiCl}_2$
  - $(\text{CH}_3)_2\text{SiCl}_2$  and  $(\text{CH}_3)_3\text{SiCl}$
  - $(\text{CH}_3)_3\text{SiCl}$  and  $(\text{CH}_3)_2\text{SiCl}_2$
19. Which one of the following statements is **INCORRECT** about a complex of a divalent ion with atomic number 25?  
(BM = Bohr Magneton)
- Complex with weak field ligands in tetrahedral geometry has a magnetic moment of 1.73 BM.
  - Complex with weak field ligands in tetrahedral geometry has a magnetic moment of 5.92 BM.
  - Complex with strong field ligands in octahedral geometry has a magnetic moment of 1.73 BM.
  - Complex with weak field ligands in octahedral geometry has a magnetic moment of 5.92 BM.
20.  $\text{Ni}(\text{CO})_4$  is diamagnetic because
- Ni has completely filled 3d orbitals.
  - it is a square planar complex.
  - CO is a strong field ligand.
  - it has synergic bonding.

21. The correct order for the relative energies of the following sawhorse conformations is



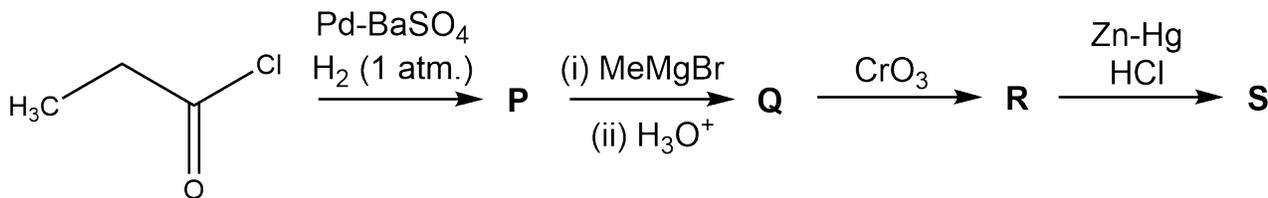
- A. **IV** > **III** = **II** > **I**.  
 B. **IV** > **III** > **II** > **I**.  
 C. **II**  $\approx$  **III** > **IV** > **I**.  
 D. **I** > **II** = **III** > **IV**.

22. Among the haloarenes (**I-IV**) shown below, the correct order of reactivity for the substitution reaction with NaOH is



- A. **II** > **III**  $\approx$  **I** > **IV**.  
 B. **I** > **IV** > **III** > **II**.  
 C. **II** > **III** > **IV** > **I**.  
 D. **IV** > **I**  $\approx$  **III** > **II**.

23. Consider the following reaction sequence,



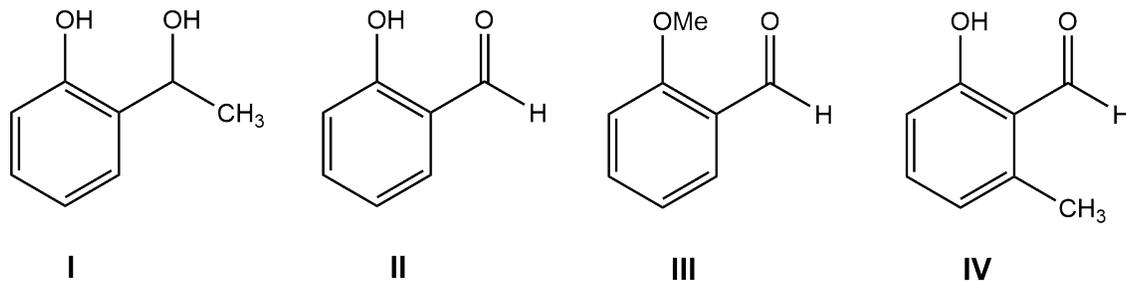
and identify the correct statements:

- (i) The products **P** and **R** can form addition product with HCN.  
 (ii) The product **Q** has no chiral center.  
 (iii) The product **R** can undergo Cannizzaro reaction.  
 (iv) The product **S** is a saturated hydrocarbon.

- A. (i) and (iv)  
 B. (iii) and (iv)  
 C. (i) and (ii)

D. (ii) and (iii)

24. The major product of the reaction of salicylaldehyde with one equivalent of MeMgBr, followed by acid neutralization is



- A. II.  
B. I.  
C. IV.  
D. III.

25. The total number of stereoisomers possible for the following structure is



- A. 8.  
B. 4.  
C. 2.  
D. 6.

26. For a homogeneous reaction involving ideal gases, equilibrium constants at 27 °C are  $K_p = 9.98 \times 10^{27}$  and  $K_c = 4.0 \times 10^{24}$ . If the enthalpy change of the reaction is  $-18.4 \text{ kJmol}^{-1}$ , the internal energy change is

[Use  $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$ ]

- A.  $-20.89 \text{ kJmol}^{-1}$ .  
B.  $-15.91 \text{ kJmol}^{-1}$ .  
C.  $-13.41 \text{ kJmol}^{-1}$ .  
D.  $-23.39 \text{ kJmol}^{-1}$ .

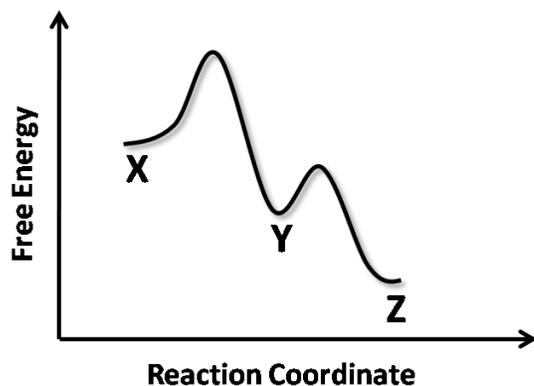
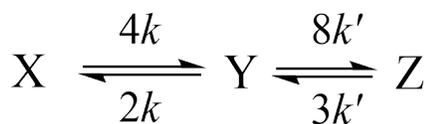
27. The probability density of an electron in 1s orbital for an H atom is maximum

- A. at the nucleus.  
B. at the Bohr radius.  
C. at twice the Bohr radius.  
D. at infinite distance.

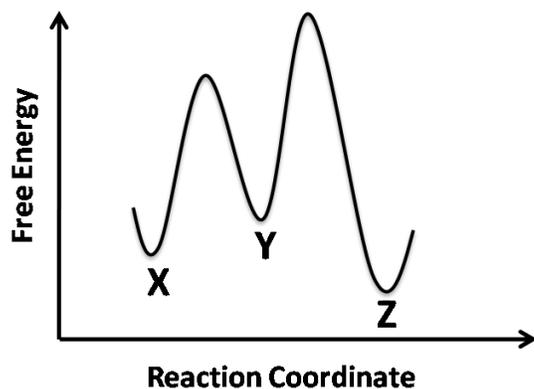
28. Which of the following statements is **INCORRECT**?

- A. Half-life of a zero order reaction is proportional to the rate constant.

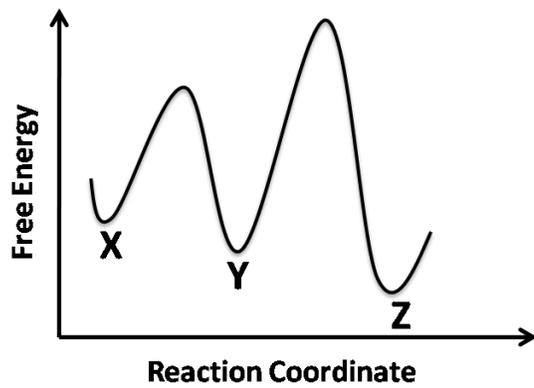
- B. Half-life of a zero order reaction is proportional to the initial concentration of reactant.  
 C. Half-life of a first order reaction is independent of the initial concentration of reactant.  
 D. Half-life of a first order reaction is inversely proportional to the rate constant.
29. The time required for reducing 1 mole of  $\text{MnO}_4^- (\text{aq.})$  to  $\text{Mn}^{2+} (\text{aq.})$  when a current of 2.5 A is passed during electrolysis is
- A. 53.6 hours.  
 B. 12.9 microeconds.  
 C. 10.7 hours.  
 D. 64.8 microseconds.
30. Based on the relative stabilities and barriers, which among the following schematic energy diagrams would best correspond to the reaction scheme shown below? [ $k$  and  $k'$  are similar in magnitude]



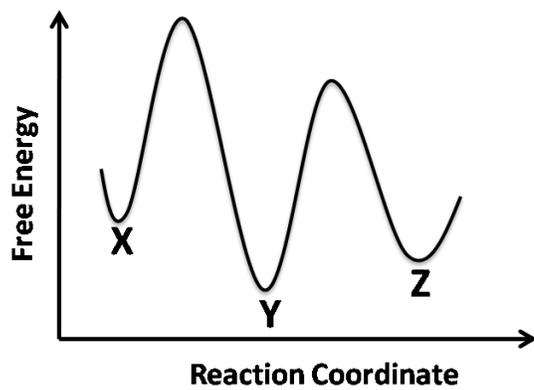
A.



B.



C.



D.

## Mathematics

31. What is the maximum value of  $\cos^4(x) + \sin^2(x) + \cos(x)$ , when  $x \geq 0$ ?
- A. 2
  - B. 1
  - C.  $\sqrt{2}$
  - D.  $2\sqrt{2}$
32. Out of a pack of ten cards numbered 1 to 10, a boy draws a card at random and keeps it back. Then a girl draws a card at random from the same pack. If the boy's card reads  $m$ , and the girl's card reads  $n$ , then what is the probability that  $m > n$ , given that  $m$  is even?
- A.  $\frac{1}{2}$
  - B.  $\frac{1}{3}$
  - C.  $\frac{1}{4}$
  - D.  $\frac{1}{5}$
33. Suppose  $a, b \in \mathbf{R}$  are such that the points  $(a, b)$ ,  $(a^2, b^2)$ , and  $(a^3, b^3)$  in the coordinate plane are distinct, collinear, and the line passing through these points is not parallel to the  $y$ -axis. Then, for all such choices of  $(a, b)$ , the slope of the line passing through these three points can take
- A. exactly two values.
  - B. infinitely many values.
  - C. exactly three values.
  - D. exactly one value.
34. Define  $f : [2, 22] \rightarrow \mathbf{R}$  by  $f(x) = \max\{n(1 - |x - (2n + 1)|) : n = 1, 2, \dots, 10\}$ . The area of the region  $\{(x, y) : 0 \leq y \leq f(x), x \in [2, 22]\}$  is
- A. 55.
  - B. 60.
  - C. 5.
  - D. 10.
35. The value of the limit  $\lim_{x \rightarrow 0^+} (\sin x)^{\sqrt{x}} (e^x + x)^{\frac{1}{x}}$  is
- A.  $e^2$ .
  - B. 1.
  - C.  $e$ .
  - D. 0.

36. Let  $f : \mathbf{R} \rightarrow \mathbf{R}$  be a continuous function satisfying

$$f(x) = e^{x^2/2} + \int_0^x tf(t)dt \quad \text{for all } x.$$

Then which of the following is correct?

- A.  $5 < f(\sqrt{2}) < 6$
- B.  $2 < f(\sqrt{2}) < 3$
- C.  $3 < f(\sqrt{2}) < 4$
- D.  $4 < f(\sqrt{2}) < 5$

37. For each  $a \in \mathbf{R}$ , define

$$p_a(z) = z^2 + 2e^{a-e^a}z + e^{a-e^a}.$$

Then, which one of the followings is true?

- A.  $p_a$  has only non-real complex roots for all  $a \in \mathbf{R}$ .
- B.  $p_a$  has a real root for all  $a \in \mathbf{R}$ .
- C.  $p_a$  has a real root if and only if  $a \geq 1$ .
- D.  $p_a$  has a real root if and only if  $a \leq -1$ .

38. The number of functions  $f : \{1, 2, 3, 4, 5\} \rightarrow \{1, 2, 3, 4, 5\}$  such that  $f(f(n)) = n$  for all  $n \in \{1, 2, 3, 4, 5\}$ , is

- A. 41.
- B. 25.
- C. 31.
- D. 120.

39. Let  $P_1 : x + y + z = 1$ ,  $P_2 : 2x + y + z = 3$  be two planes, and let  $L$  denote the line of intersection of  $P_1$  and  $P_2$ . Let  $P$  be the plane passing through the point  $(1, 2, 1)$ , and normal to  $L$ . Which of the following equations represents  $P$ ?

- A.  $y - z = 1$
- B.  $x + z = 2$
- C.  $x + 2y + z = 6$
- D.  $x + y + 2z = 5$

40. Let  $f(x) = \ln(1 + x)$  for  $x \geq 0$ . The value of

$$\int_0^{\frac{\pi}{2}} \frac{f(\sqrt[3]{\cos \theta})}{f(\sqrt[3]{\sin \theta}) + f(\sqrt[3]{\cos \theta})} d\theta$$

is

- A.  $\frac{\pi}{4}$ .

- B.  $\frac{\pi}{6}$ .
- C.  $\frac{\pi}{3}$ .
- D.  $\frac{\pi}{2}$ .

41. The area enclosed by the curves  $y = 1 + |\sin x|$ ,  $y = -|\sin x|$  and the lines  $x = 0$ ,  $x = 2\pi$  is

- A.  $8 + 2\pi$ .
- B.  $8 + 4\pi$ .
- C.  $8 + 6\pi$ .
- D.  $8 + 8\pi$ .

42. Consider the function  $f : \mathbf{R} \rightarrow \mathbf{R}$  defined by

$$f(x) = x^2|x|.$$

Then, which of the following statements is correct?

- A.  $f'$  is differentiable but  $f''$  is not differentiable.
- B.  $f$  is continuous but not differentiable.
- C.  $f$  is differentiable but  $f'$  is not differentiable.
- D.  $f''$  is differentiable.

43. Let  $A$  be a  $2 \times 2$  matrix such that

$$A^2 + A + \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}.$$

Let  $I$  denote the  $2 \times 2$  identity matrix. Which of the following statements is correct?

- A. Both  $A$  and  $A + I$  are invertible.
- B.  $A$  is invertible but  $A + I$  may not be invertible.
- C.  $A + I$  is invertible but  $A$  may not be invertible.
- D. Neither  $A + I$  nor  $A$  may be invertible.

44. If three real numbers  $a, b, c$  are in arithmetic progression, the value of the determinant

$$\begin{vmatrix} x^2 + 3 & x^2 + 4 & x^2 + 5 \\ x^2 + 4 & x^2 + 5 & x^2 + 6 \\ x^2 + a & x^2 + b & x^2 + c \end{vmatrix}$$

is

- A. 0.
- B.  $2a$ .
- C.  $a + c - b$ .
- D.  $x^2 + 2b$ .

45. Consider the two data sets

$$S_1 = \{1, 2, 4, 8, 9, 11, 15, 20, 27, 29, 33\},$$

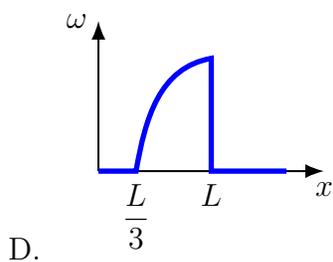
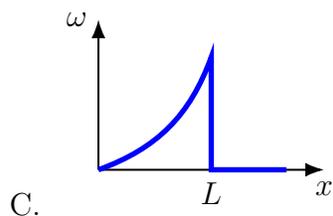
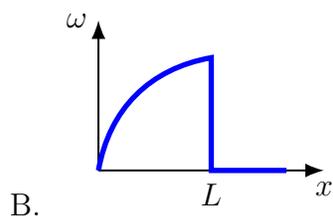
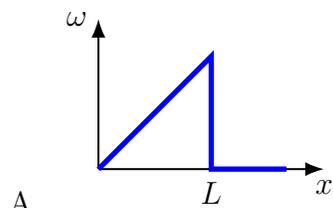
$$S_2 = \{51, 52, 54, 58, 59, 61, 65, 70, 77, 79, 83\}.$$

Let  $m_1$ ,  $m_2$  and  $v_1$ ,  $v_2$  be the means and the variances of  $S_1$  and  $S_2$ , respectively. Then, which of the following relations is correct?

- A.  $m_2 = m_1 + 50$ ,  $v_2 = v_1$ .
- B.  $m_2 = m_1 + 50$ ,  $v_2 = v_1 + 50$ .
- C.  $m_2 = m_1$ ,  $v_2 = v_1$ .
- D.  $m_2 = m_1 + 50$ ,  $v_2 < v_1$ .

## Physics

46. A door of mass  $M$  and width  $L$  is hinged at one end and rotates about a vertical axis without friction. A bullet of mass  $m$  ( $m \ll M$ ) fired perpendicularly to the door at a speed  $v$  gets embedded in it at a distance  $x$  from its axis of rotation. Assuming the door was stationary initially, how does the resultant angular speed  $\omega$  of the door vary as a function of  $x$ ?



47. A body of mass  $m$  executes simple harmonic motion along a line with time period  $T$  and energy  $E$ . What is the magnitude of the maximum acceleration of the body?

- A.  $\frac{2\sqrt{2}\pi}{T} \sqrt{\frac{E}{m}}$   
 B.  $\frac{2\pi}{T} \sqrt{\frac{E}{m}}$   
 C.  $\frac{\sqrt{2}}{T} \sqrt{\frac{E}{m}}$   
 D.  $\frac{\pi}{T} \sqrt{\frac{E}{m}}$

48. An athlete runs on a straight track. She starts from rest and runs with a constant acceleration for the first 2 seconds, reaching a speed of  $9 \text{ m s}^{-1}$ . She then continues at this constant speed for some time before slowing down to a halt at a constant deceleration. The total time taken, from start to

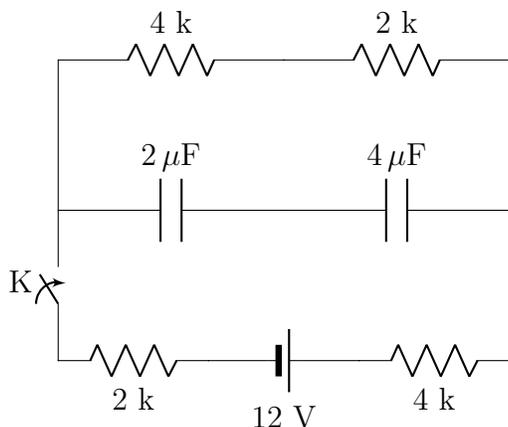
finish, is 12 seconds. If the magnitude of her acceleration is twice the magnitude of deceleration, then what is the total distance covered by her?

- A. 81 m
- B. 108 m
- C. 90 m
- D. 72 m

49. A capacitor of capacitance  $C$  consists of two large parallel metal plates. The coefficient of linear expansion of the metal is  $\alpha$ . What is the change in capacitance if the temperature of the plates rises by  $\Delta T$ , while the gap between the plates is kept fixed?

- A.  $2\alpha\Delta TC$
- B.  $\alpha\Delta TC$
- C.  $-\alpha\Delta TC$
- D.  $-2\alpha\Delta TC$

50. What are the charges stored in the  $2\mu\text{F}$  and  $4\mu\text{F}$  capacitors in the given circuit a long time after the key K is closed?



- A.  $8\mu\text{C}$  and  $8\mu\text{C}$  respectively
- B.  $18\mu\text{C}$  and  $18\mu\text{C}$  respectively
- C.  $\frac{16}{3}\mu\text{C}$  and  $\frac{8}{3}\mu\text{C}$  respectively
- D.  $\frac{8}{3}\mu\text{C}$  and  $\frac{16}{3}\mu\text{C}$  respectively

51. Consider a point charge  $+q$  moving with a constant velocity  $\vec{v} = v\hat{k}$  in vacuum in the presence of an electric field  $\vec{E} = E_x\hat{i} + E_y\hat{j}$  and a magnetic field  $\vec{B} = B_x\hat{i} + B_y\hat{j}$ . Unit vectors  $\hat{i}$ ,  $\hat{j}$ , and  $\hat{k}$  are in the directions of  $x$ ,  $y$ , and  $z$  axes, respectively. Which of the following relations is correct?

- A.  $E_x = v B_y, E_y = -v B_x$
- B.  $E_x = -v B_x, E_y = -v B_y$
- C.  $E_x = -v B_y, E_y = v B_x$
- D.  $E_x = v B_x, E_y = v B_y$

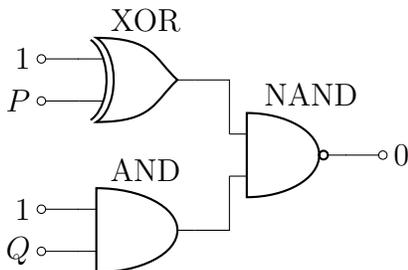
52. Four point charges  $q$ ,  $-2q$ ,  $-3q$  and  $4q$  are placed at the four vertices of a regular tetrahedron of side  $L$ , while a charge  $5q$  is placed at its center. What is the total electrostatic energy of the system? (Vacuum permittivity is denoted by  $\epsilon_0$ .)

- A.  $-\frac{15q^2}{4\pi\epsilon_0 L}$   
 B.  $\frac{15q^2}{4\pi\epsilon_0 L}$   
 C.  $-\frac{30q^2}{4\pi\epsilon_0 L}$   
 D.  $\frac{30q^2}{4\pi\epsilon_0 L}$

53. The half life of a radioactive element is 2000 hours. Approximately how much time is required for the decay of  $2/3$  of its nuclei?

- A. 3170 hours  
 B. 3000 hours  
 C. 1170 hours  
 D. 2830 hours

54. A 2-input *exclusive* OR (XOR) gate with inputs  $X$  and  $Y$  produces the output  $\bar{X}Y + X\bar{Y}$ . In the Boolean circuit shown below, which values of the inputs  $P$  and  $Q$  will produce the output 0?



- A.  $P = 0, Q = 1$   
 B.  $P = 0, Q = 0$   
 C.  $P = 1, Q = 0$   
 D.  $P = 1, Q = 1$

55. In an experiment on the photoelectric effect, the de Broglie wavelength of the emitted electron is  $\lambda_B$ . The energy of the photon incident on the metal is five times the work function. If  $h$  is Planck's constant and  $m_e$  is the electron mass, then what is the work function?

- A.  $\frac{h^2}{8m_e\lambda_B^2}$   
 B.  $\frac{h^2}{10m_e\lambda_B^2}$   
 C.  $\frac{h^2}{12m_e\lambda_B^2}$

D.  $\frac{h^2}{4m_e\lambda_B^2}$

56. An ambulance traveling at a speed  $20 \text{ m s}^{-1}$  emits a sound of frequency  $540 \text{ Hz}$  from its siren. Sunanda is driving a car which approaches the ambulance from the opposite direction at a speed of  $20 \text{ m s}^{-1}$ . What will be the change in detected frequency by Sunanda, as she crosses the ambulance? (Given, the speed of sound in air is  $340 \text{ m s}^{-1}$ .)

- A.  $127.5 \text{ Hz}$
- B.  $128.8 \text{ Hz}$
- C.  $135.5 \text{ Hz}$
- D.  $72.00 \text{ Hz}$

57. Consider a Young's double slit experiment with monochromatic light of wavelength  $600 \text{ nm}$ . The intensity of the light is  $I_0$  at a point on the screen where the path difference is  $600 \text{ nm}$ . What would be the intensity of light at a point on the screen where the path difference is  $100 \text{ nm}$ ?

- A.  $\frac{3}{4}I_0$
- B.  $\frac{1}{4}I_0$
- C.  $\frac{1}{2}I_0$
- D.  $\frac{\sqrt{3}}{2}I_0$

58. Consider a mixture of  $\text{O}_2$  and  $\text{N}_2$  gases at temperature  $27^\circ\text{C}$ . Which of the following relations is correct?

- A. RMS speed of  $\text{O}_2$  molecules  $<$  RMS speed of  $\text{N}_2$  molecules
- B. Average kinetic energy of  $\text{O}_2$  molecules  $<$  Average kinetic energy of  $\text{N}_2$  molecules
- C. Average kinetic energy of  $\text{O}_2$  molecules  $>$  Average kinetic energy of  $\text{N}_2$  molecules
- D. RMS speed of  $\text{O}_2$  molecules  $>$  RMS speed of  $\text{N}_2$  molecules

59. Two identical objects A and B are at initial temperatures  $T_A$  and  $T_B$  ( $T_A > T_B$ ), respectively. The specific heat capacity of the material of these objects increases with temperature. If these two objects are brought in contact then their final equilibrium temperature is  $T$ . Assuming that there is no heat exchange with the surroundings, then

- A.  $T > \frac{T_A + T_B}{2}$ .
- B.  $T > T_A$ .
- C.  $T = \frac{T_A + T_B}{2}$ .
- D.  $T < \frac{T_A + T_B}{2}$ .

60. Which one of the following expressions has the dimension of electrical resistance where  $e$  is the charge of an electron and  $h$  is Planck's constant?

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