

Date: 22/05/2022



Corporate Office: Aakash Tower, 8, Pusa Road, New Delhi-110005 | Ph.: 011-47623456

# Questions & Answers

Time: 3 hrs.

Max. Marks: 100

*for*

## KVPY (SA) 2021-22

### INSTRUCTIONS TO CANDIDATES

Read the following instructions carefully before you open the question booklet.

The question paper consists of two parts (both contain only multiple choice questions) for 100 marks.

There will be four sections in Part I (each section containing 15 questions) and four sections in Part II (each section containing 5 questions)

#### Part-I

- (i) There are 60 objective type questions. 15 questions from each subject (Mathematics, Physics, Chemistry & Biology). All questions are compulsory.
- (ii) Each correct answer gets **1 mark** and for each incorrect answer **0.25 mark** will be deducted.

#### Part-II

- (i) There are 20 objective type questions. 5 questions from each subject (Mathematics, Physics, Chemistry & Biology). All questions are compulsory.
- (ii) Each correct answer gets **2 marks** and for each incorrect answer **0.5 mark** will be deducted.

## PART-I : MATHEMATICS

1. Let  $ABC$  be a scalene triangle with incentre  $I$  and circumcentre  $O$ . Suppose,  $B, C, I, O$  are concyclic points. Then  $\angle B + \angle C$  is
- (A)  $60^\circ$  (B)  $105^\circ$   
 (C)  $120^\circ$  (D)  $135^\circ$

**Answer (C)**

2. Suppose  $ABCD$  ( $AB \parallel CD$ ) is a trapezium such that the diagonals  $AC, BD$  bisect the angles  $\angle DAB, \angle CBA$  respectively. Then
- (A) no two sides of the trapezium are equal (B) exactly two sides of the trapezium are equal  
 (C) exactly three sides of the trapezium are equal (D) none of the options above can be concluded

**Answer (C)**

3. Suppose  $ABC$  is a triangle and  $D, E$  are points on the sides  $AB$  and  $AC$  respectively. If  $AD : AB = 3 : 5$  and  $AE : AC = 2 : 3$ , then the ratio of the areas of the triangles  $ABC$  and  $ADE$  lies in the interval
- (A)  $(1, 2]$  (B)  $\left(2, \frac{5}{2}\right]$   
 (C)  $\left[\frac{5}{2}, 3\right]$  (D)  $\left(3, \frac{7}{2}\right]$

**Answer (B)**

4. Let  $ABCD$  be a convex quadrilateral in which  $AC = BD, AB = CD, \angle BAC = 70^\circ$  and  $\angle BCD = 60^\circ$ . The acute angle between  $AC$  and  $BD$  is
- (A)  $70^\circ$  (B)  $75^\circ$   
 (C)  $80^\circ$  (D)  $85^\circ$

**Answer (C)**

5. Integers  $1, 2, 3, \dots, n, (n \geq 3)$  are written on a black board and an integer  $k$  ( $1 < k < n$ ) is erased. The average of the remaining numbers is 16. Then  $n + k$  is
- (A) 31 (B) 40  
 (C) 47 (D) 50

**Answer (C)**

6. Let  $p = 99$  and  $q = 101$ . Define  $p_1 = \log\left(\frac{p+q}{2}\right)$  and  $q_1 = \frac{1}{2}(\log p + \log q)$  and  $p_2 = \log\left(\frac{p_1 + q_1}{2}\right)$ ,  $q_2 = \frac{1}{2}(\log p_1 + \log q_1)$ , where all logarithms have base 10. Then
- (A)  $\log p_1 > p_2 > q_2 > \log q_1$  (B)  $\log p_1 > q_2 > p_2 > \log q_1$   
 (C)  $\log q_1 > p_2 > q_2 > \log p_1$  (D)  $\log q_1 > q_2 > p_2 > \log p_1$

**Answer (A)**

7. Let  $a$  be the largest real root and  $b$  be the smallest real root of the polynomial equation  $x^6 - 6x^5 + 15x^4 - 20x^3 + 15x^2 - 6x + 1 = 0$ . Then  $\frac{a^2 + b^2}{a + b + 1}$  is

- (A)  $\frac{1}{2}$  (B)  $\frac{2}{3}$   
 (C)  $\frac{5}{4}$  (D)  $\frac{13}{7}$

**Answer (B)**

8. The number of ordered pairs  $(a, b)$  of integers such that  $1 \leq a, b \leq 2021$  and the equations  $x^2 - ax + b = 0$  and  $x^3 - ax^2 + bx + a - b = 0$  have a common real root is

- (A) 2017 (B) 2018  
 (C) 2019 (D) 2021

**Answer (B)**

9. The number of positive integers  $x$  satisfying the equation  $\frac{1}{x} + \frac{1}{x+1} + \frac{1}{x+2} = \frac{13}{12}$  is

- (A) 0 (B) 1  
 (C) 2 (D) more than 2

**Answer (B)**

10. A contractor has two teams of workers, team  $A$  and team  $B$ . Team  $A$  can complete a project  $P$  in 12 days and team  $B$  can complete  $P$  in 36 days. Team  $A$  starts working on  $P$  and team  $B$  joins team  $A$  after four days. Team  $A$  is withdrawn after another two days and team  $B$  is asked to double its efficiency. The number of additional days required for team  $B$  to complete  $P$  is

- (A) 6 (B) 8  
 (C) 15 (D) 16

**Answer (B)**

11. The number of positive integers  $n$  such that  $n + 3$  divides  $n^3 - 3$  is

- (A) 3 (B) 4  
 (C) 5 (D) 8

**Answer (C)**

12. Suppose we have an arithmetic progression  $a_1, a_2, \dots, a_n, \dots$  with  $a_1 = 1, a_2 - a_1 = 5$ . The median of the finite sequence  $a_1, a_2, \dots, a_k$ , where  $a_k \leq 2021$  and  $a_{k+1} > 2021$ , is

- (A) 1011 (B) 1011.5  
 (C) 1013.5 (D) 1016

**Answer (A)**

13. The value of the fifth root of  $10^{10^{10}}$  is

- (A)  $10^{2 \times 10^9}$  (B)  $10^{20 \times 10^9}$   
 (C)  $10^{10^2}$  (D)  $10^{2^{10}}$

**Answer (A)**

14. Let  $A$  denote the set of all 2-digit numbers in base 10 that are equal to four times the sum of the factorial of their digits. The sum of the numbers in  $A$  is
- (A) 12 (B) 34  
(C) 44 (D) 54

**Answer (C)**

15. In a class of 100 students, 15 students chose only physics (but not mathematics and chemistry), 3 chose only chemistry (but not mathematics and physics), and 45 chose only mathematics (but not physics and chemistry). Of the remaining students, it is found that 23 have taken physics and chemistry, 20 have taken physics and mathematics, and 12 have taken mathematics and chemistry. The number of students who chose all the three subjects is
- (A) 6 (B) 9  
(C) 12 (D) 15

**Answer (B)**

## PART-I : PHYSICS

16. You are holding a shallow circular container of radius  $R$ , filled with water to a height  $h$  ( $h \ll R$ ). When you walk with speed  $v$ , it is seen that water starts spilling over. This happens due to the resonance of the periodic impulse given to the container (due to walking) with the oscillation of the water in the container. If the time period of water oscillating in the container is inversely proportional to  $\sqrt{h}$ , then  $v$  is proportional to
- (A)  $R$  (B)  $\sqrt{R}$   
(C)  $\frac{1}{\sqrt{R}}$  (D)  $\frac{1}{R}$

**Answer (D)**

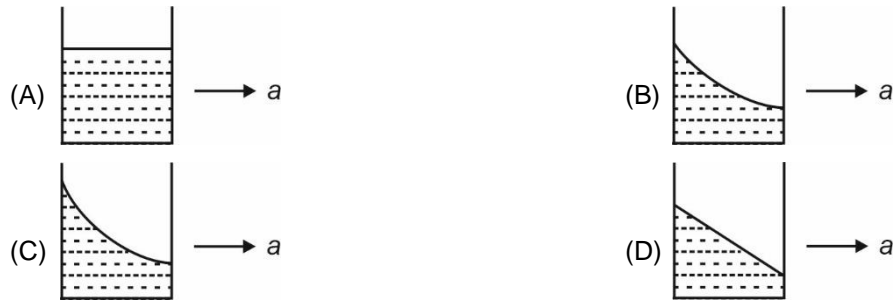
17. A lens placed 10 cm away from a wall casts a sharp inverted image of a candle on it. It again casts a sharp image when the lens is moved 20 cm further away from the wall. Now, the candle and the lens are moved such that a sharp inverted image with unit magnification is formed on the wall. To achieve this configuration, the candle was moved
- (A) 20 cm towards the wall. (B) 20 cm away from the wall.  
(C) 10 cm away from the wall. (D) 10 cm towards the wall.

**Answer (D)**

18. An electrical circuit consists of ten  $100 \Omega$  resistors. Out of these 10 resistors, a group of  $n_1$  resistors are connected in parallel and another group of  $n_2$  resistors are separately connected in parallel. These two groups are then connected in series and this combination is connected to a voltage source of 100 V. If the net current through the circuit is 2.5 A, the values of  $n_1$  and  $n_2$  are
- (A) 6, 4  
(B) 5, 5  
(C) 2, 8  
(D) 3, 7

**Answer (B)**

19. A rectangular box has water in it. It is being pulled to the right with an acceleration  $a$ . Which of the following options shows the correct shape of water surface on it?



**Answer (D)**

20. On fission a  $U^{235}$  nucleus releases  $3 \times 10^{-11}$  J of energy. In a 1 GW nuclear reactor 4.2% of this energy is converted to useful energy. The  $U^{235}$  consumed (in grams) in half an hour is closest to (Avogadro number  $N_A = 6.023 \times 10^{23}$ )
- (A) 5 (B) 50  
(C) 500 (D) 1000

**Answer (C)**

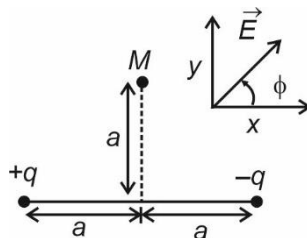
21. The International Avogadro Coordination project created the world's most perfect sphere using Silicon in its crystalline form. The diameter of the sphere is 9.4 cm with an uncertainty of 0.2 nm. The atoms in the crystals are packed in cubes of side  $a$ . The side is measured with a relative error of  $2 \times 10^{-9}$ , and each cube has 8 atoms in it. Then, the relative error in the mass of the sphere is closest to (assume molar mass of Silicon and Avogadro's number to be known precisely)
- (A)  $6.4 \times 10^{-9}$  (B)  $4.0 \times 10^{-10}$   
(C)  $1.2 \times 10^{-8}$  (D)  $5.0 \times 10^{-8}$

**Answer (C)**

22. A laser beam is incident on a flat/plane mirror at some angle and results in a reflected beam. The mirror is now rotated by an angle  $\delta$  while the direction of incident laser beam is kept the same. The angle between the new reflected beam and the reflected beam before the mirror was rotated is
- (A)  $2\delta$  (B) 0  
(C)  $\delta$  (D)  $\delta/2$

**Answer (A)**

23. Consider two charges,  $+q$  and  $-q$ , ( $q > 0$ ) placed at a distance  $2a$  from each other. At the point  $M$  (see figure below), the electric field makes an angle  $\phi$  from the  $x$  axis. The correct value of  $\phi$  is



- (A)  $0^\circ$  (B)  $90^\circ$   
(C)  $180^\circ$  (D)  $270^\circ$

**Answer (A)**

24. A particle starts from rest at  $x = 0$  m with an acceleration of  $1 \text{ m/s}^2$ . At  $t = 5$  s it receives an additional acceleration in the same direction as its motion. At  $t = 10$  s its speed and position are  $v$  and  $x$ , respectively. Had the additional acceleration not been provided, its speed and position would have been  $v_0$  and  $x_0$ , respectively. It is found that  $x - x_0$  is 12.5 m. Then one can conclude that  $v - v_0$  is
- (A) 5 m/s (B) 10 m/s  
(C) 15 m/s (D) 20 m/s

**Answer (A)**

25. The heat required to change 1 kg of ice at  $-8^\circ\text{C}$  into water at  $20^\circ\text{C}$ , at 1 atm of pressure, is closest to (Assume that ice has a specific heat capacity  $2.1 \text{ kJ/kg/K}$ , water has a specific heat capacity  $4.2 \text{ kJ/kg/K}$ , and latent heat of fusion of ice is  $333 \text{ kJ/kg}$ )
- (A) 414 kJ (B) 424 kJ  
(C) 434 kJ (D) 444 kJ

**Answer (C)**

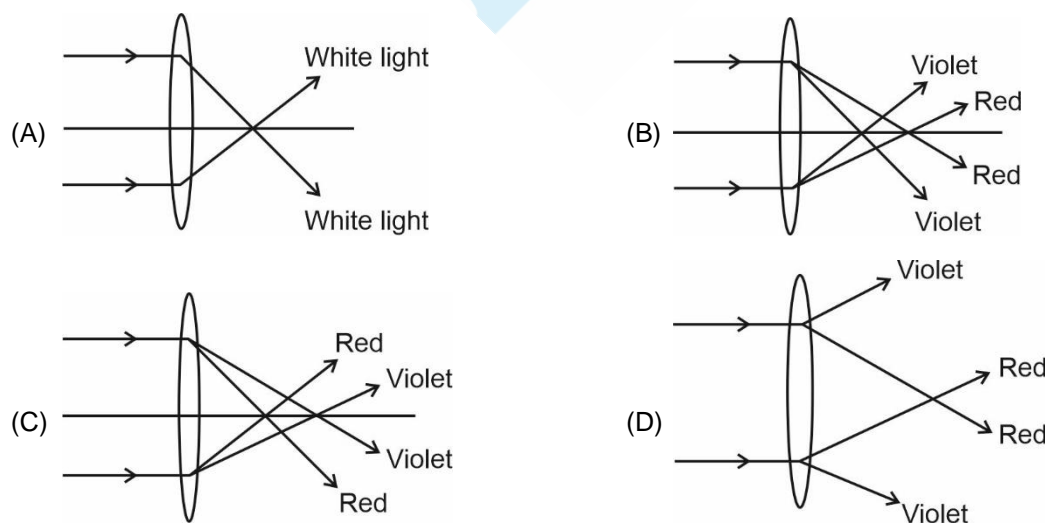
26. A button battery is rated 3 V and 225 mAh. A cricket ball (mass = 0.163 kg) having energy equal to that stored in the battery will have speed closest to
- (A) 20 m/s (B) 70 m/s  
(C) 90 m/s (D) 170 m/s

**Answer (D)**

27. An airplane airspeed indicator reads  $100 \text{ m/s}$  and its compass shows that it is heading  $37^\circ$  east of north. The meteorological information provided to the navigator is that the wind velocity is  $20 \text{ m/s}$  towards east. The speed of the airplane relative to the ground is closest to
- (A) 111 m/s (B) 113 m/s  
(C) 115 m/s (D) 120 m/s

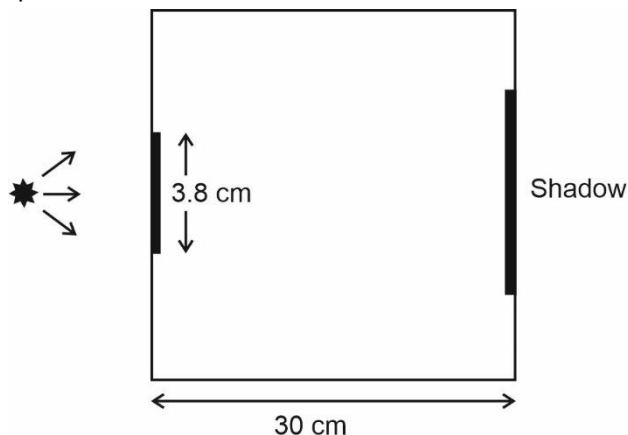
**Answer (B)**

28. A white light is falling on a bi-convex lens. Which of the following options represents the correct qualitative behaviour of the focussing of this light?



**Answer (B)**

29. Shown in the figure is a transparent tank of length 30 cm. A black strip of width 3.8 cm is stuck on its left wall. When a source of light is kept to the left of it, a shadow of width 7.6 cm is formed on the right wall.

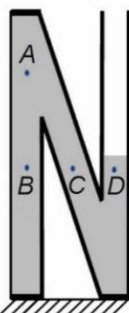


Now, the tank is filled with a liquid of refractive index  $n$ , and the width of the shadow reduces to 6.4 cm. The value of  $n$  is closest to

- (A) 1.20 (B) 1.35  
(C) 1.45 (D) 1.55

**Answer (C)**

30. Consider a mercury-filled tube as shown in the figure below.



Which of the following options about the pressures at the lettered locations (A, B, C, D) is true?

- (A)  $P_B > P_A > P_C > P_D$  (B)  $P_B = P_C = P_D > P_A$   
(C)  $P_B = P_C = P_D < P_A$  (D)  $P_A = P_B = P_C = P_D$

**Answer (B)**

## PART-I : CHEMISTRY

31. Consider the reaction,  $P(aq) \rightleftharpoons Q(aq)$  with an equilibrium constant  $K = 1.5$ . The reaction is started in a vessel with a concentration of  $[P]$  of 2 M and concentration of  $[Q] = 0$ . When the equilibrium is established, half the amount of P is removed, and the reaction is allowed to re-equilibrate. The concentration of Q in the vessel (in M) is closest to
- (A) 0.64  
(B) 0.96  
(C) 0.24  
(D) 1.20

**Answer (B)**

32. A gas is reversibly expanded from the same initial state to the same final volume using isobaric, isothermal and adiabatic processes. The correct order of the work done by the system on the surroundings in the three different methods is
- (A) Isobaric > isothermal > adiabatic                      (B) Isobaric > adiabatic > isothermal  
 (C) Adiabatic > isothermal > isobaric                      (D) Isothermal > isobaric > adiabatic

**Answer (A)**

33. When 22.4 liters of  $H_2$  (g) is mixed with 5.6 liters of  $Cl_2$  (g), each at S.T.P., the moles of HCl (g) formed after completion of the reaction is closest to
- (A) 1.0    (B) 0.75  
 (C) 0.5    (D) 0.25

**Answer (C)**

34. A bulb emits monochromatic yellow light of the wavelength 0.57 micron. If the rate of emission of quanta per second of the bulb is  $14.33 \times 10^{19}$ , the power of the bulb (in Watt) is
- (A) 25    (B) 50  
 (C) 75    (D) 100

**Answer (B)**

35. An isolated chamber is divided into two halves by a partition with an ideal gas in one half. By making a hole in the partition, the gas is allowed to expand to the full chamber. Among the following, the parameter with changes in the process is
- (A) Internal energy    (B) Heat  
 (C) Temperature    (D) Pressure

**Answer (D)**

36. Iodination of a hydrocarbon ( $C-H \rightarrow C-I$ ) with molecular iodine is a slow and reversible reaction. However, it can be carried out in the presence of an oxidizing agent such as
- (A)  $H_3BO_3$     (B)  $HIO_3$   
 (C)  $H_3PO_4$     (D)  $CH_3CO_2H$

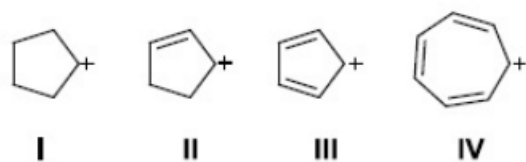
**Answer (B)**

37. A mixture of 1 mole of benzene and 1 mol of nitrobenzene is reacted with 1 mol of acetyl chloride in the presence of  $AlCl_3$ . The major product(s) is/are
- (A) acetophenone  
 (B) 3-nitroacetophenone  
 (C) 1 : 1 mixture of acetophenone and 3-nitroacetophenone  
 (D) 1, 3-diacetyl benzene

**Answer (A)**



38. The stability of the carbocations



follows the order

(A) I > II > III > IV

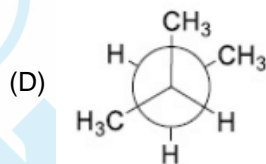
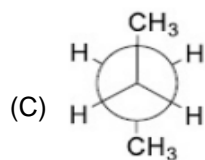
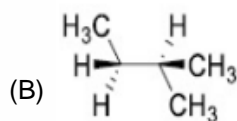
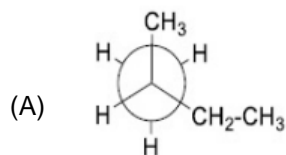
(B) III > II > IV > I

(C) IV > II > I > III

(D) IV > I > III > II

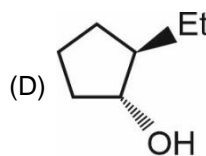
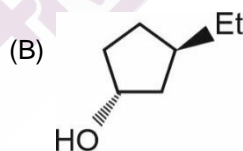
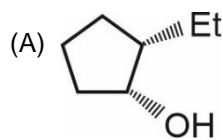
**Answer (C)**

39. Among the following, the structure which does NOT represent 2-methyl butane is



**Answer (C)**

40. The reaction of 1-ethylcyclopentene with  $\text{BH}_3/\text{THF}$  followed by treatment with  $\text{H}_2\text{O}_2/\text{NaOH}$  produces



**Answer (D)**

41. The similar chemical properties of lithium and magnesium arise due to their similar

(A) Electron affinities

(B) Ionic sizes

(C) Ionization potential

(D) Hydration enthalpy

**Answer (B)**

42. The INCORRECT statement about the dissolution of an alkali metal in liquid ammonia is
- (A) It produces a blue coloration of the solution
  - (B) The blue coloration occurs due to ammoniated electrons that absorb in visible region of light
  - (C) On standing, the blue solution liberates hydrogen gas
  - (D) The blue solution is diamagnetic

**Answer (D)**

43. Among the following, the correct statement for thionyl tetrafluoride is
- (A) The geometry of thionyl tetrafluoride is trigonal bipyramidal having the sulphur-oxygen bond on the trigonal plane.
  - (B) The geometry of thionyl tetrafluoride is trigonal bipyramidal having the sulphur-oxygen bond perpendicular to the trigonal plane.
  - (C) The geometry of thionyl tetrafluoride is square pyramidal having the sulphur-oxygen bond on the square plane.
  - (D) The geometry of thionyl tetrafluoride is square pyramidal having the sulphur-oxygen bond perpendicular to the square plane.

**Answer (A)**

44. The thermal stability of the hydrides of group-16 elements follows the order
- (A)  $\text{H}_2\text{Te} < \text{H}_2\text{S} < \text{H}_2\text{Se} < \text{H}_2\text{O}$
  - (B)  $\text{H}_2\text{O} < \text{H}_2\text{Se} < \text{H}_2\text{S} < \text{H}_2\text{Te}$
  - (C)  $\text{H}_2\text{Te} < \text{H}_2\text{Se} < \text{H}_2\text{O} < \text{H}_2\text{S}$
  - (D)  $\text{H}_2\text{Te} < \text{H}_2\text{Se} < \text{H}_2\text{S} < \text{H}_2\text{O}$

**Answer (D)**

45. The number of acidic protons present in  $\text{H}_3\text{PO}_2$ ,  $\text{H}_3\text{PO}_3$  and  $\text{H}_3\text{PO}_4$ , respectively, are
- (A) 1, 2, and 3
  - (B) 2, 3, and 3
  - (C) 1, 2 and 2
  - (D) 3, 3 and 3

**Answer (A)**

## PART-I : BIOLOGY

46. Which ONE of the following biomolecules is an end product of amylolysis?
- (A) Amino acids
  - (B) Fatty acids
  - (C) Monosaccharides
  - (D) Nucleotides

**Answer (C)**

47. Which ONE of the following is **NOT** used in constructing phylogenetic trees?
- (A) Nuclear DNA
  - (B) Mitochondrial DNA
  - (C) Anatomical features
  - (D) Habitat similarity

**Answer (D)**

48. Caecum is located between
- (A) Ileum and ascending colon
  - (B) Oesophagus and pharynx
  - (C) Rectum and descending colon
  - (D) Stomach and duodenum

**Answer (A)**

49. Which ONE of the following plants is an invasive species that has spread to many parts of the Indian subcontinent?
- (A) *Prosopis juliflora* (B) *Ficus religiosa*  
(C) *Cocos nucifera* (D) *Lotus corniculatus*

**Answer (A)**

50. Which ONE of the following processes maximally facilitates the ascent of sap?
- (A) Guttation (B) Photosynthesis  
(C) Photorespiration (D) Transpiration

**Answer (D)**

51. Which ONE of the following biomolecules is **NOT** present in healthy colostrum?
- (A) Antibodies (B) Lysozyme  
(C) Carbohydrates (D) Haemoglobin

**Answer (D)**

52. You have made a mixed vegetarian curry with potato, cauliflower, radish, and tomato, and spiced it with mustard, cinnamon and clove. The final product of this culinary adventure consists of
- (A) Root, flower, fruit, bark, leaf (B) Stem, flower, root, fruit, bark  
(C) Stem, meristem, root, fruit, seed, bark, bud (D) Stem, meristem, root, fruit, seed, bud, leaf

**Answer (C)**

53. Which ONE of the following processes would be an immediate effect on a plant if there is a sudden and large increase in soil salinity?
- (A) Plasmolysis of root cells (B) Closure of stomata  
(C) Increase in transpiration (D) Increase in root turgidity

**Answer (A)**

54. High blood glucose in diabetic patients is known to induce cataract. This is because high glucose
- (A) Crystallises in the lens and blocks light  
(B) Causes osmotic changes in aqueous humor promoting lens impairment  
(C) Is polymerised into starch and is deposited in the lens  
(D) Reflects light from the lens thereby impairing vision

**Answer (B)**

55. Which one of the following is most likely to occur because of climate change-driven temperature increase?
- (A) Fish shift their ranges to shallower wates (B) Mammals shift their ranges towards lower latitudes  
(C) Frogs shift their ranges towards the equator (D) Birds shift their ranges to higher elevations

**Answer (D)**

56. Which ONE of the following cell types contains Nissl's granules?
- (A) Eosinophils (B) Hepatocytes  
(C) Cardiomyocyte (D) Neurons

**Answer (D)**

57. Within the kingdom Animalia, which ONE of the following features is primarily used for classification of the organisms?
- (A) Body symmetry (B) Habitat  
(C) Mode of nutrition (D) Locomotory organs

**Answer (A)**

58. In ureotelic animals, urea is produced through
- (A) Cori cycle (B) Krebs's cycle  
(C) Ornithine cycle (D) Pentose phosphate pathway

**Answer (C)**

59. Which of the following is **INCORRECT** about pollen grains?
- (A) Angiosperm species can be identified from their pollen morphology  
(B) Pollen movement is facilitated by flagella in angiosperms  
(C) Pollen outnumbered ovules in angiosperm flowers  
(D) Pollen is found only in angiosperms

**Answer (B, D)**

60. Food chains seldom exceed four or five trophic levels because
- (A) Only 10% of energy in all levels is available for decomposers to convert into nutrients for the entire ecosystem  
(B) Only 10% of energy at all heterotroph levels is available for conversion of biomass by autotrophs  
(C) Almost 90% of energy at the autotrophs level are converted to biomass by heterotrophs in all trophic levels.  
(D) Almost 90% of energy in each heterotroph level is not converted into biomass at the next level

**Answer (D)**

## PART-II : MATHEMATICS

61. The sum of the sides of a right-angled triangle is 42, and the difference between the median and altitude drawn from the vertex at the right angle is 2. The area of the triangle is
- (A) 42 (B) 51  
(C) 63 (D)  $9\sqrt{51}$

**Answer (C)**

62. The number of ordered pairs  $(a, b)$  of integers such that  $a - b$  is a root of  $x^2 + ax + b = 0$  is
- (A) 3 (B) 4  
(C) 5 (D) 6

**Answer (B)**

63. Let  $a, b, c, d$  be positive integers. Consider the following statements
- I. If 9 divides  $a^3 + b^3 + c^3$ , then 3 divides  $abc$ .  
II. If 9 divides  $a^3 + b^3 + c^3 + d^3$ , then 3 divides  $abcd$ .
- Then
- (A) Both I and II are true (B) I is true but II is false  
(C) I is false but II is true (D) Both I and II are false

**Answer (B)**

64. Let  $\lambda$  be the positive root of the equation  $x^2 - x - 1 = 0$ , and set  $a_n = \frac{1}{\sqrt{5}}(\lambda^n - (1-\lambda)^n)$  for  $n \in \mathbb{N}$ , where  $\mathbb{N}$  is the set of all natural numbers. Consider the sets
- $A = \{n \in \mathbb{N} : a_n \text{ is a rational number, but not an integer}\}$ , and
- $B = \{n \in \mathbb{N} : a_n \text{ is an irrational number}\}$ .
- Then
- (A) both the sets  $A$  and  $B$  are empty
- (B) the set  $A$  is empty but the set  $B$  is non-empty
- (C) the set  $A$  is non-empty and set  $B$  is empty
- (D) both the sets  $A$  and  $B$  are non-empty

**Answer (A)**

65. The number of integers  $q$ ,  $1 \leq q \leq 2021$ , such that  $\sqrt{q}$  is rational, and  $\frac{1}{q}$  has a terminating decimal expansion, is
- (A) 1 (B) 11
- (C) 22 (D) 44

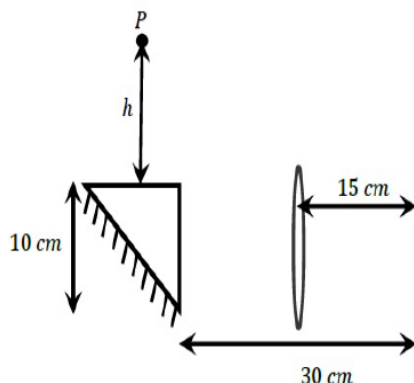
**Answer (B)**

## PART-II : PHYSICS

66. A student of mass  $M$  is 1.5 m tall and has her centre of mass 1 m above ground when standing straight. She wants to jump up vertically. To do so, she bends her knees so that her centre of mass is lowered by 0.2 m and then pushes the ground by a constant force  $F$ . As a result, she jumps up such that the maximum height of her feet is 0.3 m above ground. The ratio  $F/Mg$  is
- (A) 1.5 (B) 2.5
- (C) 3.5 (D) 4.5

**Answer (B)**

67. The  $45^\circ - 45^\circ - 90^\circ$  prism of height 10 cm (see image below) has a refractive index 2, with a silvered- hypotenuse surface.

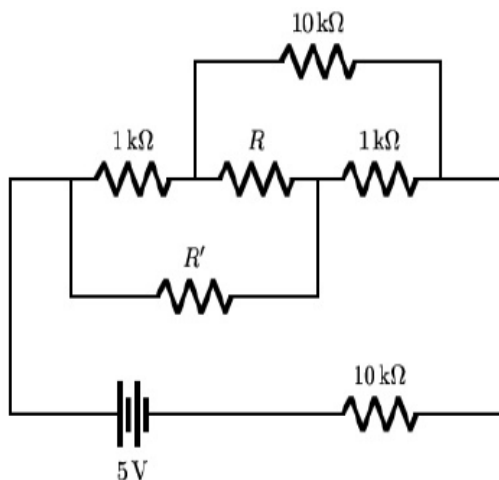


A convex lens of focal length 10 cm placed 15 cm in front of the wall produces a sharp image of  $P$  on it. The value of  $h$  (in cm) is closest to

- (A) 20 (B) 15
- (C) 10 (D) 5

**Answer (C)**

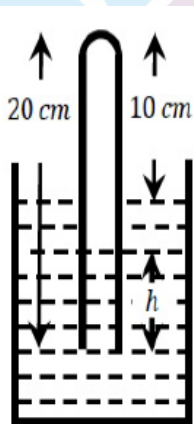
68. When the resistance  $R$  (indicated in the figure below) is changed from  $1\text{ k}\Omega$  to  $10\text{ k}\Omega$ , the current flowing through the resistance  $R'$  does not change. What is the value of the resistor  $R'$ ?



- (A)  $5\text{ k}\Omega$
- (B)  $100\ \Omega$
- (C)  $10\text{ k}\Omega$
- (D)  $1\text{ k}\Omega$

**Answer (B)**

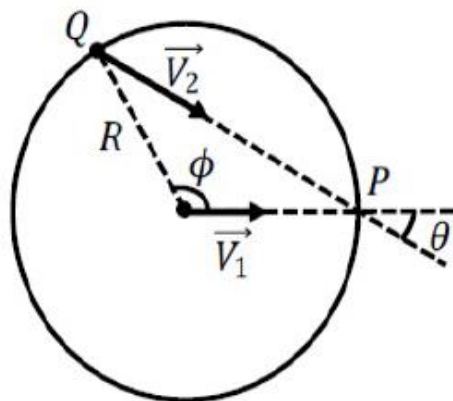
69. A  $20\text{ cm}$  long tube is closed at one end. It is held vertically, and its open end is dipped in water until only half of it is outside the water surface. Consequently, water rises in it by height  $h$  as shown in the figure. The value of  $h$  is closest to (assume that the temperature remains constant,  $P_{\text{atmosphere}} = 10^5\text{ N/m}^2$ , density of water =  $10^3\text{ kg/m}^3$ , and acceleration due to gravity  $g = 10\text{ m/s}^2$ )



- (A)  $2\text{ cm}$
- (B)  $1\text{ cm}$
- (C)  $0.4\text{ cm}$
- (D)  $0.2\text{ cm}$

**Answer (D)**

70. Two particles, one at the centre of a circle of radius  $R$ , and another at a point  $Q$  on the circle, start moving towards a point  $P$  on the circle at the same time (see figure below). Both are at rest initially and move with uniform velocities  $\vec{V}_1$  and  $\vec{V}_2$  respectively. They also reach the point  $P$  at the same time. If the angle between the velocities is  $\theta$  and the angle subtended by  $P$  and  $Q$  at the centre is  $\phi$  (as shown in the figure), then



(A)  $\tan \frac{\phi}{2} = \cot \theta$

(B)  $\tan \phi = \cot \theta$

(C)  $\cot \frac{\phi}{2} = \cot \theta$

(D)  $\tan \frac{\phi}{2} = \cot \frac{\theta}{2}$

**Answer (A)**

## PART-II : CHEMISTRY

71. A hydrocarbon having molecular formula  $C_5H_{10}$  produced a tertiary alcohol upon treatment with a few drops of conc. sulphuric acid and water. The same hydrocarbon when reacted with acidic potassium permanganate produced a ketone and a carboxylic acid. The hydrocarbon is:

- (A) cyclopentane
- (B) 1-pentene
- (C) 2-methyl-2-butene
- (D) 2-pentene

**Answer (C)**

72. Nitrogen present in an unknown organic compound was estimated by Dumas method to be 17.7% by weight. The compound is very likely to be:

- (A) nitrobenzene
- (B) pyridine
- (C) nitromethane
- (D) aniline

**Answer (B)**

73. A pink coloured aqueous solution of  $\text{Co}(\text{NO}_3)_2$  turns blue on addition of  $\text{HCl}$  gradually. This colour change happens due to the formation of

- (A)  $[\text{CoCl}_4]^{2-}$
- (B)  $[\text{CoCl}_6]^{4-}$
- (C)  $[\text{Co}(\text{H}_2\text{O})_4\text{Cl}_2]$
- (D)  $[\text{Co}(\text{H}_2\text{O})_2\text{Cl}_4]^{2-}$

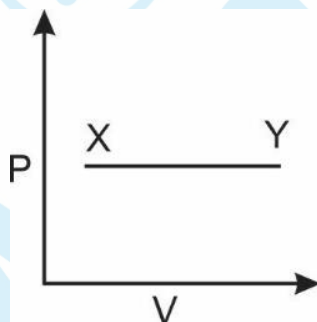
**Answer (A)**

74. 50 ml of 0.1 M of a weak acid  $\text{HA}$  is titrated with 0.1 M of  $\text{NaOH}$ . The ionization constant of  $\text{HA}$  ( $K_a$ ) is  $1.8 \times 10^{-5}$ . Using the given information and from the options shown below, the best indicator for the titration of  $\text{HA}$  with  $\text{NaOH}$  is

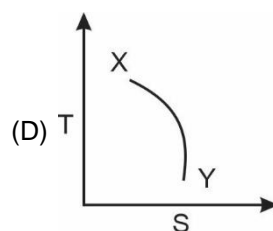
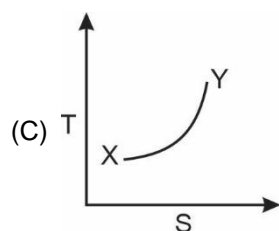
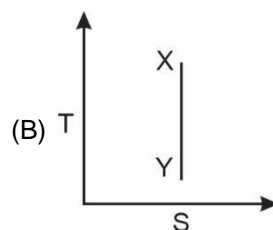
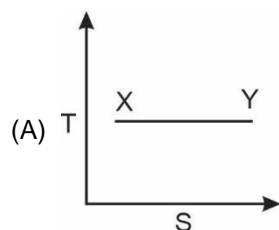
- (A) Methyl orange (changes colour from red to yellow as the pH changes from 3.2 to 4.4)
- (B) Methyl red (changes colour from red to yellow as the pH changes from 4 to 6.3)
- (C) Phenolphthalein (changes from colourless to pink to as the pH changes from 8.3 to 11)
- (D) Sodium salt of Alizarin yellow (changes colour from yellow to red as the pH changes from 10 to 12)

**Answer (C)**

75. Consider the P-V (pressure-volume) diagram given below where an ideal gas is reversibly converted from state A to state B



Among the following, the correct T-S (temperature-entropy) diagram, which corresponds to this process is

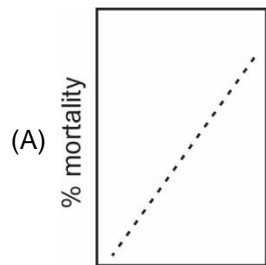


**Answer (C)**

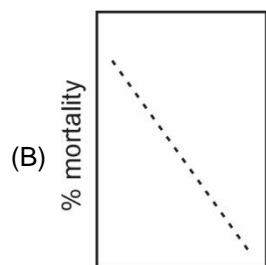


**PART-II : BIOLOGY**

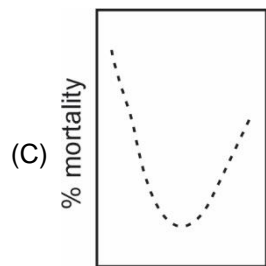
76. Which one of the following plots would best describe the relationship between human infant mortality and birth weight (1-10 kgs)?



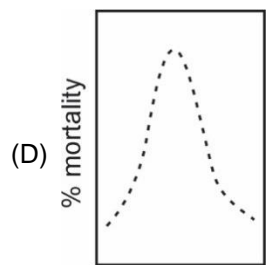
Birth weight



Birth weight



Birth weight



Birth weight

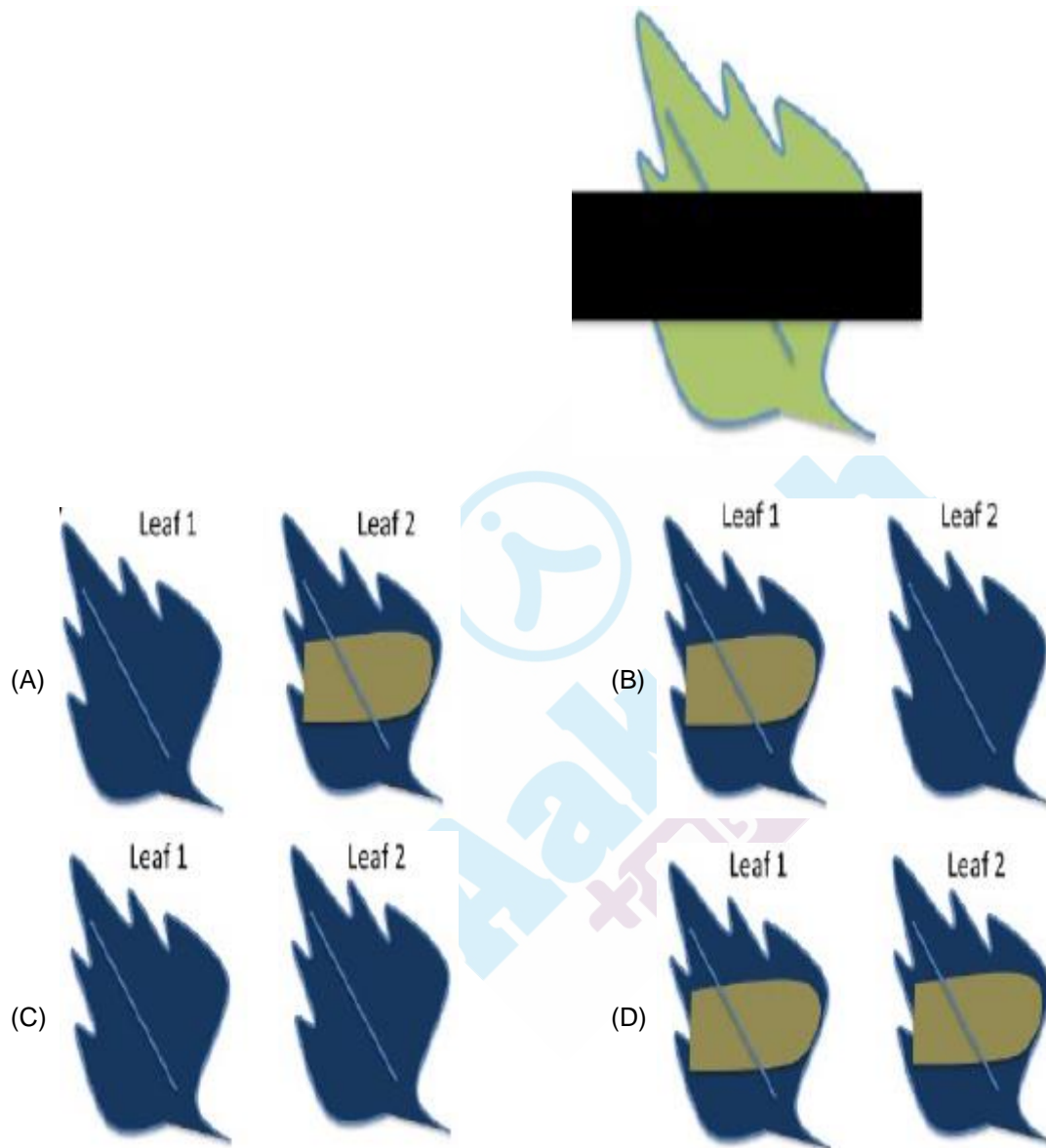
**Answer (C)**

77. A genetic form of a locus would be called an allele only when

- (A) its frequency in a population is  $> 0.01$  and it is heritable
- (B) its frequency in a population is  $> 0.01$  irrespective of its heritability
- (C) it is heritable irrespective of its frequency
- (D) it is a tandem repeat irrespective of its frequency

**Answer (A)**

78. A student conducted an experiment to determine the role of sunlight in photosynthesis. Two plants were used, while plant 1 was kept in the dark for 48 hours before the experiment, plant 2 was kept in the sunlight. The student covered one leaf from each plant with a black paper, as shown in the figure. Then, both the plants were kept in the sunlight for a few hours and the levels of starch was immediately examined in the leaves (leaf 1 from plant 1 and leaf 2 from plant 2). Which ONE of the following figures **CORRECTLY** represent the results of this experiment?



**Answer (D)**

79. In the exponential population growth model, population growth rate is given by  $\frac{dN}{dt} = rN$ , where  $r$  is a measure of the population's intrinsic rate of increase and  $N$  is population size. The parameter ' $r$ ' is determined by

- (A) birth rate and density
- (B) death rate only
- (C) birth rate only
- (D) birth rate and death rate

**Answer (D)**

80. Match the fibres in **Column I** with the primary constituents in **Column II** given below.

**Column I**

- P. Cobweb
- Q. Silk
- R. Cotton
- S. Hair

**Column II**

- i. Fibroin
- ii. Sericin
- iii. Keratin
- iv. Cellulose

Choose the **CORRECT** combination.

- (A) P-i; Q-i, ii; R-iv; S-iii
- (B) P-iii; Q-ii; R-iv; S-i
- (C) P-i, ii; Q-ii; R-iv; S-iii
- (D) P-i, ii; Q-i, ii; R-iii; S-i

**Answer (A)**

