PART -A

One-Mark Question

MATHEMATICS

1. A student notices that the roots of the equation $x^2 + bx + a = 0$ are each 1 less than the roots of the equation $x^2 + ax + b = 0$. Then $a + b$ is.

(A) Possibly any real number (B) – 2

(C) – 4 (D) – 5

Ans. **(C)**

Sol. $\alpha + \beta = -b$ and $\alpha\beta = a$

$\alpha + 1 + \beta + 1 = -a \Rightarrow \alpha + \beta + 2 = -a \Rightarrow -b + 2 = -a$

$b - a = 2$ .....(1)

$(\alpha + 1)(\beta + 1) = b \Rightarrow \alpha\beta + \alpha + \beta + 1 = b \Rightarrow a + (-b) + 1 = b$

$2b - a = 1$ ....(2)

from (1) & (2), b = – 1, a = – 3, $a + b = -4$

2. If x, y are real numbers such that $3^{\frac{x}{y}+1} - 3^{\frac{x}{y}-1} = 24$, then the value of $(x + y) / (x - y)$ is

(A) 0 (B) 1 (C) 2 (D) 3

Ans. **(D)**

Sol. $3^{\frac{x}{y}+1} - 3^{\frac{x}{y}-1} = 24 \Rightarrow 3^{\frac{x}{y}} \times 3 - \frac{3^{\frac{x}{y}}}{3} = 24$

$\frac{8}{3}\left(3^{x/y}\right) = 24 \Rightarrow \frac{x}{y} = 2$

$\frac{x+y}{x-y} = 3$

3. The number of positive integers n in the set {1, 2, 3,…….100} for which the number $\frac{1^2 + 2^2 + 3^2 + ... + n^2}{1 + 2 + 3 + ... + n}$ is an integer is

(A) 33 (B) 34 (C) 50 (D) 100

Ans. **(D)**

Sol. $\frac{a^n + b^n + c^n + ...}{a + b + c + ...}$ is always an integer if n = odd

n = 7 odd here

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4. The three different face diagonals of a cuboid (rectangular parallelopiped) have lengths 39, 40, 41. The length of the main diagonal of the cuboid which joins a pair of opposite corners is -

(A) 49 (B) $49\sqrt{2}$ (C) 60 (D) $60\sqrt{2}$

Ans. **(A)**

Sol. $\sqrt{a^2+b^2} = 39$ ….(i)

$\sqrt{b^2+c^2} = 40$ ….(ii)

$\sqrt{c^2+a^2} = 41$ …(iii)

$\sqrt{a^2+b^2+c^2} = ?$

Square and add (i), (ii) & (iii)

$2(a^2+b^2+c^2) = 39^2 + 40^2 + 41^2 = 4802$

$a^2+b^2+c^2 = 2401 \Rightarrow \sqrt{a^2+b^2+c^2} = 49$

5. The sides of a triangle *ABC* are positive integers. The smallest side has length l. Which of the following statement is true ?

(A) The area of *ABC* is always a rational number

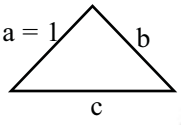
(B) The area of *ABC* is always an irrational number

(C) The perimeter of *ABC* is an even integer

(D) The information provided is not sufficient to conclude any of the statements *A*, *B* or *C* above

Ans. **(B)**

Sol.



$1 + b > c \Rightarrow c - b < 1$

$1 + c > b \Rightarrow b - c < 1$

$-1 < b - c < 1$

b, c are integers so $b - c = 0 \Rightarrow b = c$

semi perimeter $S = \frac{2b+1}{2} = b + \frac{1}{2}$

area $A = \sqrt{\left(b+\frac{1}{2}\right)\left(b+\frac{1}{2}-b\right)\left(b+\frac{1}{2}-c\right)\left(\frac{b}{2}+\frac{1}{2}-1\right)} = \frac{1}{2}\sqrt{b^2-\frac{1}{4}}$ = Irrational

6. Consider a square ABCD of side 12 and let M, N be the midpoints of AB, CD respectively. Take a point P on MN and let AP = r, PC = s. Then the area of the triangle whose sides are r, s, 12 is-

(A) 72 (B) 36 (C) $\frac{rs}{2}$ (D) $\frac{rs}{7}$

Ans. **(B)**

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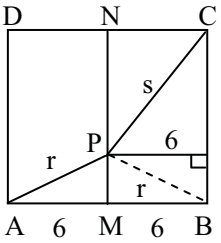
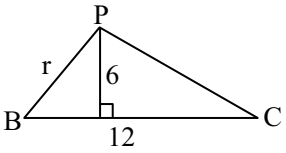
Sol.



PA = r, PC = s

So PB = r

Triangle with sides r, s & 12 is ΔPCB



area = $\frac{1}{2}$ base × height = $\frac{1}{2}$ × 6 × 12 = 36

7. A cow is tied to a corner (vertex) of a regular hexagonal fenced area of side a metres by a rope of length 5a/2 metres in a grass field. (The cow cannot graze inside the fenced area.) What is the maximum possible area of the grass field to which the cow has access to graze ?

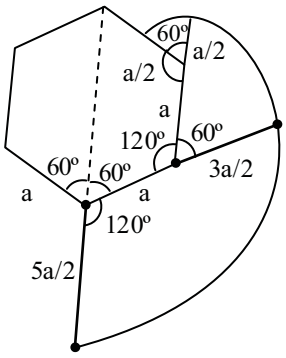
(A) $5\pi a^2$ (B) $\frac{5}{2}\pi a^2$ (C) $6\pi a^2$ (D) $3\pi a^2$

Ans. **(A)**

Sol. Area = $2\left[\frac{120}{360}\times\pi\left(\frac{5a}{2}\right)^2+\frac{60}{360}\times\pi\left(\frac{3a}{2}\right)^2+\frac{60}{360}\times\pi\left(\frac{a}{2}\right)^2\right]$

$= \frac{2\pi}{3}\left[\frac{25a^2}{4}+\frac{9a^2}{8}+\frac{a^2}{8}\right]$

$= \frac{2\pi}{3}\times\frac{30a^2}{4} = 5\pi a^2$



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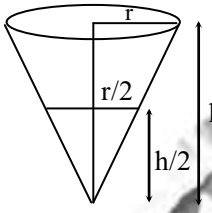
8. A closed conical vessel is filled with water fully and is placed with its vertex down. The water is flow out at a constant speed. After 21 minutes, it was found that the height of the water column is half of the original height. How much more time in minutes does it require to empty the vessel ?

(A) 21 (B) 14 (C) 7 (D) 3

Ans. **(D)**

Sol. Rate of outflow of water $\Rightarrow \left(\pi r^2 h - \pi \left(\frac{r}{2} \right)^2 \frac{h}{2} \right)$ litres in 21 minutes i.e. $\frac{7\pi r^2 h}{8} L$ in 21 minutes.

Hence $\frac{\pi r^2 h}{8} L$ in 3 min.



9. I carried 1000 kg of watermelon in summer by train. In the beginning, the water content was 99%. By the time I reached the destination, the water content had dropped to 98%. The reduction in the weight of the watermelon was-

(A) 10 kg (B) 50 kg (C) 100 kg (D) 500 kg

Ans. **(D)**

Sol. Initially 1000 kg [990 kg water + 10 kg rest]

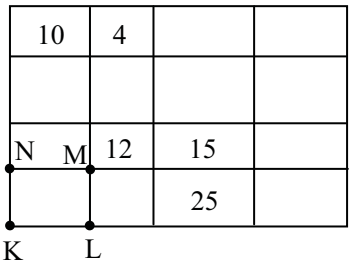
Now x kg melon $\left[\frac{98x}{100} water + \frac{2x}{100} rest \right]$

Weight of solid part should remain same

$$\frac{2x}{100} = 10 \quad \Rightarrow x = 500$$

Weight reduction 1000 – 500 = 500 kg

10. A rectangle is divided into 16 sub-rectangles as in the figure, the number in each sub rectangle represents the are of that sub-rectangle. What is the area of the rectangle KLMS ?



(A) 20 (B) 30 (C) 40 (D) 50

Ans. **(D)**

Sol. Area = 10 × 5 = 50 (from figure)
(assuming all sides to be integers)

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PHYSICS

11. A hollow pendulum bob filled with water has a small hole at the bottom through which water escapes at a constant rate. Which of the following statements describes the variation of the time period (T) of the pendulum as the water flows out -

(A) T decreases first and then increases

(B) T increases first and then decreases

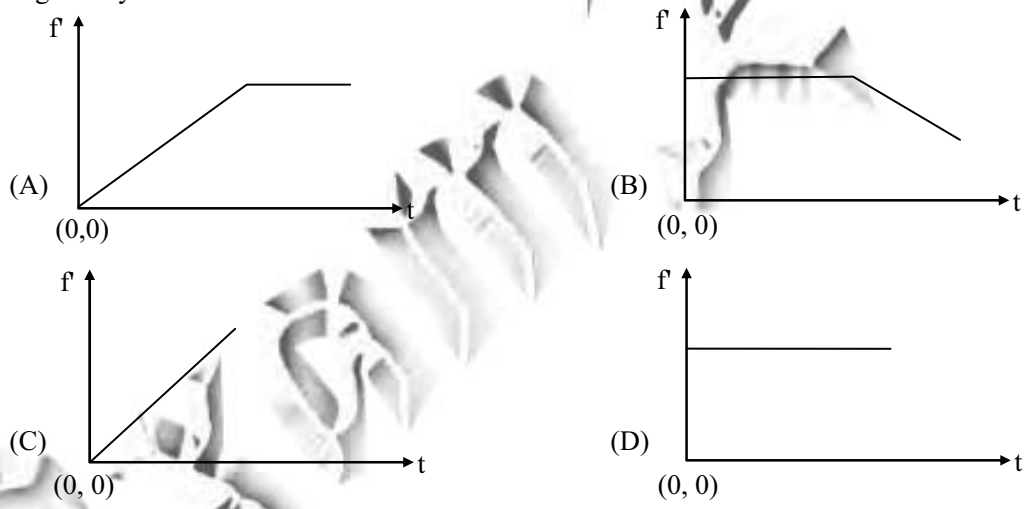
(C) T increases throughout

(D) T does not change

Ans. **(B)**

Sol. Because initially the separation of centre of gravity from point of suspension increases & then finally decreases hence time period will initially increase & then decrease.

12. A block of mass M rests on a rough horizontal table. A steadily increasing horizontal force is applied such that the block starts to slide on the table without toppling. The force is contained even after sliding has started. Assume the coefficients of static end kinetic friction between the table and block to be equal. The correct representation of the variation of the frictional force , f_l exerted by the table on the block with time t is given by -



Ans. **(A)**

Sol. Initially when the block does not move the friction is static in nature and it will be equal (& opposite) to the magnitude of applied force so initially friction will increase. But once the body starts the motion the kinetic friction will come and it does not change with applied force

13. A soldier with a machine gun, falling from an airplane gets detached from his parachute. He is able to resist the downward acceleration if the shoots 40 bullets a second at the speed of 500 m/s. If the weight of a bullet is 49 gm, what is the weight of the man with the gun ? Ignore resistance due to air and assume the acceleration due to gravity g = 9.8 ms ^{2} -

(A) 50 kg (B) 75 kg (C) 100 kg (D) 125 kg

Ans. **(C)**

Sol. To nullify the downward acceleration

$(M_m + M_g)\ 9.8 = 40 \times 500 \times 49 \times 10^{3}$

$\Rightarrow (M_m + M_g) = 100$ kg

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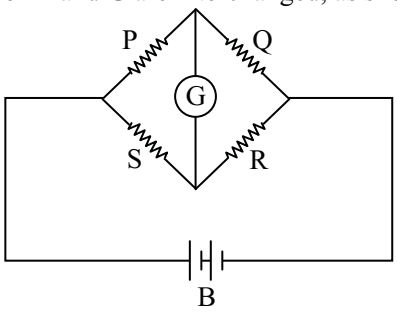
14. A planet of mass m is moving around a star of mass M and radius R in a circular orbit of radius r. The star abruplly shrinks to half its radius without any loss of mass. What change will be there in the orbit of the planet ?

(A) The planet will escape from the star
(B) The radius of the orbit will increase
(C) The radius of the orbit will decrease
(D) The radius of the orbit will not change

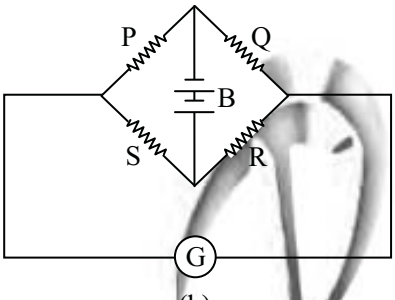
Ans. **(D)**

Sol. If radius of star is decreasing without any change in mass of star then it will not affect the force exerted by star on planet which is the required centripetal force. So radius of the orbit of planet with remain unaffected.

15. Figure (a) below shows a wheat stone bridge in which P, Q, R, S are fixed resistances, G is a galvanometer and B is a battery. For this particular case the galvanometer shows zero deflection. Now, only the positions of B and G are interchanged, as shown in figure (b). The new deflection of the galvanometer -



(a)

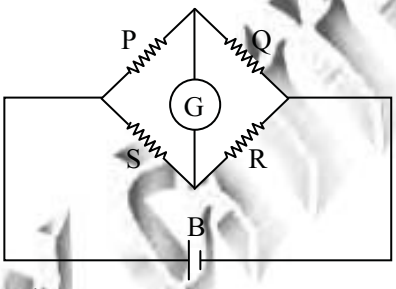


(b)

(A) is to the left
(B) is to the right
(C) is zero
(D) depends on the values of P, Q, R, S

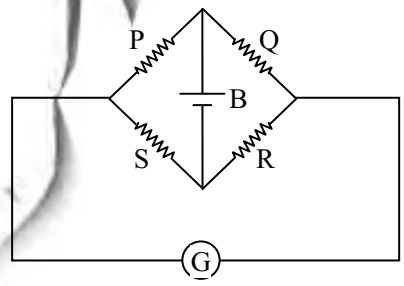
Ans. **(C)**

Sol.



For null deflection

$\frac{P}{Q} = \frac{S}{R}$ or $\frac{P}{S} = \frac{Q}{R}$



$\frac{P}{Q} = \frac{S}{R}$ still valid

$\therefore$ deflection is zero.

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16. 12 positive charges of magnitude q are placed on a circle of radius R in a manner that they are equally spaced. A charge Q is placed at the entre. If one of the charges q is removed, then the force on Q is -

(A) zero

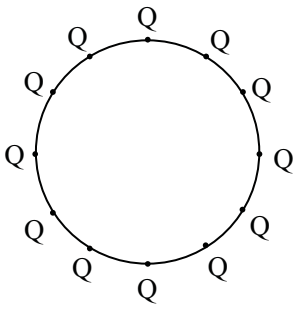
(B) $\frac{qQ}{4\pi\varepsilon_0 R^2}$ away from the position of the removed charge

(C) $\frac{11qQ}{4\pi\varepsilon_0 R^2}$ away from the position of the removed charge

(D) $\frac{qQ}{4\pi\varepsilon_0 R^2}$ towards the position of the removed charge

Ans. **(D)**

Sol.



If one charge is removed then net force on Q is $\frac{q \times Q}{4\pi\varepsilon_0 R^2}$

Towards the position of removed charge

17. An electric heater consists of a nichrome coil and runs under 220 V, consuming 1 kW power. Part of its coil burned out and it was reconnected after cutting off the burn portion. The power it will consume now is -

(A) more than 1 kW (B) less than 1 kW, but not zero

(C) 1 kW (D) 0 kW

Ans. **(A)**

Sol. Part of coil turned then resistance decreases

$\therefore$ Power consumption will be more than 1 kW

18. White light is split into a spectrum by a prism and it is seen on a screen. If we put another indentical inverted prism behind it in contact, what will be seen on the screen ?

(A) Violet will appear where red was

(B) The spectrum will remain the same

(C) There will be no spectrum, but only the original light with no deviation

(D) There will be no spectrum, but the original light will be larcrally displaced

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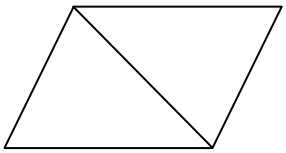
Ans. **(C)**

Sol.



This system will behave as slab.

$\therefore$ No dispersion

No deviation

19. Two identical blocks of metal are at 20ºC and 80ºC respectively. The specific heat of the material of the two blocks increases with temperature. Which of the following is true about the final temperature T_f when the two blocks are brought into contact (assuming that so seta is lost to the surroundings) -

(A) T_f will be 50ºC

(B) T_f will be more than 50ºC

(C) T_f will be less than 50ºC

(D) T_f can be either more than or less than 50ºC depending on the precise variation of the specific heat with temperature

Ans. **(D)**

Sol. If sp. heat is constant, then

Total heat gain = 0

$ms (T_f - 20) + ms (T_f - 80) = 0$

$T_f - 20 + T_f - 80 = 0$

$T_f = 50ºC$

Now T_f can be more than 50 or less than 50ºC, depending on sp. heat variation with temperature.

20. A new temperature scale uses X as a unit of temperature, where the numerical value of the temperature t_x in this scale is related to the absolute temperature T by $t_x = 3T + 300$. If the specific heat of a material using this unit is 1400 J kg^1X^{-1} its specific heat in the S.I. system of units is- c

(A) 4200 J kg^{-1} K^{-1}

(B) 1400 J kg^{-1} K^{-1}

(C) 466.7 J kg^{-1} K^{-1}

(D) impossible to determine from the information provided

Ans. **(A)**

Sol. $t_x = 3T + 300$

If in SI system the temperature has to be changed by one unit then in the given side the temperature has to be changed by three units

so specific heat in SI scale = $3(1400) \Rightarrow 4200$ J/(kg – K)

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CHEMISTRY

21. The boiling points of 0.01 M aqueous solution of sucrose, NaCl and $CaCl_2$ would be -

(A) the same (B) highest for sucrose solution

(C) highest for NaCl solution (D) highest for $CaCl_2$ solution

Ans. **(D)**

Sol. ∵ Elevation of boiling point is proportional to the no. of foreign species.

$CaCl_2 \rightarrow Ca^{2+} + 2Cl$; 3

$NaCl \rightarrow Na^{+} + Cl$; 2

Sucrose remains an dissociated mostly ; 1

22. The correct electronic configuration for the ground state of silicon (atomic number 14) is -

(A) $1s^2\,2s^2\,2p^6\,3s^2\,3p^2$ (B) $1s^2\,2s^2\,2p^4\,3s^2\,3p^4$

(C) $1s^2\,2s^2\,2p^6\,3s^2\,3p^4$ (D) $1s^2\,2s^2\,2p^6\,3s^1\,3p^2$

Ans. **(A)**

23. The molar mass of $CaCO_3$ is 100 g. The maximum amount of carbon dioxide that can be liberated on heating 25 g of $CaCO_3$ is -

(A) 11 g (B) 55 g (C) 22 g (D) 2.2 g

Ans. **(A)**

Sol. 25g $CaCO_3 \Rightarrow \frac{25}{100} = \frac{1}{4}$ mole of $CaCO_3$

$CaCO_3 \rightarrow CaO + CO_2$

∵ 1 mole $CaCO_3$ produce 1 mole CO_2

∴ $\frac{1}{4}$ mole $CaCO_3$ produce $\frac{1}{4}$ mole CO_2

and $\frac{1}{4}$ mole $CO_2 = \frac{1}{4} \times 44$ g of $CO_2 = 11$ g

24. The atomic radii of the elements across the second period of the periodic table -

(A) decrease due to increase in atomic number

(B) decrease due to increase in effective nuclear charge

(C) decrease due to increase in atomic weights

(D) increase due to increase in effective nuclear charge

Ans. **(B)**

25. Among NH_3, BCl_3, Cl_2 and N_2 the compound that does not satisfy the octet rule is -

(A) NH_3 (B) BCl_3 (C) Cl_2 (D) N_2

Ans. **(B)**

Sol. BCl_3 is electron deficient


Clearly B has only 6 e , Octet is not complete

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26. The gas produced on heating MnO_2 with cone. HCl is -

(A) Cl_2 (B) H_2 (C) O_2 (D) O_3

Ans. **(A)**

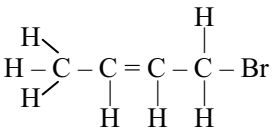
Sol. MnO_2 Oxidises Cl of HCl to Cl_2

27. The number of covalent bonds in $C_4H_7Br_2$ is -

(A) 12 (B) 10 (C) 13 (D) 11

Ans. **(A)**

Sol.



12 bonds = 10 single + 1 double

28. An aqueous solution of HCl has a pH of 2.0 When water is added to increase the pH to 5.0 the hydrogen ion concentration -

(A) remains the same (B) decreases three-fold

(C) increases three-fold (D) decreases thousand-fold

Ans. **(D)**

Sol. $pH = 2 \Rightarrow [H^+] = 10^{-2}$

$pH = 5 \Rightarrow [H^+] = 10^{-5}$

$$\therefore \quad \frac{[H^+]new}{[H^+]old} = \frac{10^{-5}}{10^{-2}} = 10^{-3}$$

29. Consider two sealed jars of equal volume. One contains 2 g of hydrogen at 200 K and the other contains 28 g of nitrogen at 400 K. The gases in the two jars will have -

(A) the same pressure (B) the same average kinetic energy

(C) the same number of molecules (D) the same average molecular speed

Ans. **(C)**

Sol. $2g\ H_2 \Rightarrow$ 1 mole gas at 200 K

$28g\ N_2 \Rightarrow$ 1 mole gas at 400 K

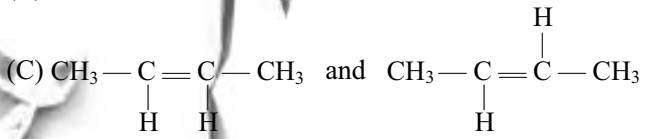
$PV = nRT$

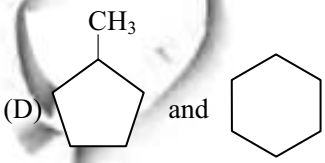
$\Rightarrow P \propto nT$

30. Identify the stereoisomer pair from the following choices -

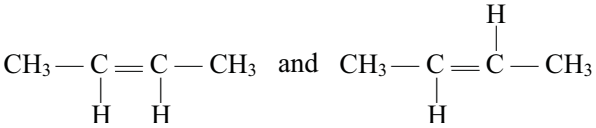
(A) $CH_3CH_2CH_2OH$ and $CH_3CH_2OCH_3$

(B) $CH_3CH_2CH_2Cl$ and $CH_3CHClCH_3$

(C)  and

(D)  and

Ans. **(C)**

Sol.  and

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BIOLOGY

31. Which of the following is a water-borne disease ?

(A) Tuberculosis (B) Chickenpox (C) Malaria (D) Cholera

Ans. (D)

32. In his seminal work on genetics, Gregor Mendel described the physical traits in the pea plant as being controlled by two 'factors'. What term is used to define these factors today ?

(A) Chromosomes (B) Alleles (C) Genes (D) Hybrids

Ans. (C)

33. A majority of the tree species of penensular Indian origin fruit in the months of

(A) April – May (B) December – January

(C) August – September (D) All months of the year

Ans. (A)

34. In frogs, body proportions do not change with their growth. A frog that is twice as long as another will be heavier by approximately

(A) Two-fold (B) Six-fold (C) Four-fold (D) Eight-fold

Ans. (A)

35. Which of the following has the widest angle of binocular vision ?

(A) Rat (B) Duck (C) Eagle (D) Owl

Ans. (C)

36. The two alleles of a locus which an offspring receives from the male and female gametes are situated on

(A) Two different homologs of the same chromosome

(B) Two different chromosomes

(C) Sex chromosomes

(D) A single chromosome

Ans. (A)

37. Ants locate sucrose by

(A) Using a strong sense of smell

(B) Using a keen sense of vision

(C) Physical contact with sucrose

(D) Sensing the particular wave length of light emitted reflected by sucrose

Ans. (C)

38. The interior of a cow-dung piece kept for a few days is quite warm. This is mostly because

(A) Cellulose present in the dung is a good insulator

(B) Bacterial metabolism inside the dung releases heat

(C) Undigested material releases heat due to oxidation by air

(D) Dung is dark and absorbs a lot of heat

Ans. (B)

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39. Which one of these is the correct path for a reflex action?

(A) Receptor-Motor Neuron-Spinal Cord-Sensory Neuron-Effector

(B) Effector-Sensory Neuron-Spinal Cord-Motor Neuron-Receptor

(C) Receptor-Sensory Neuron-Spinal Cord-Motor Neuron-Effector

(D) Sensory Neuron-Receptor-Motor-Neuron-Spinal Cord-Effector

Ans. **(C)**

40. Insectivorous plants digest insects to get an essential nutrient. Other plants generally get this nutrient from the soil. What is this nutrient ?

(A) Oxygen (B) Carbon dioxide

(C) Nitrogen (D) Phosphates

Ans. **(B)**

Sol. Insectivorous plant growing nitrogen deficient soil, so they get N_2 by trapping & digesting insect.

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PART -B

Two-Mark Question

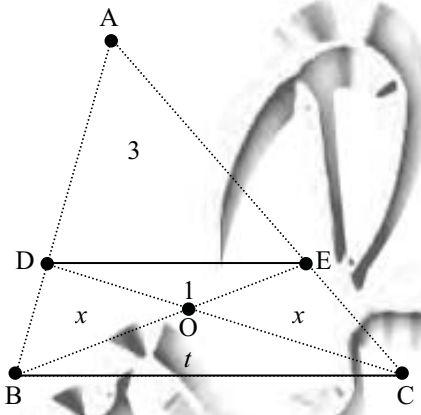
MATHEMATICS

1. In a triangle ABC, D and E are points on AB, AC respectively such that DE is parallel to BC. Suppose BE, CD intersect at O. If the areas of the triangles ADE and ODE are 3 and 1 respectively, find the area cf the triangle ABC, with justification

Ans.

Sol. We denote the area of triangle PQR by $[PQR]$. We see that $[BOD]$ and $[COE]$ are equal. Let the common value be x, and let $[BOC] = t$. Using the fact that the ratio of areas of two triangles having equal altitudes is the same as the ratio of their respective bases, we obtain.

$$\frac{x}{1} = \frac{BO}{OE} = \frac{t}{x}.$$



This gives $t = x^2$. Now ADE and ABC are similar so that

$$\frac{[ADE]}{[ABC]} = \frac{DE^2}{BC^2} = \frac{[ODE]}{[OBC]},$$

since ODE and OCB are also similar. This implies that

$$\frac{3}{4+2x+t} = \frac{1}{t},$$

which simplifies to $t = 2 + x$, using $t = x^2$ we get a quadratic in x : $x^2 - x - 2 = 0$. Its solution are $x = 2$ and $x = -1$. Since x cannot be negative, $x = 2$ and $t = 4$. Thus $[ABC] = 4 + 2x + t = 4 + 4 + 4 = 12$

2. Leela and Madan pooled their music CD's and sold them. They got as many rupees for each CD as the total number of CD's they sold. They share the money as follows Leela first takes 10 rupees, then Madan takes 10 rupees and they continue taking 10 rupees alternately till Madan is left out with less than 10 rupees to take. Find the amount that is left out for Madan at the end, with justification.

Ans. **()**

Sol. Let t be the total number of CD's that Leela and Madan together sold. Then they obtain t^2 rupees together. Since Leela is the first one to take 10 rupees and also the last one to take 10 rupees, we must have

$$t^2 = 10(\text{an old number}) + (\text{a number less than } 10).$$

Suppose $t = 10q + r$, where r is the remainder when t is divided by 10. Then $t^2 = 100q^2 + 20qr + r^2$. Comparing, we conclude that

$$r^2 = 10(\text{an odd number}) + (\text{a number less than } 10).$$

But we know that $0 \le r < 10$. Taking $r = 0, 1, 2,.....9$, we see that $r = 4$ or 6 (for other value of r, tens place in r^2 is even). But then $r^2 = 16$ or 36. Hence the amount left for Madan at the end is 6 rupees.

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3. (a) Show that for every nutural number n relatively prime to 10, there is another natural number m all of whose digits are 1's such that n divides m.

(b) Hence or otherwise show that every positive rational number can be expressed in the form $\frac{a}{10^b(10^c-1)}$

for some natural numbers a, b, c.

Ans. ()

Sol. (a) Divide the $n+1$ numbers 1, 11, 111, ..., 111, ...1 (all having only 1 as digits) by n. Among the $n+1$ remainders so obtained, two must be equal as the possibilities for remainders are 0, 1, 2,...., $n-1$ which are n in number. Thus there must be two numbers $x = 11.....1$ and $y = 11.....1$ having say j digits and k digits respectively which leave the same remainders after division by n. We may take $j < k$. Now we see that $y - x$ is divisible by n. But $y - x = 11 .... 100 ... 0$ where there are $k - j$ number of 1's and remaining zeros. Since n is coprime to 10, we see that n divides $m = 11 ... 1$, a number having only 1's as its digits.

(b) If p/q is any rational number ($p > 0$, $q > 0$), then we may write $q = 2^r 5^s t$, where t is coprime to 10. Choose a number m having only 1's as its digits and is divisible by t. Consider $9m$, Which has only 9 as its digits and is still divisible by t. Let $k = 9m/t$. We see that;

$$qk = 9m\,2^r5^s = (10^o - 1)\,2^r5^s,$$

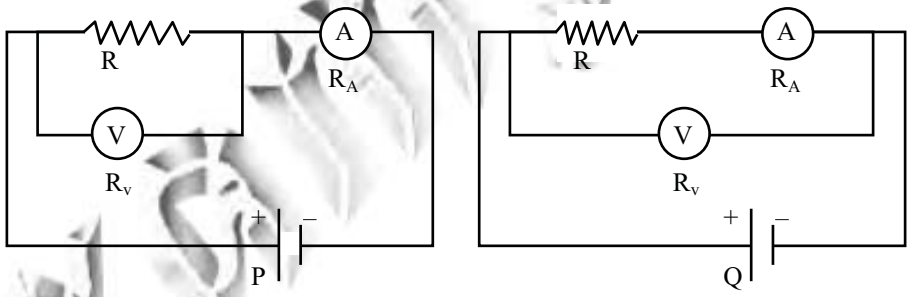
where c is the number of digits in m. Hence we can find d such that $qd = 10^b(10^c - 1)$ (multiply by a suitable power of 2 if $s > r$ and by a suitable power of 5 if $r > s$). Then

$$\frac{p}{q} = \frac{pd}{qd} = \frac{a}{10^b(10^c-1)}$$

where $a = pd$.

PHYSICS

4. Consider the two circuits P and Q, shown below, which are used 20 measure the unknown resistance R.



In each case, the resistance is estimated by using Ohm's law $R_{est} = V / I$, Where V and I are the readings of the voltmeter and the ammeter respectively. The meter resistances, R_v and R_A are such that $R_A << R << R_v$. The internal resistance of the battery may be ignored. The absolute error in the estimate of the resistance is denoted by $\delta R = |R - R_{est}|$.

(a) Express δR_p in terms of the given resistance values

(b) Express δR_Q in terms of the given resistance values

(c) For what value of R will $\delta R_P \approx \delta R_Q 7$

Ans. ()

Sol. For P : $I = I_R + I_V = V / R + V/R_V$

$$R = \frac{V}{I}\left[\frac{R_V}{R_V - V/I}\right]$$

$$= R_{est}\left[\frac{Rv}{1 - R_{est}/R_v}\right]$$

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$\approx R_{est}\,[1 + R_{est} / R_V]$ (neglecting higher order terms in R_{est} / R_V)

$\delta R_P = |R_{est} - R| = R_{est}^2 / R_V \approx \dfrac{R^2}{R_V}$.

Alternatively,

$R_{est} = \dfrac{V}{I} = \dfrac{R_V R}{R_V + R}$

$\delta R_P = |R_{est} - R| = R\left[\dfrac{R_V}{R_V + R} - 1\right] \approx \dfrac{R^2}{R_V}$

For Q : $V = I\,(R + R_A)$

$R = V / I - R_A = R_{est} - R_A$

$\delta R_Q = |R_{est} - R| = R_A$

If $R = \sqrt{R_A R_V}$, then $\delta R_P / \delta R_Q = R_{est}^2 / (R_A R_V) = R_{est}^2 / R^2 \approx 1$

5. A point source is placed 20 cm to the left of a concave lens of focal length 10 cm.

(a) Where is the image formed ?

(b) Where to the right of the lens would you place a concave mirror of focal length 5 cm so that the final image is coincident with the source ?

(c) Where would the final image be formed if the concave mirror is replaced by a plane mirror at the same position ?

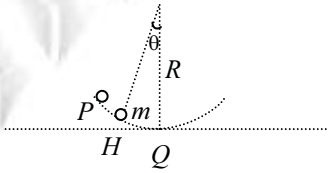
Ans. ()

Sol. (a) Object is at $2f$, so the image is formed at the same distance from the lens (20 cm) to the right.

(b) Since light has to retrace its path, the mirror should be placed so that the previous image is at its centre of curvature. Thus the mirror must be placed 30 cm to the right of the lens.

(c) For the plane mirror, reflection forms an image 40 cm to the right of the lens. Using the lens formula, we see that the final image is formed at a distance of 40/3 cm to the left of the lens.

6. A block of mass m is sliding on a fixed frictionless concave surface of radius R. It is released from rest at point P which is at a height of $H << R$ from the lowest point Q.



(a) What is the potential energy as a function of θ, taking the lowest point Q as the reference level for potential energy ?

(b) What is the kinetic energy as a function of θ ?

(c) What is the time taken for the particle to reach from point P to the lowest point Q ?

(d) How much force is exerted by the block on the concave surface at the point Q ?

Ans. ()

Sol. (a) $V(\theta) = mgR\,(1 - \cos\theta)$, (b) $mgH - mgR(1 - \cos\theta)$, (c) for $H << R$ the body executes *SHM* with a time period of $\dfrac{1}{2\pi}\sqrt{\dfrac{R}{g}}$ – the time taken for it to travel from P to Q will be a quarter of this, i.e., $\dfrac{1}{8\pi}\sqrt{\dfrac{R}{g}}$.

(d) At the lowest point, the speed is given by $\dfrac{1}{2}\,mv^2 = mgH$. So, $T - mg = \dfrac{mv^2}{R} = \dfrac{2mgH}{R}$, and thus $T = mg\left(1 + \dfrac{2H}{R}\right)$.

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CHEMISTRY

7. Copper in an alloy is estimated by dissolving in conc. nitric acid. In this process copper is converted to cupric nitrate with the evolution of nitric oxide (NO). The misture when treated with potassium iodide forms cupric iodide. Which is unstable and decomposes to cuprous iodide and iodine. The amount of copper in the alloy is estimated by litrating the libereated iodine with sodium thiosulphate. The reactions are

a $Cu + b\ HNO_3 \rightarrow\ c\ Cu(NO_3)_2 + d\ NO + e\ H_2O$

f $CuI_2 \rightarrow g\ Cu_2I_2 + h\ I_2$

i $Na_2S_2O_3 + \hat{j}\ I_2 \rightarrow\ k\ Na_2S_4O_6 + lNaI$

(Fill up the blanks)

(a) The coefficients are : $a =$. $b =$, $c =$, $d =$ and $e =$.

(b) The coefficients are : $f =$, $g =$ and $h =$

(c) The coefficients are : $i =$, $j =$, $k =$ and $l =$.

(d) If 2.54 g of I_2 is evolved from a 2.0 *g* sample of the alloy, what is the percentage of copper in the alloy ? (atomic, weight of iodine and coper are 127 and 63.5, respectively)

Ans. **()**

Sol. (a) $a = 3$, $b = 8$, $c = 3$, $d = 2$ and $e = 4$

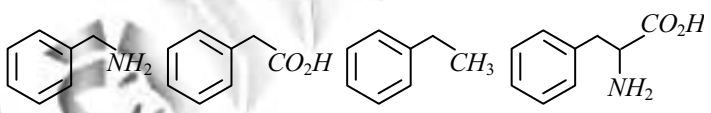
(b) $f = 2$, $g = 1$, $h = 1$.

(c) $i = 2$, $j = 1$, $k = 1$, $1 = 2$

(d) 2.54 *g* of I_2 = 1/100 mole of I_2 = 2/100 gm atom of *Cu*

% Cu = (2/100) × 63.5 / 2) = 63.5%

8. You have been given four bottles marked *A*, *B*, *C* and *D* each containing one of the organic compounds given below



I *II* *III* *IV*

The following observation were made.

(i) The compound in the bottle *A* did not dissolve in either 1 *N NaOH* or 1 *N HCl*.

(ii) The compound in the bottle *B* dissolved in 1 *N NaOH* but not in 1 *N HCl*.

(iii) The compound in the bottle *C* dissolved in both 1 *N NaOH* and 1 *N HCl*.

(iv) The compound in the bottle *D* did not dissolved in 1*N NaOH* but dissolved in 1 *N HCl*.

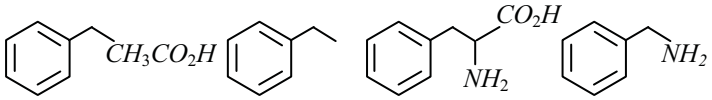
(Fill up the blanks)

(a) Indicate the compounds in : bottle *A* : , bottle *B* : , bottle *C* = and bottle *D* = .

(b) The compound with the highest solubility in distilled water is .

Ans. **()**

Sol. Bottle *A* = III, Bottle *B* = II, Bottle *C* = IV, Bottle *D* = I



Compound with the highest solubility in distilled water : IV

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9. Assume that a human body requires 2500 kcal of energy each day for metabolic activity and sucrose is the only source of energy, as per the equation

$C_{12}H_{22}O_{11}(s) + 12\ O_2(g) \rightarrow 12\ CO_2(g) + 11\ H_2O\ (l)$; $\Delta H = -5.6 \times 10^6$ J.

(Fill up the blanks)

(a) The energy requirement of the human body per day is kJ.

(b) The mass of sucrose required to provide this energy is g and the volume of CO_2 (at *STP*) produced is litres.

Ans. **()**

Sol. (a) 2500×4.184 kJ = 10460 kJ;

(b) 342 *g* of sucrose produces 5600 kJ of energy. To provide 10460 kJ we need $10460 \times 342 / 5600$ g = 638 g

638 g/342 g × 12 × 22.4 L = 501 L

BIOLOGY

10. Mohini, a resident of Chandigarh went to Shimla with her parents. There she found the same plant that they have in their backyard, at home. However, she observed that while the plants in their backyard bore white flowers, those in Shimla had pink flowers. She brought home some seeds of the plant from Shimla and planted them in Chandigarh. Upon performing self breeding for several generations she found that the plant from Shimla produced only white flowers.

(a) According to you what might be the reason for this observation-genetic or eavironmental factors ?

(b) Suggest a simple experiment to determine whether this variation is genetic in nature

(c) Suggest another experiment to check whether this variation in flower color is due to environmental fctors.

Sol. (a) Difference in flower color is most likely due to environmental factors

(b) Perform cross breeding between the plants from Chandigarh and those from Shimla to find out whether we get any pink flowers or flowers with any shade of color between pink and white in the F1 generation

(c) Grow the plants from Chandigarh in Shimla and check whether they still produce white flowers or bear pink flowers

11. The break-down of glucose in a cell occurs in any of the following pathways :

Glucose → Pyruvic Acid → CO_2+H_2O (in the presence of C_2 e.g. in mitochondria)

Pyruvic Acid → Ethanol + CO_2 (in the absence of O_2 e.g. Yeast)

Pyruvic Acid → Lactic acid (in the absence of O_2 e.g. lactic acid bacteria)

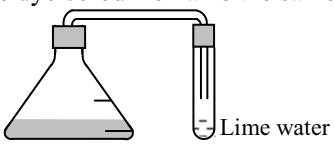
Three experiments (A, B, C) have been set up. In each experiment, a flask contains the organism in growth medium, glucose and a brown dye that changes its colour to yellow when the pH decreases. The mouth of the flask is attached to a test tube containing lime water (Calcium hydroxide ; as shown in the figure). In C, but not in A and B, air is removed from the flask before beginning the experiment.

After a period of growth, the following observation were made :

A : Lime water turns milky; the dye colour remains the same

B : The dye colour changes ; lime water does not turn milky

C : Lime water turns milky ; the dye colour remains the same



(a) Question : Identify which of the reactions is the pathways depicted above is taking place in each experiment. Give reasons for your answer.

(b) Question : Identify which of the reactions in the pathways depicted above is expected to occur in Red Blood Cells (RBCs)

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Sol. (a) In experiment A, ethanol fermentation occurs producing CO_2, turning lime water milky. Since acid is not produced the dye colour does not change.

In experiment B, lactic acid fermentation takes place, which produces acid but does not produce CO_2. Hence dye colour changes to yellow but the lime water does not turn milky.

In experiment C, since the lime water turns milky, ethanol fermentation is occurring. In addition, since removal of air did not affect the reaction, the fermentation is anaerobic and yeast must be the organism in the flask.

(b) In RBCs, lactic acid fermentation occurs.

12. A scientist has a house just beside a busy highway. He collects leaves from some plants growing in his garden to do radio-carbon dating (to estimate the age of the plant by estimating the amount of a radioisotope of carbon in its tissues). Surprisingly the radio-carbon dating shows that the plant is a few thousand years old.

(a) Was the result of the radio-carbon dating wrong or can you propose a reason for such an observation ?

(b) What simple experiment can be done to test the reason that you have proposed ?

Sol. (a) The result of the radio-carbon dating was correct.

Reason : Vehicles running on the highway beside the house emitted carbon dioxide from the combustion of petrol or diesel, which are fossil fuels. The carbon in this carbon dioxide, coming from living material that has been converted into petroleum millions of years ago, would get assimilated into the tissues of the plant as it uses carbon dioxide from the surrounding atmosphere for photosynthesis. Therefore tissues of the plant, when used for radio-carbon dating, would show the age of the plant to be many thousands of years old.

(b) A simple experiment to test the validity of this explanation would be to collect seeds from the plant and grow them in a plot of land away from the highway or other sources of carbon dioxide coming from the burning of fossil fuels. Radio-carbon dating of plants growing from these seeds should show them as young plants.

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