

IOQJS 2021

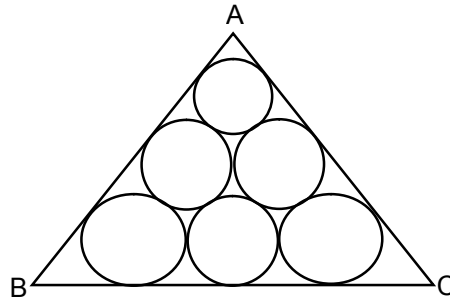
PAPER WITH SOLUTION



MOTION[™]
JEE / NEET / Earlylead

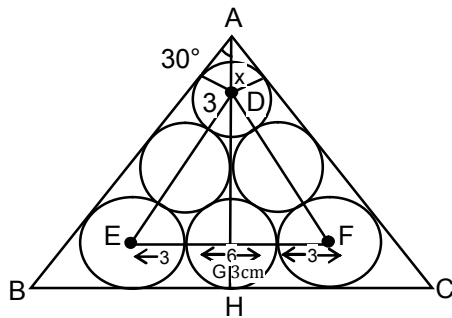
PART - 1

1. Six circles each of radius 3cm are inscribed in an equilateral triangle ABC such that they touch each other and also touch the sides of the triangle as shown in the adjacent figure height of triangle ABC is



- (A) $6(2\sqrt{3} + 3)$ (B) $3(2\sqrt{3} + 6)$ (C) $3(2\sqrt{3} + 3)$ (D) $6(2 + \sqrt{3})$

Sol. (C)



ABC is an equilateral triangle
 We join centers of circle and forms
 Equilateral triangle DEF with side 12 cm

$$\begin{aligned} \text{Height } DG &= \frac{\sqrt{3}}{2} \times 12 \\ &= 6\sqrt{3} \end{aligned}$$

$$AD \Rightarrow \sin 30^\circ = \frac{3}{x}$$

$$x = 6 \text{ cm}$$

$$\begin{aligned} \text{Height of triangle ABC} &= AD + DG + GH \\ &= 6 + 6\sqrt{3} + 3 \text{ cm} \\ &= 9 + 6\sqrt{3} \\ &= 3(3 + 2\sqrt{3}) \end{aligned}$$



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2. Find the remainder when x^{51} is divided by $x^2 - 3x + 2$
 (A) x (B) $(2^{51} - 2)x + 2 - 2^{51}$
 (C) $(2^{51} - 1)x + 2 - 2^{51}$ (D) 0

Sol. (C)

$$x^{51} = (x^2 - 3x + 2)g(x) + r(x)$$

$$x^{51} = (x - 2)(x - 1)g(x) + (ax + b)$$

degree of $r(x) <$ degree of division

put $x = 1$

$$1^{51} = a + b$$

$$a + b = 1 \quad \dots(1)$$

put $x = 2$

$$2^{51} = 2a + b \quad \dots(2)$$

$$(2) - (1)$$

$$a = 2^{51} - 1$$

put in equation (1)

$$2^{51} - 1 + b = 1$$

$$b = 2 - 2^{51}$$

$$r(x) = ax + b$$

$$= (2^{51} - 1)x + (2 - 2^{51})$$

3. If $\frac{3}{x-2} < 1$, where x is a real number, then
 (A) $2 < x < 5$ (B) $x < 2$ or $5 < x$
 (C) $x < -2$ or $x > 5$ (D) None of these

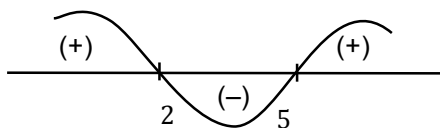
Sol. (B)

$$\frac{3}{x-2} - 1 < 0$$

$$\frac{3-x+2}{x-2} < 0$$

$$\frac{5-x}{x-2} < 0$$

$$\frac{x-5}{x-2} > 0$$



$$x \in (-\infty, 2) \cup (5, \infty)$$

So, $x < 2$ or $5 < x$



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4. If $x^2 + ax + b = 0$ and $x^2 + bx + a = 0$ have one common root, then

- (A) $a + b = 0$ (B) $a + b = 1$ (C) $a + b = -1$ (D) $a^2 + b^2 = 1$

Sol. (C)

$$x^2 + ax + b = 0$$

$$x^2 + bx + a = 0$$

Common root α .

$$\frac{\alpha^2}{a^2 - b^2} = \frac{\alpha}{b - a} = \frac{1}{b - a}$$

From (ii) & (iii)

$$\alpha = 1$$

From Ist & (II)

$$\alpha^2 = \frac{(a + b)(a - b)}{b - a}$$

$$\frac{(1)^2}{(a + b)(a - b)} = \frac{1}{(a - b)}$$

$$a + b = 1$$

5. If $100^{25} - 25$ is written in decimal notations, then the sum of its digits is

- (A) 444 (B) 442 (C) 424 (D) 422

Sol. (A)

$$100^{25} - 25$$

$$(10^2)^{25} - 25$$

$$10^{50} - 25$$

$$\begin{array}{c} 9999 \text{ ----- } 75 \\ \underbrace{\hspace{10em}} \\ 48 \text{ times} \end{array}$$

$$\text{Digit sum} = 9 \times 48 + 7 + 5$$

$$= 432 + 12$$

$$= 444$$

6. ABC is a triangle the bisector of angle A meets BC in D. The relation between AD, AB and AC is

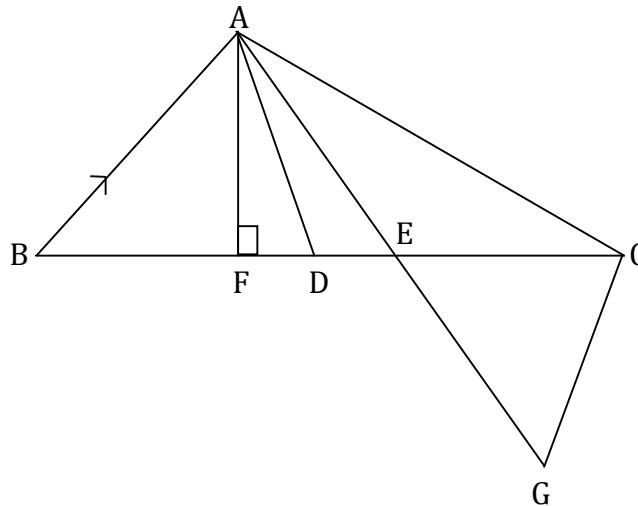
- (A) $AD > \sqrt{AB \cdot AC}$ (B) $AD > AB \cdot AC$ (C) $AD = \sqrt{AB \cdot AC}$ (D) $AD < \sqrt{AB \cdot AC}$



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Sol. (D)



$$\frac{AB}{AC} = \frac{BD}{CD} \text{ thus } BD < CD \text{ \& D}$$

Lies to Left of E

in ΔABC $\angle B > \angle C$

$$\angle A + \angle B + \angle C = 180^\circ$$

$$\angle A + 2\angle C < 180$$

$$\Rightarrow \frac{\angle A}{2} < 90^\circ - \angle C$$

In ΔAFD & ΔAFE

$$AD < AE$$

$$\Delta ABE \cong \Delta GCE$$

$$\text{then } CG = AB \text{ \& } AG = 2AE$$

from ΔACG

$$AB + AC > 2AE > 2AD \Rightarrow \frac{AB + AC}{2} > AD$$

$$\text{Now ar}\Delta ABC = \frac{1}{2} AB \cdot AC \sin A$$

$$= AB \cdot AC \sin \frac{A}{2} \cos \frac{A}{2}$$

$$\text{ar}\Delta ABD = \frac{1}{2} AB \cdot AD \sin \frac{A}{2}$$

$$\text{ar. } \Delta ACD = \frac{1}{2} AC \cdot AD \sin \frac{A}{2}$$

Thus we have

$$AB \cdot AC \sin \frac{A}{2} \cos \frac{A}{2} = \frac{1}{2} AD \sin \frac{A}{2} (AB + AC)$$



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By simplification

$$AB \cdot AC \cos \frac{A}{2} = AD \frac{(AB+AC)}{2}$$

$$\therefore \frac{AB+AC}{2} > AD$$

$$AB \cdot AC \cos A/2 > AD^2$$

$$0 < \cos \frac{A}{2} < 1$$

$$AB \cdot AC > AD^2$$

7. If in a wheat mutant, the length of chromosome 1B was found to be $6.7\mu\text{m}$, instead of $5.0\mu\text{m}$, approximately how many additional base pairs are incorporated in the mutant chromosome?

(A) 0.5×10^4 bp (B) 5×10^4 bp (C) 1.7×10^4 bp (D) 5.78×10^4 bp

Sol. (A)

Wheat Mutant

Given \rightarrow Length of chromosome 1B

$\rightarrow 6.7\mu\text{m}$ = new length

$\rightarrow 5.0\mu\text{m}$ = old length

Change in length after mutation = $6.7 - 5.0\mu\text{m} = 1.7\mu\text{m}$

$\rightarrow 3.4\text{ \AA}$ is the length between two base pair

$\rightarrow 3.4 \times 10^{-10}$ meter

$\rightarrow 3.4 \times 10^{-10} \times 10^6\mu\text{m} = 3.4 \times 10^{-4}\mu\text{m}$

$\rightarrow 3.4 \times 10^{-4}\mu\text{m} \rightarrow 1$ Base pair

$\rightarrow 1\mu\text{m} \rightarrow \frac{1}{3.4 \times 10^{-4}}$ Base Pair

$\rightarrow 1.7\mu\text{m} \rightarrow 1.7 \times \frac{1}{3.4 \times 10^{-4}}$ Base pair

$$= \frac{1.7}{3.4} \times 10^4 \text{ Base pair}$$

$$= 0.5 \times 10^4 \text{ Base Pair}$$

\rightarrow So the correct option is A

8. Considering following characteristics, identify the correct inheritance pattern from the given options.



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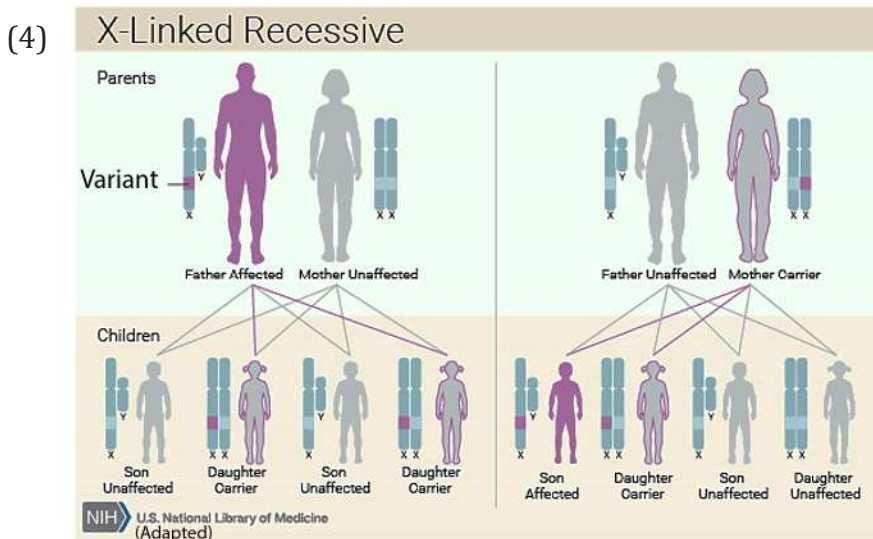
- Most affected individuals are male.
- Affected Sons result from female parents who are either affected or who are known to be carriers because they have affected brothers, fathers or maternal uncles.
- Affected daughters are born to affected fathers and either affected or carrier mother
- The sons of affected mothers should be affected.
- Approximately half the sons of carrier mothers should be affected.

- (A) Autosomal Recessive Inheritance (B) Autosomal Dominant Inheritance
 (C) Sex-Linked Recessive Inheritance (D) Sex-Linked Dominant Inheritance

Sol. (C)

X-linked recessive inheritance is a mode of **inheritance** in which a mutation in a gene on the **X** chromosome causes the phenotype to be always expressed in males. A male carrying such a mutation will be affected, because he carries only one X chromosome.

- (1) Males with an **X-linked recessive** disorder always inherit the disease-associated allele from their mother.
- (2) Females (who have two X chromosomes) must have a mutation on both X chromosomes in order to be affected with the condition. If only the father or the mother has the mutated X-linked gene, the daughters are usually not affected and are called carriers because one of their X chromosomes has the mutation but the other one is normal.
- (3) Sons will be affected if they inherit the mutated X-linked gene from their mother. Fathers cannot pass X-linked recessive conditions to their sons.



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9. The transpiration pull is maximum under which of the following conditions?

- (A) Closed stomata, low light intensity, humid air
- (B) Open stomata, dry air, moist soil
- (C) Open stomata, dry air, dry soil
- (D) Open stomata, high humidity in air, moist soil

Sol. (B)

Plants transpire more rapidly at high temperature because water evaporates more rapidly as a temperature rises.

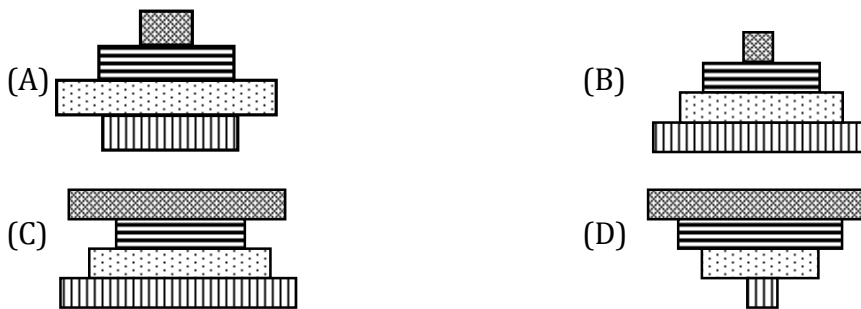
Humidity is expressed as the percentage of water vapour present in the atmosphere.

The higher the relative humidity of the outside atmosphere, the lower the rate of transpiration.

A plant cannot continue to transpire rapidly if its water loss is not made up by replacement from the soil. When absorption of water by the roots fails to keep up with the rate of transpiration, loss of turgor occurs, and the stomata close. This immediately reduces the rate of transpiration.

Hence, transpiration pull will be maximum under open stomata, dry atmosphere and moist soil.

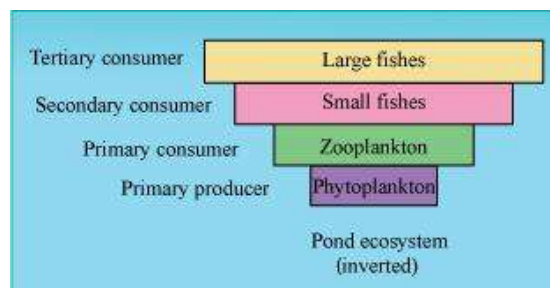
10. In a marine ecosystem with rich diversity of fauna which of the following images would be a correct representation of pyramid of biomass?



Sol. (D)

The biomass pyramid of aquatic ecosystem is inverted. Here the biomass of primary producers is much less than the small fish and big fish having the maximum biomass.

The biomass of zoo plankton is greater than phytoplankton, the producer because of their small size and low biomass.



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11. Curcuma longa, Azadirachtaindica, Basmati Rice. Indian Ginseng are all related to which of the following concepts?
- (A) Bioterrorism (B) Biomagnification
(C) Biopiracy (D) Biodegradation

Sol. (C)

The practice of commercial exploitation of biochemicals or genetic materials which occur naturally is known as biopiracy. Developed countries are exploiting developing countries' genetic resources and indigenous communities' traditional knowledge in the name of patent on invention derived from those genetic resource and traditional knowledge.

For e.g., Turmeric (*Curcuma longa*), Neem (*Azadirachta indica*), Basmati Rice, *Ashwagandha* (*Indian Ginseng*).

12. Read following criteria carefully.
- Slow evolutionary change relative to similar entities.
 - Gross similarity to an ancestral fossil
 - Very low taxonomic richness today compared to the past
 - Phylogenetic inference of specific characters as plesiomorphic
 - Phylogenetic inference of a genealogical divergence between other groups that diverged in the distant past.
 - Known in the fossil record before being discovered alive.

These criteria can be used to categorize a group of organisms the most probably into

- (A) Connecting links (B) Living fossils
(C) Endangered species (D) Extinct species

Sol. (B)

Living fossils have two main characteristics, although some have a third:

1. Living organisms that are members of ataxon that has remained recognisable in the fossil record over an unusually long time span.
2. They show little morphological divergence, whether from early members of the lineage, or among extant species. (slow-evolutionary-change-relative-to-similar-entities)
3. They tend to have little taxonomic diversity(very-low-taxonomic-richness-today-compared-to-past)
4. exceptionally little change throughout a long fossil record, giving the impression that the extant taxon had remained identical through the entire fossil and modern period.(known-in-the-fossil-record-before-being-discovered-live)
5. living fossil is a surviving representative of an archaic lineage does not imply that it must retain all the "primitive" features plesiomorphies ("near form")of its ancestral lineage(pedigree)

So,the correct answer is living fossil.



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13. Gravitational collapse is the contraction of an astronomical object under its own gravity. This draws the matter inwards towards the centre of gravity. A neutron star is an example of the collapsed core of a giant star. A certain neutron star of radius 10km is of mass $1.5M_{\odot}$. The acceleration due to gravity on the surface of the neutron star is nearly
- (A) $2.0 \times 10^8 \text{ m/s}^2$ (B) $2.0 \times 10^{12} \text{ m/s}^2$
 (C) $2.6 \times 10^{16} \text{ m/s}^2$ (D) $2.6 \times 10^{20} \text{ m/s}^2$

Sol. (B)

Given That,

$$R = 10 \text{ km} = 10000\text{m}$$

Gravitational force between two objects is

Given by;

$$F = \frac{G M_1 M_2}{R^2} = \frac{G M_n M_s}{R^2};$$

M_n = mass of neutron

M_s = mass of sun

G = universal gravitational constant

$$\therefore g = \frac{GM_s}{R^2}$$

$$\Rightarrow g = \frac{6.67 \times 10^{-11} \times 1.5 \times 1.99 \times 10^{30}}{10^8}$$

$$\Rightarrow g = 6.7 \times 1.5 \times 2 \times 10^{11}$$

$$\Rightarrow g = 20 \times 10^{11}$$

$$\Rightarrow g = 2 \times 10^{12} \text{ m/sec}^2$$

14. The tympanic membrane (ear drum) is a very delicate component of the human ear. Typically, its diameter is 1cm. The maximum force the ear can withstand is 2.5N. In case a diver has to enter sea water of density $1.05 \times 10^3 \text{ kg/m}^3$ without any protective gear, the maximum safe depth for the diver to go into water is about
- (A) 12m (B) 9m (C) 3m (D) 1.5m

Sol. (C)

$$D = 1 \text{ cm}$$

$$\Rightarrow R = \frac{1}{200} \text{ m}$$

$$F = 2.5 \text{ N}$$

$$\rho = 1.05 \times 10^3 \text{ kg/m}^3$$



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$$\because p = \rho gh$$

$$\Rightarrow \frac{F}{A} = \rho qh \Rightarrow h = \frac{F}{A\rho g} \Rightarrow h = \frac{F}{\pi r^2 \rho g}$$

$$\Rightarrow h = \frac{2.5\text{N}}{3.14 \times \left(\frac{1}{200}\text{m}\right)^2 \times 1.05 \times \frac{10^3\text{kg}}{\text{m}^3} \times \frac{9.8\text{m}}{\text{sec}^2}}$$

$$\Rightarrow h = \frac{2.5\text{N}}{3.14 \times (0.005\text{m})^2 \times 1.05 \times 10^3 \text{kg} / \text{m}^3 \times 9.8\text{m} / \text{sec}^2}$$

$$\Rightarrow h = 3.125 \text{ m}$$

$$\Rightarrow h \approx 3 \text{ m}$$

15. A nuclear reactor is working at 30% efficiency (i.e. conversion of nuclear energy to electrical energy). In this reactor ${}_{92}^{235}\text{U}$ nucleus undergoes fission and releases 200 MeV energy per atom. If 1000kW of electrical power is obtained in this reactor, then the number of atoms disintegrated (undergone fission) per second in the reactor is

(A) 1.04×10^{17} (B) 6.5×10^{12} (C) 3.125×10^{12} (D) 3.25×10^{32}

Sol. (A)

$$\text{Given efficiency } (\eta) = 30\% \quad \dots(1)$$

$$\begin{aligned} \text{Energy per atom} &= 200 \text{ MeV} \\ &= 20 \times 1.6 \times 10^{-19} \times 10^6 \quad \dots (2) \end{aligned}$$

$$\text{Electrical power} = 1000 \text{ kW} = 10^6 \text{ W} \quad \dots (3)$$

Now from equation (1), (2) and (3)

$$\frac{30}{100} = \frac{10^6}{n \times 200 \times 1.6 \times 10^{-19} \times 10^6}$$

$$\Rightarrow \frac{30}{1} = \frac{1}{3.2 \times 10^{-19} \times n}$$

$$\Rightarrow n = 1.04 \times 10^{17}$$

16. Two illuminated point objects O_1 and O_2 are placed at a distance 24cm from each other along the principal axis of a thin convex lens of focal length 9cm such that images of both the objects are formed at the same positions. Then the respective distances of the lens from O_1 and O_2 (in cm) are

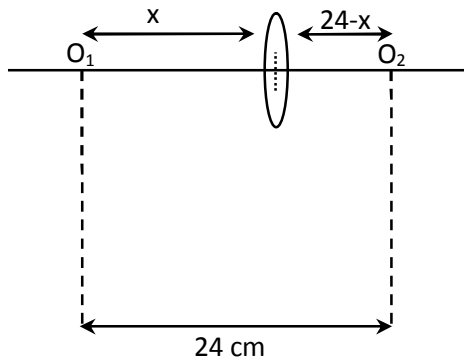
(A) 12 and 12 (B) 18 and 6 (C) 14 and 10 (D) 16 and 8



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Sol. (B)



Given that focal length of convex lens = 9 cm

Let first object is at a distance x from the convex lens.

By using lens formula i.e. $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$$\text{We get, } \frac{1}{v} - \frac{1}{-x} = \frac{1}{9} \Rightarrow \frac{1}{v} = \frac{1}{9} - \frac{1}{x} \quad \dots(1)$$

Now for second object

$$\frac{1}{-v} - \frac{1}{-(24-x)} = \frac{1}{9} \Rightarrow \frac{1}{v} - \frac{1}{24-x} = \frac{-1}{9}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{24-x} - \frac{1}{9} \quad \dots(2)$$

\therefore Image formed at the same distance from the lens for both the objects

\therefore From equation (1) and (2)

$$\frac{1}{9} - \frac{1}{x} = \frac{1}{24-x} - \frac{1}{9}$$

$$\frac{2}{9} = \frac{1}{x} + \frac{1}{24-x}$$

$$\frac{2}{9} = \frac{24-x+x}{x(24-x)}$$

$$x(24-x) = \frac{24 \times 9}{2} = 108$$

$$x^2 - 24x + 108 = 0$$

From Sridharacharya rule

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{24 \pm \sqrt{576 - 4 \times 1 \times 108}}{2}$$

$$x = \frac{24 \pm \sqrt{144}}{2}$$

$$x = 18, 6$$

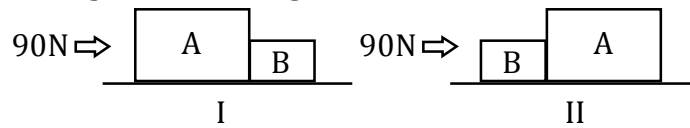
\therefore The correct option is (B).



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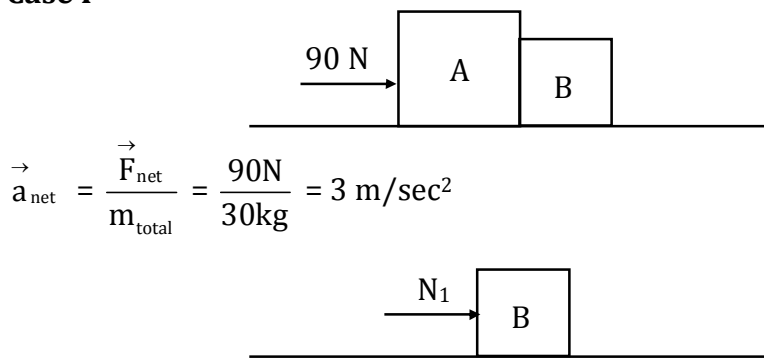
17. Two blocks A and B are in contact with each other and are placed on a frictionless horizontal surface. A force of 90N is applied horizontally on block A (situation I) and the same force is applied horizontally on block B (situation II). Mass of A is 20kg and B is 10kg. Then the correct statement is



- (A) Since both the blocks are in contact, magnitude of force by block A on B will be 90N (situation I) and magnitude of force by block B on A will also be 90N (Situation II).
- (B) Magnitude force by block A on B is 30N (situation I) and Magnitude of force by block B on A is 60N (situation II).
- (C) Magnitude of force by block A on B is 60N (situation I) and magnitude of force by block B on A is 30N (situation II).
- (D) The 90N force will produce acceleration of different magnitudes in A and B.

Sol. (B)

Case I



$$\vec{a}_{net} = \frac{\vec{F}_{net}}{m_{total}} = \frac{90N}{30kg} = 3 \text{ m/sec}^2$$

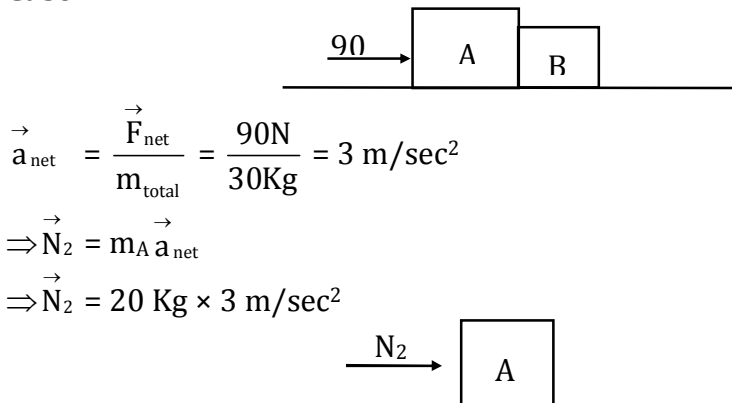
[N₁ is normal force applied by A on B]

$$\Rightarrow \vec{N}_1 = m_B \vec{a}_{net}$$

$$\Rightarrow \vec{N}_1 = 10 \text{ Kg} \times 3 \text{ m/sec}^2$$

$$\Rightarrow \vec{N}_1 = 30 \text{ N}$$

Case II



$$\vec{a}_{net} = \frac{\vec{F}_{net}}{m_{total}} = \frac{90N}{30Kg} = 3 \text{ m/sec}^2$$

$$\Rightarrow \vec{N}_2 = m_A \vec{a}_{net}$$

$$\Rightarrow \vec{N}_2 = 20 \text{ Kg} \times 3 \text{ m/sec}^2$$

$$\Rightarrow \vec{N}_2 = 60 \text{ N}$$

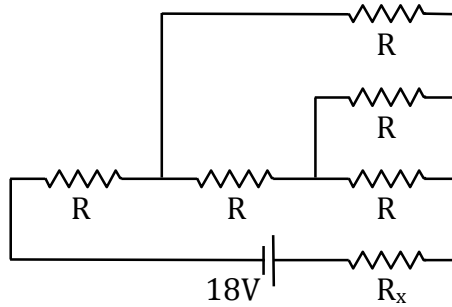
So, option (B) is correct.



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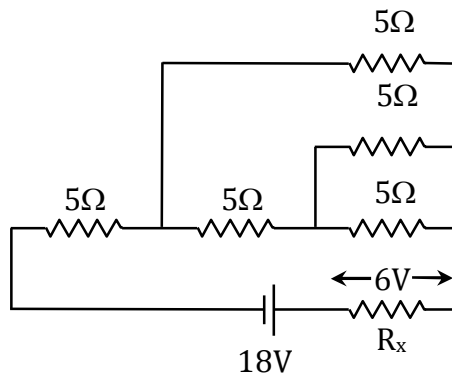
18. In the adjoining circuit, $R = 5\Omega$. It is desired that of R_x should be



- (A) 4Ω (B) 12Ω (C) 16Ω (D) 20Ω

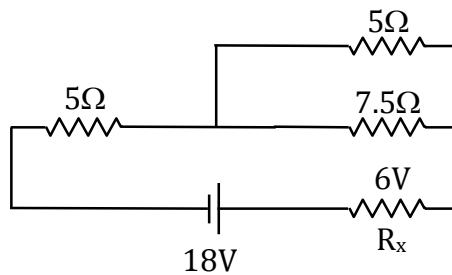
Sol. (A)

Now, according to the question;

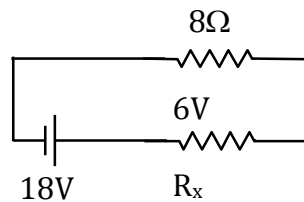


On reducing the circuit.

⇒



⇒



$$R_{eq} = 8 + R_x$$

Now according to ohm's law;

$$\therefore V = IR$$

$$\Rightarrow I = \frac{V}{R_{eq}} = \frac{18}{8 + R_x}$$



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Now, $V_x = I \times R_x$

$$V_x = \left(\frac{18}{8 + R_x} \right) \times R_x$$

$$6 = \left(\frac{18}{8 + R_x} \right) \times R_x$$

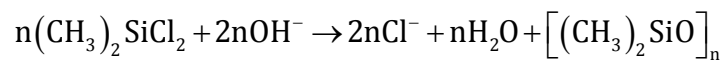
$$\Rightarrow 6(8 + R_x) = 18 \times R_x$$

$$\Rightarrow 8 + R_x = 3 R_x$$

$$\Rightarrow 8 = 2 R_x$$

$$\Rightarrow R_x = 4 \Omega$$

19. In one process for waterproofing, a fabric is exposed to $(\text{CH}_3)_2\text{SiCl}_2$ vapors. The react with the hydroxyl groups on the surface of the fabric or with traces of water to form the waterproofing film $[(\text{CH}_3)_2\text{SiO}]_n$, by the reaction;



Where n stands for a larger integer. The waterproofing film is deposited on the fabric layer upon layer. Each layer is 6\AA thick [the thickness of the $(\text{CH}_3)_2\text{SiO}$ group]. How much $(\text{CH}_3)_2\text{SiCl}_2$, is needed to waterproof one side of a piece of fabric, 1 m by 2 m, with a film 300 layers thick? The density of the film is 1.0g/cm^3 .

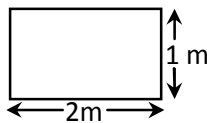
(A) 0.63g

(B) 0.36g

(C) 6.3g

(D) 3.6g

Sol. (B)



$$1\text{ m} \times 2\text{ m}$$

$$\Rightarrow 100\text{ cm} \times 200\text{ cm}$$

$$\Rightarrow \text{Area} = 2 \times 10^4\text{ cm}^2$$

300 layer thick ($6\text{\AA}/\text{layer}$)

$$1800\text{ \AA} = 1800 \times 10^{-10}\text{ m} = 18 \times 10^{-8}\text{ m} = 18 \times 10^{-6}\text{ m}$$

$$d = 1\text{ gm/cm}^3$$

$$\text{Volume} = 2 \times 10^4\text{ cm}^2 \times 10^{-6}\text{ cm}$$

$$\Rightarrow 36 \times 10^{-2}\text{ cm}^3$$

$$\Rightarrow 0.36\text{ cm}^3$$

$$d = \frac{\text{mass}}{\text{volume}}$$

$$\text{Mass} = \frac{1\text{ gm}}{\text{cm}^3} \times 0.36\text{ cm}^3$$

$$\text{Mass} = 0.36\text{ gm}$$



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20. Given that at a certain temperature, in 1.5L vessel, 5.0mole of A, 7.0mole of B and 0.1 mole of C are present. Then the value of equilibrium constant for the reaction $A + B \rightleftharpoons 2C + \text{heat}$ is about

(A) 7.22×10^{-5} (B) 2.31×10^{-4} (C) 7.22×10^{-4} (D) 6.11×10^{-4}

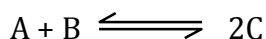
Sol. (B)

1.5 L

$n_A = 5 \text{ mol}$

$n_B = 7 \text{ mole}$

$n_C = 0.1 \text{ mol}$



$$K_c = \frac{[C]^2}{[A][B]}$$

$$\text{Concentration} = \frac{\text{mole}}{V_{\text{sol.}} (\text{L})}$$

$$[C] = \frac{0.1}{1.5}; \quad [A] = \frac{5}{1.5} \quad [B] = \frac{7}{1.5}$$

$$K_c = \frac{\left[\frac{0.1}{1.5}\right]^2}{\left[\frac{5}{1.5}\right]\left[\frac{7}{1.5}\right]} = \frac{10^{-2}}{35} \Rightarrow \frac{100 \times 10^{-4}}{35}$$

$$K_c = 2.86 \times 10^{-4}$$

Choose the closest option

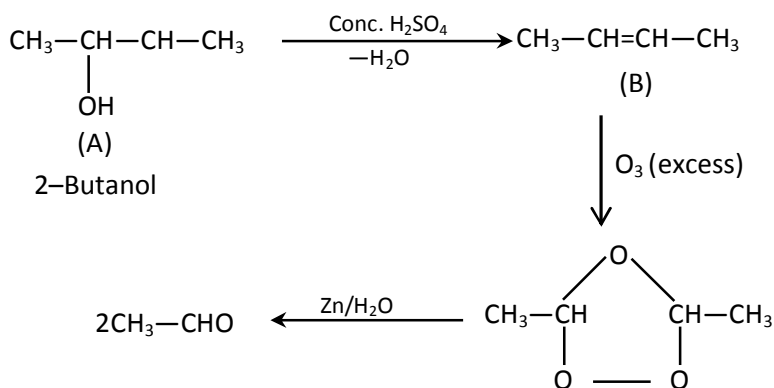
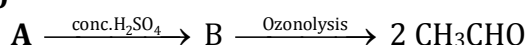
Hence option (B) is correct

i.e. 2.31×10^{-4}

21. An alcohol (A) on dehydration with conc. H_2SO_4 at a high temperature yields compound (B). On ozonolysis every molecule of compound (B) yields two molecules of acetaldehyde. Which of the following is the starting alcohol (A)?

(A) 1 - butanol (B) 2 - butanol (C) propanal (D) 2 - propanol

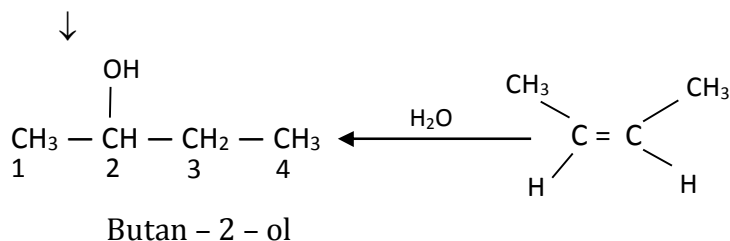
Sol. (B)



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Alternate



22. In an experiment with 100 mL 0.1 M solution of Copper Chloride, by mistake 5 gms of a mixture containing equal weights of Tin, Silver, Lead and Calcium, was added. Finally after some time the solution gets completely decolorized. This is mainly due to:

- (A) Silver reacts with Copper Chloride
 (B) Calcium reacts with Copper Chloride
 (C) All the metals react with Copper Chloride
 (D) Only Lead reacts with Copper Chloride Forming white precipitate of lead chloride

Sol. (B)

Given: $\text{CuCl}_2 \longrightarrow 100 \text{ ml } 0.1 \text{ M}$

5g mixture of equal weight of Sn, Pb, Ca & Pb

$$\text{Wt of Ca in mixture} = \frac{5}{4} = 1.25 \text{ g}$$

$$\text{Moles of Ca} = \frac{1.25}{40} = 0.03125 \text{ mol}$$

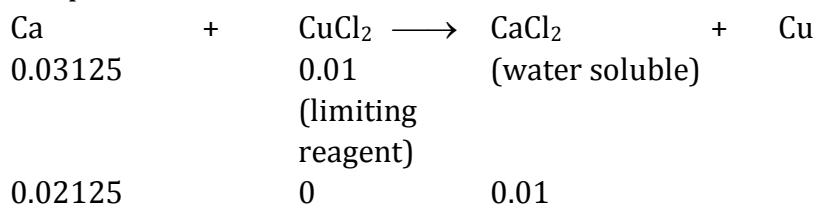
According electrochemical series, reactivity order of metal
 $\text{Ca} > \text{Sn} > \text{Pb} > \text{Cu} > \text{Ag}$

$$\therefore \text{ We know that } M = \frac{\text{Moles}}{V(L)}$$

$$0.1 = \frac{\text{Moles of CuCl}_2}{0.1(L)}$$

Moles of $\text{CuCl}_2 = 0.01 \text{ mol}$

\therefore Here Ca have highest reactivity So it react firstly with CuCl_2 and form CaCl_2 compound as follow -



Hence due to formation of CaCl_2 colour of solution decolorized.



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23. Suppose that A and B forms compound B_2A_3 and B_2A . If 0.05 mole of B_2A_3 weighs 12 g and 0.1 mole of B_2A weighs 10 g, what are the atomic weight of A and B respectively?
 (A) 70 and 25 (B) 50 and 20 (C) 40 and 30 (D) 30 and 40

Sol. Bonus

$$\text{Given : (Mole)}_{B_2A_3} = 0.05 \text{ Mol}$$

$$= (\text{Weight})_{B_2A_3} = 12 \text{ g}$$

$$(\text{Mole})_{B_2A} = 0.1 \text{ Mol}$$

$$(\text{Weight})_{B_2A} = 10 \text{ g}$$

$$\text{We know, mole} = \frac{\text{weight}}{\text{molecular weight}}$$

$$\text{Molecular weight} = \frac{\text{weight}}{\text{mole}}$$

$$(\text{m.wt.})_{B_2A_3} = \frac{12}{0.05} = 240$$

$$2B + 3A = 240 \quad \dots(i)$$

$$(\text{m.wt.})_{B_2A} = \frac{10}{0.1} = 100$$

$$2B + A = 100 \quad \dots(ii)$$

equation (i) - equation (ii)

$$2B + 3A = 240$$

$$2B + A = 100$$

$$- \quad - \quad -$$

$$2A = 140 \Rightarrow A = 70$$

$$\text{and } B = 15$$

24. Tirclosan ($C_{12}H_7Cl_3O_2$) is an antibacterial and antifungal agent. It is a polychlorophenoxy phenol. It is widely used as a preservative and antimicrobial agent in personal care product such as soaps, skin crasms, and deodorants etc. A label on a 200 mL hand sanitizer bottle claims that it contains Triclosan 0.2% w/v. what will be the number of molecules of Triclosan present in the bottle? (N_A is Avogadro's Numbr)
 (A) $1.4 \times 10^{25} N_A$ (B) $1.4 \times 10^{24} N_A$ (C) $1.4 \times 10^{23} N_A$ (D) $1.4 \times 10^{22} N_A$



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Sol. Bonus**Given :**

$$200 \text{ mL} \longrightarrow 0.2 \% \text{ w/V}$$

$$\text{In } 100 \text{ mL weight of triclosan} = 0.2 \text{ g}$$

$$\text{So in } 200 \text{ mL} \longrightarrow 0.4 \text{ g}$$

$$\text{Weight of Triclosan } (\text{C}_{12}\text{H}_7\text{Cl}_3\text{O}_2) = 0.4 \text{ g}$$

$$\text{Mole} = \frac{\text{Weight}}{\text{Molecular weight}} = \frac{0.4}{289.5}$$

$$\text{Mole} = 0.001382 = 0.0014 = 1.4 \times 10^{-3}$$

$$\text{Mole} = \frac{\text{Number of molecules}}{N_A}$$

$$\text{No. of molecules} = 1.4 \times 10^{-3} \times N_A$$

25. If $0 \leq x \leq \pi$ and $81^{\sin^2 x} + 81^{\cos^2 x} = 30$, then $x =$

(A) $\frac{\pi}{6}$

(B) $\frac{\pi}{3}$

(C) $\frac{5\pi}{6}$

(D) $\frac{2\pi}{3}$

(Useful information: $\pi^c = 180^\circ$, $\sin(180 - \theta) = \sin \theta$, $\sin \theta \geq 0$ when $0 \leq \theta \leq 180^\circ$)

Sol. (ABCD)

$$81^{\sin^2 x} + 81^{(1-\sin^2 x)} = 30$$

$$81^{\sin^2 x} + \frac{81}{81^{\sin^2 x}} = 30 \quad \{\text{Let } 81^{\sin^2 x} = t\}$$

$$t + \frac{81}{t} = 30$$

$$t^2 + 81 = 30t.$$

$$t^2 - 30t + 81 = 0$$

$$(t - 3)(t - 27) = 0$$

$$t = 3, t = 27$$

$$81^{\sin^2 x} = 3 \text{ or } 81^{\sin^2 x} = 27 \quad \{\text{By Power compare}\}$$

$$\sin^2 x = \frac{1}{4} \text{ or } \sin^2 x = \frac{3}{4}$$

$$\sin x = \frac{1}{2}, \sin x = \frac{\sqrt{3}}{2}$$

$$\sin x = \frac{\pi}{6} \text{ or } \sin x = \frac{\pi}{3}$$

$$\text{or } x = \pi - \frac{\pi}{6} = \frac{5\pi}{6} \text{ or } \sin x = \pi - \frac{\pi}{3} = \frac{2\pi}{3}$$



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$$\text{So, } x = \frac{\pi}{6}, \frac{\pi}{3}, \frac{5\pi}{6} \text{ and } \frac{2\pi}{3}$$

26. Given $(a - b)^2 + (a - c)^2 = (b - c)^2$, then which of the following statements are true?

- (A) equation is valid when $b = c$ and $a \neq c$
 (B) equation is valid when $a = b$
 (C) equation is valid when $a = c$
 (D) Given equation is not valid when a, b and c are distinct.

Sol. **(BCD)**

$$(a - b)^2 + (a - c)^2 = (b - c)^2$$

(A) $b = c, a \neq c$

$$(a - c)^2 + (a - c)^2 = 0$$

$$2(a - c) = 0$$

$$a = c \text{ (Not Follow)}$$

(B) $a = b$

$$(a - a)^2 + (a - c)^2 = (a - c)^2$$

$$a = c$$

(C) $a = c$

$$(a - b)^2 + (a - a)^2 = (b - a)^2$$

$$(a - b)^2 = (b - a)^2$$

$$a - b = b - a$$

$$2a = 2b$$

$$a = b$$

(D) We can say from option (B) and (C) that (D) is also correct.

27. Choose the correct statement from following options.

- (A) A robust adaptive immune response is initiated using weakened form of the bacterium known as live attenuated vaccines.
 (B) Administration of a killed or chemically inactivated virus can trigger a weaker adaptive immune response, but can be strengthened with booster doses.
 (C) A conjugate or multivalent component always reduces immunogenicity of the vaccine.
 (D) Inclusion of alum, cytokines, and / or lipids always reduces the immune response to a vaccine.

Sol. **(AB)**

- (A) An attenuated vaccine is a vaccine created by reducing the virulence of a pathogen but still keeping it live. It stimulates a strong and effective immune response that is long lasting.



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Administration of a killed or chemically inactivated virus can trigger a weaker adaptive immune response, but can be strengthened with booster doses.

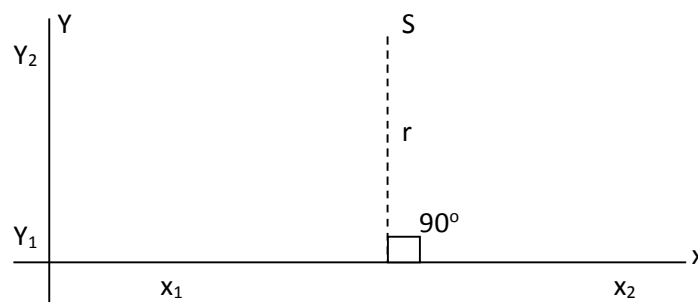
28. The minimum energy required to exist that is the energy required to perform chemical reactions even when a person is at rest is called the basal metabolic rate (BMR), which accounts for about 50 to 70% of the daily energy expenditure in most sedentary individuals. It is influenced by many factors. Some statements are made about these factors. Choose the correct statements from the following options.

- (A) Thyroid hormone decreases metabolic rate
 (B) Growth hormone increases metabolic rate
 (C) Fever decreases metabolic rate
 (D) Malnutrition decreases metabolic rate

Sol. (BD)

- (B) Growth hormone increase the metabolic rate as it increases protein and carbohydrate metabolism for body growth.
 (D) Malnutrition slows growth rate, delays maturity and small adult stature because overallly BMR will be low.

29. An infinitely long conductor when carrying current/ produces a magnetic field B around it, if such a conductor is placed along the X-axis, then the magnitude of B at a distance r is given by the relation $B = \frac{\mu_0 2I}{4\pi r}$, (where $\frac{\mu_0}{4\pi} = 10^{-7} \text{NA}^{-2}$ is a constant). The Following figure shows such an infinitely long conductor placed along X-axis carrying current / and B at S is $2 \times 10^{-4} \text{T}$, directed into the plane of the paper at S. Given $r = 1 \text{ cm}$. Then, the correct statements are :



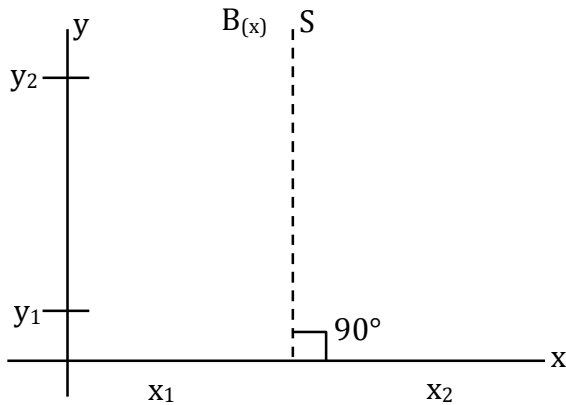
- (A) $I = 10 \text{ A}$
 (B) The number of electrons transported across the cross section of the conductor during time 1s is 6.25×10^{19}
 (C) The direction of current is from x_2 to x_1
 (D) The electrons will flow in the direction x_2 to x_1



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Sol. (ABC)



$$\text{Given that magnitude of magnetic field } B = \frac{\mu_0 2I}{4\pi r} \dots(1)$$

$$\frac{\mu_0}{4\pi} = 10^{-7} \text{ NA}^{-2} \dots(2)$$

Current = I

$$B = 2 \times 10^{-4} \text{ T} \dots(3)$$

$$r = 1 \text{ cm} = 1 \times 10^{-2} \text{ m.} \dots(4)$$

Substituting the values from equations (2), (3) and (4) in equation (1), we get

$$2 \times 10^{-4} = 10^{-7} \times \frac{2I}{10^{-2}}$$

$$\Rightarrow I = 10 \text{ A}$$

\therefore Option (A) is correct

$$\text{As from the definition of current } (I) = \frac{\text{Charge}(q)}{\text{time}(t)}$$

$$\Rightarrow q = I \times t = 10 \times 1 = 10 \text{ C}$$

$$\therefore q = ne \quad \Rightarrow n = \frac{q}{e}$$

$$\text{The number of electrons } n = \frac{10}{1.6 \times 10^{-19}} = 6.25 \times 10^{19}$$

Option (B) is correct.

From right hand thumb rule as magnetic field is directed into the plane of paper, therefore thumb represents the direction of current i.e., from x_2 to x_1 .

\therefore Option (C) is correct.

\therefore Electrons flows opposite to the direction of current, therefore the direction of electrons flow will be from x_1 to x_2 .

\therefore Option (D) is incorrect.

Option (A, B, C) are correct.



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30. The ratio of the charge of an ion or subatomic particle to its mass (q/m) is called specific charge. Then the Correct options are
 (A) SI unit of specific charge can be written as A-S / kg.
 (B) If all the isotopes of hydrogen are ionized then tritium will have least specific charge among them.
 (C) Specific charge of an α -particle will be greater than that of an electron.
 (D) Specific charge ratio of an electron is 1.75×10^{11} / kg.

Sol. (ABD)

$$\text{Specific charge (S.C.)} = \frac{C \leftarrow \text{Column}}{m \leftarrow \text{Kg}}$$

$$(A) \text{ S.I. unit } \Rightarrow \text{C/Kg} \Rightarrow \frac{\text{Amp.sec}}{\text{Kg}} \quad (\text{Correct})$$

(B) Ionized isotopes : (${}_1\text{H}^1$)⁺, (${}_1\text{H}^2$)⁺, (${}_1\text{H}^3$)⁺,

$$\text{S.C.} \propto \frac{1}{\text{mass}} \quad (\text{Here charge is same})$$

Mass of ${}_1\text{H}^3$ is maximum S.C. of ${}_1\text{H}^3$ is minimum (Correct)

(C) Incorrect

(D) Correct

31. Acetylene torches and burner used by glassblowers produce intense ultraviolet light. Glassblowers wear special glasses that contain which of the following elements to absorb the UV?

(A) Neodymium (B) Praseodymium (C) Cerium (D) Didymium

Sol. (D)

At almost 1600°C , our furnaces and these torches gives off harmful UV rays that could permanently damage any part of the human eye.

Didymium works by filtering yellowish light that is closely related to UV rays.

Since didymium does not absorb all visible light.

32. Equal lengths of magnesium ribbons are taken in four test tubes A, B, C and D. In test tube A, 1M acetic acid is added; in test tube B, 1M HCl is added; in test tube C, 1M HNO_3 is added; and in test tube D, 1M NaOH is added. The observed results will be:

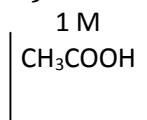
(A) The fizzing occurs more vigorously in A.

(B) The fizzing occurs more vigorously in B.

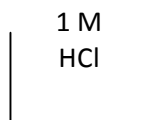
(C) The fizzing occurs more vigorously in C.

(D) The fizzing occurs more vigorously in D.

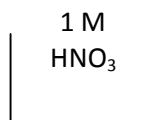
Sol. (BC)



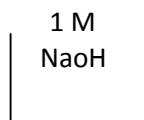
(A)



(B)



(C)



(D)

Both HCl and HNO_3 are strong acid. So, they vigorously reacts with Mg ribbon and produces $\text{H}_2(\uparrow)$. Hence (B) and (C) are correct.



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PART - 2

1. The autonomous nervous system regulates involuntary functions of the body and can be subdivided into the sympathetic and the parasympathetic nervous system. Both of these systems control the same group of body functions, but have opposite effects on the function they regulate. The sympathetic nervous system prepares the body for intense physical activity like the fight-or-flight response. The parasympathetic nervous system has the opposite effect and relaxes the body and inhibits or slows many high energy functions. Which of the following involuntary effects in the body are brought about by the sympathetic nervous system during a fight-or-flight situation?

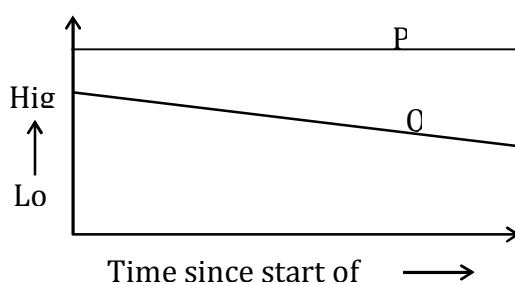
- | | |
|--|-------------------------|
| i. Increased salivation | ii. Increased digestion |
| iii. Loss of bowel and bladder control | iv. Body shivering |
| v. Crying | vi. Pupil dilation |
- (A) i, ii and vi
(B) i, iv and v
(C) iii, iv and vi
(D) ii and v

Sol. (C)

During fight or flight situation the following involuntary effects are brought about by sympathetic nervous system.

- The salivation decreases as effect of decrease activity of digestive system.
- Pupil dilation- allow more light for proper visibility.
- Loss of bowel and bladder control: It is very common to lose voluntary control of bladder or bowel control in a stressful and dangerous situation.
- Body shivering: Due to anxiety.
- Crying depends on an individual.

2. When a person starts exercising, many body parameters change from the original state of rest. The trends in two such parameters are shown in the graph during the initial phase of exercise.



P and Q most likely represent:

- | | |
|-------------------------------------|------------------------------------|
| (A) P: carbon dioxide level in vein | Q: oxygen level in artery. |
| (B) P: breathing rate | Q: carbon dioxide level in artery. |
| (C) P: oxygen level in artery | Q: carbon dioxide level in vein. |
| (D) P: oxygen level in artery | Q: oxygen level in vein. |



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Sol. D

Given graph represent the initial phase of exercise.

P and Q most likely represent

P – Oxygen level in artery

Q – Oxygen level in vein

As we start exercise initially the tissue/cells begins cellular respiration at a higher pace so the oxygen level in vein will decrease mean while the oxygen level in artery will remain same. Now this changed situation signals will be sent to brain leading to further changes.

3. Descriptions of four biological samples (I - IV) are given below.

I: Can be viewed using a light microscope with a total magnification of 1000x; possesses cell wall and does not possess mitochondria.

II. Can be seen using a light microscope with a total magnification 100x; possesses cell wall and has nucleus.

III. Need electron microscope for viewing; can be found attached to the membrane system in the cytoplasm.

IV. Needs electron microscope for viewing; cannot replicate on its own, needs other specific cells for replication.

I, II, III, and IV respectively represent.

(A) virus, plant cell, ribosome; bacteria.

(B) plant cell: bacteria: vacuole, virus.

(C) bacteria, plant cell; ribosome, virus.

(D) bacteria; protist; plant cell vacuole; mitochondria.

Sol. (C)

I. Prokaryote bacteria: Possess cell wall and does not have any cell organelle like mitochondria. They can be viewed using a light microscope (1000x).

II. Plant cell: Magnification – 100X possess a cell wall, have a nucleus (eukaryotic).

III. Ribosome: Found attached to endoplasmic reticulum in the cytoplasm.

IV. Virus: They cannot replicate on their own and require other specific cell for their replication.

Since they are very very small so we need electron microscope for visualising them.

4. Raja's mother collects all the kitchen waste every day and puts it in a pot. She then adds a few cut pieces of old papers, a spoonful of sour buttermilk and some soil. She covers the pots, and keeps it aside with of decomposition in this composting process the a nutrient-rich compost to grow plants. In the context of decomposition in this composting process, the most appropriate statement among the following is



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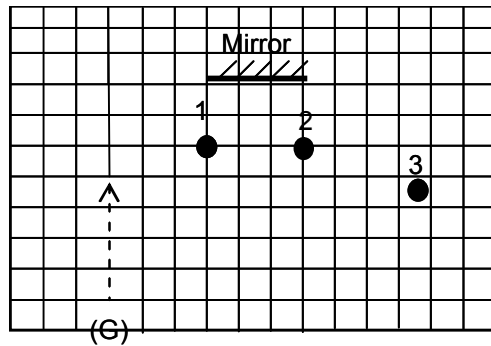
- (A) Paper acts as a good source of carbon while buttermilk gives the correct acidity to the mixture.
- (B) Soil acts as a good source of inorganic nitrogen while buttermilk is a good source of proteins.
- (C) Paper is a good source of carbon while buttermilk is a good source of starter bacteria.
- (D) Paper is a good source of fibre while a buttermilk is a good source of s.

Sol. C

Component for decomposition in a pot: Kitchen waste + few cut piece of old papers + spoonful of sour buttermilk + some soil.

Paper is a good source of carbon while buttermilk is a good source of starter bacteria as this starter bacteria has lactobacillus which also acts as a decomposer.

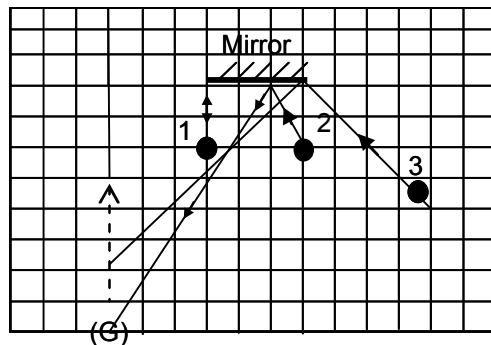
5. A girl (G) walks into a room along the path shown by the dashed line (see figure on right). She tries to observe images of small numbered 1, 2 and 3 in the plane mirror on the wall.



The order in which she will see images of the toys is:

- (A) 3, 2, 1
- (B) 3, 2
- (C) 1, 2, 3
- (D) 2, 3

Sol. D



G will be able to see image of 2 then image of 3.

6. A heating element in the form of a wire with uniform circular cross sectional area has a resistance of 310Ω , and can bear a maximum current of 5.0 A . The wire can be cut into pieces of equal length. The number of pieces, arranged suitably, so as to draw maximum power when connected to a constant voltage of 220 V , is
- (A) 7
 - (B) 8
 - (C) 44
 - (D) 62



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Sol. $P = \frac{V^2}{R}$

$P_{\max} = \frac{V^2}{R_{\min}}$; so that power will be maximum

As, $I_{\max} = 5A$

$\therefore I = \frac{V}{R}$

$5 = \frac{220}{R}$

$R = 44 \Omega$

Resistance minimum when connected in parallel

$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + n \text{ Resistors}$

$\frac{1}{44} = n \left(\frac{1}{310} \right)$

$n = 7.04 \cong 7 \text{ resistors}$

7. Consider the following two statements:

Statement S1: If you put 100g ice at 0°C and 100g water at 0°C into a freezer, which is maintained at -10°C, the ice will eventually lose the larger amount of heat.

Statement S2: At 0°C, water is denser than ice. Choose the correct statement among the following.

(A) Both S 1 and S 2 are true and S 2 is the correct explanation of S 1.

(B) Both S I and S 2 are true but S 2 is not the correct explanation of S 1.

(C) S1 is true but S 2 is false.

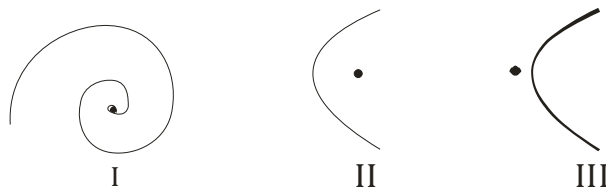
(D) S1 is false but S 2 is true.

Sol. (i) Since final temperature will less then 0°C

So water will lose more heat so statement 1 is false

(ii) At 0°C density of water is more then ice. So statement 2 is true

8. Consider the paths of(1) Halley’s Comet near the sun and (2) an alpha particle scattered by a nucleus. In the figures below, the dots represent the Sun/Nuclei, and the curves with arrows mark the paths of that comet/alpha particles schematically,



The correct statement about the trajectories is:



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- (A) I represents trajectory for Halley's Comet and II for the scattering of alpha particles.
- (B) III represents trajectory for Halley's Comet and II for the scattering of alpha particles.
- (C) II represents trajectory for Halley's Comet and I for scattering of alpha particles.
- (D) II represents trajectory for Halley's Comet and III for scattering of alpha particles.

Sol. D

9. When water changes phase from liquid to vapour, some bonds are broken. The correct statement relating to this change is:
- (A) New bonds are formed between nearby H/H and O/O while H–O bonds break.
- (B) Hydrogen bonds between H_2O molecules are broken.
- (C) Covalent bonds existing within the H_2O molecules are broken.
- (D) Ionic bonds existing between H^+ ions and OH^- ions are broken.

Sol. B

10. Jyoti was asked by her mother to add a pinch of potassium permanganate to water in a container to disinfect it. As she added the crystals and observed the changes in water, the phenomena of diffusion came to her mind. She wrote the following statements. Identify the statement made by Jyoti that is incorrect.
- (A) When the entire liquid is of uniform color no further diffusion can be observed.
- (B) The diffusion gets completed almost instantaneously.
- (C) Diffusion will take place slower if the water is colder.
- (D) Maximum color in liquid originates from the bottom of the flask.

Sol. B

11. Ramen collected rain water and measured its electrical conductivity. He boiled the water for a few minutes. Then he covered the container and allowed the water to cool to room temperature. Electrical conductivity of water now measured was lower than that measured before boiling. The reason for this most likely is:
- (A) precipitation of CaCO_3 from the water during boiling.
- (B) removal of dissolved oxygen from the water.
- (C) removal of dissolved carbon dioxide from the water.
- (D) Reaction of cationic species in the water with atmospheric oxygen.

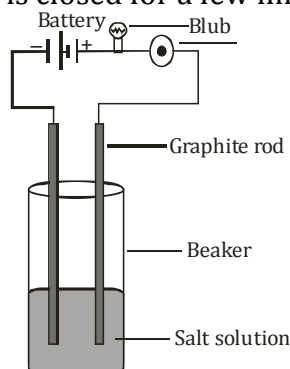
Sol. C



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12. Consider a setup in which two graphite rods are immersed in a 2M NaCl(aq.) solutions. The rods are connected to two terminals of a 9V battery with a bulb in series as shown in the figure. Of the following, the change that will NOT be observed when the circuit is closed for a few minutes is:

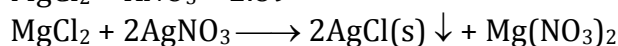


- (A) The bulb will glow.
 (B) The pH of solution near the cathode will increase.
 (C) Oxygen gas would be generated near the +ve electrode which all oxidize the graphite electrode.
 (D) Total mass of liquid in the beaker will decrease.

Sol. C

13. (3 marks) A student was given 2.89 g of a mixture containing anhydrous MgCl_2 and KNO_3 , and had to quantify amount of MgCl_2 in the mixture. The student uses excess $\text{AgNO}_3(\text{aq})$ to precipitate the chloride ions as $\text{AgCl}(\text{s})$, and find the mass of the AgCl precipitate to be 5.32g. Calculate the mass percentage of MgCl_2 , in the original mixture. (Atomic masses should be taken as per the data given.)

Sol. Given amount of mixture of



Amount of AgCl formed = 5.32 gm

Molar mass of AgCl = 107.87 + 35.45

$$= 143.32 \text{ gm}$$

$$\text{Moles of AgCl formed} = \frac{5.32}{143.32}$$

$$\text{Moles of MgCl}_2 \text{ required to form above amount of AgCl} = \frac{5.32}{143.32} \times \frac{1}{2}$$

$$\text{Moles of MgCl}_2 = 24.30 + 35.45 + 35.45 = 95.2$$

$$\text{Mass of MgCl}_2 \text{ reacted} = \frac{5.32}{143.32} \times \frac{1}{2} \times 95.2$$

Mass percentage of MgCl_2 in the mixture.

$$\frac{\frac{5.32}{143.32} \times \frac{1}{2} \times 95.2}{2.89} \times 100 = 61.14\%$$



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14. (12 marks) Iodine, an essential element for humans, is naturally present in some marine fishes, plants and ecosystems at large. Solubility of elemental iodine in water is negligible but is high in non-polar organic solvents. The most common form of iodine used in the diet of humans and animals is potassium iodide (KI), a white solid powder at room temperature, which is highly soluble in water.
- 14.1 In a chemistry laboratory period, 36 students of a class had to perform tests.
- 0.5 gram KI is dissolved in about 5cm^3 distilled water. A drop of this solution is put on a moist pH paper.
 - 0.5 gram KI is dissolved in about 5cm^3 distilled water. Part of this solution is mixed with lead (II) nitrate solution. The colour changes in the mixture are observed.
 - 0.5 gram KI is put in a test tube containing about 5cm^3 distilled water. Then they are to observe whether the test tube becomes hot or cool on mixing.
- In test ii, a yellow precipitate is observed. In test iii, the test tube becomes colder as KI dissolves.
- Identify the colour imparted on pH paper in test i.
 - Being very expensive, KI should be economically used. What is the minimum amount of KI (in grams) required for the complete class for carrying out the above three tests procedures?

Write necessary calculations/reasoning needed to arrive at your answer.

- Sol. (a) green
- (b) only one test tube of 0.5 gm KI is sufficient for each student, then for whole class minimum amount of KI required = $36 \times 0.5 = 18\text{ g}$.
- 14.2 An aqueous solution of KI treated with acidified solution of hydrogen peroxide (in sulphuric acid) gives a precipitate of Iodine crystals.
- write the balanced molecular equation for the reaction.
 - identify the reducing agent in the reaction.
 - The most appropriate option to separate iodine from the above mixture is:
A. Filtration
B. distillation
C. steam distillation
D. chromatography
E. using a magnet

- Sol. (a) $[\text{H}_2\text{SO}_4 + \text{H}_2\text{O}_2 + 2\text{KI} \longrightarrow \text{K}_2\text{SO}_4 + \text{I}_2 + 2\text{H}_2\text{O}]$
- (b) KI – reducing agent
- (c) filtration



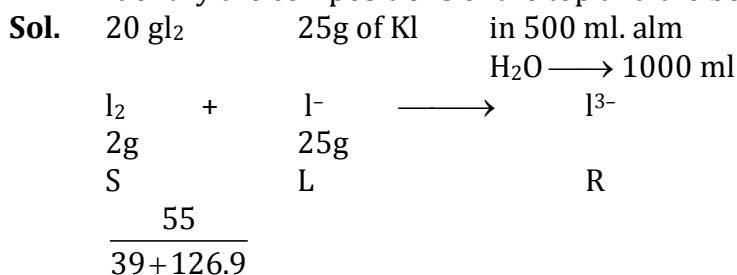
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- 14.3** When solid KI is heated in an open dry test tube, a gas is liberated from the test tube.
- (a) What is the colour of the gas?
 (b) After the gas evolution stops, what remains in the test tube? Write its chemical symbol/formula (if mixture, write formulae of components) and its state (solid/liquid).
 (c) The reaction can be classified as(identify the correct option(s)):
 (A) thermal combination (B) thermal decomposition
 (C) double displacement (D) displacement reaction
- Sol.** (a) Violet (b) Potassium (Solid) (c) Thermal decomposition.

- 14.4** Tincture iodine is an antiseptic, also effective in inactivating the novel coronavirus. It is prepared by dissolving 20 g of Iodine and 25 g of KI in 500mL alcohol and then adding distilled water to make the volume 1000ml. In this process, iodine combines with I^- to produce I_3^- species. Sumit and Rekha were separately preparing tincture iodine using the above procedure. Sumit was working hurriedly, as he wanted to join a birthday party. By mistake, he added carbon tetrachloride in the flask instead of alcohol. At the end of the procedure, two immiscible liquid layers remained separate. He observed that the lower layer was strongly colored. While the upper layer had a faint colour different from the lower layer. Rekha followed the protocol perfectly and get a homogenous mixture.

Identify the compositions of the top and the bottom layers in Sumit's flask.



I_2 reacts with KI to form KI_3 .

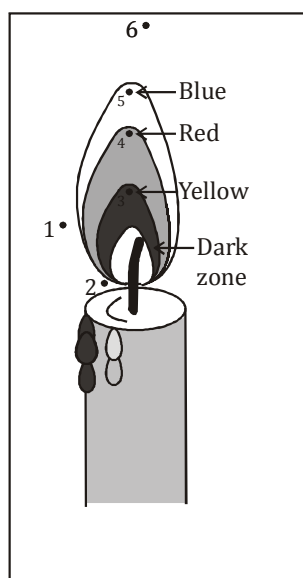
Here KI & KI_3 both are salts. Which are more soluble in water so KI & KI_3 remain in top layer hence there will be yellowish brown colour due to presence of KI_3 salt. While I_2 is a nonpolar molecule, which is more soluble in CCl_4 where it would exhibit the characteristic violet colour of solution of molecular iodine in bottom layer of sumit's flask.

- 15.** Flame is a hot bright stream of burning gases, Flames have different structures and properties depending on fuel and burning conditions. The attached figure (drawn approximately to scale) shows a candle flame burning in open air in which three regions are distinctly visible surrounding air in which three innermost zone that is pale yellow in colour, surrounded by a red zone, with a bluish envelop at the outside. Point 1–6 represent different locations in the inside and surrounding flame. Consider wax to have chemical formula $C_{24}H_{50}$.



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15.1 Among points 1–6, identify

(a) the hottest point.

(b) the coldest point.

(c) the point where water vapour concentration is the highest.

Sol. (a) point - 5 (b) point - 2 (c) point - 6

15.2 From the following list, identify two substances that are present at point 3 but not at point 6. Also write chemical equations for the reactions causing removal of these substances.

List: Oxygen, Nitrogen, Carbon, Wax, Carbon dioxide, Carbon monoxide, Water.

Sol. Carbon and carbon monoxide

15.3 The space at point 2 prominently has (identify the correct option):

(A) only air.

(B) air with freshly evaporating wax vapour.

(C) air with extra carbon dioxide released from combustion.

(D) oxygen rich air (as oxygen concentration has locally increased due to diffusion).

Sol. (D) oxygen rich air (as oxygen concentration has locally increased due to diffusion).

15.4 Another flame used in laboratories is produced from Bunsen burner. It is used for heating, combustion, sterilization process, etc. By adjusting the ratio of gas (fuel) and air in Bunsen burner, it is possible to get a stable blue flame, which is largely non-luminous. Shlok was given two different organic compound: naphthalene ($C_{10}H_8$) and citric acid ($C_6H_8O_7$). He burned 1.0g of each compound separately in a porcelain piece in a blue Bunsen burner flame.

For which of the two compound, the flame would emit more yellow light? Write reason for your answer, along with necessary supporting calculations/arguments.

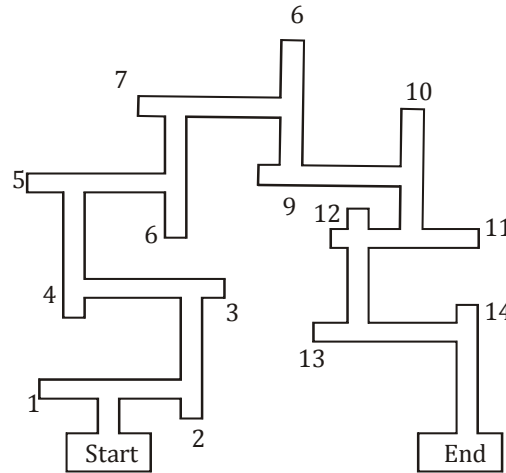
Sol. **Reason** : naphthalene ($C_{10}H_8$) emit more yellow light because it is an unsaturated hydrocarbon.



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16. (8 marks) A famous experiment performed by Tolman and Honzik (in 1930) studied the behavior of rats in a complex maze (shown in the figure) for a period of 17 days. The rats had to find their way around the maze once every day. All rats were healthy and were given regular meals throughout the experiment. The rats were divided into 3 groups, which were treated as follows on reaching the end of the maze.



Group I:

Day 1-17 every time the rats reached the end, they were given additional food.

Group 2:

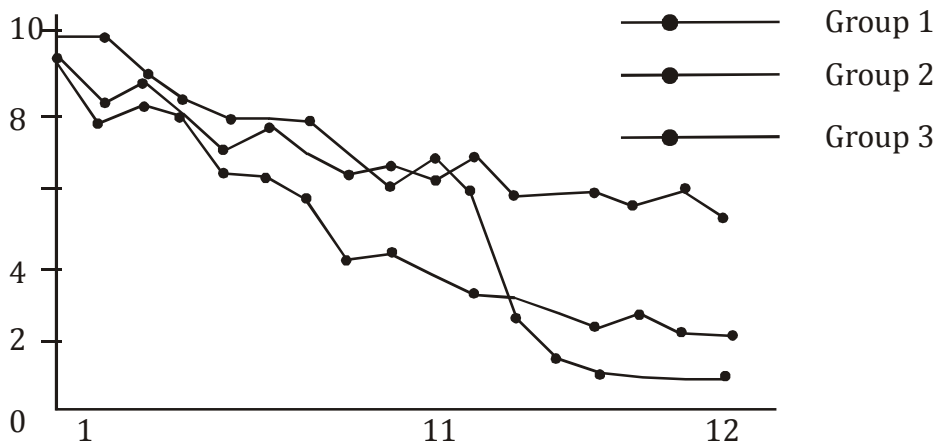
Day 1-10. Every time the rats reached the end, they were removed from the maze.

Day 11-17 every time the rats reached the end, they were given additional food.

Group 3:

Day 1-17: every time the rats reached the end, they were removed from the maze.

The average number of errors (any deviation from the shortest correct path to reach the end) observed for each group of rats is shown in the graph below.



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- 16.1** A few statements are listed below statements as True or False.
- (a) Rats need good nutritional status to perform well in the maze.
 - (b) Result shows characteristic stimulus (maze) - response (reaching the end) behavior which is genetically determined and hence not changeable.
 - (c) The find of end of the maze is by trial and error method and not due to learning.
 - (d) Rewarding the rats has improved the end results.
 - (e) There was active learning happening in rats in group 2 even before day 11 .

- Sol.**
- (a) Flase: There is no rleation of nutrition and performance in the maze.
 - (b) False: The response towards the stimulus is not genetically determined and is basically behaviourly learned which can be changed.
 - (c) False: the find of end of the maze is due to learning.
 - (d) True: Yes rewarding the rats has improved the end results.
 - (e) True: Group 2- before lay 11 - every time the rats reached the end, they were removed from the maze.

So, this was also active learning.

- 16.2** What response can be expected if the rats in the group I were kept hungry before the experiment? Assume that all other conditions in the above experiment setup remain the same. Choose the most appropriate option from choices below and justify your choice based on the experimental observations presented above (only) Also give reasons for rejecting the other three options.

- (A) Overall rise of line 1 above line 3 .
- (B) Increase in errors as the experiment proceeds.
- (C) Steeper decrease in the line 1 in lesser time.
- (D) Same response as line 3 in the graph.

- Sol. (C)**

When rats of group 1 are kept hungry before the experiment so they will reach quickly at the end when kept in maze as the end point will give them food. So the chances of errors will decrease and this will increase learning.

So (C) is the correct option.

Steeper decrease in the line 1 in lesser time.

- 17.** (7 marks) In the early nineteenth century, two scientists Payen and Persoz ground barley seed in water to prepare a crude extract (A). The scientists then carried out a series of treatments on the extract A. At every step, iodine tests were carried out as follows.

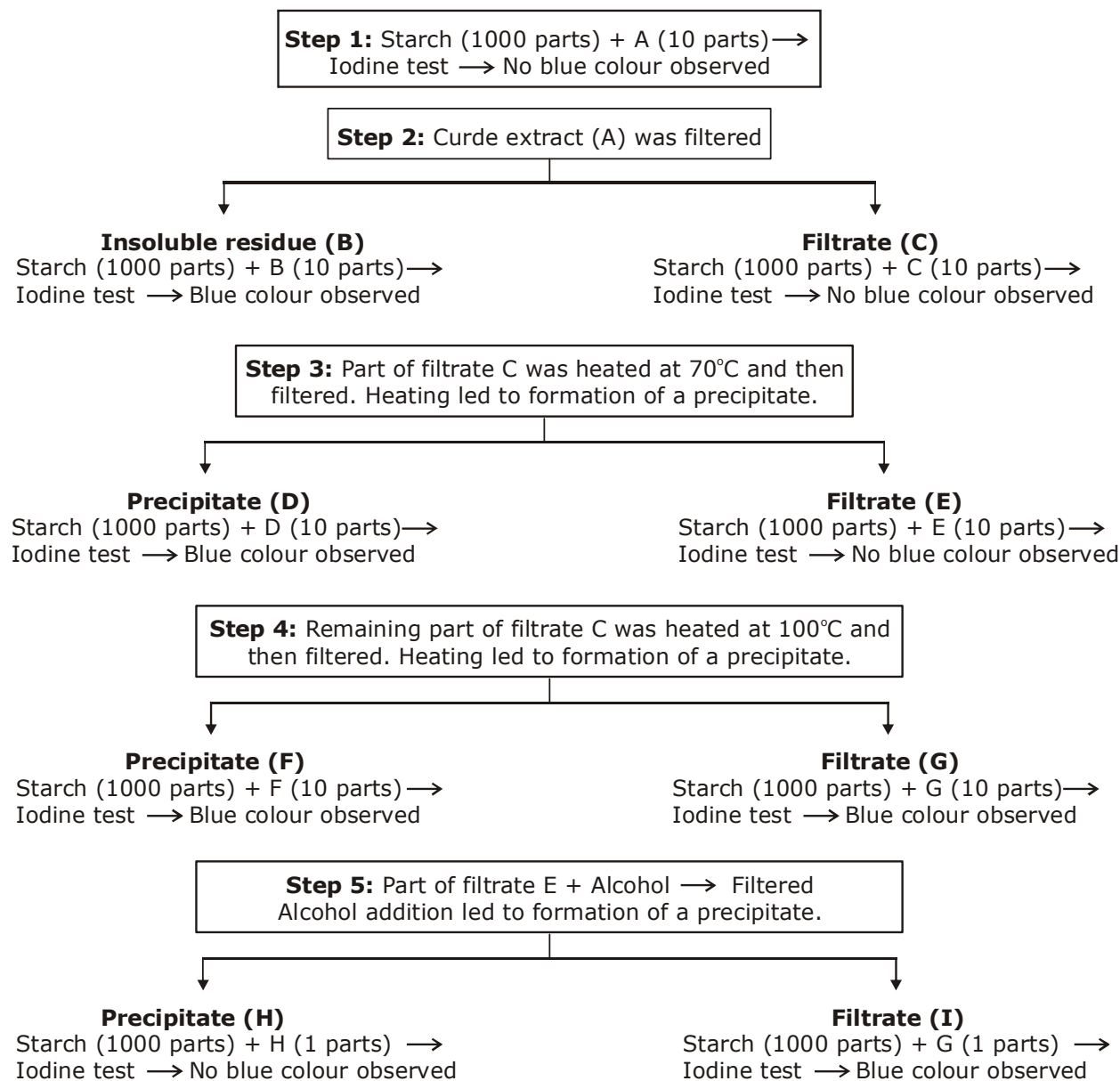
Iodine test: Mixture (Starch + sample) → wait for 10 mins → Add iodine → Check for colour changes.



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The different steps of treatment and the result recorded are shown in the flow chart below.



17.1 Blue colour indicates: (identify the correct option)

- (A) that starch is a polymer of glucose units.
- (B) that starch is digested into small units of glucose.
- (C) glucose units released from starch have formed complex with iodine.
- (D) iodine is trapped in the intact polymer of starch.

Sol. D



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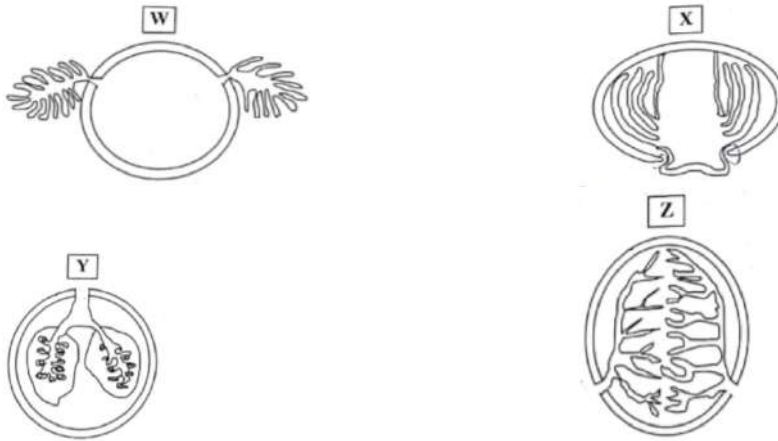
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- 17.2** Based on the observations, identify each of the following statements as True or False.
 (a) Barley seeds contain a substance that converts glucose to starch.
 (b) Barley seed coat contains a substance that can convert starch to glucose but it gets destroyed by heat.
 (c) The substance present in Barley seeds is water soluble and breaks starch into small units.
 (d) The process of heating up to 70°C enhances the chemical activity of the barley filtrate but heating above 70°C inactivates it.
- Sol.** (a) T, (b) F, (c) T, (d) T

- 17.3** Which of the preparations (A to I) indicate the presence of the "active substance" being analyzed in the experiment?

Sol. A, C, E, H contain active substance

- 18.** (7 Marks) Different types of respiratory organs in animals occupying different habitats are represented in the figure (W–Z) below.



- 18.1** The organs most likely belong to: (choose from the options) cockroach, prawn, tadpole and rabbit?

The Fick's law of diffusion shows how various factors influence the rate of diffusion and is represented as:

$$Q = DA(P_1 - P_2)/L$$

Where Q = rate at which a gas such as O₂ diffuses between two locations

D = diffusion coefficient, which is characteristic of the diffusing substance (eq., a gas), the medium and the temperature.

A = cross sectional area over which the gas is diffusing

P₁ and P₂ are the partial pressure of the gas at the two locations.

L = path length or distance between the two locations.

Sol. W – Tadpole → Gills

X – Prawn → Gills

Y – Rabbit → Lungs

Z – Cockroach → Trachea



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18.2 If the temperatures of the habitats, in which the four animals having the organs of type W–Z live, are the same, then based on the medium used for gas exchange, the value of D would be higher for animals possessing respiratory organs of the types (a) _____ as compared to animals with organs of types (b) _____ (choose from W–Z).

Sol. Given, The Fick's law of diffusion shows how various factors influence the rate of diffusion and is represented as:

$$Q = DA(P_1 - P_2)/L$$

Where Q = rate at which a gas such as O₂ diffuses between two locations

D = diffusion coefficient, which is characteristic of the diffusing substance (eq., a gas), the medium and the temperature.

A = cross sectional area over which the gas is diffusing

P₁ and P₂ are the partial pressure of the gas at the two locations.

L = path length or distance between the two locations.

So if the temperature of the habitats in which the four animals having organs W–Z live are same, then, based on the medium used for gas exchange, the value of D would be higher for animals possessing respiratory organs of the type (a) Y, Z as compared to animals with organs of type (b) W, X.

18.3 Two features of respiratory organs in animals are listed in Column I in the given table. Fill in.

- column II with the appropriate factor from Fick's law equation that will be affected by the feature mentioned in the column I,
- column III with the effect that the feature will have on the factor mentioned in Column II, and
- - column IV with the corresponding effect on the rate of diffusion (Q).

(Marks will be given only for completely correct row.)

Column I	Column II	Column III	Column IV
Feature	Factor affected (D/A/P ₁ or P ₂ /L or none)	Effect (increase/decrease/no change)	Effect on Q (increase/decrease no change)
1. Highly branched and folded extensions	-	-	-
2. Presence of very thin-walled tissues	-	-	-



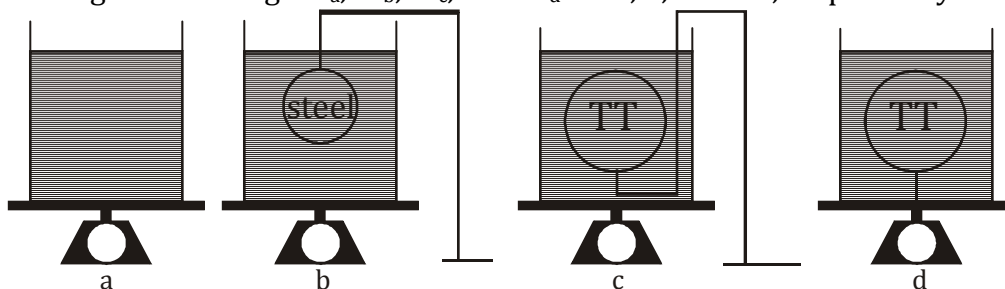
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Sol.

Column I	Column II	Column III	Column IV
Feature	Factor affected (D/A/P1 or P2/L or none)	Effect (increase/decrease/no change)	Effect on Q (increase/decrease no change)
1. Highly branched and folded extensions	A	Increase	Increase
2. Presence of very thin-walled tissues	L	Decrease	Increase

19. (7 Marks) Four identical beakers, as shown below, contain the same amount of water. Beaker 'a' contains only water. A steel ball (mass 0.800 kg) is held submerged in the beaker 'b' by a string from above. A same-sized plastic TT ball (mass 0.020kg) is held submerged in beaker 'c' by a string attached to a stand from outside, as shown in the figure Beaker 'd' contains same sized TT ball held submerged from a string attached to the bottom of the beaker. The volume of each ball is 10^{-4} m^3 . These beakers (without stands) are placed on weighing pans and register readings $W_a, W_b, W_c,$ and W_d for a, b, c and d, respectively.

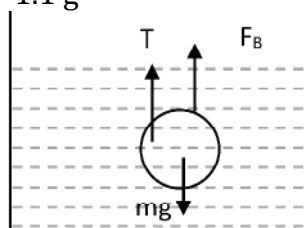


If $W_a = 1\text{kg}$, then obtain $W_a, W_c,$ and W_d . Show the main steps of your calculations. For calculation purpose, ignore the part of stand and the thread submerged in water.

Sol.

Case A: $W_A = 1\text{g}$

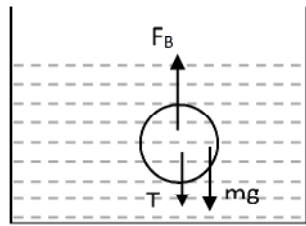
Case B: $W_B = W_A + F_B$
 $= 1\text{g} + (1000)(10^{-4})\text{g}$
 $= 1\text{g} + 0.1\text{g}$
 $= 1.1\text{g}$



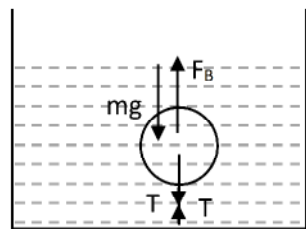
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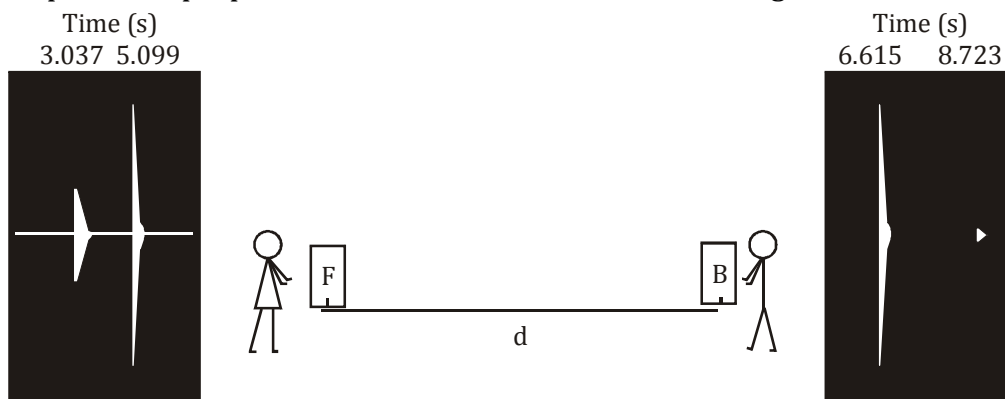
Case C: $W_C = W_A + F_B$
 $W_C = 1g + (1000)(10^{-4})g$
 $W_C = W_B = 1.1g$



Case D: $T = F_B - mg$
 $= 10^3 \times 10^{-4} g - 0.02 g$
 $= (0.1 - 0.02) g$
 $= 0.08 g$
 $W_D = W_A + F_B - T$
 $= W_A + 10^3 \times 10^{-4} g - 0.08 g$
 $= 1g + 0.1 g - 0.08g$
 $= 1.02 g$
 $= 1.02 kg$



20. (6 marks) Smartphones can be used to perform simple experiments related to sound. There are various apps which record the intensity of an audio signal. An app (WaveEditor™ here) displays the audio signal in the form of a wave, whose amplitude is proportional to the loudness of the audio signal.



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Two students Fatima (F) and Bharat (B) conduct a simple experiment using smartphones. In an open field, both place their smartphones at a distance d from each other as shown in the figure. They stand next to their smartphones, and clap one after another. The audio signals from the claps are digitally recorded by WaveEditor™ and the output produced on their smartphones screens image is the time of the peak amplitude for each clap's audio signal received in their phones, respectively. They determine the speed of sound from this experiment to be 363 m/s. Calculate the distance d (in m). Show the main steps of your calculation.

Sol. $\Delta t_1 = 6.615 - 3.037 = 3.578 \text{ sec.}$

$$\Delta t_2 = 8.723 - 5.99 = 3.624 \text{ sec}$$

$$t_{\text{avg}} = \frac{\Delta t_1 + \Delta t_2}{2} = 3.601 \text{ sec}$$

$$\begin{aligned} \text{Distance} &= \text{speed} \times \text{time (avg)} \\ &= 363 \times 3.601 \\ &= 1307.16 \text{ m} \end{aligned}$$

21. (6Marks) With about half of its surface always having day, Earth constantly receives heat from the Sun and maintains an average of 288K. From this heat, an average power of $4.3 \times 10^{16} \text{ W}$ goes into the evaporation of water. The water evaporated from the Earth finally precipitates over its surface. Suppose one collects this water for one year and the thickness of this water shell is h over the surface of the Earth; this value in meters is the well-known average annual rainfall on the globe. For the following question, make suitable assumptions wherever needed.

21.1 Estimate h .

21.2 The fresh water requirement is about 6800 l/day per head, which includes drinking water and water used for irrigation and industry. Estimate the ratio of water requirement for the population of the world and the total water received through rain over the land annually.

Sol.

21.1 Since, the phase of water changed;

$$Q = mL_v$$

$$\frac{Q}{t} = \frac{m}{t} L_v$$

$$P = \left(\frac{m}{t} \right) 2.46 \times 10^6 \text{ J/kg}$$

$$\frac{4.3 \times 10^{16} \text{ W}}{2.46 \times 10^6} = m$$



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$$\frac{4.3 \times 10^{16} (365 \times 24 \times 60 \times 60)}{2.46 \times 10^6} = m$$

$$m = 55123902.4 \times 10^{10} \cong 5.512 \times 10^{17} \text{ kg}$$

$$D = \frac{m}{v}$$

$$\therefore M = D \times V$$

$$m = 4\pi R^2 h D$$

$$h = \frac{m}{4\pi R^2 D}$$

$$h = \frac{5.512 \times 10^{17}}{4 \times 3.14 \times (6357)^2 \times 10^2 \times 1000}$$

$$h = 1.071 \text{ m}$$

21.2 Total water received $m = \frac{4.3 \times 365 \times 24 \times 36}{2.46}$

$$= 5.5 \times 10^{17} \text{ kg}$$

Water needed 6800 kg/day/person

Water needed for world population for one year

$$m' = 6800 \times 365 \times 140 \times 10^7$$

$$m' = 68 \times 365 \times 14 \times 10^{10} = 3.5 \times 10^{15} \text{ kg}$$

$$\frac{\text{water required}}{\text{water received}} = \frac{m'}{m} = \frac{3.5 \times 10^{15}}{5.5 \times 10^{17}}$$

$$\frac{m'}{m} = \frac{7}{1100}$$



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