

# INDIAN OLYMPIAD QUALIFIER IN JUNIOR SCIENCE-2020-21

Date: 17/01/2021

(PAPER CODE : 51) PART-A

Max. Marks: 120

## SOLUTIONS

Time allowed: 1 Hour

### PART : A-1

1. Gravitational collapse is the contraction of an astronomical object under its own gravity. This draws the matter inwards the centre of gravity. A neutron star is an example of the collapsed core of giant star. A certain neutron star of radius 10 km is mass  $1.5 M_{\odot}$ . 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)  $2.6 \times 10^{20} \text{ m/s}^2$

Ans. Option (b) is correct.

Sol. Given solar mass  $M_{\odot} = 2 \times 10^{30} \text{ kg}$

$$1.5 M_{\odot} = 1.5 \text{ solar mass} = 1.5 \times 2 \times 10^{30} \text{ kg}$$

$$g = \frac{GM}{r^2}$$

$$g = \frac{6.674 \times 10^{-11} \times 1.5 \times 2 \times 10^{30}}{(10 \times 1000)^2}$$

$$g = 20.002 \times 10^{-11 + 30 - 8}$$

$$g = 2.0 \times 10^{12} \text{ ms}^{-2}$$

2. The tympanic membrane (ear drum) is a very delicate component of the human ear. Typically, its diameter is 1 cm. The maximum force the ear can withstand is 2.5 N. 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) 9 m      (c) 3 m      (d) 1.5 m

Ans. Option (c) is correct.

Sol.  $F = P.A.$

$$F = (h \rho g) (\pi r^2)$$

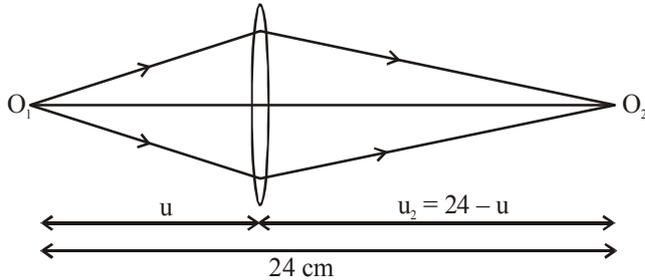
$$2.5 = (h \times 1.05 \times 10^3 \times 10) \pi (0.5 \times 10^{-2})^2$$

$$h = 3 \text{ m}$$

3. Two illuminated point objects  $O_1$  and  $O_2$  are placed at a distance 24 cm from each other along the principal axis of a thin convex lens of focal length 9 cm such that images of both the objects are formed at the same position. 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

**Ans.** Option (b) is correct.

**Sol.**



Using Len's formula  $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\text{For } O_1 \Rightarrow \frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f}$$

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

$$\frac{1}{v} = \frac{1}{9} + \frac{1}{(-u)} \quad \dots(1)$$

$$\text{For } O_2 \Rightarrow \frac{1}{v_2} - \frac{1}{u_2} = \frac{1}{f}$$

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

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

for  $O_1$  and  $O_2$ , v will be af opposite signs, so  $\frac{1}{9} - \frac{1}{u} = -\left(\frac{1}{9} - \frac{1}{24-u}\right)$

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

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

$$-u^2 + 24u = 108$$

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

$$u = \frac{24 \pm \sqrt{(24)^2 - 4 \times 108}}{2}$$

$$u = \frac{24 \pm \sqrt{576 - 432}}{2}$$

$$u = \frac{24 \pm 12}{2}$$

$$\therefore u = 18, 6$$

4. 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 1000 kW of electrical power is obtained in this reactor, then the number of atoms disintegrated (undergone fission) per second in the reactor is :

- (a)  $1.04 \times 10^{17}$       (b)  $6.5 \times 10^{12}$       (c)  $3.125 \times 10^{12}$       (d)  $3.25 \times 10^{32}$

**Ans.** Option (a) is correct.

**Sol.**  $n = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100$

Let 'N' be the number of atoms disintegrated per second

$$\frac{30}{100} = \frac{1000 \times 10^3}{N \times 200 \times 10^6 \times 1.6 \times 10^{-19}} = N = 1.04 \times 10^{17}$$

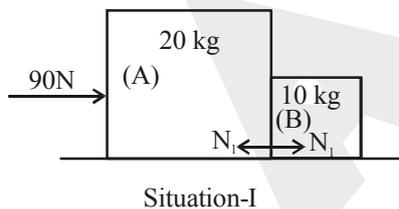
5. Two blocks A and B are in contact with each other and are placed on a frictionless horizontal surface. A force of 90N is applied horizontally on block A (situation I) and the same force is applied horizontally on block B (situation II). Mass of A is 20 kg and B is 10 kg. Then the correct statement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



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

**Ans.** Option (b) is correct.

**Sol.**



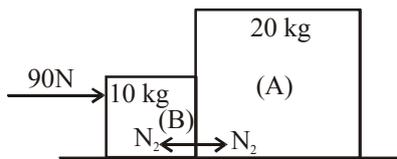
From fig a =  $\frac{F_{\text{net}}}{\text{Total mass}} = \frac{90}{30} = 3 \text{ ms}^{-2}$

For block 'B'

$$N_1 = m_B a$$

$$N_1 = 10 (3)$$

$$N_1 = 30 \text{ N}$$



Situation-II

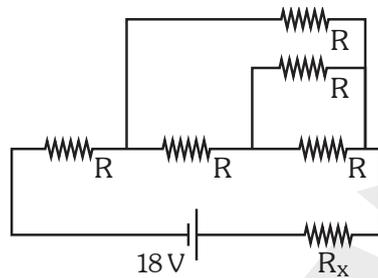
For block 'A'

$$N_2 = m_A a$$

$$N_2 = 20 \times 3$$

$$N_2 = 60 \text{ N}$$

6. In the adjoining circuit,  $R = 5\Omega$ . It is desired that the voltage across  $R_x$  should be 6V, then the value of  $R_x$  should be



(a)  $4\Omega$

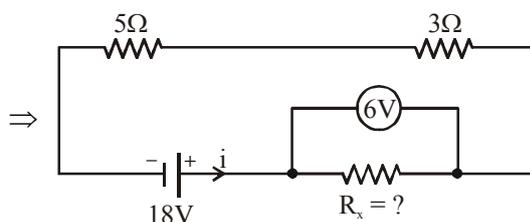
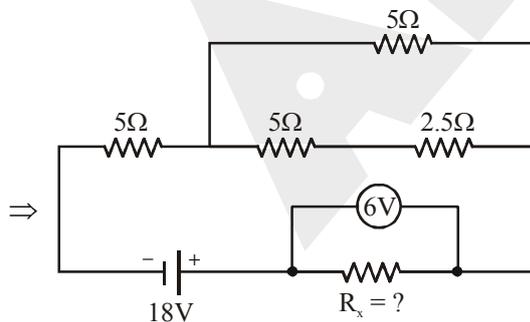
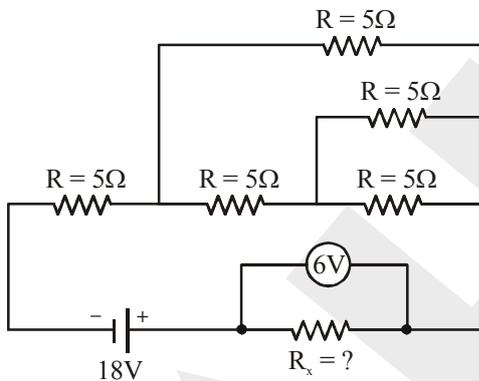
(b)  $12\Omega$

(c)  $16\Omega$

(d)  $20\Omega$

Ans. Option (a) is correct.

Sol.



$$18V - iR_x - i8 = 0$$

$$18 - 6 = i8$$

$$12 = i8$$

$$i = \frac{12}{8} = \frac{3}{2} \text{ A}$$

$$\therefore V = iR_x$$

$$6 = iR_x$$

$$6 = \frac{3}{2} R_x$$

$$R_x = 4\Omega$$

7. In one process for waterproofing, a fabric is exposed to  $(\text{CH}_3)_2\text{SiCl}_2$  vapours. The vapours 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 ;  $n(\text{CH}_3)_2\text{SiCl}_2 + 2n\text{OH}^- \longrightarrow 2n\text{Cl}^- + n\text{H}_2\text{O} + [(\text{CH}_3)_2\text{SiO}]_n$  where n stands for a larger integer. The waterproofing film is deposited on the fabric layer upon layer. Each layer is  $6\text{\AA}$  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, 1m by 2m, with a film 300 layers thick? The density of the film is  $1.0\text{g/cm}^3$ .
- (a) 0.63g                      (b) 0.36g                      (c) 6.3g                      (d) 3.6g

**Ans.** Option (a) is correct.

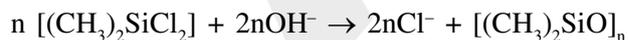
**Sol.**  $d = \frac{W}{v} \text{ g/cm}^3$

$$1 = \frac{W}{\{(100\text{cm} \times 200\text{cm} \times 6 \times 10^{-8}\text{cm}) \times 300 \text{ layers}\}}$$

$$W = 0.36 \text{ g}$$

$$\text{Molar mass } [(\text{CH}_3)_2\text{SiO}]_n = 74n$$

$$\text{Moles of } [(\text{CH}_3)_2\text{SiO}]_n = \frac{0.36}{74n}$$



$$n \times \frac{0.36}{74n} \text{ moles} \qquad \qquad \qquad \frac{0.36}{74n} \text{ moles}$$

$$\text{Amount} = \frac{0.36}{74} \times 129$$

$$= 0.627 \text{ g}$$

8. Given that at a certain temperature, in 1.5 L vessel, 5.0 mole of A, 7.0 mole 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)  $7.22 \times 10^{-4}$                       (b)  $2.31 \times 10^{-4}$                       (c)  $7.22 \times 10^{-5}$                       (d)  $6.11 \times 10^{-4}$

**Ans.** Option (b) is correct.

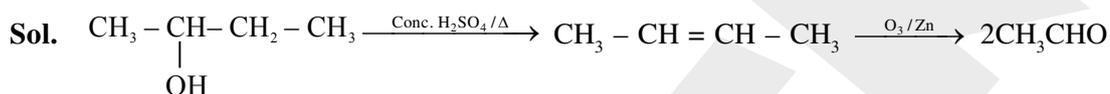
**Sol.**  $A + B \rightleftharpoons 2C + \text{Heat}$

Conc.(mole/L)                       $\frac{5}{1.5}$                        $\frac{7}{1.5}$                        $\frac{0.1}{1.5}$

$$K_c = \frac{(0.1/1.5)^2}{(5/1.5)(7/1.5)} = 2.857 \times 10^{-4}$$

9. 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

**Ans.** Option (b) is correct.



10. In an experiment with 100mL 0.1 M solution of Copper Chloride, by mistake 5gms 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

**Ans.** Option (b) is correct.

**Sol.** Ca replaces  $Cu^{2+}$  from  $CuCl_2$  to form colourless aqueous solution of  $CaCl_2$ .

11. Triclosan ( $C_{12}H_7Cl_3O_2$ ) is an antibacterial and antifungal agent. It is a polychloro phenoxy phenol. It is widely used as a preservative and antimicrobial agent in personal care products such as soaps, skin creams, and deodorants etc. A label on a 200mL hand sanitizer bottle claims that it contain Triclosan 0.2% w/v. What will be the number of molecules of Triclosan present in the bottle?

( $N_A$  is Avogadro's Number)

- (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)  $1.4 \times 10^{22} N_A$

**Ans.** Option (NA) is correct.

**Sol.**  $0.2 = \frac{W}{200} \times 100 \Rightarrow W = 0.4 \text{ g}$

Molar mass of Triclosan = 289.5g

$$N = \frac{0.4}{289.5} N_A = 1.38 \times 10^{-3} N_A$$

12. Suppose that A and B forms compound  $B_2A_3$  and  $B_2A$ . If 0.05 mole of  $B_2A_3$  weighs 12g and 0.1 mole of  $B_2A$  weighs 10g, 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

**Ans.** Option (NA) is correct.

**Sol.**  $\therefore$  0.05 mole  $B_2A_3 = 12g$

$$\Rightarrow 1 \text{ mole } B_2A_3 = \frac{12}{0.05} = 240 \text{ g/mole}$$

$\therefore$  0.1 mole  $B_2A = 10g$

$$\Rightarrow 1 \text{ mole } B_2A = 100g/mole$$

$$3A + 2B = 240$$

$$A + 2B = 100$$

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$$2A = 140$$

$$A = 70 \text{ g}$$

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

13. 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)  $0.5 \times 10^4$  bp                      (b)  $5 \times 10^4$  bp                      (c)  $1.7 \times 10^4$  bp                      (d)  $5.375 \times 10^4$  bp

**Ans.** Option (a) is correct.

**Sol.**  $1B = 6.7 \mu\text{m}$  instead of  $5.0 \mu\text{m}$

$$\text{So difference} = 6.7 - 5.0 = 1.7$$

$$1\text{m} = 10^6 \mu\text{m} = 10^{10} \text{ \AA}$$

$$1\mu\text{m} = 10^4 \text{ \AA}$$

$$\text{So } 1.7 \times 10^4 \text{ \AA}$$

$$\text{distance between 2 base pair} = 3.4 \text{ \AA}$$

$$\text{So } \frac{1.7 \times 10^4}{3.4} = 5000 \text{ bp}$$

$$\text{i.e. } 0.5 \times 10^4 \text{ bp}$$

14. Considering following characteristics, identify the correct inheritance pattern from the given options.  
 (i) Most affected individuals are male.  
 (ii) 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.  
 (iii) Affected daughters are born to affected fathers and either affected or carrier mothers.  
 (iv) The sons of affected mothers should be affected.  
 (v) 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

**Ans.** Option (c) is correct.

**Sol.** Sex – linked recessive  
 Condition

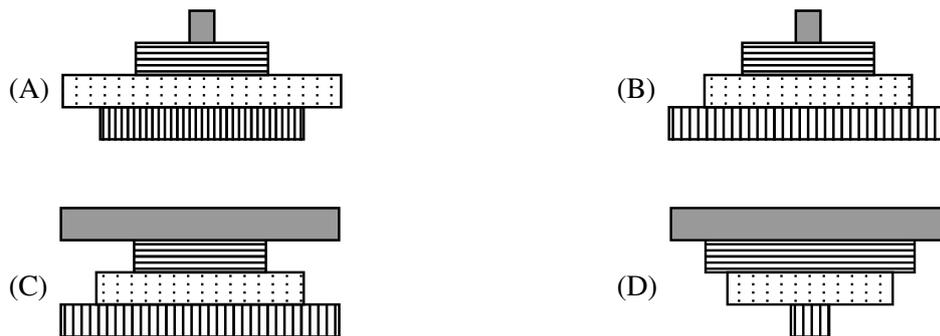
Father diseased – Daughter may be normal

Daughter diseased – Father always affected

Mother diseased – Son always affected

Son affected – Mother may be normal

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



**Ans.** Option (d) is correct.

**Sol.** The pyramid of Biomass to a marine ecosystem with rich diversity is inverted.

16. The Transpiration pull is maximum under which of the following conditions ?
- Closed stomata, low light intensity, humid air
  - Open stomata, dry air, moist soil
  - Open stomata, dry air, dry soil
  - Open stomata, high humidity in air, moist soil

**Ans.** Option (b) is correct.

**Sol.** Transpiration pull (Rate of transpiration)  $\propto$  opening of stomata  $\propto$  Dry air  $\propto$  moist soil

17. *Curcuma longa*, *Azadirachta indica*, Basmati Rice, Indian Ginseng are all related to which of the following concepts?
- Bioterrorism
  - Biomagnification
  - Biopiracy
  - Biodegradation

**Ans.** Option (c) is correct.

**Sol.** *Curcuma longa*  $\rightarrow$  Turmeric

*Azadirachta indica*  $\rightarrow$  Neem

Basmati Rice  $\rightarrow$  Rice

Indian Ginseng  $\rightarrow$  Ashwagandha

All have Indian germplasm but patent by other country. This is known as Biopiracy.

18. 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 –
- Connecting links
  - Living fossils
  - Endangered species
  - Extinct species

**Ans.** Option (b) is correct.

**Sol.** Living fossils it is the characters of an organism that has remained essentially unchanged from earlier geologic time & whose close relatives are usually extinct.

19. 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)  $a^2 + b^2 = 1$

**Ans.** Option (c) is correct.

**Sol.** Let  $\alpha$  be the common root.

Then,

$$\alpha^2 + a\alpha + b = 0 \quad \dots (1)$$

$$\alpha^2 + b\alpha + a = 0 \quad \dots (2)$$

So,

$$\text{Eqn. (1)} - \text{Eqn. (2)}$$

$$\Rightarrow \alpha(a - b) = a - b$$

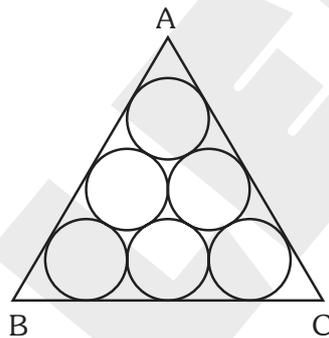
$$\Rightarrow \boxed{\alpha = 1}$$

$\therefore$  From Eqn. 1 :

$$\Rightarrow 1 + a + b = 0$$

$$\Rightarrow \boxed{a + b = -1}$$

20. Six circles each of radius 3 cm 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. Then height of triangle ABC is



- (a)  $6(2\sqrt{3} + 3)$                       (b)  $3(2\sqrt{3} + 6)$                       (c)  $3(2\sqrt{3} + 3)$                       (d)  $6(2 + \sqrt{3})$

**Ans.** Option (c) is correct.

**Sol.** In  $\triangle OBD$  :

$$\tan 30^\circ = \frac{3}{BD}$$

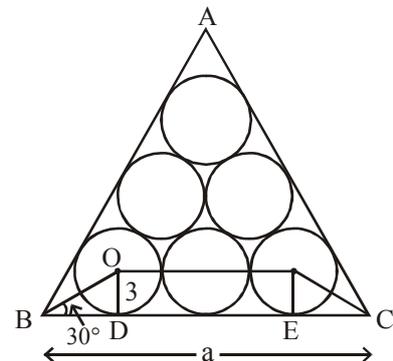
$$\Rightarrow BD = 3\sqrt{3} = EC \quad \dots (1)$$

Now,

$$BC = a = BD + DE + EC$$

$$= 3\sqrt{3} + 12 + 3\sqrt{3}$$

$$a = 12 + 6\sqrt{3} \text{ cm} \quad \dots (2)$$



$$\therefore \text{Height of an equilateral } \triangle ABC = \frac{\sqrt{3}}{2}(\text{side}) = \frac{\sqrt{3}}{2} \times (12 + 6\sqrt{3})$$

$$= \boxed{9 + 6\sqrt{3} \text{ cm}}$$

21. 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

**Ans.** Option (c) is correct.

**Sol.** Let  $(Ax + B)$  be the remainder when  $x^{51}$  is divided by  $x^2 - 3x + 2$

$$\therefore x^{51} = (x^2 - 3x + 2)Q(x) + (Ax + B)$$

$$\Rightarrow x^{51} = (x - 1)(x - 2)Q(x) + Ax + B$$

$$\text{For } x = 1, A + B = 1 \quad \dots (1)$$

$$\text{For } x = 2, 2A + B = 2^{51} \quad \dots (2)$$

From (1) and (2)

$$A = 2^{51} - 1, B = 2 - 2^{51}$$

$$\text{So, } \boxed{\text{Remainder} = (2^{51} - 1)x + (2 - 2^{51})}$$

22. 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

**Ans.** Option (b) is correct.

**Sol.**  $\frac{3}{x-2} < 1$

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

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

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

$$= \frac{(x-5)}{x-2} > 0$$



$$\Rightarrow \boxed{x < 2 \text{ or } x > 5}$$

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

- (a) 444 (b) 442 (c) 424 (d) 422

**Ans.** Option (a) is correct.

**Sol.** Let  $n = 100^{25} - 25$

$$\Rightarrow n = 999 \dots 975$$

← 48 9's →

$$\therefore \text{Sum of the digits of } n = 48 \times 9 + 7 + 5 = 444$$

24. 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)  $AD < \sqrt{AB \cdot AC}$

**Ans.** Option (d) is correct.

**Sol.** Let  $AB = c$ ,  $AC = b$

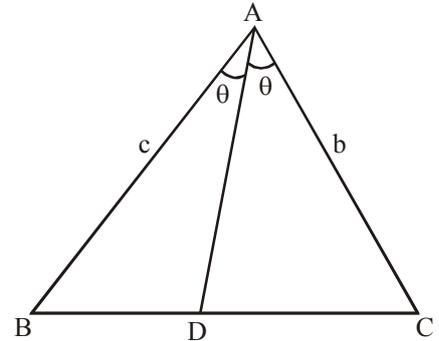
Then,

$$\text{Area of } \triangle ABC = \frac{1}{2}bc \sin 2\theta = \frac{1}{2}c \cdot AD \sin \theta + \frac{1}{2}b \cdot AD \sin \theta$$

$$\Rightarrow bc \sin 2\theta = AD \sin \theta (b + c)$$

$$\Rightarrow 2bc \sin \theta \cos \theta = AD \cdot \sin \theta (b + c)$$

$$\Rightarrow AD = \frac{2bc \cos \theta}{(b + c)} \quad \dots (1)$$



$$\text{Now, } \frac{b+c}{2} \geq \sqrt{bc}$$

$$\Rightarrow \frac{bc \cos \theta}{AD} \geq \sqrt{bc} \quad (\text{from 1})$$

$$\Rightarrow AD \leq \sqrt{bc} \cos \theta < \sqrt{bc}$$

$$\Rightarrow AD < \sqrt{bc}$$

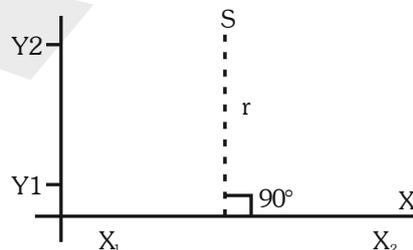
$$\Rightarrow \boxed{AD < \sqrt{AB \cdot AC}}$$

### PART : A-2

25. An infinitely long conductor when carrying current I, 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

$$B = \frac{\mu_0}{4\pi} \frac{2I}{r}, \quad (\text{where } \frac{\mu_0}{4\pi} = 10^{-7} \text{NA}^{-2} \text{ is a constant}).$$

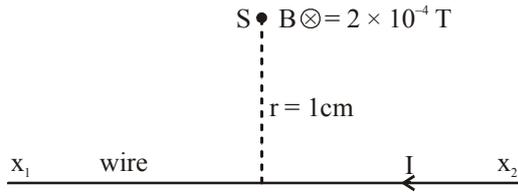
The following figure shows such an infinitely long conductor placed along X-axis carrying current I and B at S is  $2 \times 10^{-4}$  T, directed into the plane of the paper at S. Given  $r = 1$  cm. Then, the correct statement are :



- (a)  $I = 10$  A  
 (b) The number of electrons transported across the cross section of the conductor during the 1s is  $6.25 \times 10^{19}$   
 (c) The direction of current I is from  $X_2$  to  $X_1$   
 (d) The electrons will flow in the direction  $X_2$  to  $X_1$

**Ans.** Option (a,b,c) is correct.

Sol.



Checking options

$$(a) B = \frac{\mu_0 2I}{4\pi r}$$

$$2 \times 10^{-4} = 10^{-7} \frac{2I}{1 \times 10^{-2}}$$

$$10^{-6} = 10^{-7} I$$

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

$$(b) I = \frac{Q}{t} = \frac{ne}{t} \Rightarrow n = \frac{I}{e} = \frac{10}{1.6 \times 10^{-19}}$$

$$n = 6.25 \times 10^{19} \text{ electrons}$$

(c) The direction of the current is from  $x_2$  to  $x_1$  (using right hand thumb rule)

(d) Electrons will flow in direction opposite to current i.e.  $x_1$  to  $x_2$

26. The ratio of the charge of an ion or subatomic particle to its mass ( $q/m$ ) is called specific charge. Then the correct option 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  $\alpha$ -particle will be greater than that of an electron

(d) Specific charge ratio of an electron is  $1.75 \times 10^{11}\text{ C/kg}$

Ans. Option (a,b,d) is correct.

Sol. Specific charge =  $\frac{q}{m}$

checking options

$$(a) \text{ S.I. unit is } \frac{q}{m} = \frac{It}{m} \Rightarrow \frac{\text{As}}{\text{kg}}$$

(b) For isotopes of hydrogen

$$\text{For } {}_1\text{H}^1 = \frac{q}{m} = \frac{e}{m_p}$$

$$\text{For } {}_1\text{H}^2 = \frac{q}{m} = \frac{e}{2m_p}$$

$$\text{For } {}_1\text{H}^3 = \frac{q}{m} = \frac{e}{3m_p}$$

$\therefore$  for tritium it will be least

(c)  $m_\alpha = 4m_p$ ,  $q_\alpha = 2e$

Specific charge of alpha particle  $\left(\frac{2e}{4m_p} = \frac{e}{2m_p}\right)$  is less than that of electron  $\left(\frac{e}{m_e}\right)$

(d) For electron  $= \frac{q}{m} = \frac{e}{m_e} = \frac{1.6 \times 10^{-19}}{9.1 \times 10^{-31}} = 1.75 \times 10^{11}$

27. Acetylene torches and burners used by glassblowers produces 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

**Ans.** Option (a,b) is correct.

**Sol.** Informative

28. 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<sub>3</sub> 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

**Ans.** Option (b,c) is correct.

**Sol.** Mg reacts with strong acids (1M HCl and 1M HNO<sub>3</sub>) to form H<sub>2</sub> gas vigorously but do not in such manner with weak acid (1M CH<sub>3</sub>COOH) as well as 1M NaOH

29. Choose the correct statements from following options.  
(a) A robust adaptive immune response is initiated using weakened forms 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.

**Ans.** Option (a & b) is correct.

**Sol.** A → It is exaple of "Artificially active adaptive" type of immunity.

B → Killed / chemically inactivated

Virus tend to produce a weaker response by the immune system than live viruses. So multiple "boosters" injections may be required to provide an effective immune response against the inactivated pathogen.

30. 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 per cent 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

**Ans.** Option (b & d) is correct.

**Sol.** B → Growth hormone has catabolic effects on nutrients.

D → It is deficiencies of Nutrition.

31. 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 :  $\pi^c = 180^\circ$ ,  $\sin(180^\circ - \theta) = \sin \theta$ ,  $\sin \theta \geq 0$  when  $0 \leq \theta \leq 180^\circ$ ]

**Ans.** Option (a,b,c,d) are correct.

**Sol.**  $81^{\sin^2 x} + 81^{\cos^2 x} = 30$ ,  $0 \leq x \leq \pi$

$$\Rightarrow 81^{\sin^2 x} + \frac{81}{81^{\sin^2 x}} = 30$$

Let  $81^{\sin^2 x} = y$

Then,  $y + \frac{81}{y} = 30$

$$\Rightarrow y^2 - 30y + 81 = 0$$

$$\Rightarrow (y - 27)(y - 3) = 0$$

$$\Rightarrow y = 27, 3$$

$$\Rightarrow 81^{\sin^2 x} = 3^3, 3^1$$

$$\Rightarrow 3^{4\sin^2 x} = 3^3, 3^1$$

$$\Rightarrow \sin^2 x = \frac{3}{4}, \frac{1}{4}$$

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

But  $0 \leq x \leq \pi$

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

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

32. 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.

**Ans.** Option (b,c,d) are correct.

**Sol.** Given  $(a - b)^2 + (a - c)^2 = (b - c)^2$

$$\Rightarrow (a - b)^2 = (b - c)^2 - (a - c)^2$$

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

$$\Rightarrow (a - b)(a - b + b + a - 2c) = 0$$

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

Either  $b = a$  or  $a = c$

Also, Equ. is not valid when  $a, b, c$  are distinct.

Date: 17/01/2021

(PAPER CODE : 55) PART-B

Max. Marks: 100

## SOLUTIONS

### Section I

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 system control the same group of body functions, but have opposite effects on the functions they regulates. 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 ?

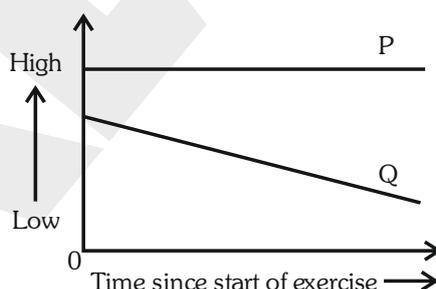
- i. Increased salivation
- ii. Increased digestion
- iii. Loss of bowel and bladder control
- iv. Body shivering
- v. Crying
- vi. Pupil dilation

(A) i, ii and vi      (B) i, iv and v      (C) iii, iv and vi      (D) iii and v

**Ans.** Option (C) is correct.

**Sol.** Sympathetic nervous system has neurons from Thoracic & lumbar part of spinal cord it is also known as thoraco-lumber out flow. It activates during 3F condition.

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) <b>P</b> : carbon dioxide level in vein | <b>Q</b> : oxygen level in artery         |
| (B) <b>P</b> : breathing rate               | <b>Q</b> : carbon dioxide level in artery |
| (C) <b>P</b> : oxygen level in artery       | <b>Q</b> : carbon dioxide level in vein   |
| (D) <b>P</b> : oxygen level in artery       | <b>Q</b> : oxygen level in vein           |

**Ans.** Option (D) is correct.

**Sol.** When you exercise and your muscles work harder, your body uses more oxygen and produces more carbon dioxide. To cope with this extra demand, your breathing has to increase.

3. Description 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 of 100X; possesses cell wall and has a nucleus.
- III. Needs 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

**Ans.** Option (C) is correct.

**Sol.** I → Posseses cell wall but not mitochondria → Bacteria

II → Cell wall + Nucleus → Plants

III → Ribosomes are attached to membrance system in the cytoplasma.

IV Virus can't replicate on its own, need other specific cell for replication.

So bacteria, plants, Ribosomes, Virus are correct.

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 intermittent mixing. After several days, it turns into a nutrient-rich compost to grow plants. If the context of decomposition in this composting process, the most appropriate statement among the following is.

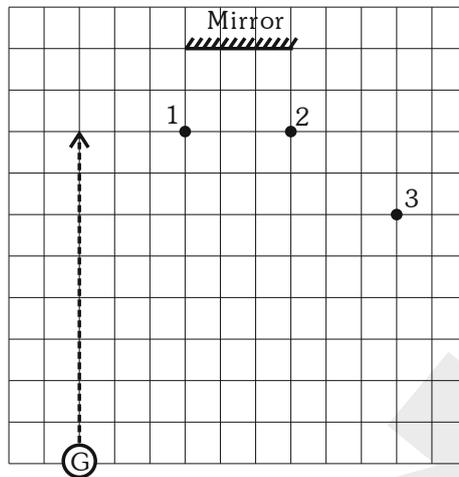
- (A) Paper acts as a good source of carbon while buttermilk gives the correct acidity to the mixture
- (B) Soil acts as a good source of carbon inorganic nitrogen while buttermilk is a good source to the mixture
- (C) Paper is a good source of carbon while buttermilk is a good source of starter bacteria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

**Ans.** Option (C) is correct.

**Sol.** Paper is a good source of carbon and butter milk is good source of bacteria which helps in the formation of nutrient rich compost.

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 toys numbered 1, 2 and 3 in the plane mirror on the wall.

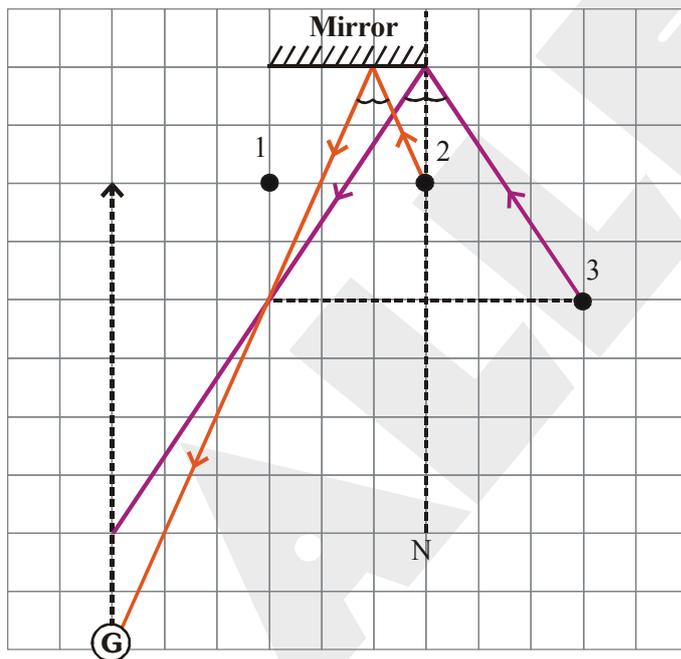
The order in which she will see images of the toys is :



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

**Ans.** Option (D) is correct.

**Sol.**



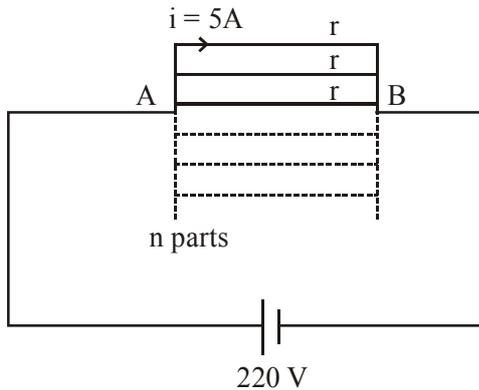
From fig. first she will see toy 2 then toy 3

6. A heating element in the form of a wire with uniform circular cross sectional area has a resistance of  $310 \Omega$ , and can bear a maximum current of  $5.0 \text{ A}$ . 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  $220 \text{ V}$ , is :

- (A) 7                      (B) 8                      (C) 44                      (D) 62

**Ans.** Option (A) is correct.

**Sol.**  $R = 310 \Omega$ ,  $i_{\max} = 5A$



$$r = \frac{R}{n} = \frac{310}{n} \Omega, V_{AB} = 220 \text{ V}$$

$$V_{AB} = ir$$

$$220 = 5 \left( \frac{310}{n} \right)$$

$$n = 7$$

7. Consider the following two statements :

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

Statement S2 : At  $0^\circ\text{C}$ , water is denser than ice.

Choose the correct statement among the following :

- (A) Both S1 and S2 are true and S2 is the correct explanation of S1
- (B) Both S1 and S2 are true but S2 is not the correct explanation of S1
- (C) S1 is true but S2 is false
- (D) S1 is false but S2 is true

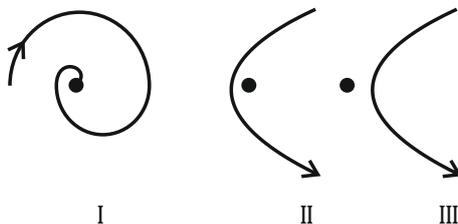
**Ans.** Option (D) is correct.

**Sol.** 100 g water at  $0^\circ\text{C}$  lose larger amount of heat ( $mL + ms\Delta T$ ) than the 100 g ice at  $0^\circ\text{C}$  ( $ms\Delta T$ ). Therefore S1 is false.

At  $0^\circ\text{C}$ , water density is  $0.99987 \text{ g/cm}^3$ , ice density is  $0.9168 \text{ g/cm}^3$

Therefore S2 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 the comet/alpha particles schematically.



The correct statement about the trajectories is :

- (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 the scattering of alpha particles.  
 (D) II represents trajectory for Halley's comet and III for the scattering of alpha particles.

Ans. Option (D) is correct.

Sol.

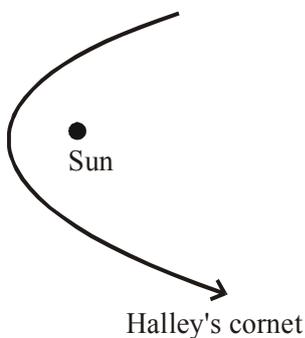


Fig. II

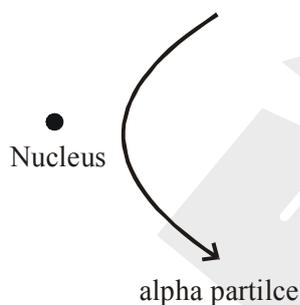


Fig. III

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 near by 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.

Ans. Option (B) is correct.

Sol. Existing H-bond in water molecules breakdown when it converts into vapour.

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.

Ans. Option (B) is correct.

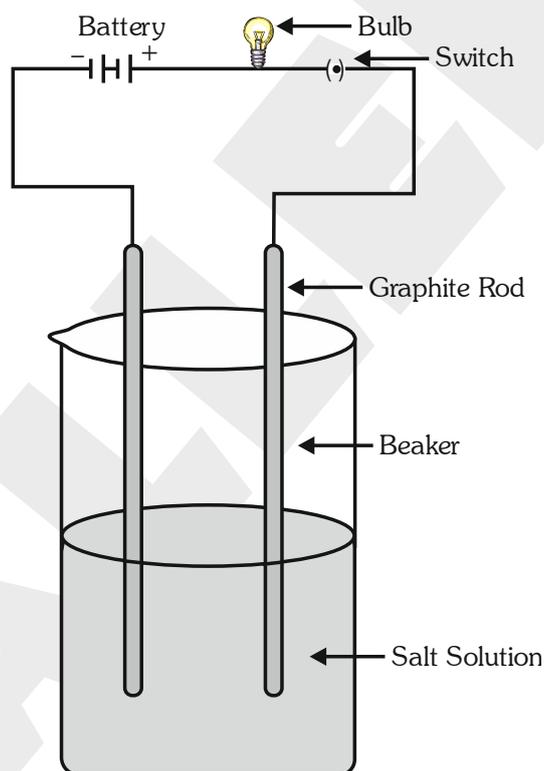
Sol. Diffusion is a slow process.

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  $\text{CaCO}_3$  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.

**Ans.** Option (C) is correct.

**Sol.** In rain water, atmospheric  $\text{CO}_2$  is present and forms of  $\text{H}_2\text{CO}_3$ ,  $\text{HCO}_3^-$  and  $\text{CO}_3^{2-}$  which are responsible for Conductivity of solution.

12. Consider a setup in which two graphite rods are immersed in a 2 M NaCl (aq.) solution. The rods are connected to two terminals of a 9 V 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:



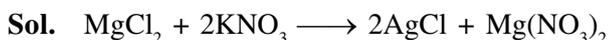
- (A) The bulb will glow.
- (B) The pH of solution near the cathode will increase.
- (C) Oxygen gas would be generated near the +ve electrode which will oxidize the graphite electrode.
- (D) Total mass of liquid in the beaker will decrease.

**Ans.** Option (C) is correct.

**Sol.**  $\text{Cl}_2$  gas produced at anode (positive electrode) due to over potential phenomena.

## Section - II

13. (3 marks) A student was given 2.89 g of a mixture containing anhydrous  $\text{MgCl}_2$  and  $\text{KNO}_3$ , and had to quantify amount of  $\text{MgCl}_2$  in the mixture. The student uses excess  $\text{AgNO}_3$  (aq) to precipitate the chloride ion as  $\text{AgCl}$ (s), and finds the mass of the  $\text{AgCl}$  precipitate to be 5.32 g. Calculate the mass percentage of  $\text{MgCl}_2$  in the original mixture. (Atomic masses should be taken as per the data given.)



$$\frac{1}{2} \times \frac{5.32}{143.5} = \frac{5.32}{143.5}$$

$$\text{Molar mass AgCl} = 107.84 + 35.45 = 143.32 \text{ g/mole}$$

$$\text{Molar mass MgCl}_2 = 24.30 + 2 \times 35.45 = 95.2 \text{ g/mole}$$

$$\text{Mass of MgCl}_2 = \frac{1}{2} \times \frac{5.32}{143.5} \times 95.2 = 1.764\text{g}$$

$$\% \text{ MgCl}_2 = \frac{1.766}{2.89} \times 100 = 61.04\%$$

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 the following tests.
- 0.5 gram KI is dissolved in about  $5 \text{ cm}^3$  distilled water. A drop of this solution is put on a moist pH paper.
  - 0.5 gram KI is dissolved in about  $5 \text{ cm}^3$  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  $5 \text{ cm}^3$  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.
- 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
- 14.3. When solid KI is heated in an open dry test tube, a gas is liberated from the test tube.
- What is the colour of the gas ?
  - 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).
  - The reaction can be classified as (identify the correct option(s)) :  
A. thermal combination B. thermal decomposition  
C. double displacement D. displacement reaction

**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 500 mL alcohol and then adding distilled water to make the volume 1000 mL. 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 appeared in his flask. Sumit shook the flask vigorously and kept it for some time. The two 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 got a homogenous mixture.

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

**Sol. 14.1** (a) Light green (pH = 7)

(b) Total KI needed =  $0.5 \times 36 = 18\text{g}$

**14.2** (a)  $2\text{KI} + \text{H}_2\text{O}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O} + \text{I}_2 \downarrow$

(b) Reducing Agent : KI

(c) Filtration, since  $\text{I}_2$  crystal forming out.

**14.3** (a) Violet (purple)  $\text{I}_2$  gas

(b)  $4\text{KI} + \text{O}_2 \longrightarrow 2\text{K}_2\text{O}(\text{s}) + 2\text{I}_2$

$\text{K}_2\text{O} + \text{CO}_2 \longrightarrow \text{K}_2\text{CO}_3(\text{s})$

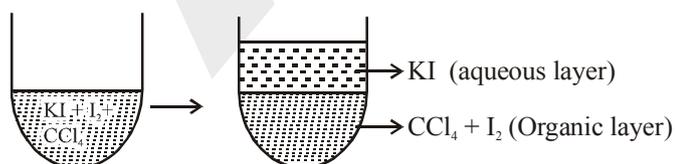
basic    acidic    Its amount depending

(Traces)    on available atmospheric

Amount     $\text{CO}_2$

(c) Displacement reaction (D)

**14.4**



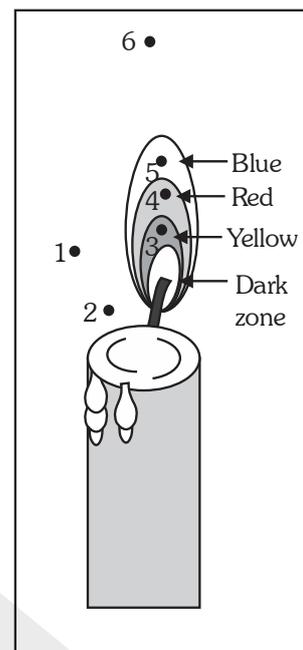
$\text{CCl}_4 + \text{I}_2$  solution = bottom layer

Aqueous layer = top layer

Strength =  $20\text{g}/0.5\text{ L} = 40\text{g/L}$

Strength =  $25\text{g}/0.5\text{ L} = 50\text{g/L}$

15. (8 marks) 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 a dark zone : an innermost zone that is pale yellow in colour, surrounded by a red zone, with a bluish envelop at the outside. Points 1-6 represent different locations in the inside and surrounding region of the flame. Consider wax to have chemical formula  $C_{24}H_{50}$ .



15.1. Among points 1-6, identify

- The hottest point.
- the coldest point.
- the point where water vapour concentration is the highest.

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.

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

- only air.
- air with freshly evaporating wax vapour.
- air with extra carbon dioxide released from combustion.
- 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, sterilisation processes, 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 compounds : naphthalene ( $C_{10}H_8$ ) and citric acid ( $C_6H_8O_7$ ). He burned 1.0 g of each compound separately in a porcelain piece in a blue Bunsen burner flame.

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

Sol. 15.1 (a) The hottest point  $\rightarrow$  5

(b) The coldest point  $\rightarrow$  2

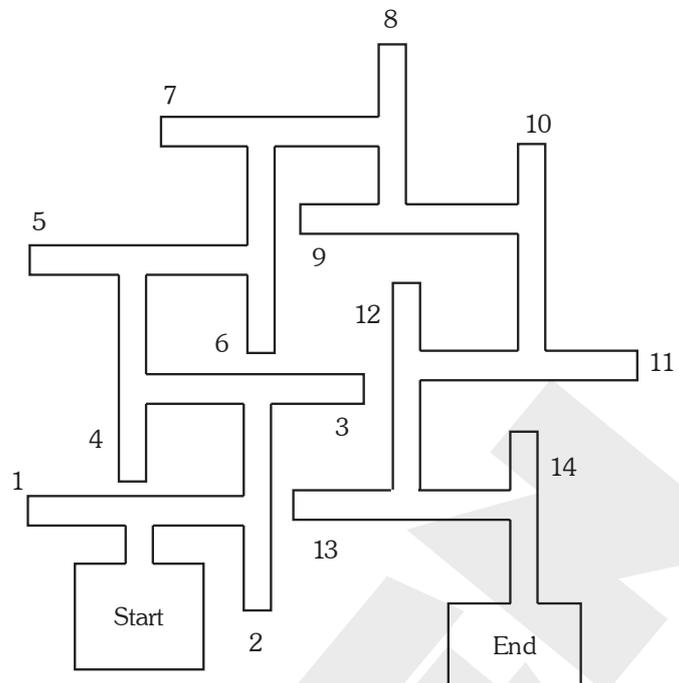
(c) The point where water vapour concentration is the highest  $\rightarrow$  6

15.2 C and CO

15.3 Answer D

15.4 Naphthalene is an aromatic compound gives sooty yellow flame on combustion.

16. (8 marks) A famous experiment performed by Tolman and Honzik (in 1930) studied the behaviour 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 1 :**

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

**Group 2 :**

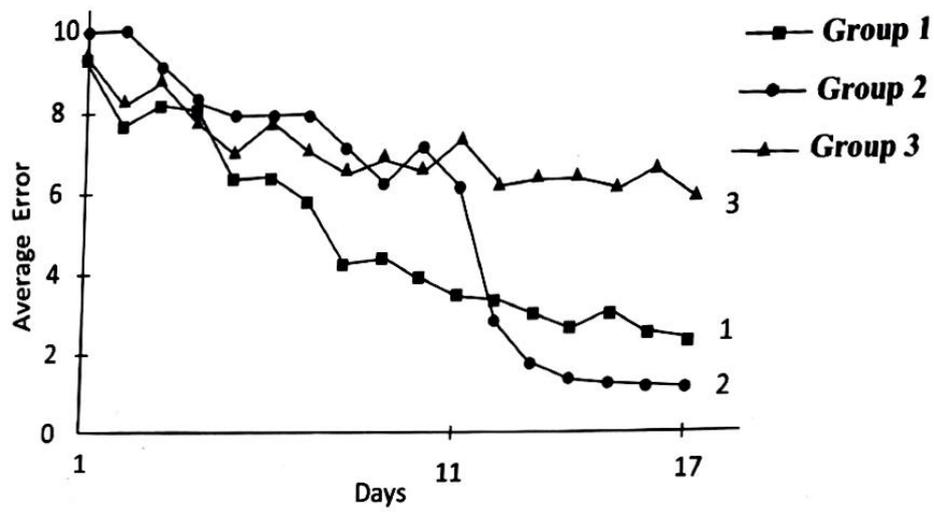
Day 1 – 10 : every time the rats reached the end, they were removed from the maze.

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 of reach the end) observed for each group of rats is shown in the graph below.



**16.1** A few statements are listed below. Based on the results of the experiment, identify each of the 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) behaviour 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.

**16.2** What response can be expected if the rats in the group 1 were kept hungry before the experiment? Assume that all other conditions in the above experimental 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. 16.1**

- (A) True → As per graph it shows recorded rat learned the maze.
- (B) False → This shows that between stimulus (the maze) and response (reaching the end of the maze) a mediational process was occurring the rats were actively processing information in their brains by mentally using their cognitive map (which they had latently learned).
- (C) False → It is due to latent learning.
- (D) True → Rewarded rat shows better pathway.
- (E) True → The delayed reward group learned the route on days 1 to 10 and formed a cognitive map of the maze.

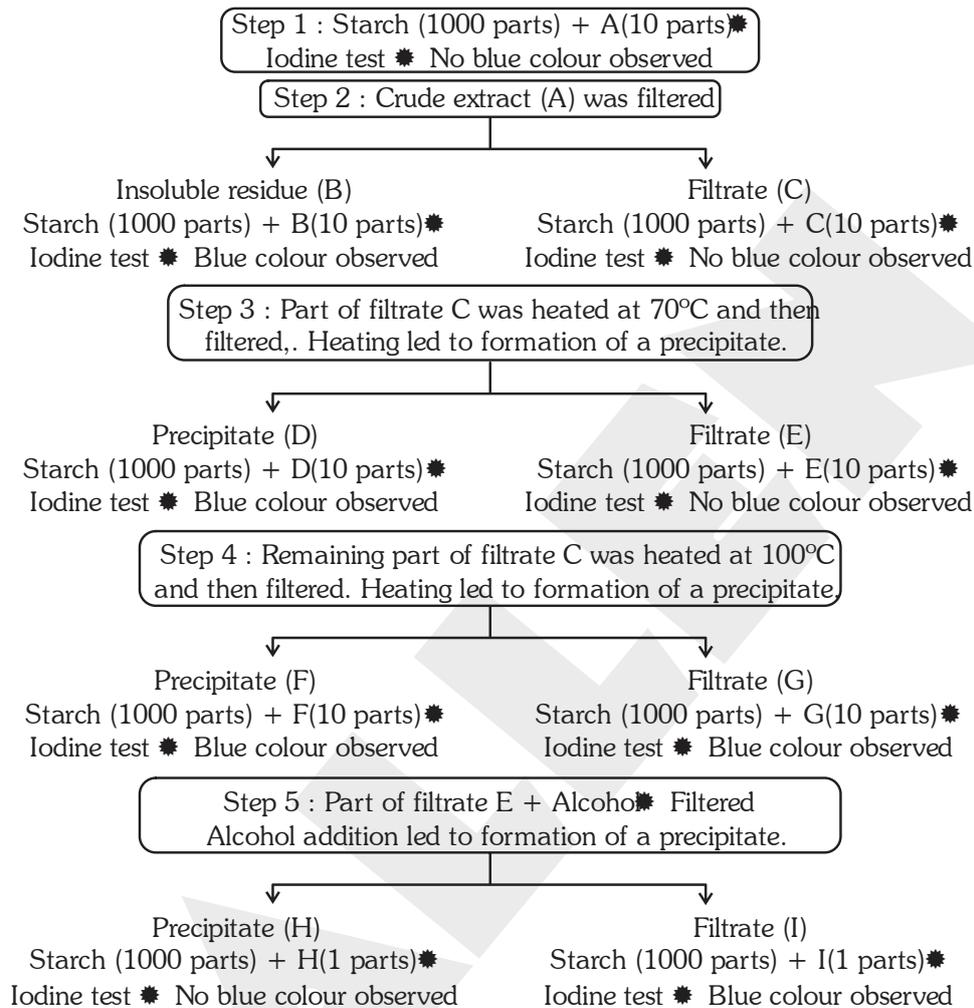
**16.2** Option (c) is correct.

Hungry rats take less time because they are going to rewarded.

17. (7 marks) In the early nineteenth century, two scientists Payen and Persoz ground barley seeds 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

The different steps of treatment and the results 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 a complex with iodine.
- (D) iodine is trapped in the intact polymer of starch.

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.

**17.3** Which of the preparation/s (A to I) indicate/s the presence of the 'active substance' being analyzed in barley ?

**Sol. 17.1** Option (d) is correct.

Amylose in starch is responsible for the formation of a deep blue colour because iodine molecule slips inside of the amylose coil.

**17.2** a → F

b → F

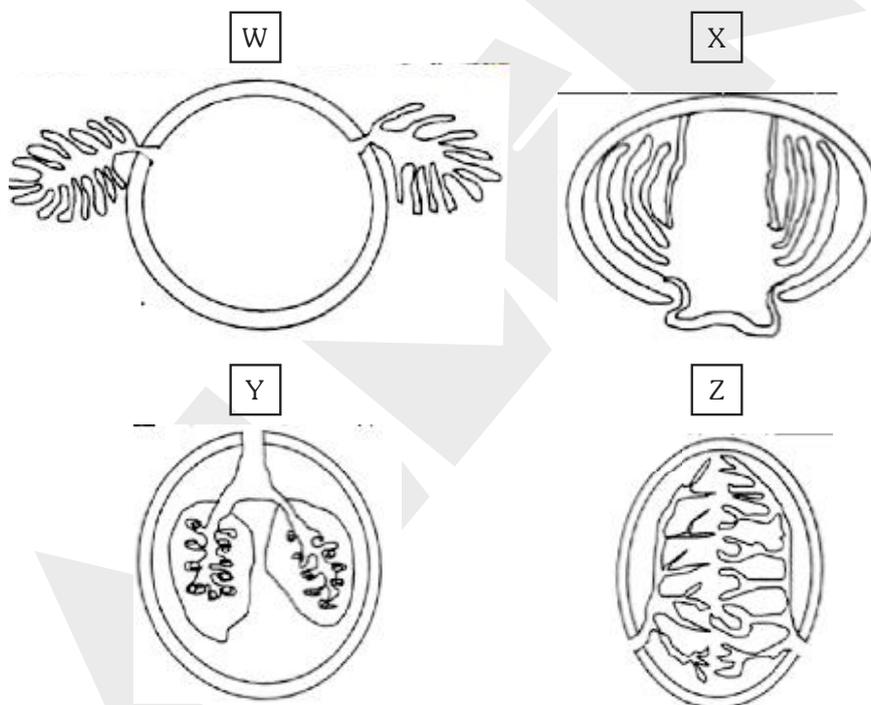
c → T

d → T

**17.3** A, C, E, H → Indicates presence of active substance being analyzed in barley. Hence no colour is found. A substance diastases ( $\alpha$ -amylase) present on seed. If it is in active form it breaks starch into glucose. So blue colour is not found in iodine test.

If it is in inactive it doesn't convert starch into glucose. So blue colour is found in iodine test.

**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:

$$Q = D A (P_1 - P_2) / L$$

Where, Q = rate at which a gas such as O<sub>2</sub> diffuses between two locations

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

A = cross sectional area over which the gas is diffusing

P<sub>1</sub> and P<sub>2</sub> are the partial pressures of the gas at the two locations

L = path length or distance between the two locations

**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**).

**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 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 / P1 or P2 / 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			

**Sol. 18.1** W → Tadpole → External gills

X → Prawn → Internal gills

Y → Rabbit → Lungs

Z → Cockroach → Tracheae

**18.2** (a) Y & Z — Easy diffusion of bases

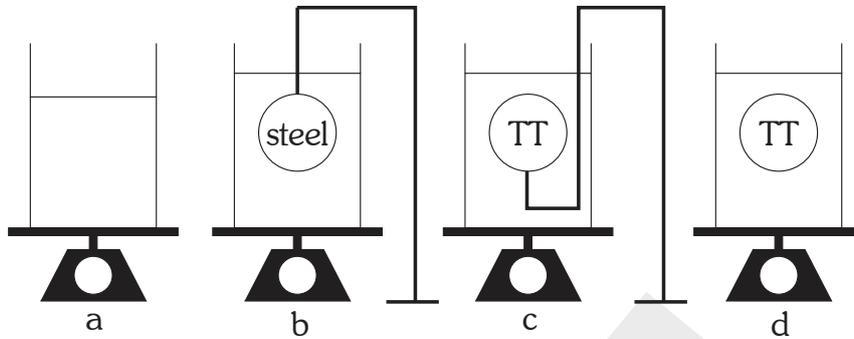
(b) W & X — Water habitat

**18.3**

	Column-I	Column-II	Column-III	Column-IV
	Feature Gills			
(1)	Highly branched & folded extension	↑ (A) larger the surface area the higher the diffusion of gases.	Increase the diffusion of gas	↑
(2)	Presence of very thin walled tissues	L	Thinner the gas exchanging surface the faster the gases will diffuse across it	↑

$$\left[ \text{Rate of diffusion} \propto \frac{\text{Surface area} \times \text{Conc. difference}}{\text{Thickness of membrane}} \right]$$

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 0.020 kg) 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  $10^{-4} \text{ m}^3$ . 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.

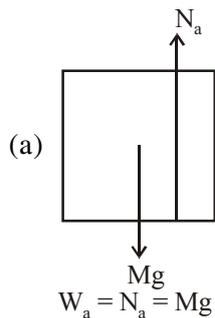


If  $W_a = 1 \text{ kg}$ , then obtain  $W_b$ ,  $W_c$ , and  $W_d$ . Show the main steps of your calculations. For calculation purpose, ignore the part of stand and the thread submerged in water.

**Sol.** Volume of each ball is  $V = 10^{-4} \text{ m}^3$

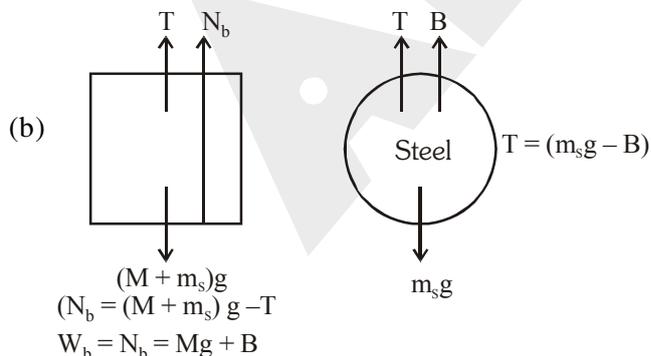
Mass of the steel ball = 0.800 kg

Mass of the plastic ball = 0.020 kg



From figure

Given  $W_a = Mg = 1 \times 10 \text{ N} = 10.0 \text{ N}$

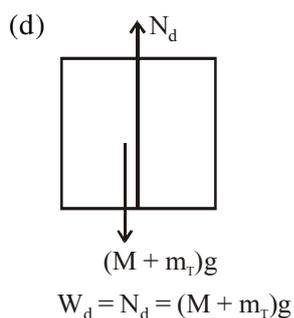
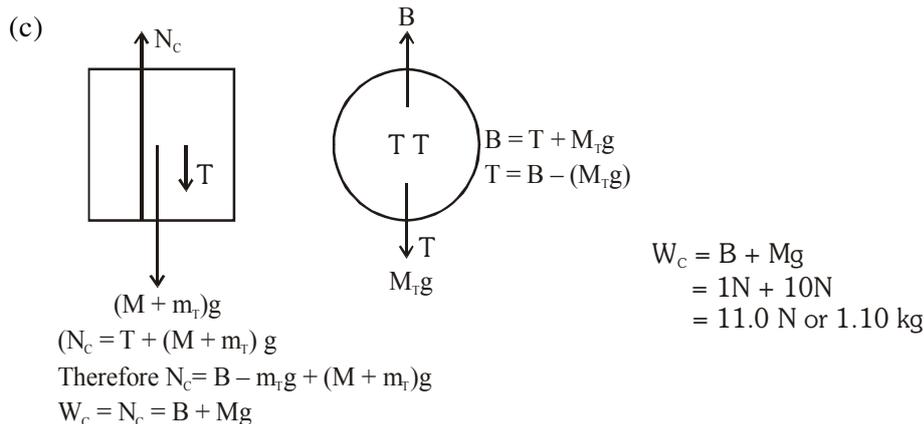


$$B = V\rho_l g$$

$$B = 10^{-4} \times 10^3 \times 10$$

$$B = 1.00 \text{ N or } 0.100 \text{ kg}$$

$$W_b = Mg + B = 1 \times 10 + 1\text{N} = 11.0 \text{ N or } 1.10 \text{ kg}$$



$W_d = Mg + M_r g = 10N + 0.02 \times 10 = 10.2 N \text{ or } 1.02 \text{ kg}$

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.



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 smartphone screens are shown next to their sketches. Note that the figure is not to scale. The time mentioned above the screen 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.** Sound produced by Bharat is received in Fatima's phone at 3.037 sec. Now sound is produced by Fatima at 5.099s. This sound is received by Bharat's phone at 8.723 s.

So time taken by sound to reach is  $t = 8.723 - 5.099 = 3.624$  sec

$\therefore$  Distance  $d = v \times t$

$$d = 363 \times 3.624$$

$$d = 1315.512 \text{ m (or) } 1.315 \text{ km}$$

**21.** (6 marks) With about half of its surface always having day, Earth constantly receives heat from the Sun and maintains an average temperature of 288 K. From this heat, an average power of  $4.3 \times 10^{16}$  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 two questions, make suitable assumptions wherever needed.

**21.1.** Estimate  $h$ .

**21.2.** The fresh water requirement is about 6800 l/day per head, which includes domestic water usage 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.** Given average temperature 288 K

$$\text{Average power} = 4.3 \times 10^{16} \text{ W}$$

$$\text{Latent heat of vaporization of water at } 288\text{K is } L = 2.46 \times 10^6 \text{ J/kg}$$

$$\text{Radius of the Earth} = R_E = 6.37 \times 10^6 \text{ m}$$

$$P = \frac{Q}{t} = \frac{mL}{t} \text{ and } m = \rho_w \times 4\pi R_E^2 \times h$$

$$4.3 \times 10^{16} = \frac{(\rho_w \times 4\pi R_E^2 \times h)(2.46 \times 10^6)}{365 \times 24 \times 60 \times 60}$$

$$4.3 \times 10^{16} = \frac{10^3 \times 4\pi \times (6.37 \times 10^6)^2 h (2.46 \times 10^6)}{365 \times 24 \times 3600}$$

$$h = 1.08 \text{ m}$$

**21.2** Given Indian population = 140.0 crores

Approximately 15% of world population = Indian population

$$\frac{15}{100} \times \text{world population} = 140 \times 10^7$$

World population =  $9.33 \times 10^9$  approximately

$$\text{Water requirement per year} = 6800 \times 365 \times 9.33 \times 10^9 = 2.31 \times 10^{16}$$

$$\text{Ratio} = \frac{\text{Water requirement}}{\text{Water received through rain}} = \frac{2.31 \times 10^{16}}{5.51 \times 10^{17}}$$

$$\text{Ratio} = 0.0419$$