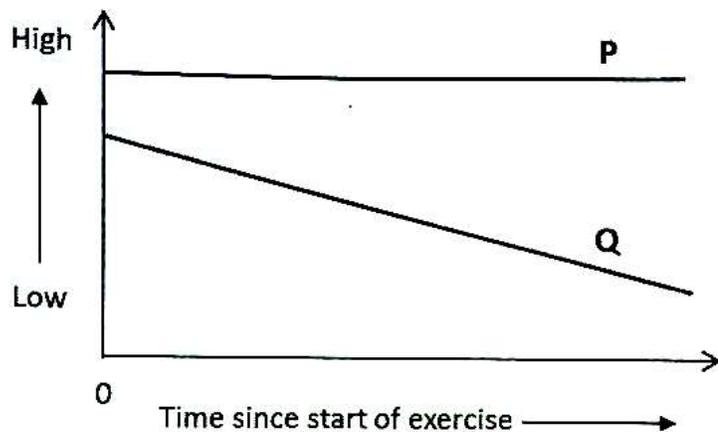


**INDIAN OLYMPIAD QUALIFIER IN JUNIOR SCIENCE**  
**(2021)**  
**PAPER CODE: 52**  
**DATE OF CONDUCTION: JAN 17, 2021**  
**PART - 2**  
**QUESTION PAPER**

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 functions 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 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

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           |

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 of 100X: possess 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

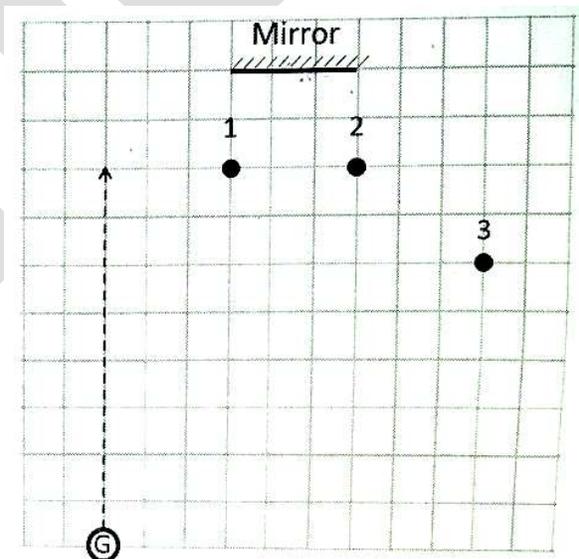
C. bacteria, plant cell, ribosome, virus

D. bacteria; protist; plant cell vacuole, mitochondria

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 compound to grow plants. In 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 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 buttermilk is a good source of fat.

5.

A girl (G) walks into a room along the path shown by the dashed line (see figure on right) She tries to observe image 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

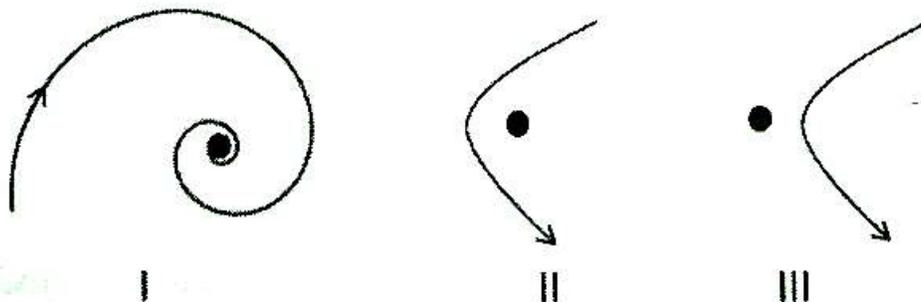
B. 3, 2

C. 1, 2, 3

D. 2, 3

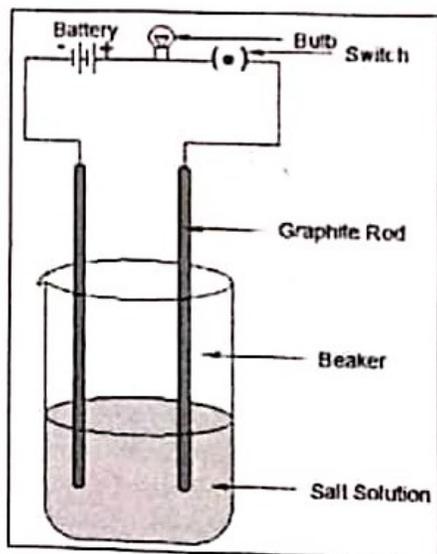
6. A heating element in the form of a wire with uniform circular cross sectioned area has a resistance of  $310 \Omega$  and can bear a maximum current of 5.0 A. The wire can be cut into pieces of equal length. The number of pieces, arranged suitably, so as the draw maximum power when connected to a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

7. Consider the following two statements:  
 Statement S1: If you put 100 g ice at  $0^{\circ}\text{C}$  and 100 g water of  $0^{\circ}\text{C}$  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
8. Consider the paths of (1) Halley's Comet near the sun and (2) an alpha particle scattered by a nucleus. In the figure 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 scattering of alpha particles  
 D. II represents trajectory for Halley's Comet and III for scattering of alpha particles
9. When water changes phase from liquid to vapor, 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  $\text{H}_2\text{O}$  molecules are broken  
 C. Covalent bonds existing within the  $\text{H}_2\text{O}$  molecules are broken  
 D. Ionic bonds existing between H ions and OH ions are broken
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 change 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 they water is colder  
 D. Maximum color in liquid originates from the bottom of the flask
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

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:

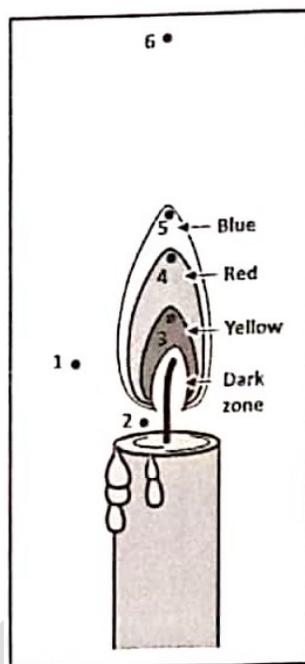


- A. The bulb will glow
- B. The pH of solution near the cathode will increase
- C. Oxygen gas would be generated near the +ve electrode which will oxidize the graphite electrode
- D. Total mass of liquid in the beaker will decrease



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

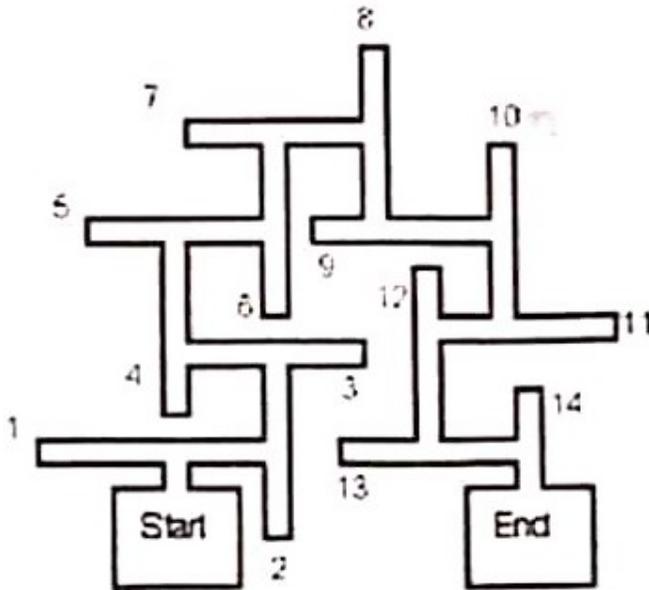
15. (8 marks) Flame is a hot bright stream of burning gases. Flames have different structure and properties depending on fuel and burning conditions. The attached figure (drawn approximately to scale) shows a candle flame burning in open air in which three regions are distinctly visible surrounding a 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 the 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 point 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, sterilization 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. Sholk 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.

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:

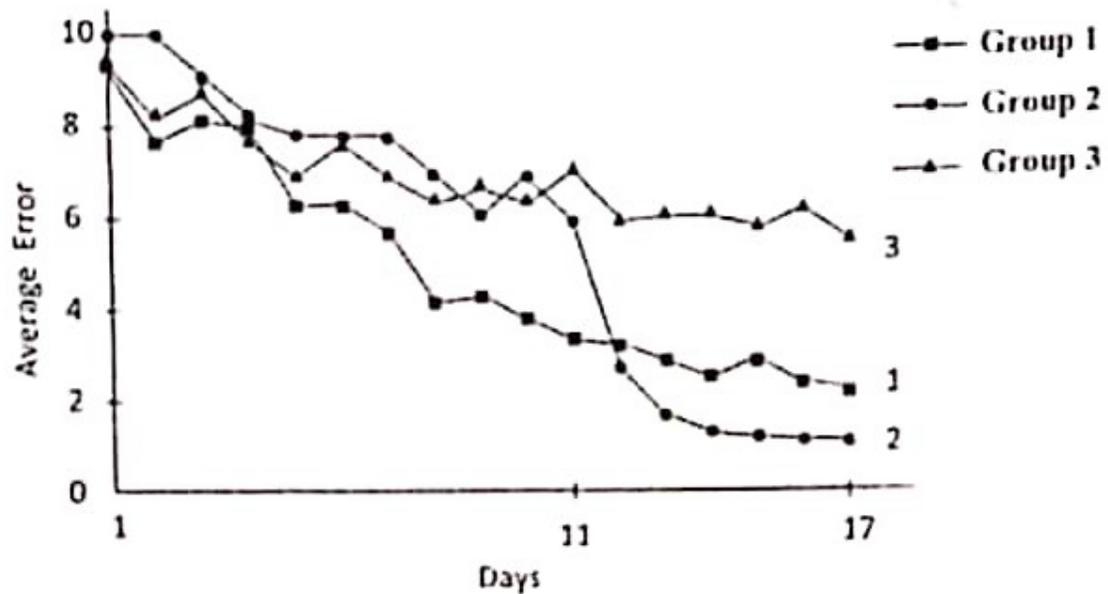
Day 1 -10 every time the rats reached the end, they were removed from the maze.

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.

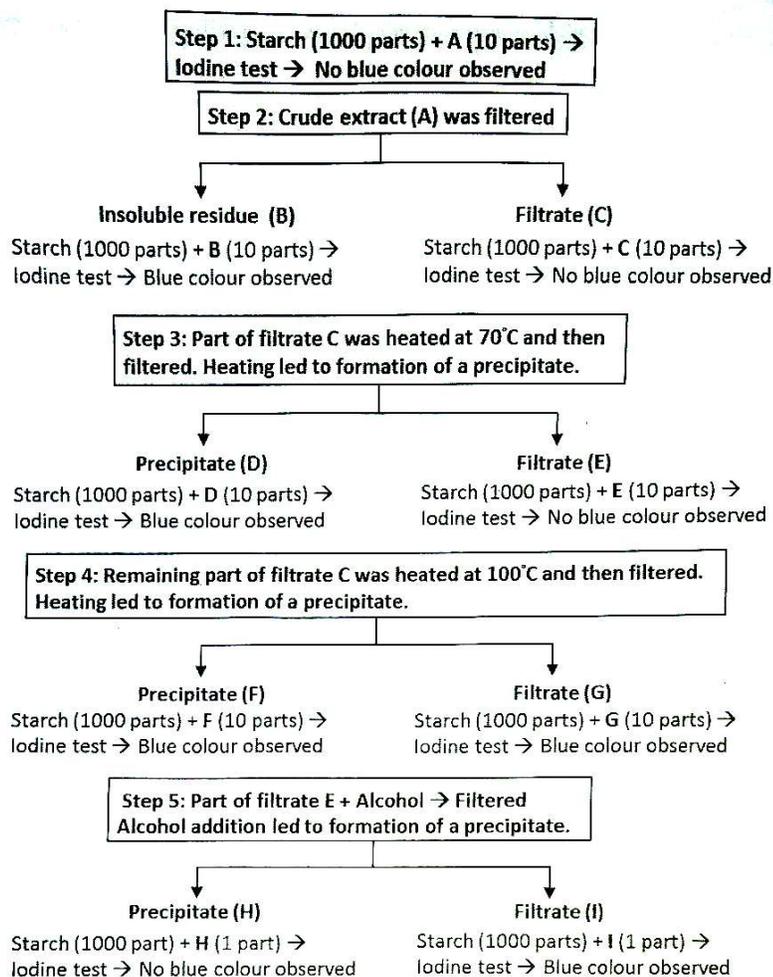
The average number of errors (any deviation from the shortest correct path to reach the end) observed for each group of rats is shown in the graph below.



- 16.1 A few statements are listed below. Based on the results of the experiment, identify each of the statements as True or False.
- Rats need good nutritional status to perform well in the maze.
  - Result shows characteristic stimulus (maze) response (teaching the end) behaviour which is genetically determined and hence not changeable.
  - The find of end of the maze is by the trial and error method and not due to learning
  - Rewarding the rats has improved the end results
  - There was active learning happening in rats in groups 2 even before day 11
- 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 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.
- Overall rise of line 1 above line 3
  - Increase in errors as the experiment proceeds
  - Steeper decrease in the line 1 in lesser time
  - Same response as line 3 in the graph
17. (7 marks) In the early nineteenth century, two scientists Payen and Person 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:

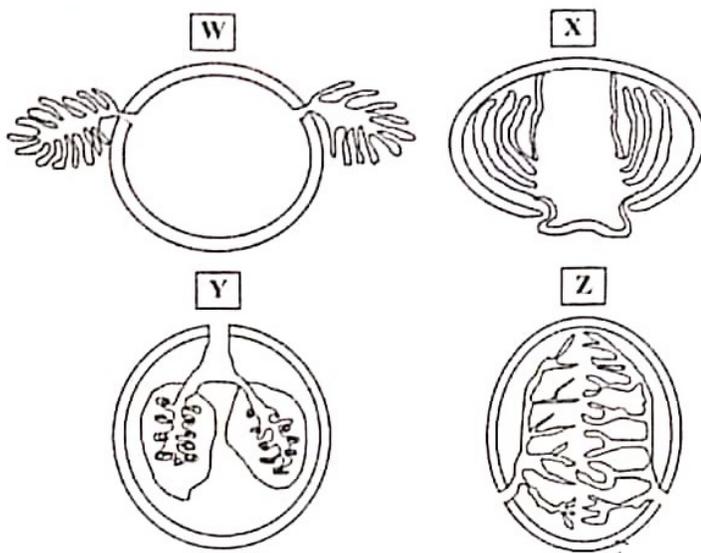
Iodine test: Mixture (Starch + sample) → Wait for 10 mins → Add iodine → Check for colour changes

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



- 17.1 Blue colour indicates (identify the correct option)
- that starch is a polymer of glucose units
  - that starch is digested into small units of glucose
  - glucose units released from starch have formed a complex with iodine
  - 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
- Barley seeds contain a substance that converts glucose to starch
  - Barley seed coat contains a substance that can convert starch to glucose but it gets destroyed by heat
  - The substance present in barley seeds is water soluble and breaks starch into small units
  - 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 preparations (A to I) indicate/s the presence of the 'active substance' being analyzed in barley?

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

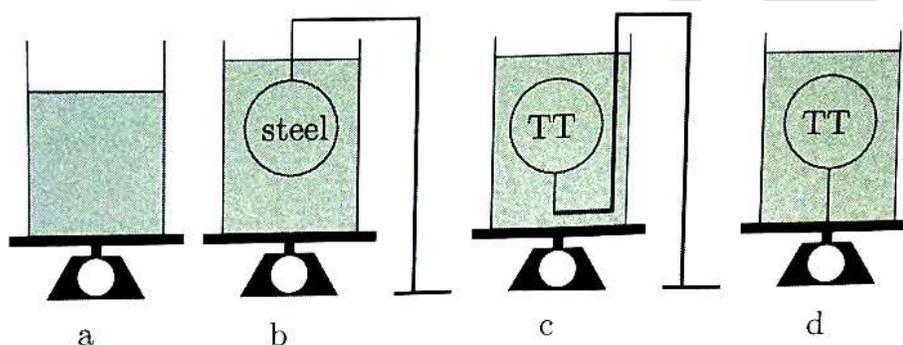
P<sub>1</sub> and P<sub>2</sub> are the partial pressures of the gas at the two locations

L = path length or distance between the two locations

- 18.2 If the temperature 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 type (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)

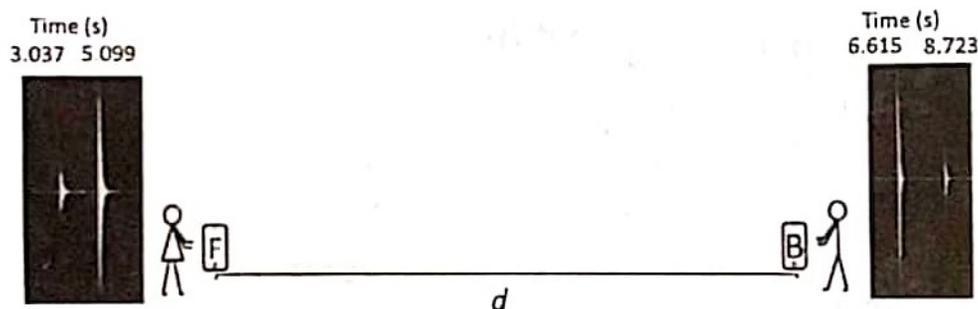
Column I Feature	Column II Factor affected ( $D / A / P1$ or $P2 / L$ or none)	Column III Effect (increase/ decrease/ no change)	Column IV Effect on $Q$ (increase/ decrease/ no change)
1. Highly branched and folded extensions	–	–	–
2. Presence of very thin-walled tissues	–	–	–

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 (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 reading  $W_a, W_b, W_c$  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.

20. (6 marks) Smart phones can be 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 smart phones. In an open field, both place their smart phones at a distance  $d$  from each other as shown in the figure. They stand next to their smart phones, and clap one after another. The audio signals from the claps are digitally recorded by WaveEditor™ and the output produced on their smart phone screens are shown next to their sketches. Note that the figure is not to scale. The time mentioned above the screen images 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 the experiment to be 363 m/s.

Calculate the distance  $d$  (in m). Show the main steps of your calculation:

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, thus 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.