Indian Olympiad Qualifier in Junior Science (IOQJS) 2020-2021

conducted jointly by
Homi Bhabha Centre for Science Education (HBCSE-TIFR)
and
Indian Association of Physics Teachers (IAPT)

Part II: Indian National Junior Science Olympiad (INJSO)

Homi Bhabha Centre for Science Education (HBCSE-TIFR)

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Solutions (January 27, 2021)

For questions requiring detailed solution or reasoning, marks will be awarded for showing the steps/reasoning involved in arriving at the answer, along with the final answer. Any alternative method of solution to questions that is scientifically and mathematically correct, and leads to the same answer will be accepted with full credit. Partially correct answers will gain partial credit. Valid assumptions/ approximations are perfectly acceptable.

1. C. Responses to fight-flight situation can either be the result of acute stress such as loss of bowel/bladder control and shivering while some could be to help overcome the situation such as pupil dilation to accept more light.

2. D. Oxygen level in the arteries has to be maintained at the same level. During exercise, since tissues utilizes more oxygen, its level in the veins will decrease.

3. C. I represents bacteria since it does not possess mitochondria but has cell wall; II represents plant cell due to presence of cell wall and nucleus; III represents ribosomes which are found attached to the endoplasmic reticulum in the cytoplasm; IV represent viruses which need host cells for replication.

4. C. Paper is made of cellulose and hence is a good source of carbon while buttermilk contain lactobacilli which help in aerobic decomposition.

5. D. Her field of view will be determined by drawing rays from each of the toys to the right and left edges of the plane mirror. She can see the image if she is within the range of these reflected rays.

6. A. Wires must be connected in parallel to draw maximum power, such that each piece draws maximum current of 5 A. Resistance of each piece will be 220/5 = 44 ohm. Hence the number of pieces will be 310/44 = 7.

7. D. Water will lose more amount of energy while first converting to ice and releasing heat equivalent to the latent heat.

8. D. Gravitational force is an attractive force and the Coulomb force, which is responsible for the scattering of alpha particles, is repulsive.

9. B. In liquid phase, water molecules have hydrogen bonding between H of one molecule and O of another molecule. In gas phase, the hydrogen bonds don't exist, but the molecules remain intact.

10. B. Diffusion is a slow process and takes time to visibly get completed (at macroscopic level). At molecular level, transport of solute molecules from one region to another never stops but average concentration of molecules in a region remains approximately constant.

11. C. Removal of CO_2 on heating reduces the concentration of H^+, carbonate, and bicarbonate ions present in rainwater which leads to reduction in electrical conductivity of water.

12. C. In concentrated NaCl solution, chloride ions get oxidized at anode to produce chlorine gas.

13. mass% of $MgCl_2$ = 61.1%
Solution:
Moles of AgCl precipitated = 0.0371 mol AgCl
Moles of $MgCl_2$ in sample = 0.0186 mol
Mass of $MgCl_2$ in sample = 1.77 g

14.

14.1. (a) Green
(b) 0.5 × 36 g = 18 g (when the tests are done in order iii → i → ii, as the same solution can be used for all three tests by a student).

14.2 (a) $H_2SO_{4(aq)} + H_2O_{2(l)} + 2KI_{(aq)} \rightarrow 2H_2O_{(l)} + I_{2(s)} + K_2SO_{4(aq)}$
(b) KI (or I^-)
(c) A

14.3. (a) Violet / Bluish pink .
(b) K_2O (solid)
(c) B and D

14.4. Bottom layer: Carbon tetrachloride (having higher density than water); with dissolved I_2.
Top Layer: Water with dissolved KI and I_3^- (both are ionic and highly soluble in water).

15.

15.1. (a) Point **5** **(b)** Point **1** **(c)** Point **5**

15.2. Carbon and wax (CO also acceptable)

$$C + O_2 \rightarrow CO_2$$
$$2C_{24}H_{50} + 73O_2 \rightarrow 48CO_2 + 50H_2O$$

15.3. A. The flow of air below the flame is from bottom to top. Hence air at point **2** would be ambient air from below which is flowing in toward the flame region. Products of combustion being hotter gases will move upwards and will not come to this region. Wax vapourization takes place in upper region of the wick, and the vapours rise upwards.

15.4. Naphthalene should give brighter (more luminous) flame as it has higher mass percentage of carbon (93.8%) than citric acid (37.5%). Thus naphthalene on burning would produce more carbon particles, which are likely to glow over longer time span.

16.

16.1. (a) False. The experimental results show that although all rats were given regular meals, i.e. had the same nutritional status they performed differently.
(b) False. Outcomes differ with different treatments and hence behavior is changeable.
(c) False. The decrease in the number of errors over time indicates learning.
(d) True. Additional food as reward leads to faster decrease of errors.
(e) True. Since during days 1 – 10 also, the errors were showing reduction.

16.2. C is correct because not getting regular meals on time will increase the need for food and hence faster learning is likely to happen when food is given as reward.

Statement A is incorrect because the line that represents the response of rats with reward will always be below the line for group without reward.
Statement B is incorrect because additional food as reward will lead to decrease in errors and not an increase.
Statement D is incorrect because the response will not be the same as line 3 since some learning is likely to happen when reward is given to the rats.

17.

17. 1. D. Iodine forms a complex with the starch polymer to impart blue colour.

17.2. (a) False. Results indicate that starch is broken down to glucose

(b) False. Insoluble residue **B** does not break down starch into glucose.

(c) True. Indicated by results with filtrate C that shows that starch is broken down to glucose.

(d) False. Although heating at 100^0C inactivates the active substance in the filtrate but there is no evidence of enhanced activity on heating up to 70^0C.

17.3. **A**, **C**, **E**, **H** (All the preparations that show absence of blue colour as the end result indicate the presence of the active substance.)

18.

18. 1. W: Tadpole (shows presence of external gills)
X: Prawn (shows presence of internal gills)
Y: Rabbit (shows lungs which is present in mammals)
Z: Cockroach (shows presence of spiracles and tracheae)

18.2. **(a) Y** and **Z** **(b) W** and **X.**
Y and **Z** are terrestrial animals. Diffusion is faster in less dense medium such as air as compared to water.

18.3.

Column I	Column II	Column III	Column IV
1	A	Increase	Increase
2	L	Decrease	Increase

19. $W_b = 1.100$ kg, $W_c = 1.100$ kg, $W_d = 1.020$ kg
Solution: In the case of b) and c), buoyancy force will contribute to the reading which is 1 N. Both will give same reading regardless of their densities. In d), TT ball can be considered as if it is kept on the floor.

20. d = 8.35 m
Solution: Two events are being recorded for each of them: clapping and receiving the other's clap. It takes d/v time to reach one's clap to the other's smartphone. Thus the time difference between his/her own clap and the receiving clap will be more for the person clapping first. From the time stamp data given in the figure, it is apparent that Bharat claps first.

Now consider the case when Fatima claps after hearing Bharat's clap.

Bharat and Fatima, both are clapping standing next to their smartphones, hence the intensity of the sound heard by their phones will be higher for their claps and lower for each other's clap. Hence the first peak in his screen belongs to this first clap (① in the figure). It takes d/v time to reach Fatima and

recorded by her phone with a lower intensity which is indicated by ② in the figure. Signals recorded for Fatima's clap are indicated by ③ and ④ in the figure.

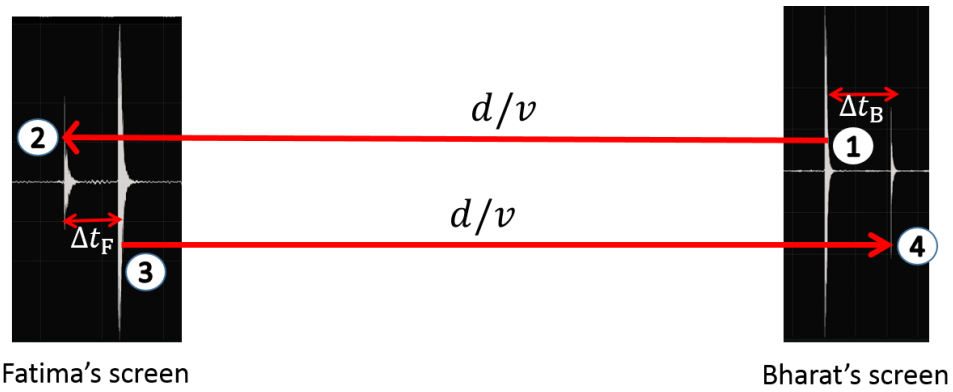

Figure: Sequence of events on a time scale

We define the following sequence of events on a timescale:

1. t_{1B} = Bharat's clap is recorded in his phone
2. t_{1F} = Bharat's clap is recorded in Fatima's phone
3. t_{2F} = Fatima's clap is recorded in her phone
4. t_{2B} = Fatima's clap is recorded in Bharat's phone

Here $\Delta t_F = t_{2F} - t_{1F}$ and $\Delta t_B = t_{2B} - t_{1B}$. Let v be the speed of sound in the medium.

$$\begin{aligned}\text{Total time from the first to the last event } (\Delta t_B) \\ = \text{Time taken from sound to reach from Bharat to Fatima} + \Delta t_F \\ + \text{ Time taken from sound to reach from Fatima to Bharat}\end{aligned}$$

$$\Delta t_B = \frac{d}{v} + \Delta t_F + \frac{d}{v}$$

It may be noted from the figure that $t_{1B} > t_{1F}$. In other words, time stamp for the first event is higher than the second time! This is possible only if the clocks for Bharat and Fatima started at different times. i.e. they initiated the recording in their apps at different times. However, this does not affect the solution in any way since only differences of time measured in each clock are being used, and not absolute time or differences across two clocks. From the figure

$$t_{1B} = 6.615 \text{ s}, t_{2B} = 8.723 \text{ s}, \qquad t_{1F} = 3.037 \text{ s}, t_{2F} = 5.099 \text{ s},$$

which gives d = 8.35 m

There could be another possibility when Fatima claps before Bharat's clap reaches her. If this is the case, then the peak ③ will belong to Bharat's clap in Fatima's phone, and the peak ④ to Fatima's clap. For this to happen, one has to assume that there is no attenuation of sound between both the observers. This case will give the distance to be 757 m which is too large for an assumption of non-attenuation to be true. Hence this scenario is considered to be unrealistic.

21.

21.1 $h \approx 1$ m

Solution: The amount of water evaporated M_w in one year will be given by

M_w = Solar power going into evaporation × One year in seconds /Latent heat

$M_w = 5.1 \times 10^{17}$ kg

Volume of water in one year = $4\pi R^2 h = 5.1 \times 10^{14} \text{m}^3$

Here R is the radius of earth and h is the depth at which this water can be filled i.e. average rain fall.

21.2. Ratio = 1/10

Solution: World's population can be estimated to be nearly five to six times that of India's population (given in the data sheet). For the global population of ~ 700 crores, water requirement for one year will be 1.7×10^{13} m^3.

In order to calculate the fresh water falling on the land area, one can estimate the total area of the land to be about 30% of Earth's surface area.

Water falling on land area in one year $= 0.3 \times 5.1 \times 10^{14}$ m^3. Hence the ratio of water requirement for the population of the world and the total fresh water received through rain over the land annually is close to $\frac{1}{10}$. (A range of values around this value will be accepted, provided they are based on appropriate logic).