

FIITJEE

INDIAN OLYMPIAD QUALIFIER IN JUNIOR SCIENCE (IOQJS)

PART – 2 (INJSO)

Held on: March 06, 2022

QUESTION PAPER

Maximum Marks: 100

Instructions

Section I of this question paper has 12 questions.

- For each question in this section, only one of the four options is a correct answer.
- For each question in this Section, a correct answer will earn 3 marks, a wrong answer will earn (–1) mark, and an un-attempted question will earn 0 marks.
- If you mark more than one option, it would be treated as a wrong answer.

Section II contains 7 questions with multiple parts.

- For questions requiring detailed solution or reasoning, an appropriate box is provided in the answer booklet. For such questions, marks will be awarded for showing the process involved in arriving at the answer, along with the final answer. Valid assumptions/approximations are perfectly acceptable. Please write your method clearly, explicitly stating all the reasoning / assumption / approximations.
- Each question involving marking a statement as True/False carries 1 mark for correct answers and –0.5 mark for a wrong answer.

Section – I

1. Neil Barlett reacted molecular oxygen (O_2) with PtF_6 to get a compound $O_2^+PtF_6^-$. He repeated the experiment with xenon (Xe) in place of O_2 to get another substances which was found to be a mixture of compounds with two of them being $XeF^+PtF_6^-$ and $Xe^+PtF_6^-$. Based on the above information, the statement that is true is
- A. second ionization potential of Xe is much lower than its is first ionization potential
 - B. first ionization potential of Xe is much lower than first ionization potential of O_2
 - C. Xe makes ionic bond with F in one of the above compounds
 - D. Xe acts as reducing agent in above reactions
2. A student took a sandy soil sample from a desert area, put it in a bucket and poured tap water on it. After some time, the soil settled down in the bucket. She wanted to know if the sample had any soluble substances in it. Comparison of which of these properties between supernatant bucket water and the original tap water will most likely answer her question definitively.
- A. pH
 - B. density
 - C. temperature
 - D. light scattering in identical container
3. When silver metal is heated, its electrical conductivity decreases. But the electrical conductivity of molten sodium chloride increases with temperature because -
- A. specific heat of molten sodium chloride is higher than that of silver metal
 - B. average speed of charge carriers increases in both cases
 - C. at a given temperature, collision decrease the average velocity of electrons much more than that of ions.
 - D. density of charge carriers in silver is less than that in sodium chloride
4. An industrial process uses $NaCl$, $CaCO_3$, H_2 and N_2 as raw materials to obtain $NaHCO_3$, using the following processes involving heat and catalysts
- $$3H_2(g) + N_2(g) \longrightarrow 2NH_3(g)$$
- $$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$
- $$NaCl(aq) + H_2O(l) + CO_2(g) + NH_3(g) \longrightarrow NaHCO_3(s) + NH_4Cl(aq)$$
- Of the following substances present in this system, those which can be heated together in another separate chamber to reduce consumption of primary raw material in this process are
- A. $H_2, CaCO_3$
 - B. NH_4Cl, H_2
 - C. CaO, NH_4Cl, H_2O
 - D. $CaCO_3, NH_4Cl$
5. A thin aluminium foil is often placed on a bowl of food to keep the food warm, The foil does this by preventing heat flow through
- A. radiation only
 - B. convection only
 - C. radiation and convection only
 - D. radiation, conduction, and convection
6. On a windy day, standing on your balcony, you hear the whistle of a stationary train at a distance. Which among the velocity and frequency of the sound is / are affected by the wind?
- A. only velocity
 - B. only frequency
 - C. both velocity and frequency
 - D. neither velocity nor frequency

7. Madhav assembled a toy cart with two wheels which were unequal in size. The left wheel was 4 cm in diameter and the right wheel was 3 cm in diameter. The wheels were connected to the opposite ends of an axle of length of 10 cm. He set the cart in motion on the floor, pointing due north. Assume that the wheels roll without slipping. Approximately after how many rotations of the wheels will the cart be pointing due west?
- A. 5
B. 10
C. 15
D. 20
8. A wooden block is floating, partially submerged in a cup of water. If the setup is taken to the Moon and assuming the set up is such that the water does not evaporate.
- A. the block will still float but the water level in the cup will rise
B. the block will still float but the water level in the cup will go down
C. the block will still float with the water level in the cup remaining the same
D. the block will sink and the water level in the cup will rise
9. A mutation has been found in gene X of mice. The expression of this gene is testis specific. The mutation alters acrosome reaction (penetration of egg membrane by the sperm) during the process of fertilization. The sperm with the mutation in gene X are slower to penetrate the membrane as compared to normal healthy sperms. A heterozygous mouse carrying this mutation is allowed to mate with a normal healthy female. In spite of having this mutation, the mouse was able to produce the progeny from this cross. What will be the percentage of the progeny that will have this mutation?
- A. All the progeny pups will have this mutation
B. 50% of the pups will carry this mutation
C. 25% of the pups will carry this mutation
D. It is unlikely that the progeny pups will carry this mutation
10. The muscular endurance of an athlete is his/her ability of perform certain physical exercise for longer period of time without getting exhausted. To achieve this high muscular endurance, most of them follows 'Carbo Loading' practice. Generally, while preparing for certain event, they increase overall exercise and conduct rigorous workout for a week or two. Then 3 – 4 days just before the actual event, they reduce the training the include complex carbohydrate rich food in their diet. How this can be helpful for their performance?
- A. The diet helps in building extra muscle tissue needed for strength
B. It increases the blood glucose level necessary for immediate raised performance
C. Excessive glycogen can be synthesized, which can be stored and utilized during the event.
D. The complex carbohydrate gets stored into fats which can provide more ATPs for strenuous performance.

11. The following observations were recorded after studying some organisms:

Character	Organism W	Organism X	Organism Y	Organism Z
Water essential for fertilization	-	+	-	+
Formation of filament from germinating spore	-	-	-	+
Plant body sporophytic, differentiated in root, stem and leaves	+	+	+	-
Male and female sex organs arranged compactly in cone	+	+	-	-
Female gametophyte enveloped by single layered covering	+	-	-	-
Triploid tissue observed in zygote	-	-	+	-

On the basis of the data, identify the group of organisms :

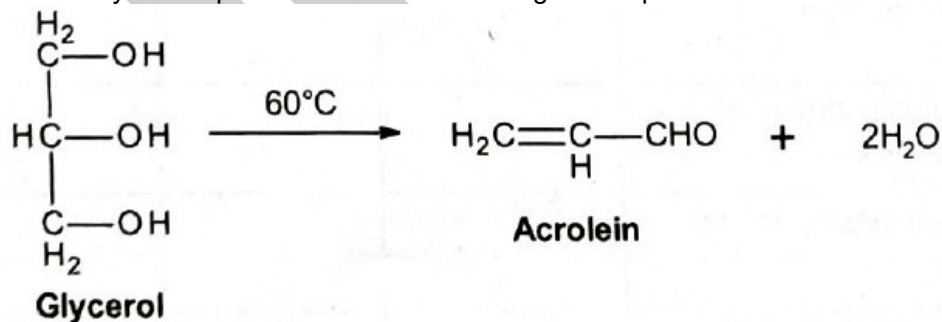
- A. W – pteridophytes, X – bryophytes, Y – angiosperms, Z – gymnosperms
 B. W – angiosperms, X – gymnosperms, Y – pteridophytes, Z – bryophytes
 C. W – angiosperms, X – bryophytes, Y – gymnosperms, Z – pteridophytes
 D. W – gymnosperms, X – pteridophytes, Y – angiosperms, Z – bryophyte

12. If the gamete of a tetraploid plant contains 26 chromosomes, the number of chromatids in cell of the plant during metaphase of mitosis and metaphase II of meiosis will be respectively
 A. 104 and 104 B. 52 and 26 C. 104 and 52 D. 26 and 26

Section – II

13. (10 marks) Glycerol is formed in large quantities as the by-product in the soap making industry. Saponification reaction is the hydrolysis of fat and oils(triglycerides) with excess alkali resulting in two products: soap and glycerol. The common raw materials required for preparing soap are: oil/fat, caustic soda(NaOH solid), sodium chloride and water.
- 13.1. In which order should these materials be mixed to obtain soap? Indicate the mixing order in 3 steps. S1 – S3. [Note that mixing of caustic soda and water produces a lot of heat]
- 13.2. Cooling the mixture is helpful after one of the mixing steps while heating the substance is helpful after another of the mixing steps. Identify the two steps(from S1-S3)
- 13.3. After soap is formed and separated, what components of the reaction mixture are left behind apart from glycerol?
- 13.4. Glycerol cannot be distilled at atmospheric pressure. It is removed from the reaction mixture by distillation under very low pressure. Based on this information, estimate the range in which boiling point of glycerol at atmospheric pressure is likely to lie. Given: Boiling point of Ethanol: 78°C.
 A. 25-27°C B. 75-90°C C. 90-110°C D. above 110°C
- 13.5. The glycerol obtained in this process is not pure. What is the predominant impurity in the distilled glycerol obtained?
- 13.6. During the saponification process three molecules of soap and one molecule of glycerol are formed by the reaction of one molecule of oil with alkali. When 5 g of an oil was completely saponified with 50.0 mL of 0.5 M NaOH solution, the resultant mixture was titrated with 0.5 M HCl and it required 14.0 mL of the acid to reach equivalent point. Calculate the amount of glycerol that can be obtained from 1 Kg of this vegetable oil.

Glycerol may decompose to form acrolein at higher temperatures as shown below:

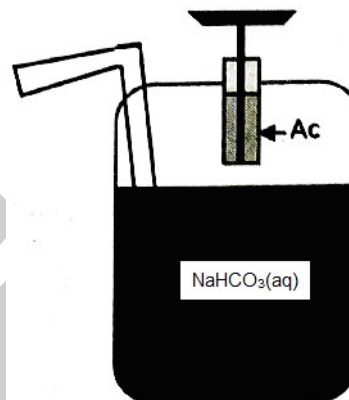


- 13.7. If under the soap making conditions described in 13.6, 1 out of 10 glycerol molecules formed decompose to acrolein, calculate the amount of glycerol that can be obtained per kg of oil.
14. (12 marks) Most fires require three components to sustain the combustion:
 i. Fuel ii. Oxygen iii. Heat to initiate and sustain the combustion
 To control unwanted/accidental fires, various methods are used to extinguish fire depending on the nature of the material(s) being burnt.
 Consider different kind of fires being fuelled by the following materials
 I. Paper stacks II. Stack of clothes III. Vegetable oil spill
 IV. Petrol in drums V. Electrical wiring with plastic insulation
 Different kind of fire-fighting strategies are effective for different fires. Here we look at four common strategies.

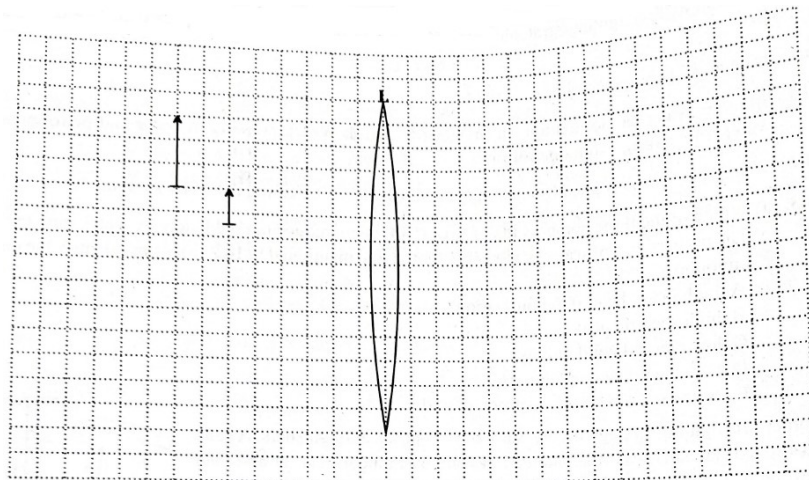
First strategy is of spraying water over the fire.

- 14.1. Spraying water cannot extinguish fires due to petrol. Which property of water and petrol prevents water from extinguishing petrol fire?
- 14.2. Among the fires sustained by materials I – V, which can be extinguished by spraying water?
- 14.3. (a) Which of the three components of fire(i - iii) is/are reduced immediately by water spraying?
- (b) The property/ies of water responsible for the role mentioned in 14.3(a) is/are (identify the correct option(s))
- A. High latent heat of vaporization
B. High specific heat
C. Low thermal conductivity
D. High electrical conductivity
E. Its property to dissolve carbon dioxide

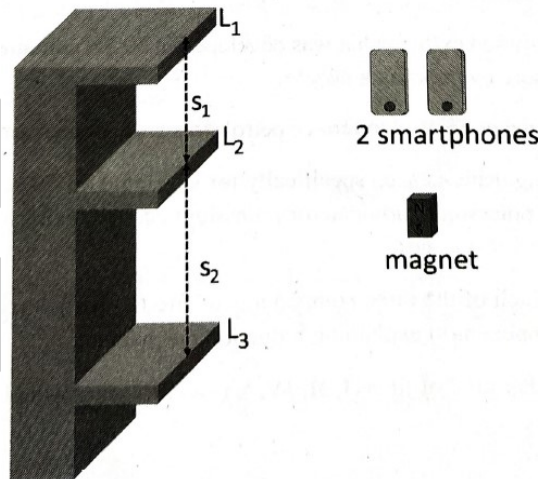
Another fire-fighting strategy involve use of CO₂-based extinguishers. A soda acid fire extinguisher was first patented in 1866 by Francois Carlier and then modified in 1881 in the U.S by Almon M Granger. The extinguisher contains a solution of sodium bicarbonate(NaHCO₃) with sulphuric acid contained in a sealed vial(labeled Ac in diagram). When the nozzle is pressed, the seal is broken and acid falls into sodium bicarbonate solution. As a result carbon dioxide and carbonic acid water is sprayed on the fire.



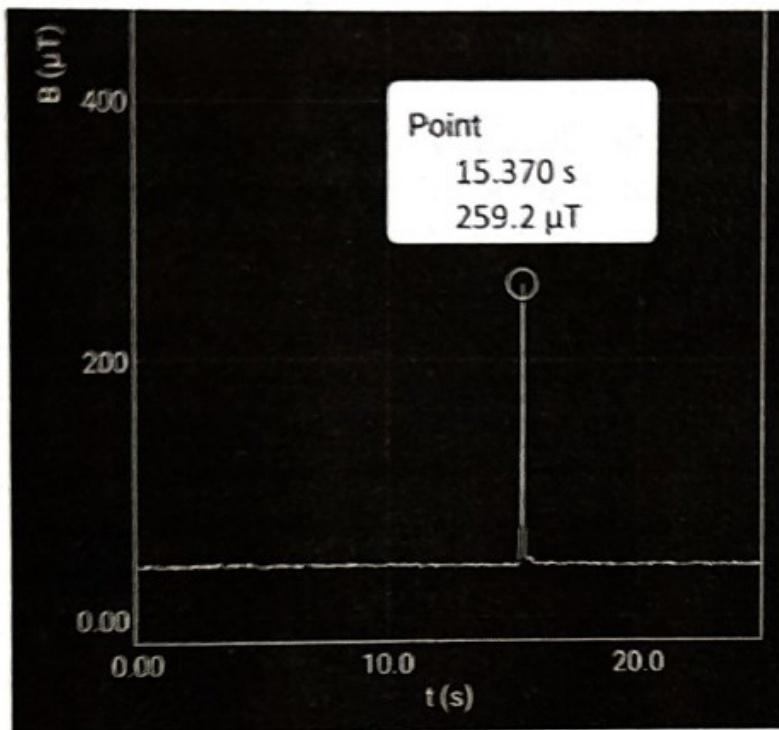
- 14.4. Which of the three components of fire(i - iii) does soda acid suppresses in fire?
- 14.5. Should a soda acid extinguisher be used to reduce petrol fires and/or first in electrical wiring? Give reason for your answer.
- Another version of CO₂ based extinguisher was developed in 1920s contains only compressed CO₂, which is released at high pressure by pressing a nozzle
- 14.6. Can a CO₂ extinguisher be used to reduce petrol fires and/or electrical fires?
- A third type of fire extinguisher is used specifically for vegetable oil fires. There fire extinguisher spray a fine spray of alkaline potassium carbonate or potassium acetate on burning oil. This fine spray cause formation of foam on the oil surfaces.
- 14.7. (a) In this case, which of the three components of fire(i - iii) get reduced? Write one sentence for each of the component(s) explaining reduction mechanism(s).
- (b) Which of the other kind of fires(I, II, IV, V) can be extinguished using this extinguisher?
15. (10 marks) The figure below shows a partial drawing of an optical system. The system consists of an object, a real image of that object (both shown by the pair of arrows), It is not explicit that which arrow represents the object. All elements are parallel to each other. Consider the centre of the lens to be at (0 cm, 0 cm). Assume each small box on the dotted grid is 0.5 cm × 0.5 cm in size.



- (a) Draw a ray diagram showing all the elements (including the mirror) of the optical system so that the given object – image pair is produced. You are not allowed to change the size or position of any of the elements shown. Also state the values of the focal length of the lens f , and the location of the mirror l (both in centimeters).
- (b) With the given object/image pair, are there any other values of f and l possible? Justify your answer.
16. (10 marks) Padma wants to devise an experiment to determine the acceleration due to gravity, g . All she had is a wooden shelf with three levels, two identical smartphones, and one small magnet.



She knows the distance S_1 and S_2 between the levels (L_1, L_2, L_3) of the shelf. She came to know that smartphones have a magnetometer sensor and there are apps which use it and display the magnetic field nearby. She experimented with an app and noticed that when a magnet passes within the close vicinity of the phone, the magnetometer in the phone shows the change in magnetic field graphically (as seen at $t = 15.37$ sec in graph below).



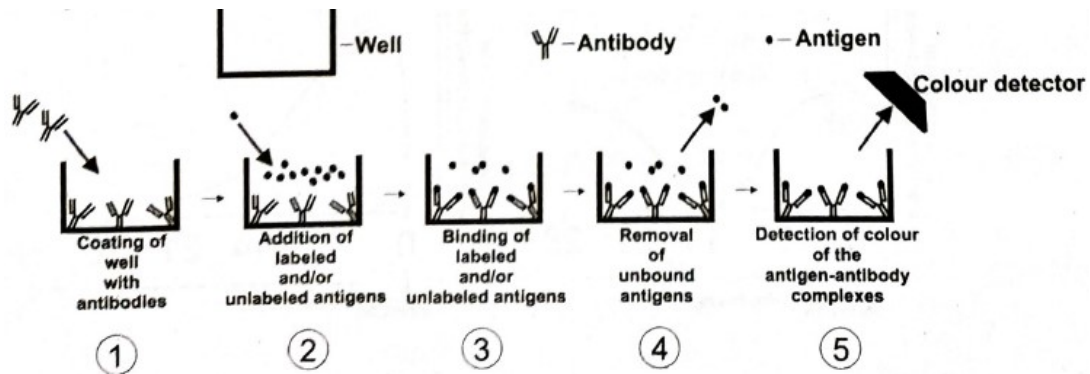
Clocks in the two phones are not synchronized but the time in the app is measured from the time the sensor is activated by pressing a switch in the app. She found that she can manually start the apps in the two phones simultaneously by pressing the start buttons in each together. However, synchronization of dropping the magnet and starting the app is very difficult, and introduces a large error in the measurement. The formula for change of magnetic field B with distance is not known to her.

Describe the experiment that she should perform to determine g as accurately as possible. You must clearly describe the setup and the procedure of measurement, as well as derive the formula for determination of g from the measured quantities. Also, list the possible sources of errors.

17. (9 marks) When an infectious agent enters the body of a person, the cells of the immune system recognize it as a foreign object and initiate immune reaction against it. The antigen-antibody reaction is one of the many mechanisms of action of our immune system to fight infection. In this, the immune system starts to form more of the cells that produce antibodies specific to the newly encountered antigen. These cells then multiply to produce large quantities of the required antibody. In a few days' time, these antibodies start eliminating the infectious agent from the body and continue to do so till the number of infectious agent becomes almost zero.

When a person is infected by any pathogen for the first time, the immune system develops antibodies and keeps the memory for variable durations depending upon the pathogen. When there are subsequent attacks by the same pathogen before the memory period is over, the immune system takes less time to initiate a response and the response generated is usually stronger than the first response.

The specificity of the antigen-antibody interactions is used as a tool for detection of the infectious agent or its parts in the body fluids / tissues. One such technique is depicted in the diagram shown below.



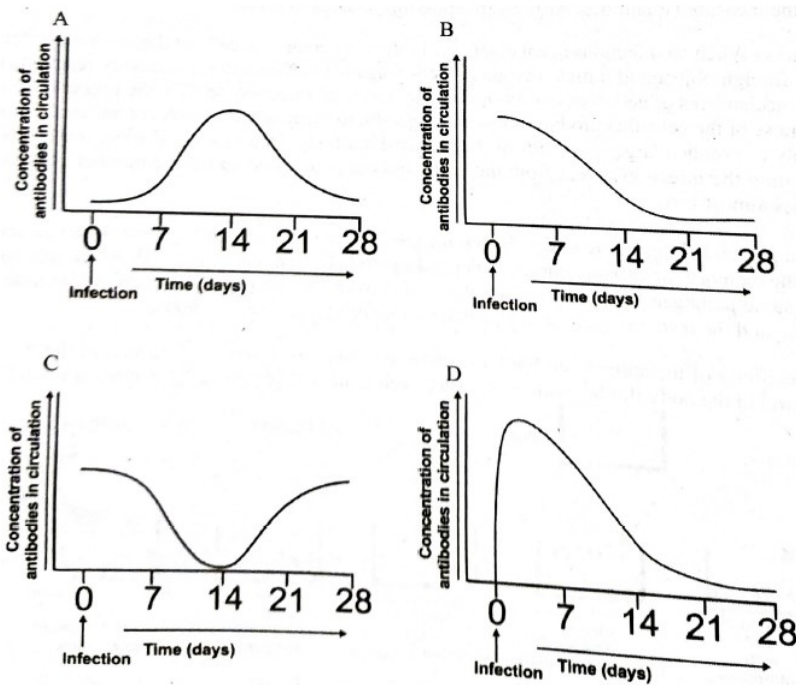
The system is developed in such a way that if the antigens are labeled, when they bind to the antibodies, they form complexes that are coloured and can be detected. The process of labeling involves chemically attaching a coloured molecule to the antigen. If the antigens are not labeled, then the complex remains colourless.

- 17.1 Suppose that this test is used for detection of a virus from circulating blood. The labeled antigens have the same capacity as that of the actual antigen to bind to the antibodies. The serum from an infected and a non-infected person are added as shown in the table below.

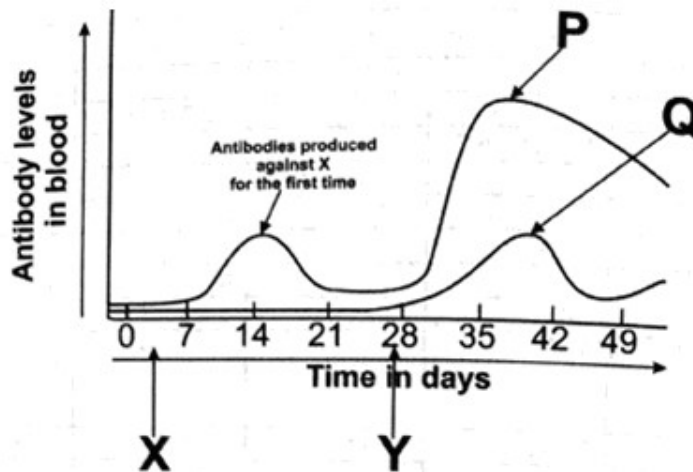
Well	Components added after antibody coating
1. Control	Labeled antigens only
2. X	Labeled antigens + serum of an infected person
3. Y	Labeled antigens + serum of a non-infected person

After allowing the antigens to bind with the antibodies, the supernatant containing unbound antigens is removed and intensity of the colour of the antigen-antibody complexes, if there are any, is detected and quantified. Based on this experimental set up, which of the following statements is CORRECT?

- Intensity of the colour detected from X is less than that from the control well.
 - Intensity of the colour detected from X is more than that from the control well.
 - Intensity of the colour detected from X is less than that from the control; but is more than that from Y.
 - Intensities of the colours detected from X and Y are equal to each other as well as with that from the control.
- 17.2 Considering the facts regarding entry of pathogen and production of antibodies, choose the correct option that depicts the response of the immune system in form of antibody production following the first time infection by a new pathogen (not encountered before) in an adult healthy human being.



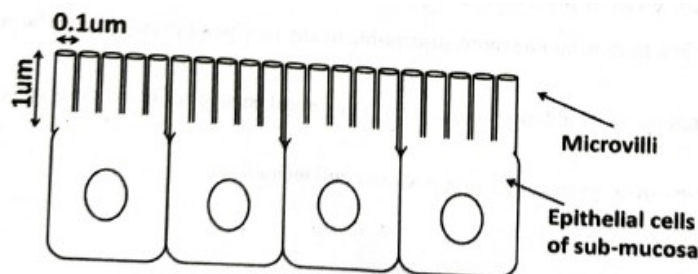
- 17.3 Vaccine-mediated immune protection depends on antigen-antibody reactions. Most of the traditional vaccines are killed/ weakened or inactivated pathogens, which are unable to cause the disease by themselves, but are able to trigger antibody production.



Considering these facts and the graph shown above, identify possibilities for labels X, Y, P and Q from the list given below.

- i. Entry of new pathogen into the body.
- ii. Second / repeat encounter of a pathogen
- iii. Vaccine administration
- iv. Administration of booster dose of vaccine
- v. Antibody levels upon entry of a new pathogen
- vi. Antibody levels upon second/repeated entry of a pathogen
- vii. Antibody levels upon administration of any vaccine
- viii. Antibody levels upon administration of booster dose of the same vaccine
- ix. Antibody levels upon administration of vaccine developed against a different pathogen

18. (3 marks) There are about 1.2×10^{10} microvilli per square of sub mucosa in gastrointestinal track of humans. Each microvillus- a rod like structure present on epithelial cell of sub mucosa- is $1 \mu\text{m}$ in length and $0.1 \mu\text{m}$ in diameter.



In a particular genetic condition associated with intractable diarrhea, the average length of the microvillus is found to be reduced by 66% (though the cross section remains almost the same).

Assume that absorption is happening predominantly on the microvilli surfaces. Calculate, in terms of percentage, how much would be the loss in total surface area available for absorption in small intestine in that genetic condition. Note that answers without calculations / explanation will not be considered.

19. (10 marks) Four farms from similar geographic location, **A**, **B**, **C** and **D** of equal size are divided into 7 lenses spatially – 1, 2, 3, 4, 5, 6, and 7. The table represents plantation strategy of farmer for the four farms in five consecutive years.

Farm name	Plantation	Kharif season of the Year				
		2015	2016	2017	2018	2019
A	Wheat	1,2,3,4,5,6,7			1,2,3,4,5,6,7	
	Soybean		1,2,3,4,5,6,7			1,2,3,4,5,6,7
	Rice			1,2,3,4,5,6,7		
B	Wheat	1,3,5,7	2,4,6	1,3,5,7	2,4,6	1,3,5,7
	Soybean	2,4,6	1,3,5,7	2,4,6	1,3,5,7	2,4,6
	Rice	0	0	0	0	0
C	Maize	2,4,6	2,4,6	2,4,6	2,4,6	2,4,6
	Pea plant	3,5	3,5	3,5	3,5	3,5
	Trap plant/grass	1,7	1,7	1,7	1,7	1,7
D	Maize	3,5,6,7	3,5,6,7	3,5,6,7	3,5,6,7	3,5,6,7
	Wheat	2,4	2,4	2,4	2,4	2,4
	Trap plant/grass	1	1	1	1	1

- 19.1 For items (a – e), write appropriate answer(s) in **the answer sheet**, based on the above table.

- (a) Intercropping is practiced in farm/s _____ in the year(s) _____.
- (b) Crop rotation is practiced in the farm/s _____.
- (c) Rice / Maize / Wheat / Pea plant / Trap grass may replace Soybean in Farm B, without affecting yield / acre of plantation strategy to a great extent. (Identify the correct option(s)).
- (d) The farm that is likely to provide least yield / hector to the farmer in the year 2019 is _____.
- (e) One of the efficient farming strategies termed 'push pull technology' involves planting insect attractant forage grass trap or 'pull' –plant at the border of field, and insect repellent leguminous 'push' plant in between the main crop. The farm/s using this strategy is / are _____.

19.2 State true or false.

- i. Chemical and visual cues given by plant will be important while choosing it as a trap crop.
- ii. Monoculture of maize in a farm would be more susceptible to any new pest infestation over farm/s **A, B** and **C**.
- iii. Mixed cropping / intercropping would discourage growth of natural enemies of insect pests compared to monocropping.
- iv. Pest infested cereal crop can be rescued by using push and pull technology.

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