Time : 2:30 PM to 3:45 PM

Question Paper Code : 52

Student's Roll No:														

Write the question paper code (mentioned above) on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be evaluated, Note that the same Question paper code appears on each page of the question paper.

INSTRUCTIONS TO CANDIDATES

1. Use of mobile phone, smart watches, and iPad during examination is STRICTLY **PROHIBITED.**

2. In addition to this question paper, you are given OMR Answer Sheet along with candidate's copy.

3. On the OMR sheet. make all the entries carefully in the space provided ONLY in BLOCK CAPITALS as well as by properly darkening the appropriate bubbles.

Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.

4. On the OMR Answer sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling bubbles.

5. Your **fourteen-digit roll number and date of birth** entered in the OMR Answer sheet shall remain your login credentials means login id and password respectively for accessing your performance result.

6. Question paper has two parts. In part A1 (Q. No.1 to 24) each question has four alternatives, out of which only one is correct. Choose the correct alternative (s) and fill the appropriate bubbles(s), as shown.

Q.No.12 a ● c d

In part A2 (Q.No. 25 to 33) each question has four alternative out of which any number of alternative may be correct. You have to choose all correct alternative and fill the appropriate bubbles(s). as shown.

Q.No.30 a ● c ●

7. For **Part A1,** each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer In **part A2,** you get 6 marks. If all the correct alternative are marked and incorrect No. negative marks in this part

8. Rough work should be done only in the space provided. There are **08** printed pages in this paper.

9. Use of **non-programmable** scientific calculator is allowed

10. No candidate should leave the examination hall before the completion of the examination.

11. After submitting answer paper, take away the question paper & candidate's copy of OMR for your reference

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR answer sheet.

OMR answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED, Scratching or overwriting may result in wrong score.

DO NOT WRITE ON THE BACK SIDE OF THE OMR ANSWER SHEET.

Instructions to Candidates (Continued):

You may read the following instructions after submitting the answer sheet.

12. Comments/Inquiries/Grievances regarding this question paper, if any, can be shared on the Inquiry/Grievance column on www.tapt.org.in on the specified format till January 15, 2022

13. The answers/solutions to this question paper will be available on the website: www.japt.org.in by January 14, 2022.

14. **CERTIFICATES and AWARDS:**

Following certificates are awarded by IAPT to students, successful in the Indian Olympiad Qualifier in Junior Science 2021-22 (Part 1)

(i) "CENTRE TOP 10%" To be downloaded from iapt.org.in after 15.03.22

(ii) "STATE TOP 1%" Will be dispatched to the examinee

(iii) "NATIONAL TOP 1%" Will be dispatched to the examince

(iv) "GOLD MEDAL & MERIT CERTIFICATE" to all students who attend OCSC-2022 at HBCSE Mumbai

Certificate for centre toppers shall be uploaded on iapt.org.in

15. List of students (with centre number and roll number only) having score above MAS will be displayed on the website: **www.iapt.org.in** by **February 06, 2022 See the** Minimum Admissible Score Clause on the student's brochure on the web.

16. List of students eligible for evaluation of IOQJS 2021-22 (Part II) shall be displayed on www.japt.org.in by February 10, 2022.

Physical constants you may need....

Mass of electron $m_e = 9.10 \times 10^{-31}$ kg	Magnitude of charge on electron e = 1.60×10^{-19}C
Mass of proton $m_P = 1.67 \times 10^{-27}$ kg	Planck's constant h = 6.625×10^{-34} Js
Acceleration due to gravity g = 9.81 ms^{-2}	Density of seawater at p = 1.03×10^3 kg m^{-3}
Universal gravitational constant G=6.67×10^{-11} Nm^2Kg^{-2}	$(1 + x)^n \approx 1 + nx$, if $\|x\| << 1$
Universal gas constant R = 8.31 $Jmol^{-1}$ K^{-1}	leV = 1.6×10^{-19} J
Boltzmann constant k = 1.38×10^{-23} JK^{-1}	sin (A – B) = sin A cos B - cos A sin B
Avogadro's constant A = 6.02×10^{23} mol^{-1}	$E = mc^2$, It's an equation which gives mass and energy equivalence.
speed of light in free space c = 3.0×10^8 ms^{-1}	One unit of electric power = 1kWh

(Part-I) (NSEJS 2021 – 22)

Time : 75 Minute **Max. Marks : 126**

Attempt All Thirty Three Questions
A – 1
OUT OF FOUR OPTIONS, ONLY ONE IS CORRECT, BUBLE THE CORRECT OPTION.

1. The variation of a certain physical parameter Z with variable u is given by the relation $Z = A\left(\frac{R}{R+u}\right)^3$, where R and A are constants and hic maximum value of u << R. Then to find R. a student plots a graph of variation of Z (Y axis) against u (X axis). The graph is a

(a) straight line passing through origin and slope = $\frac{R}{3}$

(b) straight line with intercept $\frac{3A}{2}$ and slope $= -\frac{R}{3A}$

(c) straight line with intercept A and slope = $-\frac{3A}{R}$

(d) straight line with intercept $-\frac{A}{2}$ and slope = –3 R

Ans. **(Misprint) in Code 52 but right in code 53 so Ans. will be C)**

Sol. $Z = A\left(\frac{R}{R+u}\right)^3$

Given u <<R

$Z = A \times \frac{1}{R^3}\frac{R^3}{\left(1+\frac{u}{R}\right)^3}$

$Z = A\left(1-\frac{3u}{R}\right)$

$Z = A - \frac{3A}{R}u$ ... (1)

$Y = C + mx$ ... (2)

Comparing (1) & (2)

y = z , x = u, c = A, $m = -\frac{3A}{R}$

So, it the equation of straight line with slope $-\frac{3A}{R}$ and intercept point is A

2. A submarine S_1 is parked at depth of 200 m in an ocean on earth. Assume oceans exist on Mars. At about what depths a submarine S_2 has to be parked in an ocean on Mars so that S_2 will experience same pressure as that of S_1? Acceleration due to gravity on Mars is 3.7 m/s^2. (Assume that sea water density on Earth and Mars is same $\rho = 1.03 \times 10^3$ kg/m^3)

(a) 158 m (b) 435 m (c) 530 m (d) 616 m

Ans. **(c)**

Sol. $\rho_w g_e 200 = \rho_w g_m d$

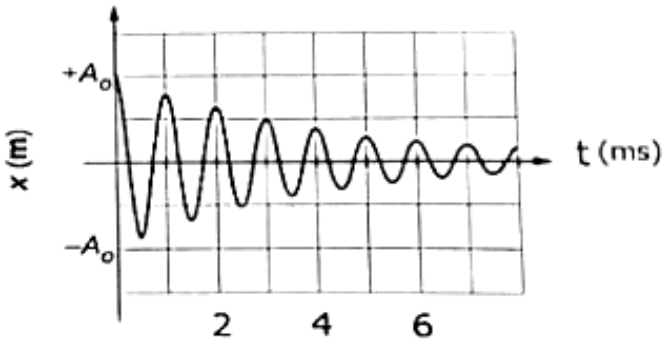
$d = 200\frac{g_e}{g_m}$ {g_m = 3.7 m/s^2}

$= 200 \times \frac{9.81}{3.7}$

= 530.27

$\approx$ 530 m

3. In an oscillating system, damping result in dissipation of the stored energy. The following figure shows the variation of displacement x with time t for an oscillating system. Which of the following statements best describes this physical phenomenon.



(a) Oscillatory motion of an object without damping

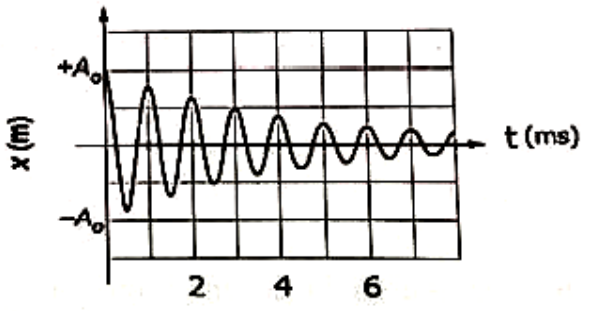
(b) Oscillatory motion of an object with damping such that time measurement was started when the system was at the mean position.

(c) Oscillatory motion of an object with damping with decreasing time period.

(d) Oscillatory motion of an object with damping such that time measurement was started when the system had maximum potential energy.

Ans. **(d)**

Sol.



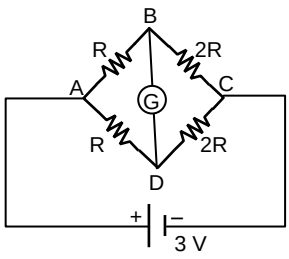
at $t = 0 \quad x = A_0$

initial PE = $\frac{1}{2} K A_o^2$ = maximum

Amplitude decreasing with time

So oscillatory motion is with damping

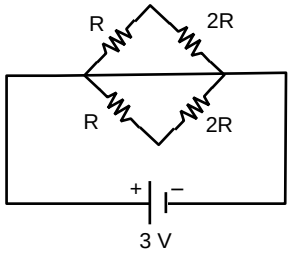
4. In the adjacent circuit, the galvanometer G does not show any deflection. If R = 2Ω, the current drawn from the cell is



(a) 1 A (b) 9 A (c) 4 A (d) $\frac{9}{4}$ A

Ans. **(a)**

Sol.



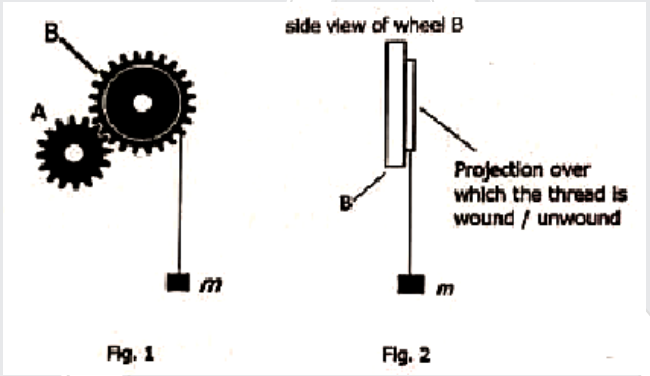
It is balanced
Wheat stone bridge

$R_{eq} = \frac{6 \times 6}{6 + 6} = 3R$

V = 3 volt

$I = \frac{3}{3} = 1$ amp

5. 'Gear' is a mechanical system used to transfer mechanical and rotary motion from one mechanical system to another. As shown in the figure below the driving wheel A drives the driven wheel B without slipping and thus forms the gear system. The wheel A has 16 teeth and B has 24 teeth. Wheel B has a projection (shown by white ring in Fig. 1 and also in the side view of Fig. 2) of radius $\frac{14}{11}$ cm.



A long massless, inextensible string can be wound/unwound over this circular projection. A mass m is attached to the free end of this long string. If the wheel A makes 6 revolutions per second in the clockwise direction, without slipping, then in $\frac{1}{2}$ second the potential energy of the m in CGS unit

(a) increases by 32 mg
(b) decreases by 32 mg
(c) increases by 16 mg
(d) decreases by 16 mg

Ans. **(c)**

Sol. Teeth in wheel A is 16 and in wheel B is 24, in 1 sec the wheel will complete 6 revolution so number of revelation of wheel B will be $n = \frac{24}{16} = \frac{6}{n}$

n = 4 revolution per sec
A is rotating clockwise so B will rotate anticlockwise hence the block will go up.
Increasing potential energy = $4 \times (2\pi r)$ mg

$= 8\pi \times \frac{14}{11}$ mg

$= 8 \times \frac{22}{7} \times \frac{14}{11}$ mg

Increase in pot. Energy = 32 mg

In $\frac{1}{2}$ sec. increase in P.E = 16 mg

6. Canopus is the second brightest star in the night sky. It is about 300 light years away. The energy is produced inside the star through nuclear reactions. If we receive 5.0×10^{-8} W/m^2 energy from Canopus, how much mass does it lose per second?
(a) 1.70×10^{-6} kg (b) 1.91×10^{9} kg (c) 5.62×10^{13} kg (d) 6.34×10^{31} kg

Ans. **(c)**

Sol. Energy radiated by Canopus per sec.
$= 4\pi (r^2)\ 5 \times 10^{-8}$ Watt.
$E = 4\pi (9.46 \times 10^{15} \times 300)^2 \times 5 \times 10^{-8}$ Watt.
$\therefore \quad E = mc^2$

$$m = \frac{E}{c^2} = \frac{4\pi \times (9.46 \times 10^{15} \times 300)^2 \times 5 \times 10^{-8}}{9 \times 10^{16}}$$

$$m = \frac{4\pi \times 9.46 \times 9.46 \times 300 \times 300 \times 10^{30} \times 5 \times 10^{-8}}{9 \times 10^{16}}$$

$$m = \frac{4 \times 3.14 \times 9.46 \times 9.46 \times 9 \times 10^{34} \times 5 \times 10^{-8} \times 10^{-16}}{9}$$

$m = 4 \times 3.14 \times 9.46 \times 9.46 \times 5 \times 16^{10}$
$= 6.28 \times 9.46 \times 9.46 \times 10^{11} \quad = 562.007248 \times 10^{11} \quad = 5.62 \times 10^{13}$ kg.

7. An average human adult radiates about 100 W energy mainly in infra-red region of the electromagnetic spectrum. 50 persons are sitting in a hall with an air conditioning system which is 50% efficient. How much electricity must be used to maintain temperature of the hall at 25°C for 4 hours?
(a) 5 units (b) 10 units (c) 20 units (d) 40 units

Ans. **(d)**

Sol. Total power radiated = 100 × 50
= 5000 W
Total energy radiated = 5000 W × 4 hrs
= 20 kwh

Total electrical energy used by air conditioning system = $\frac{20\text{kwh}}{(50/100)}$ = 40 kwh = 40 units

8. Which of the following is not a function of mature RBCs?
(a) Help in classifying blood in different blood groups
(b) Help in transport of gases
(c) Synthesis of immunoglobulins
(d) Help in maintaining acid base balance in the body

Ans. **(c)**

9. In which of the following classes of vertebrates there are groups of animals without limbs?
(a) Fish, reptiles and mammals (b) Reptiles only
(c) Reptiles and Amphibians (d) Amphibians only

Ans. **(c)**

10. Which of the following groups have only one pair of wings?
(a) Honey bee, beetle, ant (b) Butterfly, housefly, fruitfly
(c) Dragonfly, butterfly, fruitfly (d) Housefly, fruitfly, mosquito

Ans. **(d)**

11. During an expedition to planet 'Imagitica', scientists analysed the genetic material of the organisms found there and noted the following features:
i. Amount of purines and pyrimidines is unequal
ii. Absence of thymine
iii. Unstable genetic material, with high frequency of mutation
iv. Rapid degradation at pH above 12
From the above data, what genetic material might the Imagitica inhabitants contain?
(a) ssDNA (b) dsDNA (c) ssRNA (d) dsRNA

Ans. **(c)**

12. Which of the following is most likely to show aerenchyma?
(a) Leaf base of mango (b) Petiole of water hyacinth
(c) Seta of moss (d) Stem of *Opuntia*
Ans. **(b)**

13. Given below are three statements about bryophytes:
i. Bryophytes are lower plants with plant body differentiated into root, stem and leaves
ii. Bryophytes are devoid of xylem and phloem.
iii. Bryophytes require water for completion of their life cycle.
Which of the above statement/s is/are true with respect to bryophytes?
(a) ii only (b) i and ii (c) i and iii (d) ii and iii
Ans. **(d)**

14. Carbon fixation in most of the succulent plants takes place through which pathway?
(a) Calvin cycle (b) Glycolate pathway
(c) Crassulacean acid metabolism pathway (d) Hatch-Slack pathway
Ans. **(c)**

15. If a flower is large, wide-mouthed, white, showing anthesis after sunset, and emitting fruity or musky fragrance, it is most likely to be pollinated by
(a) Birds (b) Bats (c) Insects (d) Baboons
Ans. **(b)**

16. Coal is a common fossil fuel. It contains 0.2 to 5.0 percent sulphur which on burning produces a gas responsible for acid rain. The number of atoms in one mole of this gas is -
(a) 6.02×10^{23} (b) 1.81×10^{23} (c) 1.81×10^{24} (d) 1.21×10^{24}
Ans. **(c)**
Sol. $S + O_2 \rightarrow SO_2$
$\downarrow$
Given 1 mol SO_2
No. of atoms = $3 \times 6.022 \times 10^{23}$
$\approx 1.8 \times 10^{24}$

17. The stomach fluid in human contains HCl, KCl and NaCl. The stomach fluid is highly acidic and plays an important role in the digestion of food as well as killing of bacteria. The increased acidity may lead to abdominal pain, nausea, bloating, and heartburn. Such a patient is prescribed antacid tablet which mainly contains aluminium hydroxide (Mol. Wt. 78). If the concentrations of HCl, KCl and NaCl are 0.01M each and the stomach fluid volume is 2 litre the amount of $Al(OH)_3$ required to neutralize the fluid will be -
(a) 0.52 g (b) 1.08 g (c) 0.81 g (d) 2.16 g
Ans. **(a)**
Sol. $3HCl + 1\ Al(OH)_3 \rightarrow 1AlCl_3 + 3H_2O$

NaCl ┐
KCl ┘

Molar ratio 3 : 1
Given moles of HCl 0.01 molar HCl in 2L solution
Total moles of HCl = 0.02 moles
3 moles of HCl $\rightarrow$ 1 mol $Al(OH)_3$
1 mole $\rightarrow \frac{1}{3}$ $Al(OH)_3$
0.02 mol $\rightarrow \frac{1}{3} \times 0.02 = 0.0066$ mol
Mass of $Al(OH)_3 = 0.0066 \times 78 = 0.52$ gm

18. A 0.500 g mixture of calcium carbonate and calcium oxide was strongly heated to produce a non-combustible gas. If the weight of the residue obtained on heating is found to be 0.434 g, the percentage of calcium oxide in the mixture is -

(a) 70% (b) 30% (c) 35% (d) 60%

Ans. **(a)**

Sol. $CaCO_3 + CaO$

Heating $\rightarrow$ $CaO + CO_2$

Only $CaCO_3$ will convert

So suppose weight of $CaCO_3 = x$

So mass of $CaO = 0.500 - x$

$CaCO_3 \longrightarrow CaO + CO_2$ (g)

Residue

$\because$ 1 mole of $CaCO_3$ will produce = 1 mole of CaO

: : (12 + 40 + 48) 100 gm of $CaCO_3$ will produce = 56 gm of CaO (40 + 16)

$\therefore$ So x gm of $CaCO_3$ will produce = $\frac{56}{100} \times x = 0.56\ x$ gm

Now the weight of = mass of CaO formed + mass

So the weight of residue = wt. of CaO formed + wt. of CaO in mixture

$0.434 = 0.56 + (0.500 - x)$

$x = 0.15$ gm

$CaCO_3(x) = 0.15$ gm mass of $CaO = 0.500 - 0.15 = 0.35$ g

% of CaO = $\frac{0.35}{0.5} \times 100$

% of CaO = = 70%

19. Arrange the following in the increasing order of their metallic character Na, C, O, Li, Be

(a) C < O < Na < Li < Be (b) O < C , Be < Na < Li

(c) O < C < Be < Li < Na (d) C < O < Be < Li < Na

Ans. **(c)**

Sol. Metallic order

O < C < Be < Na < Li

Non metal metals

Moving from

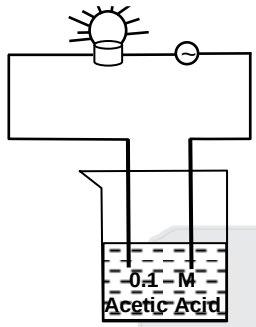
Left to right in periodic table

Metallic property decreases

Moving from top to bottom metallic property increases.

20. A 50 mL of 0.1 M acetic acid solution is taken in a beaker and two wires are dipped in it as shown in following figure.

When electric supply is switched on, the bulb glows. To this solution, distilled water is added slowly till the volume doubles. During the addition of water, the intensity of the bulb-



(a) remains unchanged (b) goes on decreasing

(c) goes on increasing (d) suddenly becomes zero

Ans. **(c)**

Sol. On dilution resistance will decreases & conductance will increases.

21. A compound X when heated with NaOH solution produces a pungent gas that turns red litmus blue. When an aqueous solution of X is treated with $AgNO_3$ solution, a white precipitate Y is obtained which on keeping in sunlight turns grey liberating pale yellowish green gas. The aqueous solution of compound X is -

(a) neutral (b) slightly acidic (c) slightly alkaline (d) strongly acidic

Ans. **(b)**

Sol. $X + NaOH \xrightarrow{\Delta} NH_3 + H_2O + NaCl$

(NH_4Cl) (8)

$NH_4Cl(aq) + AgNO_3(aq) \rightarrow NH_4NO_3(aq) + AgCl\downarrow$

White ppt(Y)

$2AgCl \xrightarrow{\text{Sulight}} 2Ag + Cl_2(g)$

(Y) (Green) Pale yellowish green gas

So X is = NH_4Cl

pH range of its aq. Solution of NH_4Cl is approximately 4.6 to 6

So aq. Solution of NH_4Cl will be slightly acidic

22. Equal masses of two gases among N_2, NO, O_2, CO, CO_2 and SO_2 occupy same volume at STP. These two gases are :

(a) N_2 and O_2 (b) CO and NO (c) SO_2 and CO_2 (d) N_2 and CO

Ans. **(d)**

Sol. In all these gases N_2 & CO has same molecular mass

So number of moles in same masses will be equal

Also the volume occupied by these two gases (N_2 & CO) will be same

(a) N_2 & CO

23. When a solution and the pure solvent are separated by a semipermeable membrane, the solution exerts a pressure on the membrane called as osmotic pressure. The osmotic pressure increases with increase in number of particles (ions or molecules) in the solution. If 10 millimoles of each of the sulphate salts of sodium, magnesium and aluminium are dissolved in 1.0 litre of water in three different beakers labelled as P, Q and R respectively, the osmotic pressure follows the order -

(a) P < Q < R (b) Q < P < R (c) P > Q > R (d) P > R > Q

Ans. **(b)**

Sol.

P	Q	R
Na_2SO_4	$MgSO_4$	$Al_2(SO_4)_3$
$2Na^+, SO_4^{2-}$	Mg^{2+} SO_4^{2-}	$2Al^{3+}$, $3SO_4^{2-}$
3 ions	2 ions	5 ions

Osmotic pressure depends on total no. of ions/molecules so $Al_2(SO_4)_3$ will exerts more osmotic pressure.

24. The axes of a coordinate system S_2 are inclined at an angle θ to those of another coordinate system S_1. The origins of both the systems are coinciding. A particle P_1 at rest in system S_1, starts from point (–2, 0) and travels along positive direction of X_1 axis with uniform acceleration of 1.25 m/s^2 for 4s and stops. In system S_2 particle P_2, starts from rest from the origin and travels for 2 s along positive direction of X_2 axis with uniform acceleration 5 m/s^2 and stops. If the final distance between P_1 and P_2 is 6 m. then the angle between $+Y_1$ axis and $+X_2$ axis is

(a) 36.8° (b) 53.2° (c) 106.8° (d) 126.8°

Ans. **(b)**

Sol. 24. $x_1 = -2$ $y_1 = 0$ $u_1 = 0$

$a_{x1} = 1.25$ m/s^2 $t_1 = 4$sec $v_1 = 0$

$x'_1 - (-2) = \frac{1}{2}(1.25)(4)^2 = 10$

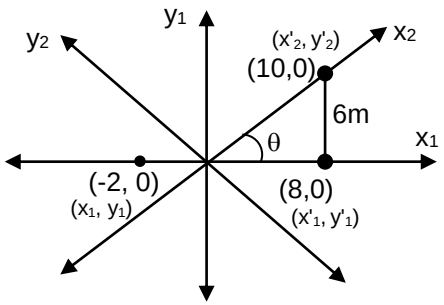
$x'_1 = 8$m

' $x_2 = 0$ $y_2 = 0$ $u_2 = 0$

$a_{x2} = 5$m/s^2 $v_2 = 0$ $t_2 = 2$sec.

$x'_2 - 0 = \frac{1}{2}(5)(2)^2$

$x'_2 = 10$



$\tan\theta = \frac{6}{8} = \frac{3}{4}$

$\theta = 36.8^o$

Angle between y_1 axis and x_2 axis = $90^o - 36.8^o$

$= 53.2^o$ (b) is correct.

A – 2
ANY NUMBER OF OPTIONS 4, 3, 2 OR 1 MAY BE CORRECT
MARKS WILL BE AWARDED ONLY IF ALL THE CORRECT OPTIONS ARE BUBBLED

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25. According to Einstein's theory, light can be assumed to be in the form of a large number of discrete energy packets called 'photons'. In case of light of frequency υ, each photon carries energy $E = h\upsilon$. In a certain surgical procedure a surgeon uses LASER beam of wavelength 650 nm in pulses of 30.0 ms duration. The average power of each pulse is 0.6 W. Here h is Planck's constant. Then
(a) The frequency of this LASER photon is 4.6×10^{14} Hz
(b) The energy in each pulse is 1.1×10^{17} eV
(c) Energy of one photon is 3.1×10^{-19} J
(d) Number of photons in each pulse is 5.9×10^{16}

Ans. **(a,b,c,d)**

Sol.

(a) $C = n\lambda$ frequency of Laser photon

$3 \times 10^8 = n \times 650 \times 10^{-9}$

$n = \frac{3\times10^8}{650\times10^{-9}} = \frac{3}{65}\times10^{16}$

$= 0.046 \times 10^{16}$

$= 4.6 \times 10^{14}$ Hz

So option (a) is correct

(b) p = 0.6 Watt

energy of pulse $= 0.6\times30\times10^{-3}$

energy of pulse $= 18 \times 10^{-3}$ Joule

$= \frac{180\times10^{-3}}{1.6\times10^{-19}}$

$= \frac{180}{16}\times10^{+16}$

$= \frac{9}{8}\times10^{17}$

$= 1.1 \times 10^{17}$ ev. (b) is correct

(c) Energy of each photon

$E = \frac{hc}{\lambda} = \frac{6.625\times10^{-34}\times3\times10^8}{650\times10^{-9}}$

$= \frac{3\times6.625\times10^{-34+8+9}}{650}$

$= \frac{3\times6.25}{65}\ 10^{-17}$

$= 0.03057 \times10^{-17}$

$= \frac{3.1}{10^2}\times10^{-17}$

$= 3.1 \times 10^{-19}$

So option (c) is correct.

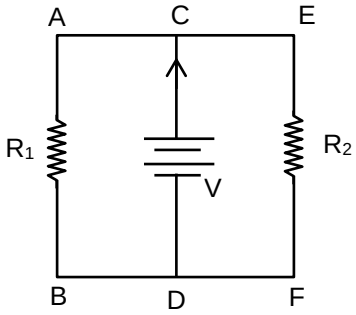
(d) $n = \frac{1.1\times10^{17}}{3.1\times10^{-19}}$

$= \frac{1.1}{3.1}\times10^{17+19}$

$= 0.35 \times 10^{36}$

(d) is incorrect

26. In the following circuit, $R_1 = 6\ \Omega$, $R_2 = 12\ \Omega$, V = 16 V. The current I_1 and I_2 flow through the resistances R_1 and R_2 respectively



(a) Power generated across R_1 is 42.6 watt

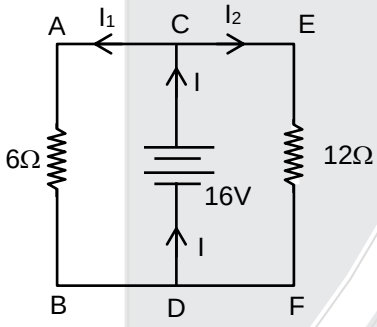
(b) The ratio of $\frac{I_1}{I_2} = 2$

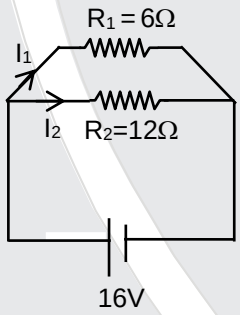
(c) Total current drawn from the cell is 4 ampere

(d) As $R_2 = 2\ R_1$, the voltage across R_2 will be twice the voltage across R_1

Ans. **(a,b,c)**

Sol.





$$\text{Total current} = \frac{\text{Net emf}}{\text{Total resistance}}$$

$$= \frac{16}{\frac{12\times 6}{12+6}} = \frac{16}{\frac{72}{18}} = 4\text{A}$$

So option (c) is correct

Now $I_1 = \frac{R_2 I}{R_1 + R_2} = \frac{12\times 4}{18} = \frac{8}{3}\text{A}$

and $I_2 = \frac{R_1 I}{R_1 + R_2} = \frac{6\times 4}{18} = \frac{4}{3}\text{A}$

So $\frac{I_1}{I_2} = \frac{\frac{8}{3}}{\frac{4}{3}} = 2$

So option (b) is also correct

(a) Power generated across R_1

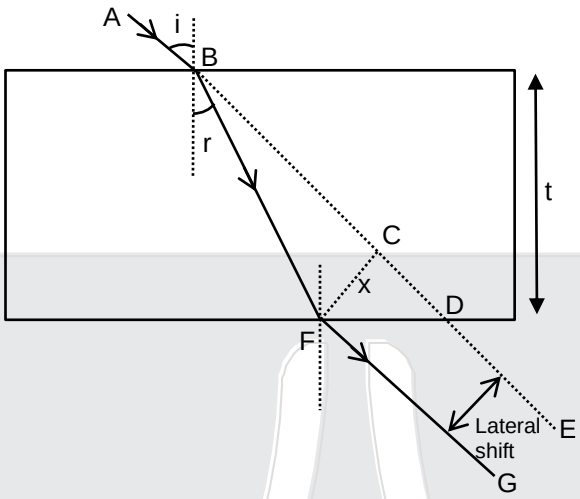
(b) $P = \frac{V^2}{R_1} = \frac{16\times 16}{6} = 42.6\,\text{W}$

So (a) option is also correct

(c) Since R_1 and R_2 are in parallel so voltage across R_1 and R_2 must be same

So option (d) is incorrect

27. A glass plate of uniform thickness t and refractive index μ is as shown in the diagram. AB is the incident ray and FG is the emergent ray. The angles of incidence and refraction are i and r respectively. The perpendicular distance FC = x between the incident and the emergent rays is called the lateral shift. Then



(a) $x = t\left(\sin i - \frac{\cos i \sin r}{\cos r}\right)$

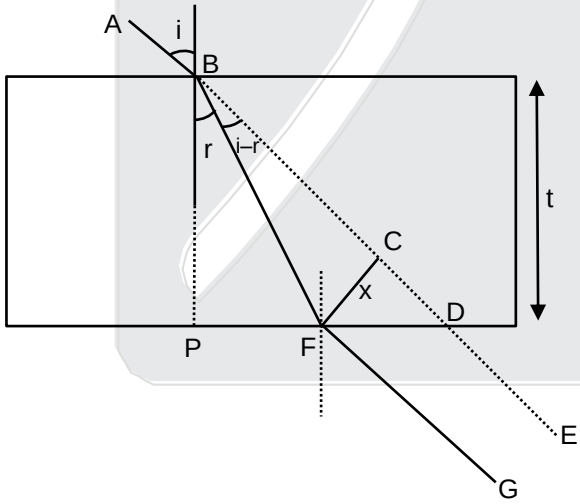
(b) x depends on refractive index μ

(c) x is independent of the wavelength λ of light

(d) Maximum value of x = t when i is close to 90°

Ans. **(a,b,d)**

Sol.



From ΔBFC

$\sin(i-r) = \frac{x}{BF}$ $\Rightarrow$ $x = BF \sin (i - r)$ ... (1)

From ΔBPF $\cos r = \frac{BP}{BF}$

$BF = \frac{BP}{\cos r}$

Here $BP = t$

So $BF = \frac{t}{\cos r}$ .... (2)

From equation (1) and (2)

$$x = \frac{t}{\cos r}\sin(i-r)$$

$$x = \frac{t}{\cos r}\sin i\cdot\cos r - \cos i\cdot\sin r$$

$$x = t\left[\sin i - \frac{\cos i\sin r}{\cos r}\right]$$ So option (a) is correct

For small angle

$x = t(i - r)$ $\Rightarrow$ $x = ti\left(1-\frac{r}{i}\right)$

$$x = ti\left(1-\frac{1}{\mu}\right)$$

(ii) So x depends on μ (b) is correct

(c) Since $\mu\alpha\frac{1}{\lambda}$ so x depends on λ. so incorrect

(d) $x = t\left(\sin i - \frac{\cos i\sin r}{\cos r}\right)$

If $i = 90^o$ then $\sin 90^o = 1$, $\cos 90^o = 0$

So $x = t$

So d option is correct

28. Given below are four statements about viruses. Which of the following statement/s is/are incorrect?
(a) All known viruses contain RNA as the genetic material.
(b) During viral multiplication, a complementary DNA is produced in riboviruses.
(c) Viruses are the smallest, freely living cells found on the planet.
(d) DNA containing viruses are more susceptible to mutations when compared to RNA containing viruses and hence show a very rapid evolution.

Ans. **(a,b,c,d)**

29. During a race, Ramesh was thrown off the horse back and suffered an injury in the front part of head. Upon through examination, Ramesh was found to have injury to the front part of the head. Which of the following can be the possible outcome/s of the injury?
(a) Trouble in speaking properly
(b) Inability to smell
(c) Inability to walk on a narrow path
(d) Inability to maintain blood pressure

Ans. **(a,b, c)**

30. Which of the following molecules are primarily responsible for structural support and motility?
(a) Actin (b) Tubulin alpha (c) Lamins (d) Desmin

Ans. **(a,b,d)**

31. The types of bonding found in dry ice is/are :
(a) Covalent (b) Ionic (c) Metallic (d) Vander Waal forces

Ans. **(a, d)**

Sol. O = C = O

Type of bonding in dry ice is covalent as well as Vander Waal forces because covalent molecules attracted by weak Vander Waal forces.

32. The compound/s that raise/s the temperature of water (from room temperature) on dissolving in it is/are:

(a) Ammonium chloride (b) Potassium hydroxide

(c) Glucose (d) Conc. HCl

Ans. **(b, d)**

Sol. # dissolution of NH_4Cl in water is endothermic

dissolution of KOH in water is exothermic

Dissolution of glucose in water is endothermic

Dissolution of conc. HCl is exothermic

Ans. (b) & (d)

33. Soaps and detergents are common agents used in laundry industry. They are long chain hydrocarbons with ionic terminals of cationic or anionic. A 1% (w/v) soap solution X and 1% (w/v) detergent solution Y were prepared in distilled water. Each of the solutions was divided in two equal parts labelled as X_1, X_2, Y_1 and Y_2, 1g NaCl was added to X_1 and Y_1 each while 1 g $CaCl_2$ was added to X_2 and Y_2 each. Which of the following observations is/are correct ?

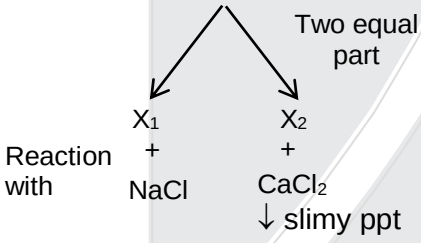
(a) X_1 shows slimy precipitate (b) X_2 shows slimy precipitate

(c) Y_1 shows slimy precipitate (d) Y_2 shows slimy precipitate

Ans. **(b)**

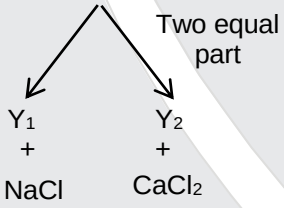
Sol Soap (X)

1% w/v solution in distilled water



Detergent (Y)

1% w/v solution in distilled water



We know that soap doest not produce froth with $CaCl_2$ (Salt of Hardwater) & it will form slimy precipitate.

Ans. (b) X_2 show slimy ppt

Question Paper Code : 55

Roll Number : | | | | | | | | | | | | | **Maximum Marks : 100**

Please Note:

- Check that the question paper has 12 printed sheets.
- Please write your roll number in the space provided above.
- Use of non-programmable scientific calculator is allowed.
- **The answer-sheet must be returned to the invigilator.** You can take this question paper with you.
- 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.'

Useful Data

Avogadro constant	$N_A \approx 6.022 \times 10^{23}$/mol
Atmospheric pressure	1 atm ≈ 101 325 Pa
Radius of the Earth	$R_E = 6.37 \times 10^6$ m
Latent heat of vaporization of water at 288 K	$L = 2.46 \times 10^6$ J / kg
Density of water	ρ (water) = 10^3 kg / m^3

Element	Atomic	Atomic Number	Element	Atomic Mass	Atomic Number
H	1.01	1	Cl	35.45	17
C	12.01	6	K	39.09	19
N	14.00	7	Ca	40.07	20
O	15.99	8	Ag	107.86	47
F	18.99	9	Xe	131.29	54
Na	22.99	11	Pt	195.08	78

PART-II

SECTION-I (PAPER CODE-55)

1. Neil Bartlett reacted molecular oxygen (O_2) with PtF_6 to get a compound O_2^+ PtF_6^-. He repeated to experiment with xenon (Xe) in place of O_2 to get another substance which was found to be a mixture 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 first ionization potential
(B) First ionization of Xe is much lower than first ionization potential of O_2.
(C) Xe makes ionic bound with F in one of the above compounds
(D) Xe acts as reducing agent in above reactions

Ans. (D)

2. A students 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 same had any soluble substances in it. Companion of which of these properties between supernatant bucket water and the original tape water will most likely answer her question definitively.
(A) pH (B) density
(C) Temperature (D) Light scattering in identical containers.

Ans. (A)

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, collisions 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.

Ans. (C)

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
$3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$
$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
$NaCl(aq) + H_2O(\ell) + CO_2(g) + NH_3(g) \rightarrow NaHCO_3(s) + NH_4Cl(aq)$
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

Ans. (D)

5. A the aluminum 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

Ans. (C)

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

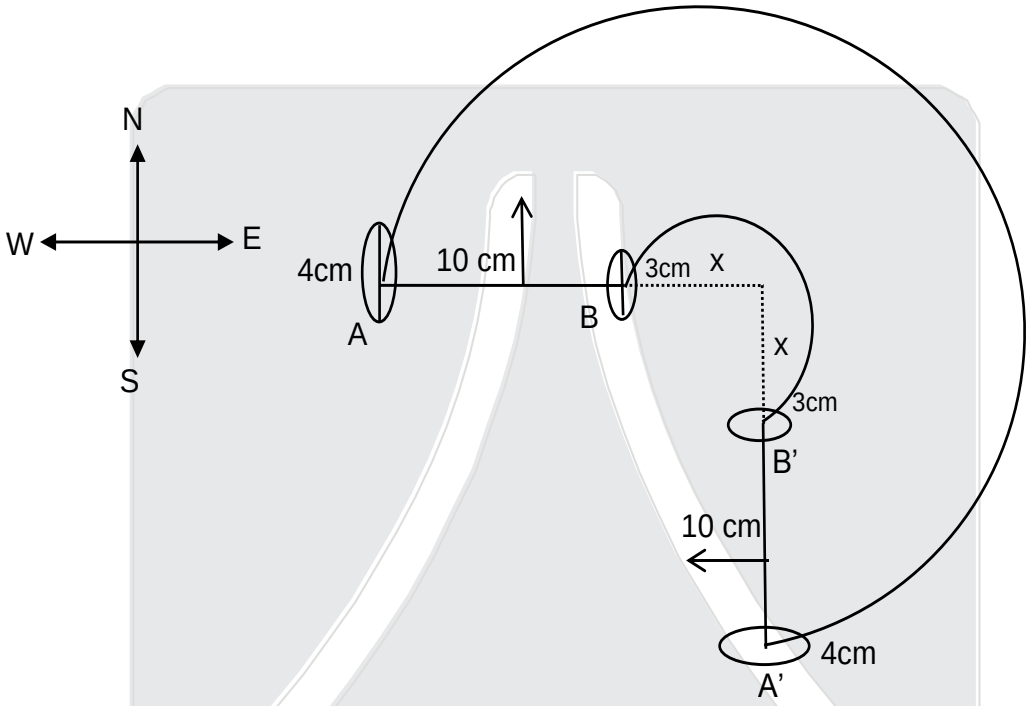
Ans. (A)

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 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

Ans. **(C)**

Sol.



Length AA' = $n\left(2\pi\left(\frac{4}{2}\right)\right) = \frac{3\pi(10+x)}{2}$ ... (1)

Length BB' = $n\left(2\pi\left(\frac{3}{2}\right)\right) = \frac{3\pi x}{2}$ ... (2)

Where n is the revolution of wheels

Using equation (2)

$2n = x$

Put value x in (1)

$$n\left(2\pi\left(\frac{4}{2}\right)\right) = \frac{3\pi(10+2n)}{2}$$

$8n = 30 + 6n$

$n = 15$

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.

Ans. **(A)**

Sol. **On earth**

Weight of object = Buoyant forces

mg = B due to water + B due to air

$mg = V_{in}\, d_w g + V_{out}\, d_{air}\, g$ ... (1)

on moon there is no air

$mg = V'_{in}\, d_w\, g$ ... (2)

from (1) & (2)

$V'_{in}\, d_w\, g + V_{out}\, d_{air}\, g = V'_{in}\, d_w\, g$

V'_{in} (on moon) $d_w = V_{in}\, d_w + V_{out}\, d_{air}$

$$V'_{in} = V_{in} + V_{out} \cdot \frac{d_{air}}{d_w}$$

So $V'_{in} > V_{in}$

So, it will sink more (float) on moon , hence water level in beaker will increase

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 sperms 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 puss 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.

Ans. **(B)**

10. The muscular endurance of an athlete is his/her ability to perform certain physical exercise for longer period of time without getting exhausted. To achieve this high muscular endurance, most of them follow '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 and 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.

Ans. **(C)**

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 form 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-angiospeerms, 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

Ans. **(D)**

12. If the gamete of a tetraploid plant contains 26 chromosomes, the number of chromatids in cells 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

Ans. **(D)**

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 material 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-S_3 [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).

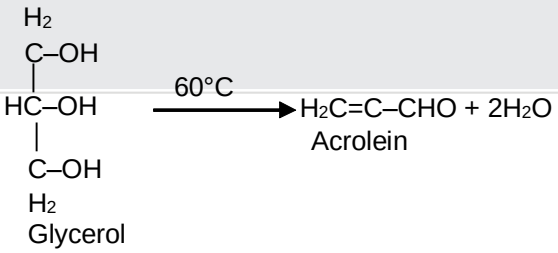
13.3. After soap is formed and separated, what components of the reaction mixture are left behind apart from glycerol ?

13.4. Glycerol cannot be distilled at atmosphere 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) 25–75°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 5g 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 decomposes to form acrolein at higher temperature as shown below:



13.7. If under the soap making conditions described in **13.6.** 1 out of 10 glycerol molecules formed decomposes to acrolein calculate the amount of glycerol that can be obtained per kg of oil.

Sol. **13.1** S-1 mixing of NaOH & water $\rightarrow$ NaOH(aq.)
S-2 oil (Triglycerides) + NaOH $\rightarrow$ Soap
S-3 Adding of NaCl $\rightarrow$ To precipitate out soap.

13.2 Cooling the mixture – S-3
Heating the mixture – S-2

13.3 NaOH(remaining), NaCl, H_2O

13.4 (a) 25°–75°C

13.5 Water

13.6 1 mole of fatty acid/triglyceride + 3NaOH $\rightarrow$ 1mole soap + 1 mole glycerol
miliequivalent of NaOH reacted = miliequivalent of NaOH – miliequivalent of HCl
= 50 × 0.5 – 14 × 0.5 = 18 miliequivalent
Moles of NaOH = 18 × 1(n-factor of NaOH) × 10^{-3} = 18 × 10^{-3}
3 moles of NaOH gives $\rightarrow$ 1 mole of glycerol
Mass of glycerol = $\frac{1}{3}$ × 18 × 10^{-3} × 92 = 0.55 gm
5gm of oil gives $\rightarrow$ 0.552 gm of glycerol
1000 gm of oil gives $\rightarrow$ $\frac{0.55}{5gm}$ × 1000 = 110.4 gm /kg of oil

13.7 1 out of 10 molecule of glycerol decompose. So = 10%
Amount of glycerol obtained = 110.4–110.4 × $\frac{10}{100}$ = 99.36gm

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

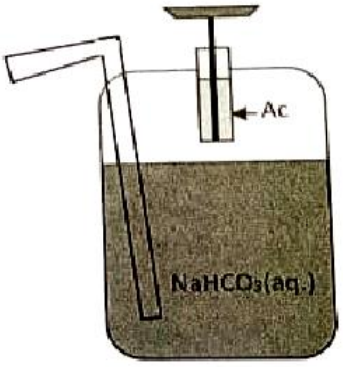
Different kind of fire-fighting strategies are effective for different fires. Here we look at four common strategies.

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 material **I-V**, which can be extinguished by spraying water?

14.3. (a) Which of the three three components of fire (**i-iii**) are reduced immediately by water spraying?
(b) The property/ies of water responsible for the 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 involves use of CO_2 - 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 ($NaHCO_3$) with sulphuric acid contained in a sealed vial (labelled Ac in diagram). When a 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 fires in electrical writing ? Give reason for your answer.
Another version of CO_2 based extinguisher was developed in 1920s contains only compressed CO_2, which is released at high pressure by pressing a nozzle.

14.6 Can a CO_2 extinguisher be used to reduce petrol fire and/or electrical fires ?
A third type of fire extinguisher is used specifically for vegetable oil fires. These fire extinguishers spray a fine spray of alkaline potassium carbonate or potassium acetate on burning oil. This fine spray causes formation of foam on the oil surfaces.

14.7 (a) In this case, which of the three components of fire (**i-iii**) get reduce ? 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.

Sol. **14.1** ⇒ Water is heavier than petrol (density)
⇒ low boiling point

14.2 ⇒ I paper stacks, II stakcs of cloth

14.3 (a) (iii) , (ii)
(b) A = high latent heat of vaporization
B = high specific heat

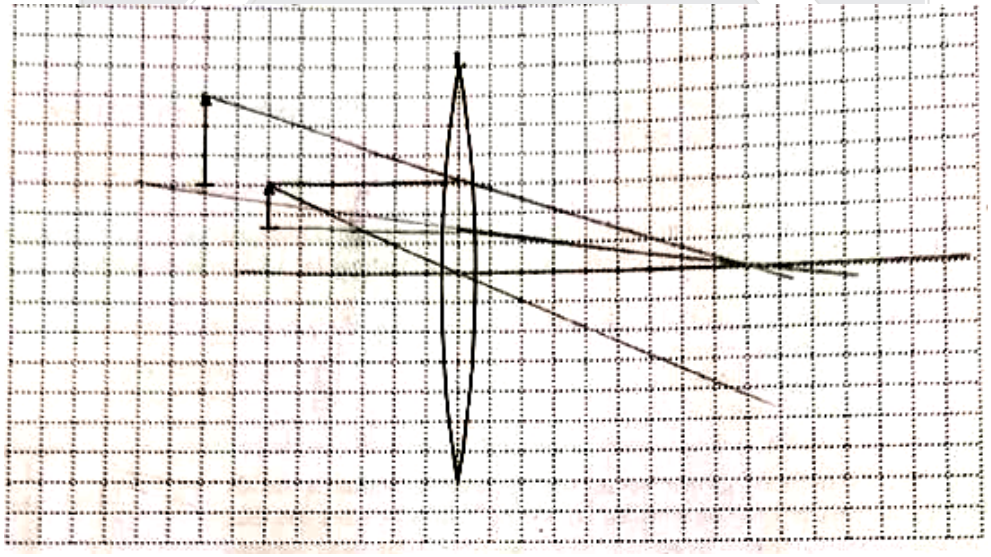
14.4 (ii) oxygen & (iii) Heat to initiate

14.5 No, because it uses water to cool the combustible substances.

14.6 Yes

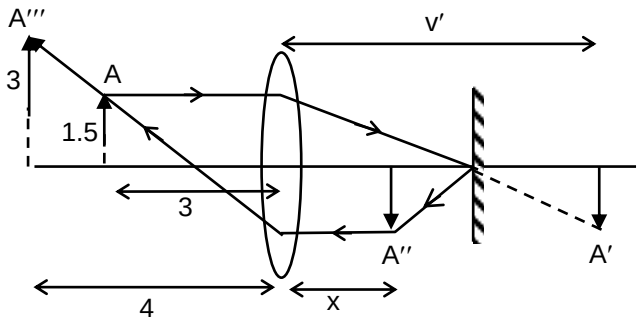
14.7 (a) (i) Fuel
They contain aqueous film forming foam also known as (AFFF).
This works by smothering the fire & sealing the flammable vapours.
Also create a barrier between liquids surface and flame.
(b) (I) – Paper stacks
(II) – Stacks of cloth

15. 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), a thin converging lens L, and a plane mirror placed to the right of the lens (not shows in the drawing). It is not explicit that which arrow represents the object. All element 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 m 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.

Sol. **(a)**



ww $\frac{1}{f}=\frac{1}{v'}-\frac{1}{-3}$ … (1) (First refraction form lens)

$\frac{1}{f}=\frac{1}{4}+\frac{1}{x}$ … (2) (Second refraction form lens)

From (1) & (2)

$\frac{1}{v'}+\frac{1}{3}=\frac{1}{4}+\frac{1}{x}$ … (3)

Now as $m_L \times m_m \times m_L = \frac{h_i}{h_0}=\frac{3}{1.5}$

$\frac{v'}{-3}\times 1\times\frac{4}{-x}=2\Rightarrow v'=\frac{3x}{2}$

Use in (3)

$\frac{2}{3x}+\frac{1}{3}=\frac{1}{4}+\frac{1}{x}$

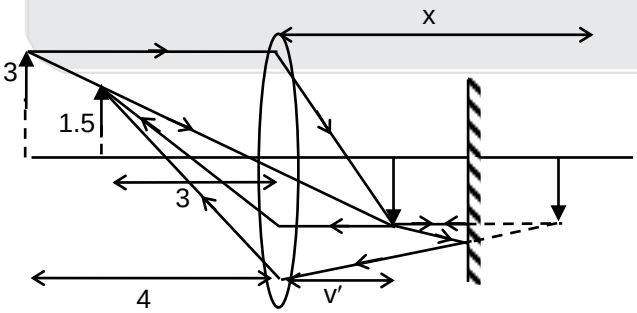
$-\frac{1}{3x}=\frac{-1}{12}\Rightarrow x=4$

$v'=\frac{3x}{2}=\frac{3\times 4}{2}=6\,cm$

Use in (1)

$\frac{1}{f}=\frac{1}{6}+\frac{1}{3}=\frac{1}{2}\Rightarrow f=2cm$

(b)



$m_1m_2 = \frac{1.5}{3}$

$\frac{v'}{4}\times\frac{3}{x}=\frac{1}{2}\Rightarrow v'=\frac{2}{3}x$ ….(1)

In first refraction

$\frac{1}{f}=\frac{1}{v'}+\frac{1}{4}$ ….(2)

$\frac{1}{f}=\frac{1}{3}+\frac{1}{x}$ ….(3)

from (2) & (3) $\frac{1}{3}+\frac{1}{x}=\frac{1}{v'}+\frac{1}{4}$

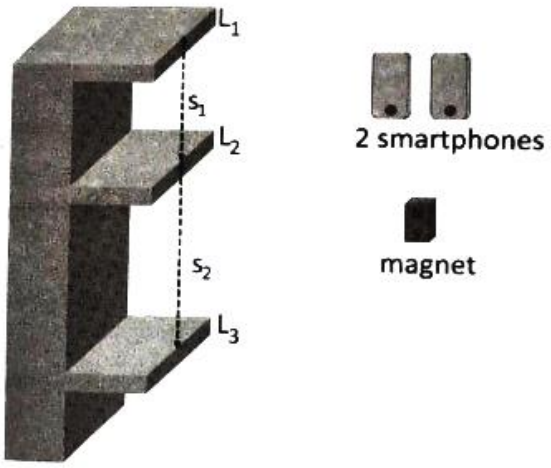
$\frac{1}{v'}-\frac{1}{x}=\frac{1}{3}-\frac{1}{4}$

use equation (1) $\frac{3}{2x}-\frac{1}{x}=\frac{1}{3}-\frac{1}{4}\Rightarrow x = 6cm$

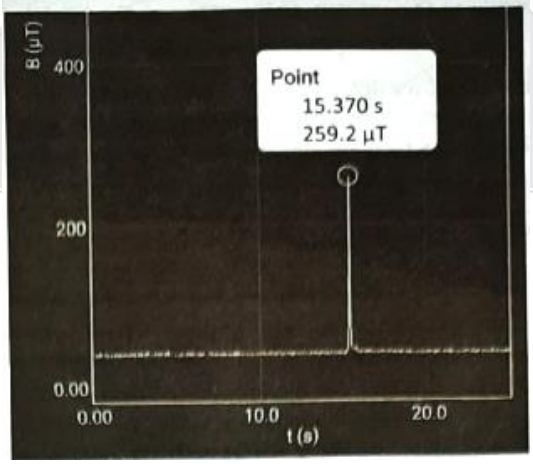
$v' = \frac{2}{3}\times 6 = 4cm$

$\frac{1}{f}=\frac{1}{4}+\frac{1}{4}\Rightarrow f = 2cm$

16. 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.



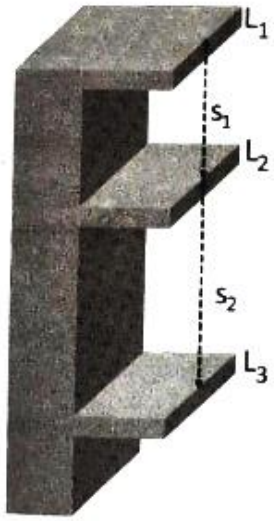
She knows the distances S_1 and S_2 between the levels (L_1, L_2, L_3) of the shelf. She came to know that smartphones have a magnetometer sensor and there are apps which use it and display the magnetic field nearby. She experimented with an app and noticed that when a magnet passes within the close 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)



Clock 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 as 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.

Sol.




2 smartphones


magnet

$S_1 = \frac{1}{2}gt_1^2$ .... (i)

$S_1 + S_2 = \frac{1}{2}gt_2^2$ .... (ii)

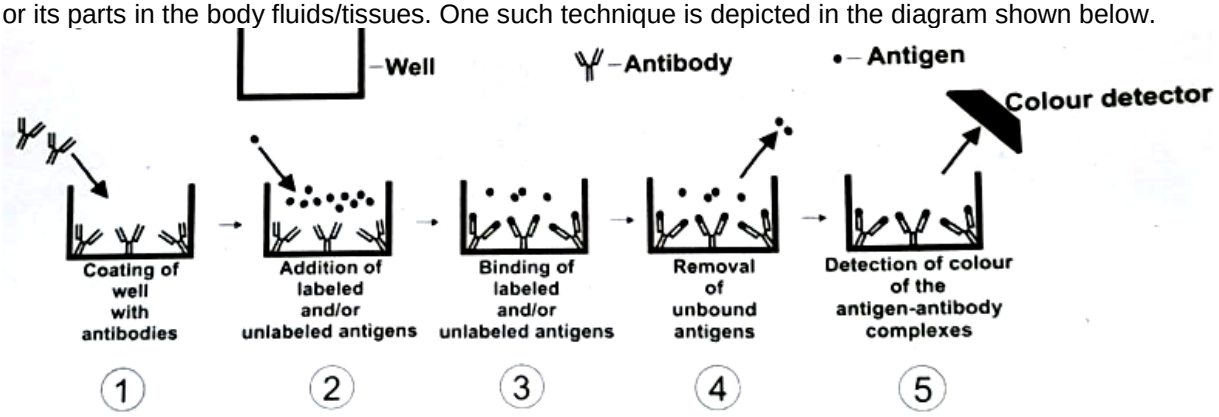
Using (ii) & (i)

$= (S_1 + S_2) - S_1 = \frac{1}{2}g\left(t_2^2 - t_1^2\right)$

$g = \frac{2S_2}{t_2^2 - t_1^2}$

By releasing magnet from rest and taking time difference using 2 smartphone we can find value of g.
Cause of errors – (i) Error due to difficultly in Synchronization
(ii) Random error
(iii) System error

17. (9 Marks) When an infectious agent enters the body of a person, the cells of the immune system recognize it is a foreign object and initiate immune reaction against it. The antigen-antibody reactions is one of the many mechanisms of action of our immune system to fight infection. It 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.

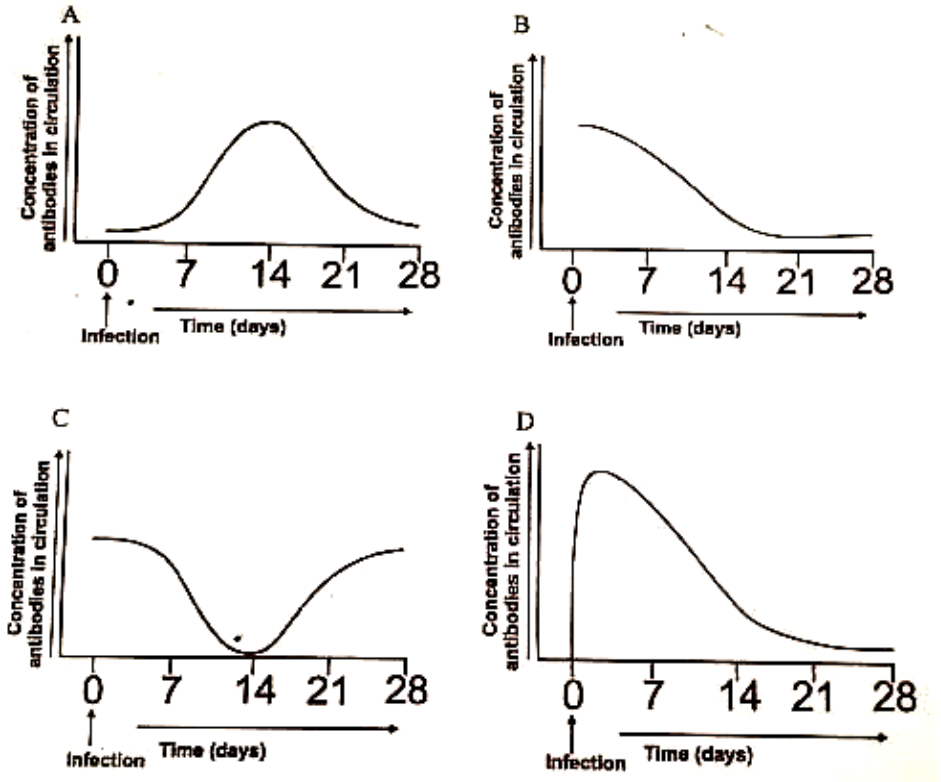
17.1 Suppose that this test is used for detection of a virus from circulating blood. The labeled antigens have the same capacity as that of the actual antigen to bind to the antibodies. The serum from an infected and a non-infected person are added as shown in the table below.

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.

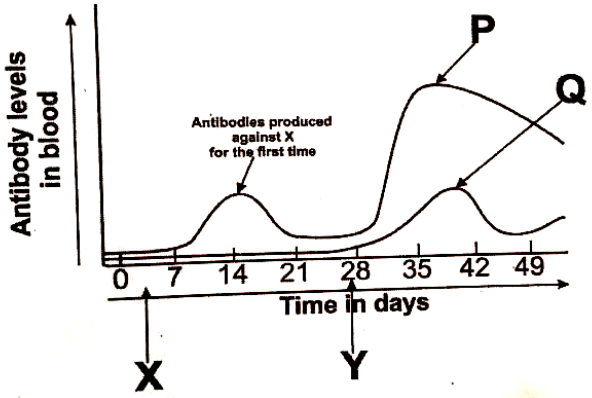
After allowing the antigens to bind with the antibodies, the supernatant containing unbound antigens is removed and intensity of the colour of the antigen-antibody complexes, if there are any, is detected and quantitified. Based on the experimental set up, which of the following statements is CORRECT?

A. Intensity of the colour detected from X is less than that from the control well.
B. Intensity of the colour detected from X is more than that from the control well.
C. Intensity of the colour detected from X less than that from the control, but is more than that from Y.
D. 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.

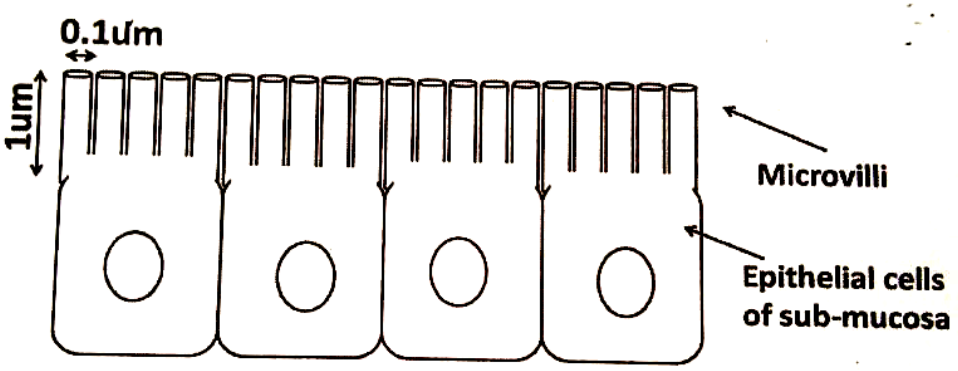
i. Entry of new pathogen into the body
ii. Second/repeat encounter of a pathogen
iii. Vaccine administration
iv. Administration of booster dose of vaccine
v. Antibody levels upon entry of a new pathogen
vi. Antibody levels upon second/repeated entry of a pathogen
vii Antibody levels upon administration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

Sol. 17.1 A, C – correct
B, D – incorrect

17.2 (A)

17.3 X → i, ii
Y → ii, iv
P → vi, viii
Q → v, vii, ix

18. (3 marks) There are about 12 x 10^{10} microvilli per square centimeter of sub mucosa in gastrointestinal track of humans. Each microvillus - a rod like structure present on epithelial cell of sub mucosa- is 1 μm in length and 0.1 μm 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.

Sol. Number of microvilli $= 1.2 \times 10^{10}$ /cm^2 $= \frac{1.2 \times 10^{10}}{10000} = 1.2 \times 10^6$ /m^2

Length of one microvilli = 1μm = 1×10^{-6} m
Diameter of one microvilli = 1μm = 1×10^{-6} m

Radius of microvilli = $\frac{1 \times 10^{-6}}{2} = 0.5 \times 10^{-6}$ m

Case –I	Case –II
Area of microvilli = $2\pi rh$ $= 2 \times 3.14 \times 0.5 \times 10^{-6} \times 1 \times 10^{-6}$ $= 3.14 \times 10^{-12}$ total surface area of microvilli $= 3.14 \times 10^{-12} \times 12 \times 10^6$ $= 37.68 \times 10^{-6}$ or 37.68 μm^2	Since there length is raduced by 66% 66% of 1 μm = $1 \times \frac{66}{100} = 0.66$ μm remaining length = 1μm – 0.66 μm = 0.34 μm Surface are of remaining length (l) = 0.34 μm r = 0.5×10^{-6} μm area $= 2\pi rh$ $= 2 \times 3.14 \times 0.5 \times 10^{-6} \times 0.34 \times 10^{-6}$ $= 1.0676 \times 10^{-12}$ total surface area = $1.0676 \times 10^{-12} \times 12 \times 10^6$ $= 12.8112 \times 10^{-6}$ or 12.8112 μm^2

% change in surface area $= \frac{\text{Initial area} - \text{Final area}}{\text{Initial area}} \times 100$

$= \frac{37.68 - 12.8112}{37.68} \times 100$

= 66%

19. (10 marks) From farms from similar geographic location, A, B, C and D of equal size are divided into 7 lanes 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	
	Soyabean		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
	Soyabean	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 or 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.

Sol. 19.1 a) B & C & years 15 – 19.
b) A
c) Replacement is maize because Soyabean is a Kharif plant.
d) c
e) c

19.2 i) T
ii) T
iii) F
iv) F

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