

# Indian National Junior Science Olympiad-2018

Date of Examination : 27<sup>th</sup> January, 2018

## SOLUTIONS

### SECTION A

Questions 1 to 30 are Multiple Choice questions with every correct answer carrying 1 mark and every wrong answer carrying –0.25 mark.

1. Natural water contains about 0.02% D<sub>2</sub>O (heavy water). When it is enriched to 20% (by volume), calculate the fraction of weight due to neutrons in 1 mole of water sample.
- (a) 0.355                      (b) 0.444                      (c) 0.455                      (d) 0.500

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

**Sol.** Natural water → D<sub>2</sub>O (0.02g) ; H<sub>2</sub>O (0.98g)

Enrichment of D<sub>2</sub>O 20% by volume ; ρ<sub>H<sub>2</sub>O</sub> = 1 g/cc

100 g water contains = 20g D<sub>2</sub>O ; 80g H<sub>2</sub>O

$$\text{Molar mass of new sample} = \frac{100}{\frac{20}{20} + \frac{80}{18}} = 18.367 \text{ g}$$

18.367% by moles of D<sub>2</sub>O

81.633% by moles of H<sub>2</sub>O

$$X = \frac{(10 \times 0.18367) + 8 \times 0.81633}{18.367} = 0.455$$

2. A piece of alloy of Al and Zn weighing 1.67 g was completely dissolved in acid and evolved 1.69 litre of hydrogen at NTP. What is the percentage of Al in the piece of alloy?
- (a) 26.5%                      (b) 48.5%                      (c) 51.5%                      (d) 73.5%

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

**Sol.** Let 'x' grams of Al and '(1.67 – x)' grams of Zn.

No. of gram eq. of Al + No. of gram eq. of Zn = No. of gram eq. of H<sub>2</sub>

$$\frac{x}{\left(\frac{27}{3}\right)} + \frac{(1.67 - x)}{\left(\frac{65.3}{2}\right)} = \frac{1.69}{11.2}$$

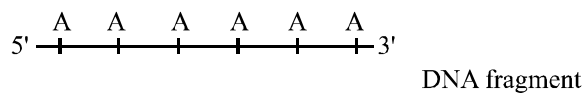
Weight of Al, x = 1.232 g

Percentage of Al in alloy = (1.232/1.67) × 100 = 73.5 %

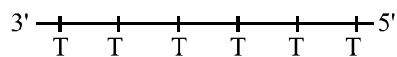
3. The DNA sequence of the genome of a virus is known and contains equal number of A, T G and C. The genome is composed of double stranded DNA molecule. It is 10Kb in length. If one searches the genome for the presence of the following sequence 5'-AAAAAA-3'3'-TTTTTT-5', predict the number of such stretches that are likely to occur. (1Kb = 1000 base pairs).

- (a) Two                      (b) Eight                      (c) Sixteen                      (d) Thirty two

Ans. Option (a) is correct.



Sol.



In this DNA sequence, probability of base A and T in above mention helix will be \_

$$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{4096}$$

$$\begin{aligned} \text{Total base pair in DNA} &= 10\text{Kb} \times 1000 \\ &= 10,000 \end{aligned}$$

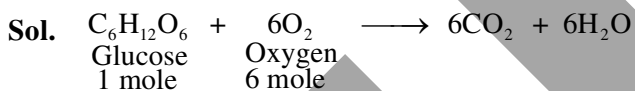
Probability of occurrence of A-T base pair will be

$$\frac{10,000}{4096} \approx 2.44$$

4. An astronaut has to burn 40g of glucose in his body per hour to get the required energy. Find the amount of oxygen that would need to be carried in space to meet his energy requirement for thirty days.

- (a) 10.2 kg                      (b) 28.8 kg                      (c) 30.7 kg                      (d) 96.1 kg

Ans. Option (c) is correct



180 g requires  $6 \times 32$  g

$40 \times 24 \times 30$  g requires x

$$x = \frac{40 \times 24 \times 30 \times 6 \times 32}{180} = 30,720 \text{ g} = \mathbf{30.72 \text{ kg of oxygen}}$$

5. A particle moves along positive X-axis with a velocity (in a suitable unit) varying as  $(4 - 3t - t^2)$  where t is time in seconds. Students draw following four conclusions.

- (i) Initially the particle is at the origin.  
 (ii) Initial speed of the particle is zero.  
 (iii) The particle decelerates till  $t = 1$  s.  
 (iv) The speed of the particle goes on increasing after  $t = 1$  s.

Therefore, conclusions

- (a) (i) & (ii) are sometimes correct, (iii) & (iv) are always correct  
 (b) (i), (iii) & (iv) are always correct and (ii) is sometimes correct  
 (c) (i), (iii) & (iv) always correct, (ii) is never correct  
 (d) (i) is sometimes correct, (ii) is never correct, (iii) & (iv) are always correct

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

**Sol.**  $v = 4 - 3t - t^2$  .....(i)

$a = -3 - 2t$  (always -ve)

$$\frac{dx}{dt} = 4 - 3t - t^2$$

$$\Rightarrow \int dx = \int (4 - 3t - t^2) dt$$

$$\Rightarrow x = 4t - \frac{3t^2}{2} - \frac{t^3}{3} + C$$

At  $t = 0$ ,  $x$  may or may not be zero.

Also,  $v = -(t - 1)(t + 4)$

$v = 0$  at  $t = 1$

$v =$  negative, for  $t > 1$

$v =$  positive, for  $t < 1$

$\therefore$  speed increases after  $t = 1$  sec

6. Titration is carried out for 3 moles of a mixture of ferrous and ferric sulphate which required 100 mL of 2 M potassium permanganate in acidic medium. Hence the mole fraction of ferrous sulphate in the mixture is \_\_\_\_\_.

(a) 1/3

(b) 2/3

(c) 2/5

(d) 3/5

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

**Sol.**  $\text{KMnO}_4 \xrightarrow{\text{Acidic medium}} \text{Mn}^{2+}$  (n-factor = 5)

$$\text{No. of gram eq. of KMnO}_4 = \frac{(M \times n\text{-factor}) \times V}{1000} = \frac{2 \times 5 \times 100}{1000} = 1 \text{ equivalent.}$$

Only ferrous sulphate reacts with  $\text{KMnO}_4$

$\text{Fe}^{2+} \longrightarrow \text{Fe}^{3+}$  (n-factor = 1)

$\therefore$  1 g. eq. of  $\text{KMnO}_4 = 1$  g. eq. of  $\text{FeSO}_4 = 1$  mole of  $\text{FeSO}_4$  (n-factor = 1)

$\therefore$  Mole fraction of ferrous sulphate =  $\frac{1}{3}$

7. Many proteins of the chloroplast are encoded by genes in the nucleus. In these cases the RNA is transcribed in the nucleus, translated by the cytoplasmic ribosomes and the protein transported to the chloroplast. For such a protein how many membrane(s) does the protein cross to reach the thylakoid space (lumen) of the chloroplast?

(a) One

(b) Two

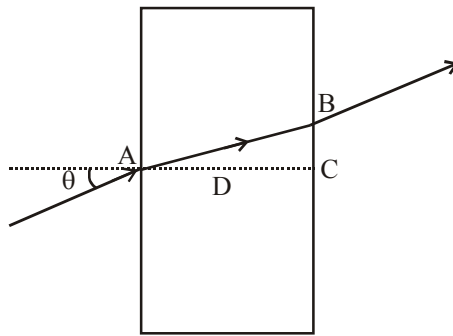
(c) Three

(d) Four

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

**Sol.** Protein will be formed in cytoplasm. From cytoplasm it will cross outer and inner membrane of chloroplast and 1 layer of thylakoid.

8. A ray of light passes through a thick glass sheet with some angle of incidence  $\theta$  as shown. The refractive index of glass is\_\_\_\_\_.



- (a) Exactly  $d/DC$  (b) Approximately  $d/DC$   
(c) Approximately  $d/AD$  (d) Approximately  $AD/AC$

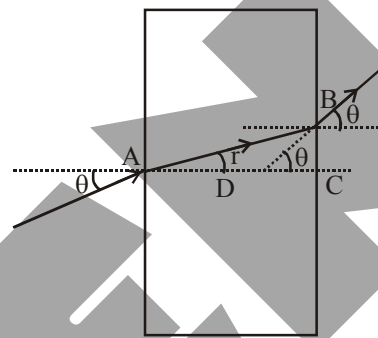
**Ans.** Option (b) is correct.

**Sol.**  $1 \times \sin\theta = \mu \times \sin r$

$$1 \times \frac{BC}{CD} = \mu \times \frac{BC}{AC} \text{ (for small angle)}$$

$$\Rightarrow \mu = \frac{AC}{CD}$$

$$\mu \text{ is approximately } = \frac{d}{DC}$$



9. A sample of clay was partially dried and then found to contain 60% silica and 8% water. The original sample of clay contained 15% water. Find the percentage of silica in the original sample.

- (a) 52.3% (b) 47.8 (c) 55.5% (d) 51.7%

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

**Sol.** After partially drying the sample, the mass of water will decrease by an unknown amount 'x'

$$\therefore \frac{15 - x}{100 - x} \times 100 = 8$$

$$x = 7.6$$

Mass of the sample after the water was dried out

$$(100 - 7.6) = 92.4$$

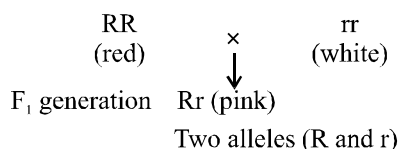
$$\% \text{ composition of silica} = 92.4 \times \frac{60}{100} = 55.5$$

10. A plant has pink flowers. When this plant was self pollinated, there were three types of progeny obtained; progeny with red flowers, pink flowers and white flowers that appeared in the ratio of 1 : 2 : 1. From the given information how many alleles are involved in the formation of these flower colours?

- (a) One (b) two (c) Three (d) Four

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

**Sol.**



11. A beaker of mass 50 g, with 262 g of water in it, is kept on a weighing machine. A uniform hollow brass ball of total volume  $36\pi$  cc is inserted into the water in the beaker. It is observed that the ball floats on water. The weighing machine now reads 400 g. Density of brass is 8 g/cc, while that of the air inside the brass ball can be neglected. Thickness of the brass used to prepare the ball must be nearest to \_\_\_\_\_.
- (a) 0.5 mm                      (b) 0.8 mm                      (c) 1 mm                      (d) 1.2 mm

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

**Sol.** Excess weight = Buoyant force = weight of sphere

$$\Rightarrow 88 = 8 \times \frac{4}{3} \pi [3^3 - r^3] \quad \{R = 3 \text{ cm}\}$$

$$\Rightarrow r \approx 2.9 \text{ cm}$$

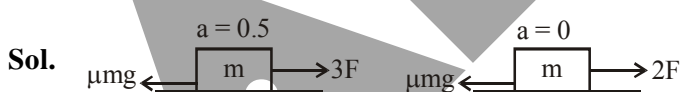
$$\text{thickness of wall} = 3 - 2.9 = 0.1 \text{ cm} = 1 \text{ mm}$$

12. If a body exerts a force on a surface, the surface exerts a reaction force on the body. This reaction force is always along normal to the surface at that point and is popularly known as the normal force N. When the body slides on a surface, the surface exerts a force of friction on the body in the direction opposite to the direction of slipping. The magnitude of this frictional force is given by  $\mu N$ , where  $\mu$  is a constant (called coefficient of friction) for the given pair of surfaces in contact and N is the normal force.

Consider a block of mass 100 kg placed on a level surface. If one person tries to push it with a force F, he is unable to do so. He receives help from two of his friends and each one applies the same force F. Now the block moves with a uniform acceleration of  $0.5 \text{ m/s}^2$ . After sometime, one of them happens to leave the exercise of pushing the block. This time the block moves with a uniform speed. The magnitude of force F and the coefficient of kinetic friction  $\mu$  are respectively \_\_\_\_\_.

- (a) 50 N, 0.05                      (b) 100 N, 0.1                      (c) 50 N, 0.1                      (d) 100 N, 0.2

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



$$3F - \mu mg = ma$$

$$1.5 \mu mg - \mu mg = ma$$

$$0.5 \mu g = a$$

$$\mu = \frac{0.5}{10 \times 0.5} = 0.1$$

$$F = \frac{0.1 \times 1000}{2} = 50 \text{ N}$$

13. The elements A, B, C and D belong to the groups 1, 2, 14, and 17 respectively of the periodic table. Which of the following pairs of elements would produce a covalent bond?

- (a) A and D                      (b) B and C                      (c) A and B                      (d) C and D

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

**Sol.**

	A	B	C	D
Group	1	2	14	17
Valency	1	2	4	1

The elements A, B, C and D belong to the alkali, alkaline earth, carbon and halogen family, respectively.

So, covalent bond is formed in between non-metals i.e. C & D.

14. How many molecules of water of hydration are present in 252 mg of oxalic acid ( $C_2H_2O_4 \cdot 2H_2O$ )?

- (a)  $1.2 \times 10^{21}$                       (b)  $1.7 \times 10^{21}$                       (c)  $2.4 \times 10^{21}$                       (d)  $3.4 \times 10^{21}$

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

**Sol.** No of moles of oxalic acid =  $\frac{252 \times 10^{-3}}{126} = 2 \times 10^{-3}$  mole =  $2 \times 10^{-3} N_A$  of oxalic acid molecules

No. of molecules of water of hydration =  $2 \times 2 \times 10^{-3} N_A = 2.4 \times 10^{21} H_2O$  molecules

15. Which of the following is NOT a component of the theory of natural selection when Darwin proposed his theory?

- (a) Heritable variations allow some individuals to compete more successfully for resources.  
(b) Selective pressure allows some individuals in a population to reproduce more than others.  
(c) All new variations in a given population arise from spontaneous mutation in genes.  
(d) Some new variations are passed on to the next generation. -

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

**Sol.** All new variation in a given Population arise from spontaneous mutation in genes is not a component of natural selection.

16. Some people face problems seeing distant objects clearly. They, however, have no problem seeing nearby objects. A person wears a spectacle with concave lenses to see distant objects. He is able to see nearby object clearly without using lenses. When this person is reading without using the spectacles the image will be formed\_\_\_\_\_.

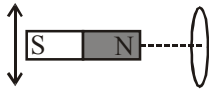
- (a) On the blind spot                      (b) Behind the retina  
(c) In front of the retina                      (d) in the fovea region on the retina.

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

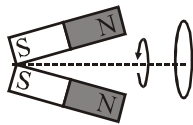
**Sol.** From the information only.

17. A magnet is in the form of a bar. Initially, the axis of the bar magnet is along X-axis. At some distance from the magnet, a coil is kept in the Y – Z plane with its centre along X-axis. Which of the following motions of the bar magnet will NOT induce electric current in the coil?

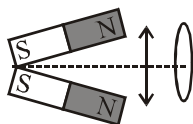
(a) Translational vibrations perpendicular to X-axis.



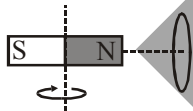
(b) The bar magnet axis is turned to make an acute angle with the X-axis and the magnet is rotated about X-axis with the south pole fixed on X-axis.



(c) The bar magnet axis is swinging back and forth about the X-axis with the south pole fixed on the X-axis.



(d) The bar magnet spins about a perpendicular bisector as its axis of rotation, with its center on the X-axis.



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

**Sol.** Only in option (b) flux is not changing.

18. A falcon and its trainer are exactly midway between two vertical & parallel hills. As the trainer fires the gun, the falcon starts flying directly towards one of the hills. The falcon hears first and second echoes of the gun-shot at 2 s and 3 s respectively. Ignore reflection of sound from the falcon and from the trainer. The air is practically still. Among the following options, respective speeds of the falcon and the sound (in m/s) could be\_\_\_\_\_.

- (a) 85 & 340                      (b) 68 & 340                      (c) 50 & 350                      (d) 40 & 360

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

**Sol.**  $\frac{v - v_1}{v + v_1} = \frac{2}{3} \Rightarrow v = 5v_1$

So, only option (b) is correct.

19. At time  $t = 0$ , an object is dropped from point A that rebounds inelastically (losing some of its kinetic energy) with a speed of 10 m/s after making a collision with the ground. It finally attains the maximum possible height at  $t = 4$  s. What is the difference of heights at  $t = 0$  and  $t = 4$  s? (ignore air resistance as well as the time of impact)

- (a) 35 m                      (b) 40 m                      (c) 45 m                      (d) zero

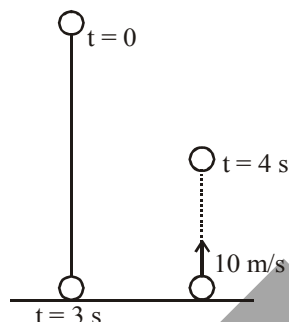
Ans. Option (b) is correct

Sol. After collision to ground.

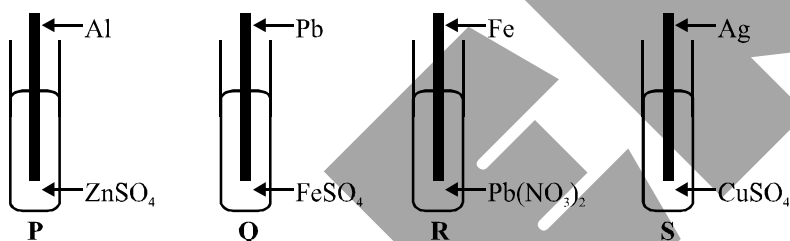
$$t = \frac{10}{10} = 1 \text{ sec}$$

to reach maximum height.

$$\text{difference} = \frac{1}{2} g (3^2 - 1^2) = 40 \text{ m}$$



20. Observe the following diagram carefully. Concentration of solution in each test tube is 0.1M. The test tube in which a chemical reaction occurs is

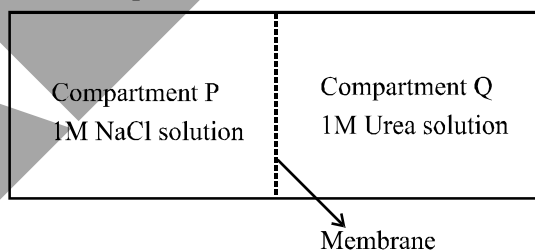


- (a) P & R                      (b) P & Q                      (c) Q & R                      (d) P & S

Ans. Option (a) is correct.

Sol. In electrochemical series :  $\text{Al} > \text{Zn} > \text{Fe} > \text{Pb} > \text{Cu} > \text{Ag}$  (reactivity order)

21. When two equimolar salt solutions are separated by a selectively permeable membrane, the movement of water molecule across the membrane depends on the water potential of the respective solutions. Water moves from higher water potential to lower water potential. Higher the concentration of ions in a solution; lower is its water potential. In an experiment, two compartments are separated by a specifically designed synthetic membrane that is permeable to water and urea and not to sodium chloride molecules.



Hint: MW of NaCl: 58.4g/mol    MW of Urea: 60g/mol.

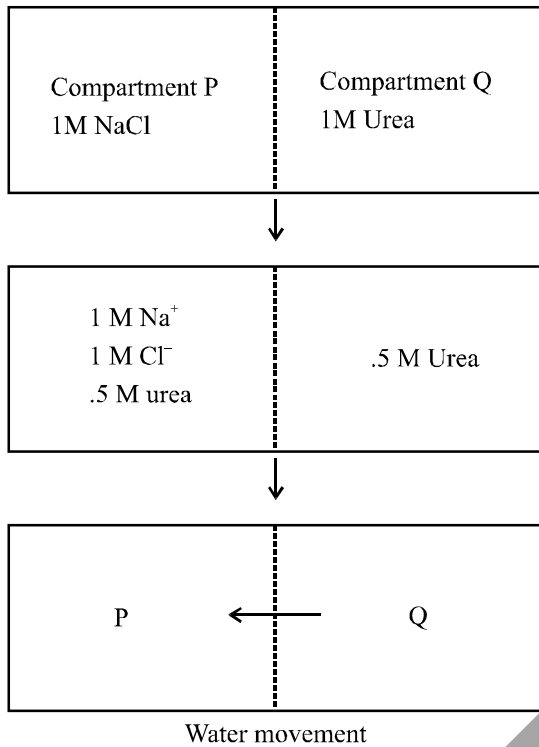
In the above condition, which one of the following options best represents the movement of water and its reason?

- (a) Water moves into P, because P has higher concentration of non-penetrating solutes.  
 (b) Water moves into P, because P has higher concentration of penetrating solutes.  
 (c) Water moves into Q, because Q has higher concentration of non-penetrating solutes.  
 (d) Water moves into Q, because Q has lower concentration of non-penetrating solutes.

Ans. Option (a) is correct.



Sol.

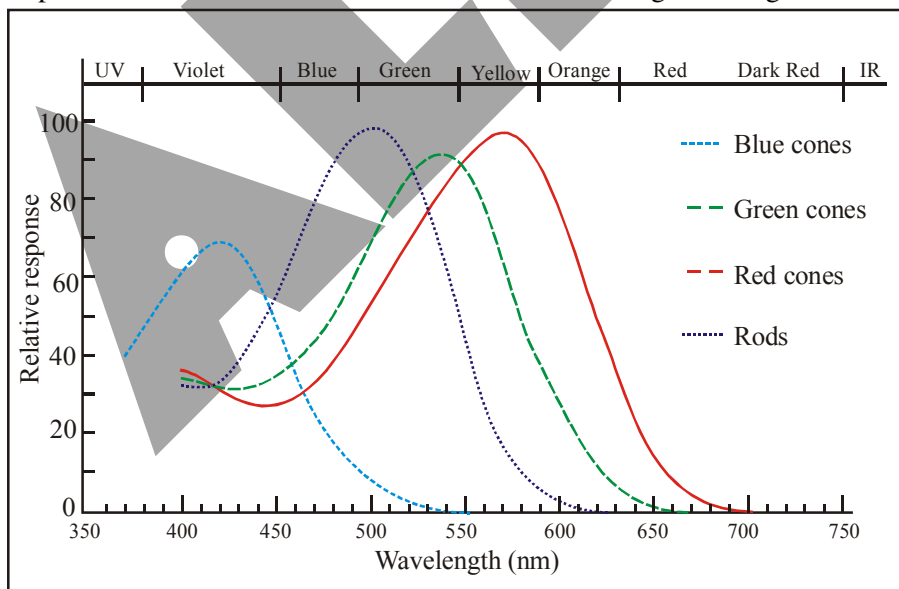


22. When 0.7 L of Hydrogen at 0.8 bar and 1.5 L of Oxygen at 0.6 bar are introduced in a 1 L vessel at 25°C, the total pressure of the gas mixture is \_\_\_\_\_.
- (a) 0.8 bar                      (b) 1.24 bar                      (c) 1.46 bar                      (d) 1.62 bar

Ans. Option (c) is correct.

Sol. Total pressure of the gas mixture =  $\frac{P_1 V_1 + P_2 V_2}{V} = \frac{(0.7 \times 0.8) + (1.5 \times 0.6)}{1} = 1.46 \text{ bar}$

23. Cone cells in human eye are responsible for colour vision. The cone cells are of three types: Red (R), Green (G) and Blue (B) cells. Each type of cone cell responds to a range of wavelengths, with a particular wavelength showing the maximum response. Given below is a graph showing relative response of rods and cone cells in different wavelengths of light.



Which of the cone cells will respond to wavelengths in the orange region?

- (a) Blue and red                      (b) Red and green                      (c) Blue and green                      (d) Only red

Ans. Option (b) is correct.

Sol. From the figure it is evident, red and green cone cell(s) will respond to wavelengths in the orange region.

24. Five polyester balls labelled P, Q, R, S & T are suspended from insulating threads. Several experiments are performed on the balls and the following observations are made.

- I. Ball P repels R and attracts Q
- II. Ball S attracts Q and has no effect on T.
- III. A negatively charged rod attracts both P and T

Which one of the following options correctly describes the nature of charges on the respective balls (0 refers to uncharged)?

	P	Q	R	S	T
(1)	+	-	+	0	+
(2)	+	-	+	+	0
(3)	-	+	-	0	0
(4)	+	-	+	0	0

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

**Sol.** From statement (II) it is clear that 'S' and 'T' are uncharged.

25. Plant tissues where carbon fixation occurs are known as 'source'. The product(s) formed is/are then transported to different parts of the plant body for its further utilization or storage, which is known as 'sink'.

Which of the following can be categorized as 'source (P)' and 'Sink (Q)'?

- (a) (P) endodermis of root; (Q) phloem cells of root
- (b) (P) epidermal region of assimilatory root; (Q) meristematic region of assimilatory root
- (c) (P) parenchyma of beet tuber; (Q) phloem cells of root
- (d) (P) xylem tissue of a green leaf; (Q) phloem tissue of the adjacent green leaf

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

**Sol.** Assimilatory roots are photosynthetic roots so act as source (P) and meristematic region is actively dividing region so act as sink (Q).

26. Immunity is the state of protection against foreign agents. It can be conferred either actively by activating a person's immune system or passively without activating his own immune system. Following are different examples of how immunity can be attained.

- I. Antibodies passed from mother to the child through breast feeding.
- II. Treatment of humans bitten by venomous snakes with antivenin, a serum from sheep or horses that have been immunized against the venom.
- III. Infection with hepatitis A virus and subsequent recovery from it.
- IV. Administration of hepatitis A vaccines.

Which of the above are examples of passive immunity?

- (a) I & II only                      (b) II & III only                      (c) I only                      (d) I & IV only

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

**Sol.** Antibodies through mother milk and antivenon are examples of passive immunity.

27. A student titrated a mixture of  $\text{NaHCO}_3$  and  $\text{Na}_2\text{CO}_3$  against a standard solution of HCl. He pipetted out a certain volume of mixture and added phenolphthalein indicator. The pink solution changed to colourless after addition of  $x$  mL of HCl. To the same solution he added methyl orange indicator and continued the titration. The end point with methyl orange indicator was obtained after addition of  $y$  mL HCl. The volume of HCl required for complete neutralization of  $\text{Na}_2\text{CO}_3$  is\_\_\_\_\_.
- (a)  $2x$                               (b)  $x/2$                               (c)  $y$                               (d)  $y - x$

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

**Sol.** In presence of phenolphthalein.

$\text{Na}_2\text{CO}_3$  changes up to  $\text{NaHCO}_3$

So, ' $x$ ' mL HCl = eq. of  $\text{Na}_2\text{CO}_3$  changed to  $\text{NaHCO}_3$

So,  $(1/2)$  eq. of  $\text{Na}_2\text{CO}_3 = x$

Hence  $2x$  mL of HCl will be required for complete neutralization of  $\text{Na}_2\text{CO}_3$ .

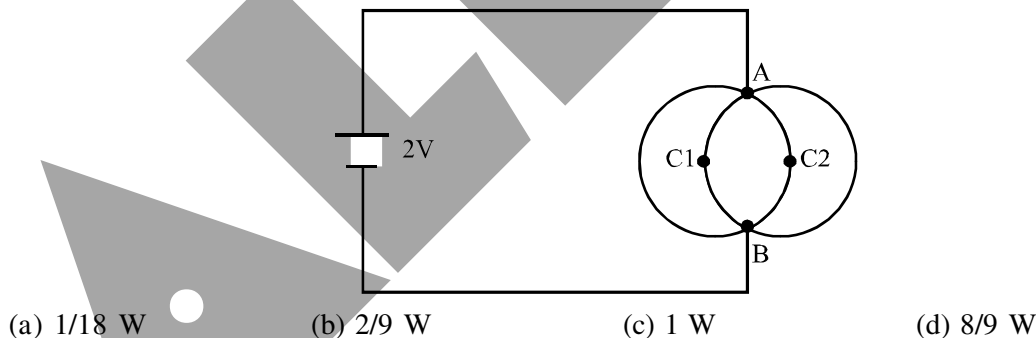
28. The organism whose body develops from two germ layers are called diploblastic, whereas the organism developed from three germ layers are called triploblastic. In some triploblastic organism the body cavity or coelom is formed from mesoderm and endoderm Such an organism is called as [P] and an example for it is \_\_\_(Q)\_\_. Choose the correct option to fill in the blanks in the above statement.
- (a) [P] - Coelomate; [Q]-Hydra                              (b) [P] - Coelomate; [Q]-Planaria  
(c) [P] - Pseudocoelomate; [Q]- Pila                              (d) [P] - Pseudocoelomate; [Q]- Ascaris

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

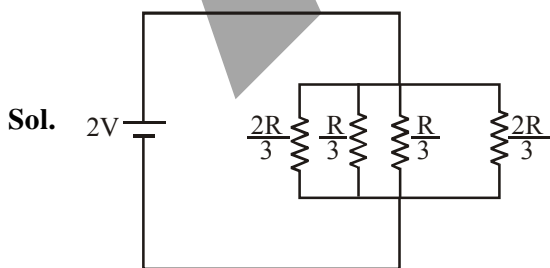
**Sol.** Pseudocoelom is formed from mesoderm and endoderm. Nematodes are pseudocoelomate organisms.

29. Two identical circular rings are placed in a plane such a way that they pass through each other's centres  $C_1$  and  $C_2$  as shown in figure. Resistance of the wire forming each ring is  $36 \Omega$ . Conducting joints are made at interaction points A and B of the rings. An ideal cell of e.m.f 2 volt is connected across A and B.

The power delivered by the cell will be\_\_\_\_\_.



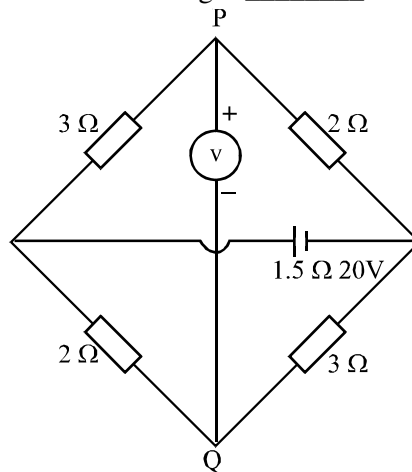
**Ans.** Option (c) is correct.



$$\frac{1}{R_{eq}} = \frac{9}{R} \Rightarrow R_{eq} = 4\Omega$$

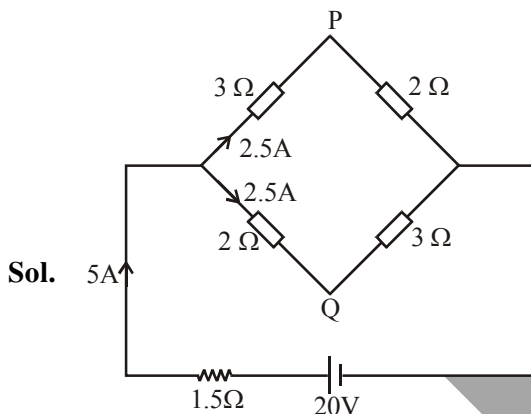
$$P = \frac{V^2}{R} = \frac{4}{4} = 1W$$

30. In the circuit shown below, the internal resistance of the battery is  $1.5 \Omega$  and its e.m.f. is  $20 \text{ V}$ . A multimeter in its voltage mode is connected between P and Q. Internal resistance of the multimeter can be taken to be infinite. The multimeter reading is \_\_\_\_\_.



- (a)  $-2.5 \text{ V}$       (b)  $-4 \text{ V}$       (c)  $4 \text{ V}$       (d)  $2.5 \text{ V}$

Ans. Option (a) is correct.



Here  $R_{eq} = 4\Omega$

$$i = \frac{20}{4} = 5\text{A}$$

$$\therefore V_p + 2.5 \times 3 - 2.5 \times 2 = V_Q$$

$$\Rightarrow V_p = -2.5 \text{ V}$$

Question 31 to 42 are long questions. Mark are indicated in the brackets. Answer the questions only in the answer sheet provided.

31. (A) An ion with mass number 79 when placed between two electrically charged plates with potential difference  $1 \text{ V}$  gains energy of  $2 \text{ eV}$  and moves towards the positive plate. If the ion contains 25% more neutrons than the electrons, identify the ion.

[Total = 3 marks]

- (B) Trisha was given a silvery white metal (A) and she was asked to heat it in air. Trisha did that and observed that a white ash (X) is formed. Out of curiosity she dissolved the ash (X) in water and obtained a solution (Y). Trisha tested the solution (Y) using pH paper and found that it turned blue. (Y) is commonly used in dental work as an antimicrobial, and is the substance of choice of dentists for forming a protective layer known as an apical barrier. (Y) when reacts with chlorine gas give (B), which is used as a toilet cleaner. To this solution (Y), she added dil sulphuric acid and obtained a white precipitate (Z). Help Trisha to identify A,B,Y, Z. Write balanced equations for all the reactions involved.

[Total = 2 marks]

Sol. (A)

$$A = p^+ + n = 79$$

$$E = qv$$

$$q = \frac{E}{v} = \frac{2ev}{1v} = 2e \text{ (2 unit charge)}$$

$\therefore$  ion is di-negative charge.  $\therefore \boxed{e^- + n = 81}$

ion contains 25% more neutron than the electrons.

$$\therefore \boxed{\frac{e^-}{n} = \frac{4}{5}}$$

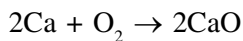
$$e^- = \frac{4}{9} \times 81 = 36$$

$$n = \frac{5}{9} \times 81 = 45$$

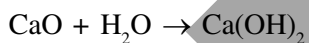
$$\therefore p^+ + n = 79$$

$$p^+ = 79 - 45 = 34 \quad \therefore \boxed{{}_{34}^{79}\text{Se}^{2-}}$$

(B)



(A) (x) White ash



(X) (y) Turns pH paper blue



(y) (B) Toilet cleaner



(y) (z) White ppt.

(A) : Ca

(B) : Ca(OCl)Cl

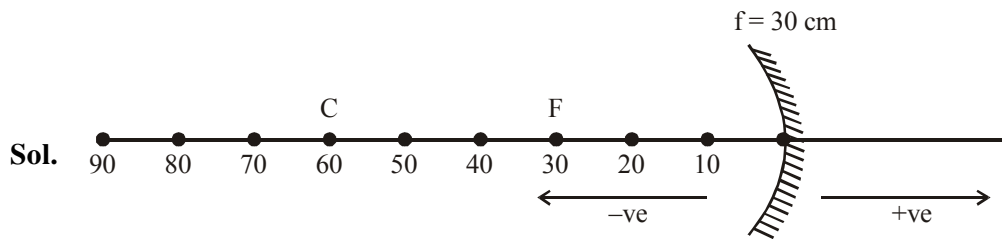
(y) : Ca(OH)<sub>2</sub>

(z) : CaSO<sub>4</sub>

32. A point object is moved away from 5 cm to 90 cm along the principal axis of a concave mirror of radius of curvature 60 cm. (distances are from centre of the mirror).

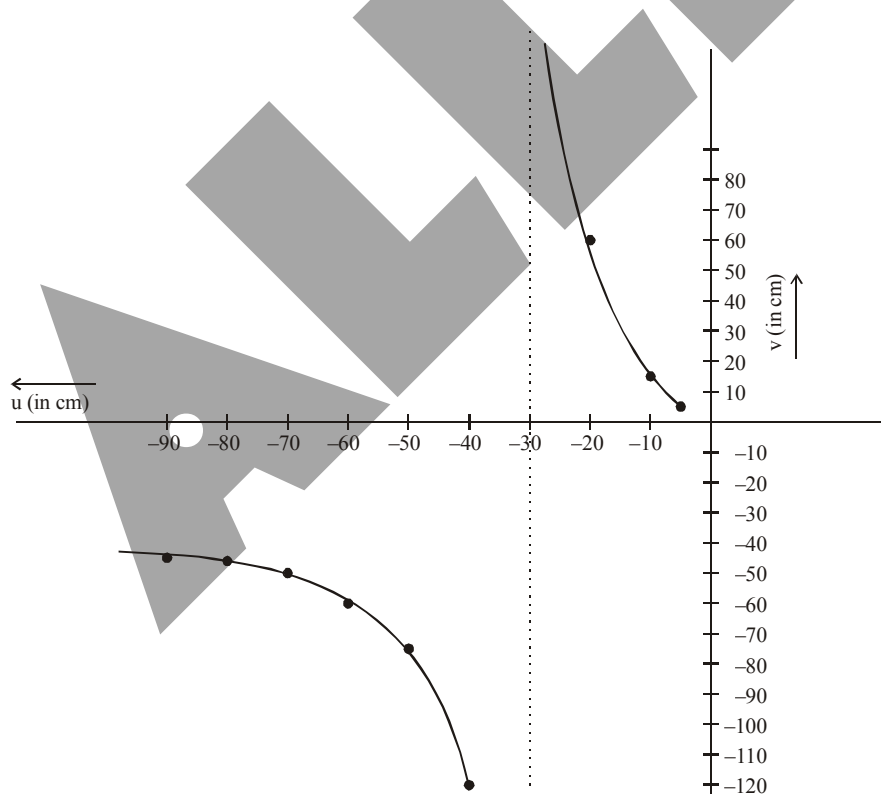
Using Cartesian sign convention, calculate image distances (v) for at least ten suitable object distances (u) and tabulate the values.

Plot a graph of v against u using the tabulated values with a proper choice of scales. [total = 5 marks]



S.N.	Object Distance u (in cm)	Image distance v (in cm)
1	-5	6
2	-10	15
3	-20	60
4	-30	$\infty$
5	-40	-120
6	-50	-75
7	-60	-60
8	-70	-52.5
9	-80	-48
10	-90	-45

Using mirror formula  $\left(\frac{1}{f} = \frac{1}{v} + \frac{1}{u}\right)$  and following sign convention, got the values as shown in above table. Following the tabular form, Graph between u and v is draw below.



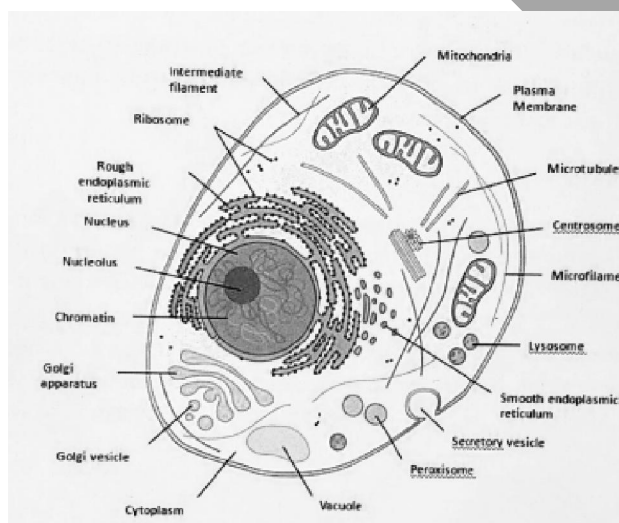
33. A sprint runner was running a 100 meter race. 10 min before starting his run in the race, he was given 200 ml of 5% glucose solution. [Assume M.W. of glucose = 180.0].

(I) Calculate how many moles of glucose was given to the sprinter. [1.5]

(II) If 100% of the glucose molecules was absorbed into his body and were used for production of pyruvic acid, calculate the moles of pyruvic acid that will be produced from these glucose molecules. [0.5]

(III) 25% of the total pyruvic acids generated from these glucose molecules are in muscle tissues and they subsequently form lactic acid. Calculate the total moles of lactic acid produced from these pyruvic acids. [0.5]

(IV) If all the pyruvic acid generated (including the muscles and other parts of body) undergo aerobic oxidation to produce CO<sub>2</sub> and water, calculate the total moles of CO<sub>2</sub> produced from these pyruvic acid. [1.0]



(V) The figure above represents a pictorial representation of components of a cell. Based on the information above predict the sites where these products are formed when glucose is metabolized by aerobic or anaerobic oxidation. [1.0]

- (i) The site of formation of pyruvic acid is \_\_\_\_\_ in the cell.
- (ii) The site of lactic acid formation is \_\_\_\_\_ in the cell.
- (iii) The site of oxidation of pyruvic acid for generation of end products such as CO<sub>2</sub> and H<sub>2</sub>O is \_\_\_\_\_.

**Sol.** (I) 100 ml of 5% glucose solution was given to sprint runner.

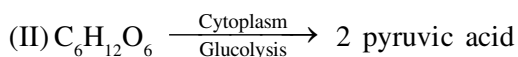
$$\text{So, } 100 \text{ ml} = 5 \text{ g}$$

$$200 \text{ ml} = 10 \text{ gm}$$

$$S = \frac{W}{200} \times 100$$

$$W = 10 \text{ gm.}$$

$$\text{mole} = \frac{\text{weight}}{\text{MW}} = \frac{10}{180} = \frac{1}{18} \text{ mole}$$



$$\text{mole of glucose is} = \frac{1}{18}$$

$$\text{mole of pyruvic acid are} = \frac{1}{18} \times 2 = \frac{1}{9} \text{ mole}$$

(III) 25% of pyruvic acid will be converted in to lactic acid in muscles.

$$\text{So } \frac{1}{9} \times \frac{25}{100} = \frac{25}{900} = \frac{1}{36} \text{ mole}$$

(IV) One pyruvic acid produce three molecules of  $CO_2$ .

So moles of  $CO_2$  will be

$$\frac{1}{9} \times 3 = \frac{1}{3} \text{ moles of } CO_2$$

(V)(i) Cytoplasm      (ii) Cytoplasm      (iii) Mitochondria

34. A stable carbon nucleus has 6 protons and 6 neutrons and a radius of  $2.7 \times 10^{-15}$  m. The six protons repel each other so that each proton experiences equal resultant force from the others which is also the minimum resultant repulsive force.

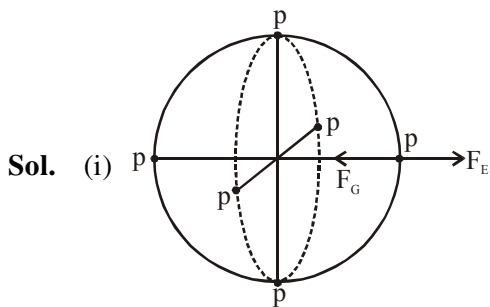
For the purpose of calculation, assume that the protons and neutrons are point particles and protons are point charges. Also assume that protons and neutrons get distributed inside or on the surface of sphere of radius given above. The nuclear force which given nucleus its stability is NOT discussed in this question.

Note : A force  $F$  has its component at an angle  $\theta$  given by  $F \cos \theta$  and in a direction perpendicular to the first (in the same plane), it is  $F \sin \theta$ .

Note : while expressing a number in scientific notation, decimal point should be placed one digit after first non-zero digit and then multiplied by appropriate power of 10, as given in the constants on the front page. **[Total = 5 marks]**

- (i) Draw a simple sketch or explain in few words the orientation of the protons in the nucleus when the above mentioned condition is satisfied. **[1.0]**
- (ii) Obtain the expression for the resultant repulsive force on one proton due to the remaining protons. **[1.0]**
- (iii) Calculate the magnitude of this resultant repulsive force. **[1.0]**
- (iv) Calculate the attractive gravitational force on this proton due to the remaining protons under the condition stated above. **[0.5]**
- (v) Calculate the approximate ratio of the repulsive electrostatic force to the attractive gravitational force.
- (vi) What is the direction of the resultant electrostatic repulsive force on this proton? **[0.5]**





The protons arranged in three diametrically opposite pair as shown above.

$$(ii) F_E = \frac{4Ke^2}{(\sqrt{2}r)^2} \cos 45 + \frac{Ke^2}{(2r)^2} \quad (\text{other components will cancelled out})$$

$$(iii) F_E \approx 52.5 \text{ N (putting the values)}$$

$$(iv) F_G = \frac{-4Gm_p^2}{(\sqrt{2}r)^2} \cos 45 - \frac{Gm_p^2}{(2r)^2} \quad (-ve \text{ sign indicates for radially inward})$$

$$\approx 4.42 \times 10^{-35} \text{ N}$$

$$(v) \frac{F_E}{F_G} = \frac{52.5}{4.42} \times 10^{35} \approx 1.2 \times 10^{36}$$

(vi) The repulsive electric force will be radially outward for each proton.

35. (A) Veeni thermally decomposed 90g of potassium chlorate of 60% purity. The total gas produced was allowed to react with hydrogen that was prepared by passing steam over hot magnesium metal. Calculate the amount of magnesium required to produce just sufficient hydrogen for completion of the reaction. **[Total = 2 marks]**

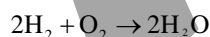
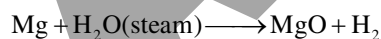
(B) When a silvery grey powder of a solid (A) is mixed with a powder of solid (B) no reaction occurs. But if the mixture is ignited and lighted using magnesium ribbon a reaction occurs with evolution of large amount of heat forming product (C) which settles down as liquid metal and the solid product (D) formed floats on the liquid (C). (C) is solid form reacts with moisture to form rust. The amount of heat generated during the reaction is so high that the reaction is used in welding of electric conductors, joints in railway track. Based on this information, answer the following questions.

(I) Identify (A), (B), (C) and (D).

(II) Write the balanced chemical equation for the reaction. Name the type of reaction.

(III) If (A) reacts with air on heating what will be the nature of oxide formed?

(IV) Does oxide of (A) react with aqueous NaOH and / or HCl. Given balance chemical equation/s.



$$2 \times 122.5 \text{ g} \longrightarrow 6 \times 24 \text{ g}$$

$$90 \times \frac{60}{100} \text{ g} \rightarrow x$$

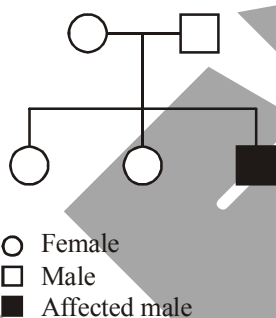
$$x = \frac{90 \times 60 \times 6 \times 24}{100 \times 2 \times 122.5} = 31.738776 \text{ g}$$

wt of Mg required = 31.738776g

**B.**

- (i) (A) Al  
(B)  $\text{Fe}_2\text{O}_3$   
(C) Fe  
(D)  $\text{Al}_2\text{O}_3$
- (ii)  $2\text{Al} + \text{Fe}_2\text{O}_3 \longrightarrow \text{Al}_2\text{O}_3 + 2\text{Fe}$  (Thermite Reaction)
- (iii)  $4\text{Al} + 3\text{O}_2 \longrightarrow 2\text{Al}_2\text{O}_3$  (Amphoteric oxide)
- (iv)  $\text{Al}_2\text{O}_3 + 6\text{HCl} \longrightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}$   
 $\text{Al}_2\text{O}_3 + 2\text{NaOH} \longrightarrow 2\text{NaAlO}_2 + \text{H}_2\text{O}$

36. Inheritance of traits in human is studied by analysing the presence or absence of a trait in a family. This is then depicted as a chart showing different generations and indicating individuals who show the trait. The following is pedigree for a rare genetic disorder representing parents (top row) and their three children. [Total = 5 marks]



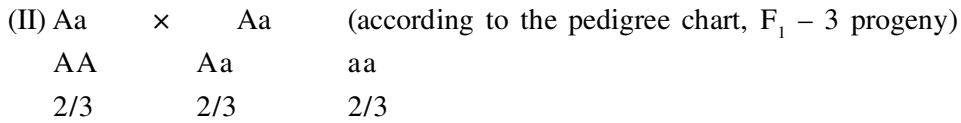
The pedigree suggests that the genetic disorder could be either autosomal recessive or X-linked recessive. The following statements were made about the genotypes (with respect to the gene responsible for the disorder) of the 5 individuals in this pedigree.

- (a) The mother is heterozygous.  
(b) The daughter could be either homozygous or heterozygous.  
(c) The daughters are only homozygous.  
(I) Which of the above statement(s) is/are correct if the genetic disorder is

[No marks will be given for partially correct answers]

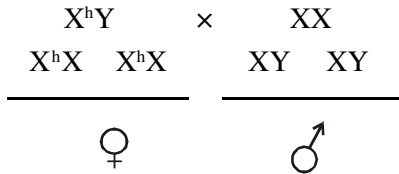
- (i) Autosomal recessive? [2.0]  
(ii) X-linked recessive?
- (II) Assuming that both the parents carry the allele responsible for the disorder, what is the probability that the first daughter would carry the same allele? [1.0]  
(a)  $1/4$  (b)  $2/4$  (c)  $1/3$  (d)  $2/3$
- (III) Assume that the trait is X-linked recessive. The affected son marries a woman who does not carry the allele for the disorder. When they have a child, what is the probability that child will carry the allele, if the child is a [2.0]  
(i) Son (ii) Daughter.

- Sol.** (I) (i) a and b both  
(ii) a and b both



- (III) (i) Son – zero (0)

- (ii) Daughter – Two (2)



**37.** A tank measuring 3m (ℓ) × 3m (b) × 2m (h) contains water to 80% of its capacity. The tank is moving with a uniform velocity along a smooth horizontal surface.

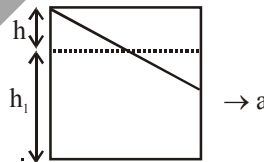
- (i) Will the free surface of water be horizontal? if not sketch the nature of the free surface. [0.5]  
(ii) From t = 5 s the tank is accelerated along its length at a m/s<sup>2</sup>. Will the free surface of water be horizontal? If not, sketch the nature of the free surface. [0.5]  
(iii) Determine the maximum value of acceleration a such that water does not spill over the tank. [3.0]  
(iv) Complete the following statement by choosing the correct option. [1.0]

During accelerated motion of the water tank an air bubble trapped inside will move \_\_\_\_.

- (a) Parallel to the direction of acceleration a.  
(b) In a direction opposite to the direction of a.  
(c) Vertically upward.  
(d) in a direction perpendicular to the free surface of the water.

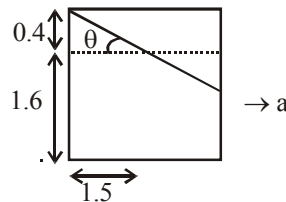
- Sol.** (i) Yes  
(ii) No

$$h_1 = \frac{3 \times 3 \times 2 \times 80}{100 \times 9} = \frac{160}{100} = 1.6 \text{ m}$$

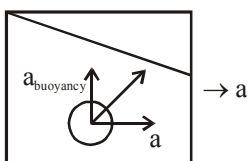


(iii)  $\tan \theta = \frac{0.4}{1.5} = \frac{a}{g}$

$$a = \frac{4}{15} g = 2.6 \text{ ms}^{-2}$$



- (iv) option d is correct



So, the resultant acceleration will be in a direction perpendicular to the free surface of water.

38. (A) Deepa has 100 ml of 10.7 % ammonium chloride solution. Vikram added some amount of slaked lime in it. The gas produced in the reaction is allowed to react with 23.85 g of copper (II) oxide to give solid copper. [Total = 3 marks]

**Calculate**

- (i) Write balanced chemical equations for all the reactions involved.  
 (ii) The amount of slaked lime required to produce sufficient amount of the gas for complete reaction with copper oxide.  
 (iii) The mass of copper after the reaction.

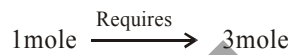
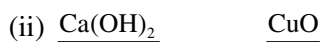
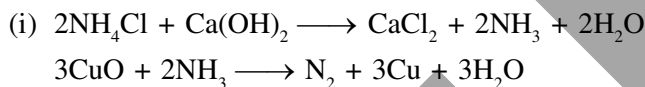
(B) 

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

a to r are elements of the fourth periodic in the period table. Answer the questions given below based on the above information. [Total = 2 marks]

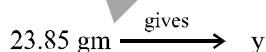
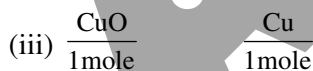
- (i) Write the formula of the compound formed when o reacts with q.  
 (ii) Which element forms maximum number of oxidation states?  
 (iii) Which element forms of purple salt which is also used as disinfectant and for sterilizing well water.  
 (iv) Identify the coinage elements in the above period.  
 (v) Which element is a metalloid?  
 (vi) Which of the above elements has the lowest percentage in the common variety of brass?

**Sol. A.**



$$x = \frac{23.85 \times 74}{3 \times 79.5} = 7.4 \text{ g}$$

wt of  $\text{Ca}(\text{OH})_2 = 7.4 \text{ g}$



$$y = \frac{23.85 \times 63.5}{79.5} = 19.05 \text{ gm}$$

Mass of copper formed = 19.05 gm

**B.**

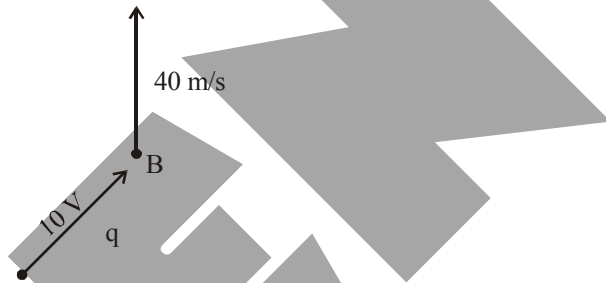
- (i)  $\text{AsBr}_3$ ,  $\text{AsBr}_5$
- (ii) Mn
- (iii)  $\text{KMnO}_4$
- (iv) Cu
- (v) Ge, As
- (vi) Zn

39. Some experiments were carried out using *Croton* sp. plants to understand the process of photosynthesis. It was observed that the leaves of the plant exposed to light for longer duration accumulated more starch. However, due to presence of pre-formed starch in the leaves, it was difficult to find the net productivity on a fixed exposure to light source. Therefore, it was necessary to obtain starch free leaves in the plant before starting the experiment. **[Total = 5 marks]**

1. Which of the following would help obtain starch free leaves in the plant? **[0.5]**
  - (a) Expose the leaves to blue light for 48 hours before starting the experiment
  - (b) Keep the plant in dark for about 48 hours before starting the experiment.
  - (c) Remove starch from the leaves by exosmosis, 48 hours before starting the experiment.
  - (d) Keep the leaves to red light for 48 hours before starting the experiment.
2. After a period of illumination, the leaves were boiled in alcohol to make them colourless. Which of the following could be used to test the end product stored in the leaves? **[0.5]**
  - (a) Cobalt chloride paper
  - (b) Litmus paper
  - (c) Iodine solution
  - (d) Copper sulphate solution
3. During the experiment it was also noted that the end product starch got accumulated only in the cells containing green plastid and upon their illumination to specific wavelengths of light. What is the immediate purpose of the specific wavelength of light used? [1.0]
  - (a) In reducing carbon dioxide
  - (b) For synthesis of glucose
  - (c) Excitation of chlorophyll
  - (d) Splitting water into oxygen and hydrogen ion.
4. Some of the starch free leaves were coated with wax on both the surfaces. The plant was maintained under normal environmental conditions. At the end of the experiment, the wax coated leaves are likely to show \_\_\_\_\_. **[1.0]**
  - (a) Accumulation of more water.
  - (b) Wilting of the wax coated leaves.
  - (c) Increase in sucrose accumulation.
  - (d) Decrease in number of chloroplasts
5. during the morning hours, using a fine blade, an incision was made to the leaves such that the phloem 'tissue was cut open. Analysis of the liquid oozing out was found to contain high amount of
  - (a) Xylose
  - (b) Ribose
  - (c) Sucrose
  - (d) Galactose
6. Leaves of the plant were homogenized in an appropriate buffer environment under appropriate temperature conditions in a test tube. In which of the following conditions is photosynthesis likely to happen in the homogenate?
  - (a) As long as the test tube is illuminated by white light and oxygen concentration is high.
  - (b) As long as the test tube is illuminated by white light and sodium bicarbonate is present in it.
  - (c) As long as oxygen concentration is high and sodium carbonate is present in the test tube.
  - (d) As long as the test tube is illuminated by white light and potassium phosphate is present in it.

- Sol.**
1. (b) because in dark condition, all starch would be utilized by plant cells.
  2. (c) Starch gives positive test with iodine solution.
  3. (c) Light will be used for excitation of chlorophyll molecule
  4. (b) Wax coated leaf will not perform transpiration that's why absorption of  $H_2O$  will not occur, so plants wilted.
  5. (c) Food translocates in form of non-reaching sugar - sucrose.
  6. (b) White light illumination helps in photosynthesis &  $NaHCO_3$  will provide  $CO_2$ .

- 40.** (A) The electrostatic potential difference  $V_B - V_A$  between two points A & B, corresponding to electrostatic forces, is defined as the change in electrostatic potential energy per unit charge as it moves from A to B. A charged particle of mass 0.02 kg moves under electrostatic forces only, from A to B having potential difference of 10 volts as shown. Velocity of the particle at A is 20 m/s and at B is 40 m/s and the directions are perpendicular. Calculate the charge q on the particle.  
[Total=2 marks]



- (B) Two helicopters X and Y are stationary at a distance of 80 m from each other and 10m above the surface of sea (near the Antarctic). The two helicopters have sound detectors. Helicopter X is stationary, vertically above a 50 m thick block of ice. (For the purpose of calculation, the vertical section of the block can be considered as rectangle). A Blue whale (W) is stationary vertically below X and 50m below the water surface in such a way that there is no ice in the line of sight between Whale W and helicopter Y. This line of sight intersects water surface at point M. Whale W gives out a call (sound, which is detected by X. Y received the same sound 0.07 seconds after X received it. (For practical purpose, helicopters are considered to be point objects).

[Total = 3 marks]

- i) How much height of ice is floating above the surface of sea? [1.0]
- ii) What is the distance YM and YW? [0.25 + 0.25]
- iii) What is the time taken for the sound to travel from W to Y after W makes the sound? [0.5]
- iv) What is the time taken for the sound to travel from W to X? [0.5]
- v) What is the velocity of sound in the ice? [1.5]

- Sol.** (A) work done =  $\Delta K$

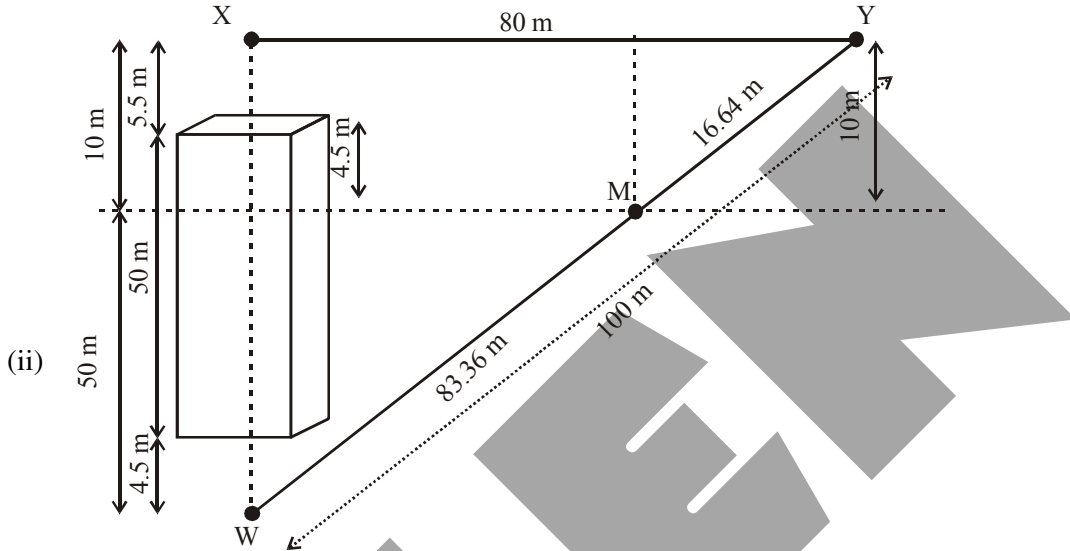
$$10q = \frac{1}{2} \times 0.02 \times (40^2 - 20^2)$$

$$q = 1.2 \text{ C}$$

(B) (i) Given  $\rho_{\text{ice}} = 910$ ,  $\rho_{\text{water}} = 1000$ ,  $\frac{V_{\text{in}}}{V} = \frac{\rho_{\text{ice}}}{\rho_{\text{water}}}$

$$\frac{A \times h_{\text{in}} g}{A \times h g} = \frac{910}{1000}$$

$$h_{\text{in}} = 45.5 \text{ m}, h_{\text{out}} = 4.5 \text{ m}$$



from figure  $WY = \sqrt{(xy)^2 + (xw)^2} = \sqrt{80^2 + 60^2} = 100 \text{ m}$

from figure  $\frac{60}{10} = \frac{100}{MY}$

$$MY = 16.64 \text{ m}$$

(iii) Time taken from W to Y ( $t_{WY}$ )

Along WY  $\Rightarrow \frac{83.36}{V_{\text{water}}} + \frac{16.64}{V_{\text{air}}} = 0.07 + t_{WX}$

$$\frac{83.36}{1500} + \frac{16.64}{350} = 0.07 + t_{WX}$$

$$t_{WX} = 0.032 \text{ s}$$

Now time taken from W to Y.

$$t_{WY} = 0.07 + t_{WX} = 0.07 + 0.32 = 0.102 \text{ s}$$

(iv) it is found that  $t_{WX} = 0.032 \text{ s}$ .

(v) Along WX

$$\frac{4.5}{1500} + \frac{50}{V_{\text{ice}}} + \frac{5.5}{350} = 0.032$$

$$V_{\text{ice}} \approx 3760 \text{ ms}^{-1}$$

41. (A) A mixture of a 5 mL sample solution of HCl and 2 drops of phenolphthalein turns pink on the addition of 2 drops of 1 M NaOH solution to it. Find the concentration and grams of HCl in the given sample solution. (100 drops of 1 M NaOH is found to be equivalent to 6 mL) [Totals = 2marks]

(B) Reshma and Shubha were working together in the chemistry laboratory. They wanted to find out the exact molarity of a solution of sodium hydroxide (NaOH), prepared by dissolving exactly one gram of sodium hydroxide pellets in water and diluting the resultant solution to 250 mL in volumetric flask. Reshma weighed exactly one gram of solid sodium hydroxide using a chemical balance; but while transferring it to a beaker, she spilled some amount of the weighed solid on the floor but she still went ahead with the preparation. Shubha was unaware of this spillage. She titrated the sodium hydroxide solution prepared by Reshma with 10 mL solution of 0.05 M dibasic acid having formula  $(C_2H_3O_2)_2$ . The constant titre reading for the titration obtained by Shubha was 11.3 mL.

(i) Calculate the amount of sodium hydroxide spilled on the floor,

(ii) How many molecules of each of the reactants were present in the titration performed by Shubha?

Sol. (A) HCl NaOH

$$M_1 = ? \quad M_2 = 1 \text{ M}$$

$$V_1 = 5 \text{ mL} \quad V_2 = (6 \times 2)/100 = 0.12 \text{ mL}$$

$$M_1 V_1 = M_2 V_2$$

$$M_1 = (M_2 V_2)/V_1 = (1 \times 0.12)/5 = 0.024 \text{ M}$$

$$\text{Weight of HCl} = \frac{M_1 V_1}{1000} \times \text{Mol. weight of HCl} = \frac{0.024 \times 5}{1000} \times 36.5 = 4.38 \times 10^{-3} \text{ g}$$

(B)

(i) NaOH Dibasic acid

$$N_1 = ? \quad N_2 = M_2 \times n\text{-factor} = 0.05 \times 2 = 0.1 \text{ N}$$

$$V_1 = 11.3 \text{ mL} \quad V_2 = 10 \text{ mL}$$

$$N_1 V_1 = N_2 V_2$$

$$N_1 = \frac{N_2 V_2}{V_1} = \frac{0.1 \times 10}{11.3} = 0.0885 \text{ N}$$

$$\text{wt of NaOH titrated} = \frac{0.0885 \times 250}{1000} \times 40 = 0.885 \text{ gm}$$

$$\text{wt of NaOH spilled on the floor} = 1 - 0.885 = 0.115 \text{ gm}$$

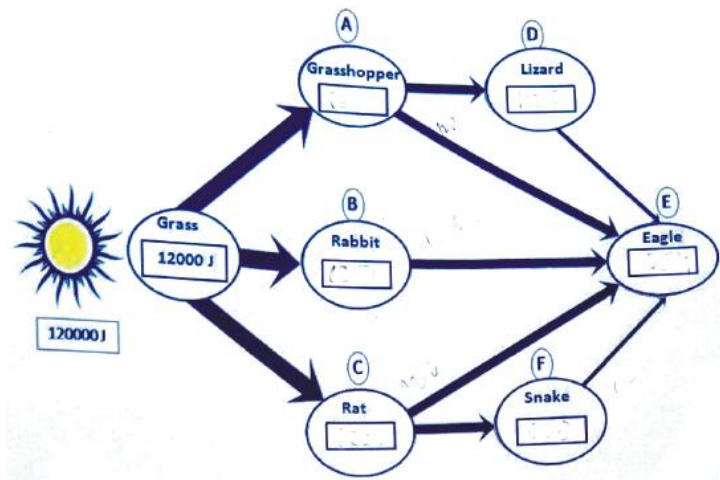
(ii) Number of mole of NaOH =  $\frac{MV}{1000} = \frac{0.0885 \times 11.3}{1000} = 1 \times 10^{-3} \text{ mole}$

$$\text{Number of NaOH molecules} = 1 \times 10^{-3} N_A$$

$$\text{Number of dibasic acid molecules} = 0.5 \times 10^{-3} N_A$$



42. (A) An analysis of food chains and the energy flow within an ecosystem provides important understanding of contingencies and mutual dependencies of organisms. The following visual depicts the energy flow within some members of a grassland ecosystem.



The grass in the above ecosystem transducer 120,000 J of sunlight and fixes it into 12,000 J of energy. It is established that 90% of the energy of one trophic level is not passed to the next trophic level. Further assume that the energy transferred from one trophic level to the next is equally shared among the different organisms at that trophic level.

[total = 5 marks.]

- (i) How many food chains are present in the food web depicted above? [0.5]
  - (ii) Based on the above information, indicate the amount of energy that an organism (A to F) may have received from an organism from the previous trophic level. [0.5]
  - (iii) In the food web depicted above, identify the most energy efficient link for tertiary consumer? [1.5]
- (B) Assume that an insect eats plant seeds containing 100 J of energy. A part of this energy is lost or is unassimilated in the form of faeces; while the rest is assimilated through respiration and biomass production. It uses 36 J of that energy of for respiration and excretes 52 J in its faeces,
- (i) How much is the insect's net secondary production ?
 

(a) 12 J	(b) 48 J	(c) 24 J	(d) 36 J
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  - (ii) Production efficiency is the percentage of energy stored in assimilated food that is not used for respiration. In the case of the insect described above, what will be its production efficiency? [1.0]

(a) 5.8%	(b) 25%	(c) 75%	(d) 92%
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- (C) Which of the following represents the correct sequence representing an increasing order of biomass production efficiencies?
- (a) Birds → Mammals → Fishes → Microorganisms
  - (b) Microorganisms → Birds → Fishes → Mammals
  - (c) Fishes → Birds → Mammals → Microorganisms
  - (d) Mammals → Fishes → Birds → Microorganisms

**Sol.** (A)(I) 5 (five)

(II) 10%

(III) Grass → Rabbit → Eagle

(B)(I) Net secondary production (a) 12 J

$$\begin{aligned}\text{Net secondary production} &= 100 - (52 + 36) \\ &= 12 \text{ J}\end{aligned}$$

$$(II) \text{ (a) Production efficiency} = \frac{\text{Net secondary production} \times 100}{\text{Assimilated food energy}} = \frac{12 \times 100}{48} = 25\%$$

(b) 25%

(C)(b) Microorganisms → Birds → Fishes → Mammals

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