1. From the characteristics of each of the organisms provided in the table below, identify the four organisms, namely P, Q, R and S – from one of the options:

	Symmetry	Germ layers	Coelom	Notochord
P	Bilateral	Triploblastic	Eucoelomate	Present
Q	Bilateral	Triploblastic	Pseudocoelomate	Absent
R	Radail	Diploblastic	Special cavity	Absent
S	Asymmetry	No Germlayers	Special cavity	Absent

A. P = Fish, Q = Roundworm, R = Starfish, S = Sponge

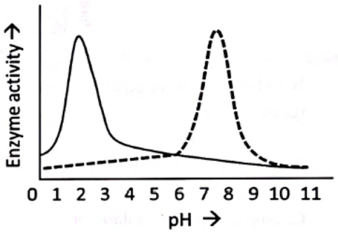
B. P = Frog, Q = Filarial worm, R = Jelly fish, S = Hydra

C. P = Bird, Q = Hook worm, R = Hydra, S = sponge

D. P = Snake, Q = Earth worm, R = Jelly fish, S = Flatworm

Answer: C

2. The graph below shows the activity spectra of two proteolytic enzymes P (bold line) and Q (dotted line). Identify the combination that identities the source of the enzymes correctly.



A. P – Mouth and Q – Stomach

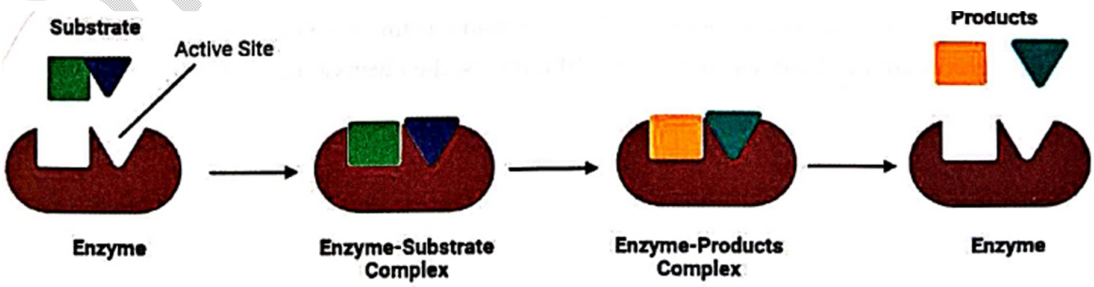
B. P – Stomach and Q – Duodenum

C. P – Duodenum and Q – Stomach

D. P – Stomach and Q - Ileum

Answer: B

3. Enzymes are biological catalysts that speed up biochemical reactions in living organisms. The active site is the region of an enzyme where substrate molecules bind and undergo a chemical reaction. The following figure demonstrates the process of enzyme-substrate reaction.



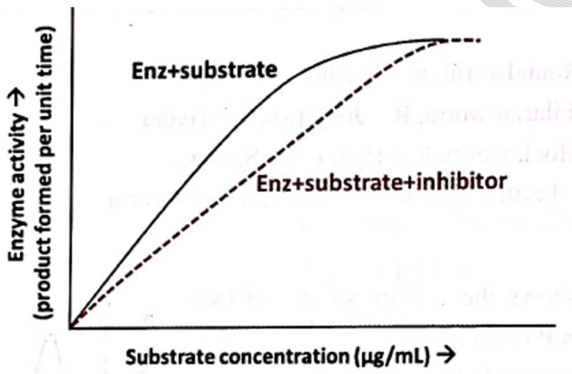
There are some molecules termed an enzyme inhibitors which bind to an enzyme and inhibit its activity or prevent them from working in a normal manner**.** It is important to note that both the substrate and inhibitor binding to the enzyme, are reversible reactions. The important types of inhibitors classified into the following three types:

i) Competitive inhibitor directly binds to the enzyme's active site.

ii) Non-competitive inhibitor binds to a location other than the active site which in turn affects active site and therefore the enzyme activity.

iii) Uncompetitive inhibitor binds to the enzyme-substrate complex and slows the rate of reaction to form the enzyme-product complex.

A group of researchers working on various plant extracts evaluated their lipase activity using a fixed concentration of enzyme with/without a fixed concentration of inhibitor, each reaction tested at varying substrate concentrations (all other factors were maintained constant), they found some interesting results. One of the extracts showed the pattern of inhibition as shown in the graph below.



Below on the above pattern of activity of the two reactions, which of the following best concludes the result.

A. Uncompetitive inhibition

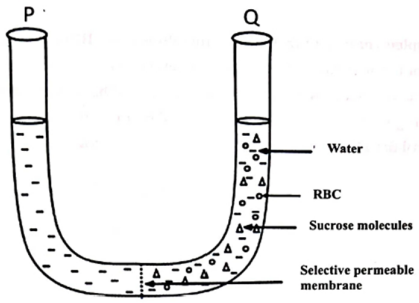
B. Competitive inhibition

C. Non-competitive inhibition

D. Unexplainable by the given data.

Answer: A

4. A U-shaped glass tube based experiment is depicted below. The two arms are separated by a selectively permeable membrane fixed at the center that allows only water molecules to pass through it. The arm "P" is filled with 10 ml distilled water while arm "Q" is filled with Red Blood Cells (RBC) suspended in 10 ml of an isotonic sucrose solution. Each arm contains 10mL of solution at 0 min and can accommodate up to a maximum of 12mL capacity. After 30 minutes, the observation would be:



A. The water level in "P" would be lower than initial while solution level in "Q" will rise with an increase in RBC size.

B. The water level in "P" will rise above initial level while in "Q" it will fall with a decrease in RBC size.

C. The water level in "P" would be lower than initial while water level in "Q" will rise with a decrease in RBC size.

D. The water level is "P" will remain the same as initial while water level in "Q" will rise with an increase in RBC size.

Answer: A

5. The component of a reflex arc are shown in the flow diagram.

$$\text{Receptor} \rightarrow \text{Sensory neuron} \rightarrow \text{Synapse} \rightarrow \text{Relay neuron} \rightarrow \text{Synapse} \rightarrow \text{Motor neuron} \rightarrow \text{Effector}$$

Which component is responsible for ensuring that the nerve impulses travel in one direction only?

A) Motor neuron B) Receptor C) Sensory neuron D) Synapse

Answer: D

6. 24 Karat gold is 100% pure gold. 18 karat gold is an alloy made by mixing 18 parts of gold with 6 parts of copper by weight. The cost of pure gold is 5560 INR/gram. When it comes to diamonds, 1carat means a diamond which weighs 200 mg. The cost of diamond is 65,000 INR/carat. If you buy a 15gram ornament made with 18 karat gold and a 2 carat diamond embedded into it, which of the following statement is not true?

A) You get more atoms of gold than carbon in the ornament

B) You pay more per atom of carbon than per atom of gold in the ornament.

C) You get almost same number (Within 5%) of atoms of gold and copper in the ornament.

D) The major cost of the ornament is for the gold component in it.

Answer: D

Solution:

18 Carat:

18gm golds 6g copper

15gram ornament:

Mass of diamond = $2 \times 200 = 400\text{mg} = 0.4$ g

Mass of 18 carat Gold = $15 - 0.4 = 14.6$g

Mass of Gold = $\frac{14.6}{24} \times 18 = 10.95$g

Mass of CU = $14.6 - 10.95 = 3.65$g

Atoms of CU = $\frac{3.65}{63.5} \times \text{No} = 0.0574\,\text{No}$

Atoms of Carbon = $\frac{0.4}{12} \times No = 0.033\,No$

Atoms of Gold = $\frac{10.95}{197} \times No = 0.055\,No$

Cost of Gold = 10.95 × 5560 = 60882 Rs

Cost one Gold atom = $\frac{60882}{0.055\,No} = \frac{1106945.45}{No} rs$

Cost of diamond = 65000 × 2 = 130000 Rs

Cart one atom of carbon = $\frac{130000}{0.033\,No} = \frac{3939393.9}{No} rs$

7. India has been implementing an Ethanol Blending Program (EBP) to increase the ethanol content in petrol. The use of ethanol can reduce greenhouse gas emissions, Ethanol, like petrol, burns in the internal combustion engine to produce water and carbon dioxide. What is the decrease in carbon dioxide emission resulting from using E20 fuel (Consider 20% ethanol by mass in petrol) in place of Just petrol. Ethanol is C_2H_3OH and petrol C_8H_{18}.

A) 20% B) 15% C) 10% D) 7.5%

Answer: D

Solution:

$C_8H_{18} + O_2 \rightarrow 8CO_2 + 9H_2O$

114 gr ____ 352 gr

100 gr ____ (x)

x = 308.7 gr

114 gr _____ 352 gr

80 gr _____ (x)

x = 247

$C_2H_5OH + O_2 \rightarrow 2CO_2 + 3H_2O$

46 gr _____ 88 gr

20 gr _____? (x)

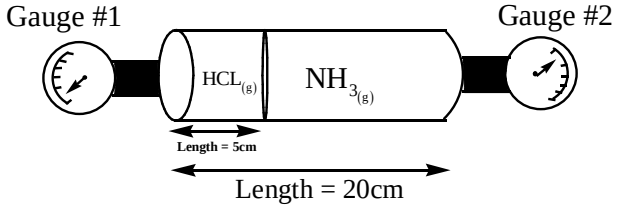
x = 38.26

$\therefore$ Total CO_2 emitted = 285 gr

$\therefore$ weight of decrease in emission of CO_2 = 23.7 gr

$\therefore$ % Decrease in emission = $\frac{23.7}{308.7} \times 100$ = 7.5%

8. Ammonia (NH_3) and hydrogen chloride (HCl) react to form solid ammonium chloride



In a cylinder of radius 5cm with two chambers as shown above, 4 gram of ammonia and 4gram of hydrogen chloride were placed in the respective compartments. After keeping at 25°C, the plate separating the two chambers was removed that enables that enables the cylinder to have a single compartment. The cylinder was allowed to come back to 25°C.

The pressure reading in gauge #1 in the initial setup and for gauge #2 after the process were:

A) 4.12 atm and 1.03 atm
B) 6.85 atm and 1.95 atm
C) 6.85 atm and 4.68 atm
D) 4.12 atm and 1.22 atm

Answer: B

Solution:

$$\text{Initial pressure of HCl, P} = \frac{nRT}{v}$$

$$= \frac{4}{36.5} \times \frac{0.0821 \times 298}{3.14 \times 125 \times 10^{-3}}$$

= 6.85 atm

Hint:

$$NH_{(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)} \downarrow$$

0.235 0.11

HCl is limiting reagent

Moles of NH_3 left = 0.125

$$\text{Final Pressure (p)} = \frac{nRT}{V}$$

$$= \frac{0.125 \times 0.0821 \times 298}{1.57}$$

= 1.95 atm

9. Rainwater runoff in which of the following cases is likely to have the highest electrical Conductivity?

A) Water flowing over rocky area
B) Water flowing through mounds of sand dumped a decade ago
C) Water flowing down a municipal waste dumped a year ago
D) Water flowing down broken concrete dumped a year ago

Answer: A

10. Standard reduction potential, often denoted as $E°$, is a measure used in electrochemistry to indicate the tendency of a species (a reduction reaction) to gain electrons and be reduced. $E°$ quantifies the relative case or difficulty with which a species can be reduced or oxidized under standard conditions. The more positive the standard reduction potential of a species, the grater its tendency to act an oxidizing agent in a chemical reaction. Conversely,, species with more negative standard reduction potential are more likely to act as electron donors.

Given the following at standard reduction potentials for the redox species:

Chemical species	Standard reduction potential $E°$ (v)
$Fe^{2+}(aq)$ becoming $Fe(s)$	–0.44
$Cu^{2+}(aq)$ becoming $Cu(s)$	+0.34
$Zu^{2+}(aq)$ becoming $Zu(s)$	–0.76
$Ag^{+}(aq)$ becoming $Ag(s)$	+0.80

When arranging these species in pairs in an electrochemical cell, which one of the following statements is correct, under standard condition?

A) $Fe^{2+}(aq)$ becomes $Fe(s)$ when paired with all $Cu(s)$, $Zu(s)$ and $Ag(s)$

B) $Fe^{2+}(aq)$ becomes $Fe(s)$ when paired with all $Ag(s)$ and $Cu(s)$, $Zu(s)$

C) Fe becomes $Fe^{2+}(aq)$ when paired with $Ag^{1+}(aq)$, $Cu^{2+}(aq)$;and $Fe^{2+}(aq)$ becomes $Fe(s)$ when paired with

D) $Fe(s)$ becomes $Fe^{2+}(aq)$ only when paired with $Zu^{2+}(aq)$

Answer: C, D

Solution:

The electrode with low S.R.P (including sign) behave as anode and electrode with high S.R.P behave as cathode, when they are connected.

At anode oxidation occurs

$M_{(s)} \rightarrow M^{n+} + ne^-$

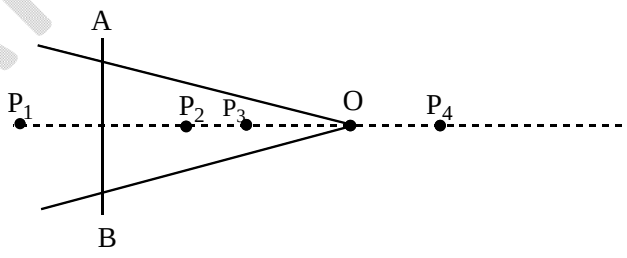
At cathode reduction Occurs

$M^{n+} + ne^- \rightarrow M_{(s)}$

In electrode behave as anode with all other electrode given and under goes oxidation. Electrodes and behave as anode with Ag and Cu electrodes.

11. A converging beam is about to converge at O. However, on introducing an optical element AB (a mirror or a lens) the point of convergence shifts from O to a new location. Column 1 is list of optical elements and column 2 is a list of possible image locations. Match the optical element with the location where the light is made to converge due to their intervention.

$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$



Optical element

Column -1	Column -2
a) Convex lens of a certain focal length *fq*	p) p_1
b) Convex lens of focal length greater than *fr*	q) p_2
c) Plane mirror *p*	r) p_3
d) Concave lens *s*	s) p_4

A) a – r ; b – q ; c – s ; d – p B) a – q ; b – r ; c – p ; d – s

C) a – r ; b – q ; c – p ; d – s D) a – q ; b – r ; c – s ; d – p

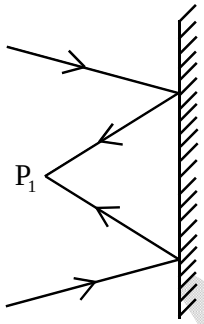
Answer: B

{a – q ; b – r ; c – p ; d – s}

Solution:

Convex lens in a rarer median is converging in nature. There fore it converges the incoming right ray before O. More the focal length lesser the converging nature.

∴ Lens of greater f form image at p_3. Plane mirror forms image at P_1 as shown concave lens diverges and from image at p_4



12. A body of mass *m* dropped from a height *h* reaches the ground with a speed of $1.2\sqrt{gh}$. The work done by air-resistance is

A) 0.12mgh B) –0.12mgh. C) –0.28mgh D) 0.28mgh

Answer: C

{ –0.28mgh }

Solution:

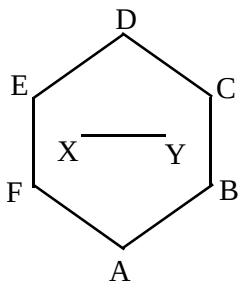
$W_{all}F = \Delta KE$

$\Rightarrow W_g + W_f = \frac{1}{2}m(1.2\sqrt{gh})^2$

$\Rightarrow mgh + W_f = 0.72\,mgh$

$W_f = -0.28\,mgh$

13. Six-point charges are placed at A, B, C, D, E and F on a regular hexagon. If a test charge (+1nC) is placed at any point on XY and it id found to go in the upward direction (in figure). Line XY is on bisector of sides EF and BC. Then the charge distribution an be respectively.



A) $+q,-q,-2q,+2q,+q,-q$ B) $-q,-q,-2q,+q,+q,+2q$

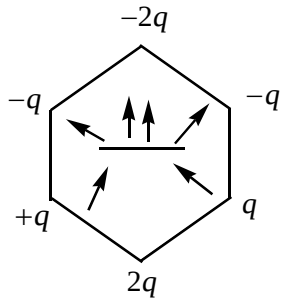
C) $+2q,+q,-q,-2q,-q,+q$ D) $+q,-2q,-q,+q,+2q,+q$

Answer: C

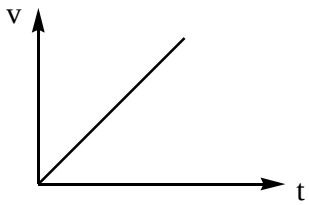
$\{+2q,+q,-q,-2q,-q,+q\}$

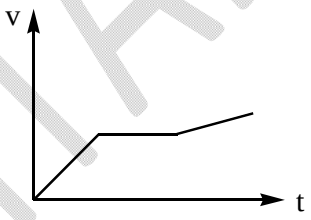
Solution:

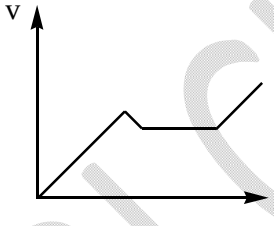
For the assembly shown F_{net} upward

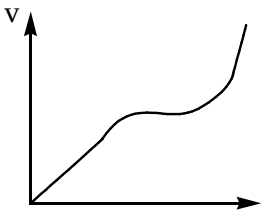


14. A bar magnet is let free to fall from some height staring from rest through a hollow conducting cylinder. Then identify speed-time graph ($v-t$ graph) that best explains its motion.

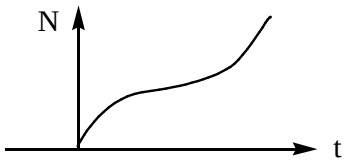
A) 

B) 

C) 

D) 

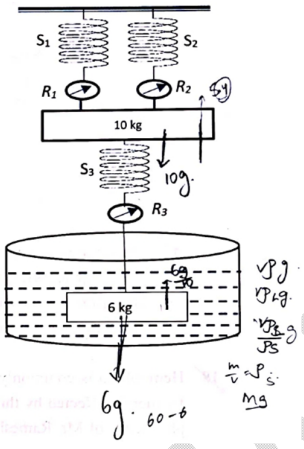
Answer: D



Solution:

Before entering conducting cylinder bar magnet experience a constant F_{net} inside more with a Constant velocity again after coming out F_{net} is constant

15. A block of mass 10 kg is suspended from a rigid support via two identical spring balances S_1 and S_2. Another block of mass 6kg is suspended from bottom of 10 kg block via a third spring balance S_3. All the spring balances are assumed to be massless. The block of mass 6kg (Relative Density = 1-) is fully immersed in water contained in a big container. The arrangement is shown in the adjacent figure. If the readings (in kg – wt) on spring balances S_1, S_2 and S_3 are R_1, R_2, R_3 respectively, choose the correct option (assume all the springs stretch within the elastic limits).



	R_1	R_2	R_3
A.	5.0	5.0	5.4
B.	8.2	8.2	6.4 .
C.	10.0	10.0	5.4
D.	7.7	7.7	5.4

Answer: D

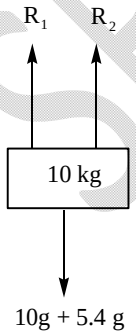
Solution:

Reading is $R_3 = W - F_B$

$$= 6g - \frac{6}{10000}(1000)g$$

$$= 5.4g$$

FBD on 10kg

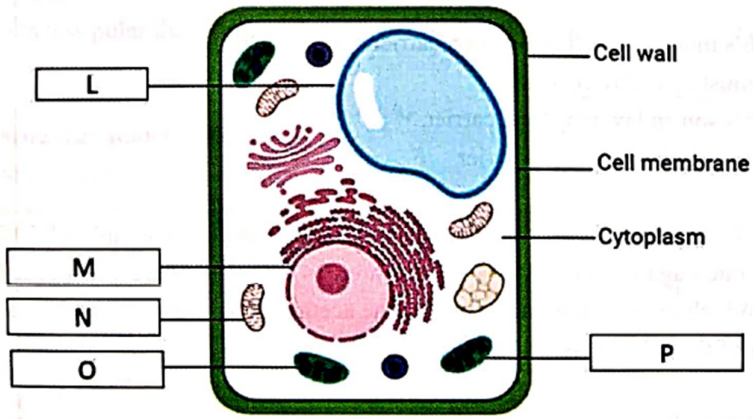


10g + 5.4 g

$$R_1 + R_2 = 15.4g$$

$$R_1 = R_2 = 7.7$$

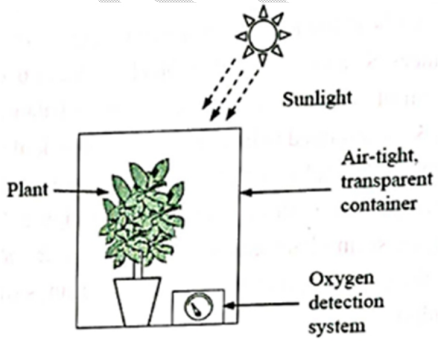
16. The figure below shows the ultrastructural details of a plant cell. Some parts are labeled as L, M, N, O and P, identify the correct statement (s) w.r.t to these labels.



A. O is a granule of reserve foof Glycogen.
B. L is concerned with spindle fibre formation.
B. M and P are energy transducers.
D. N helps in aerobic respiration

Answer: A, D

17. You are trying to demonstrate to your friends that plants require the presence of light to produce oxygen. To do this you assemble the experimental system shown below and make your observation at the beginning and the end of the experiment after 6 hours. Which setup (s) from the ones below would be useful as a control for your experiment?



A. The setup as above, bt placed in a dark room
B. The setup as above, but placed in a dark room with holes in the top of the container
C. The setup as above, but with the plant removed from the pot.
D. The setup as above, but with a constant supply of CO_2

Answer: A, B, D

18. Hemophilia is commonly called bledder's disease. It is a X- linked recessive disorder. Males are more frequently affected by this. If 'H' – is the normal gene, 'h' – is its recessive allele, trace the genotype and phenotype of Mr. Ramesh's family. Mr. Ramesh is normal, and non – hemophilic. His father is also non – hemeophilic. Ramesh marries Radha, Who is also normal, and her father is also non – hemophilic. This couple has 3 childre, one boy and two girls, who are all normal. One of the daughters marries a man who is also normal. She has a son (Ramesh's grandson) who is

hemophilic. Which of the following outcome (s) will result from the genetic trace between the F_1, F_2 and F_3 generations.

A. Ramesh's mother is definitely not a carrier. B. Radha must be a carrier.

C. Ramesh's son – in law may be a carrier D. Ramesh's daughter must be carrier

Answer: A, B, D

19. Acetic acid (CH_3COOH) is an important ingredient of vinegar. A sample of 50.0 mL of a commercial vinegar is titrated against a 0.5 M NaOH solution. 14 ML of the base was needed for the titration to be completed. Which of the following describes the acetic acid content in the vinegar?

[The density of the solution is Ig/mL]

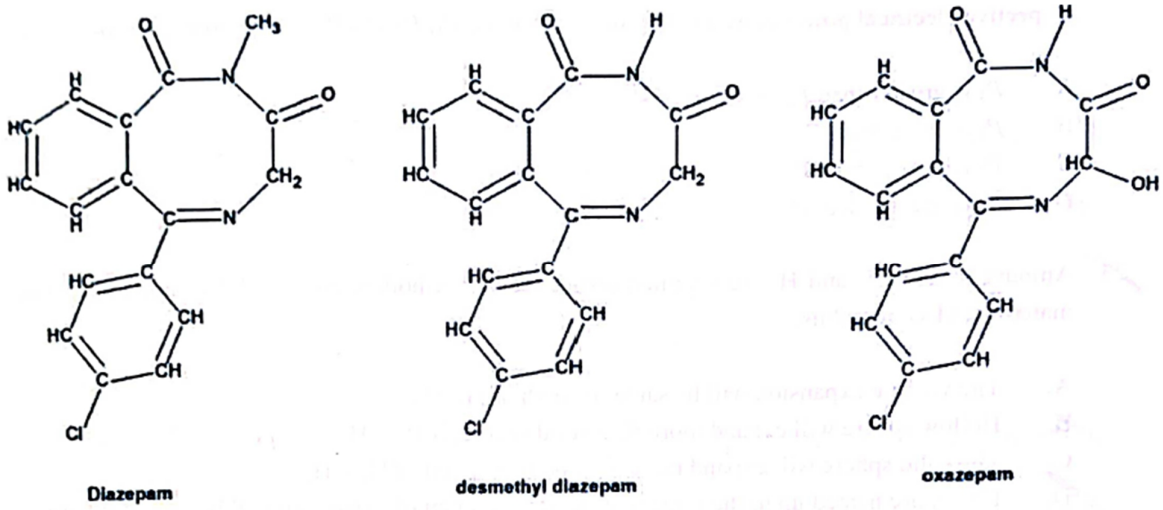
A. ~0.25 mole% B. ~5400 ppm C.~0.14 Molar D. ~ 4% weight

Answer: A, B, C

Solution:

$$n_{NaoH} = 0.5 \times 14$$
$$= 7\,\text{m.m}$$
$$= 0.007\,\text{moles}$$
$$\therefore {}^{n}CH_s\,\text{Could} = 0.007\,\text{moles}$$
$$\text{wt of } CH_3COOH = 0.42\,\text{gr}$$
$$\text{Vol. of Veniger solution} = 50\text{ml}$$
$$(d = 1\text{g/ml})$$
$$\therefore \text{Wt of veniger solution} = 50\text{gr}$$
$$\therefore \text{PPM} = \frac{0.42}{50} \times 10^6$$
$$= 8400\,\text{PPM}\ (\text{B})$$
$$n_{\text{water}} = \frac{49.58}{18} 20754$$
$$\text{Total moles} = 2.7614$$
$$\therefore \text{mole\%} = \frac{0.007}{2.7614} \times 100$$
$$= 0.25\ (\text{A})$$
$$\text{M} = \frac{0.007}{50} \times 1000 = 0.14(\text{C})$$
$$\frac{\text{w}}{\text{w}}\% = \frac{0.42}{50} \times 100 = 0.84$$

20. As xenobiotic substances, such as drug molecules, enter the bloodstream, the body needs an effective mechanism to eliminate these substances. The liver plays a crucial role in this clearance process. Diazepam, a drug, being a lipophilic (fat – loving) molecule with relatively low water solubility, undergoes metabolic transformation within the liver into desmethyl diazepam, oxazepam, and various other metabolites as it circulates through this organ.



Which statement(s) are true for this process :

A) The liver metabolizes diazepam into compounds that exhibit a greater affinity for lipids than diazepam itself, thereby prolonging the drug's presence in the body.

B) The liver transforms diazepam into metabolites that are more polar than diazepam, facilitating their elimination through urine.

C) Desmethyl diazepam possesses increased polarity compared to diazepam due to the presence of a polar N – H bond.

D) Oxazepam is less polar than diazepam because it contains one less methyl (CH_3) group.

Answer : B, C

Solution: Desmethyl diazepam and ozazepam are more polar than diazepam.
So desmethyl diazepam and ozazepam are water loving.

21. Ms. Ruhina teachers her students the concept of pH. She defines pH as negative logarithm to the base ten of hydrogen ion concentration, and says pure water at 25°C has a pH of 7. On a hot summer day when the temperature was 40°C, she wants to demonstarate that the pH of distilled water is 7 to her class. On measuring the pH of packaged distilled water with a simple pH meter, the value obtained was 6. 77. Which of the following statement(s) is/are offer(s) the best explanation for this discrepancy ?

A) At a higher temperature, the extent of ionization of water has increased and, hence, the water has become acidic.

B) At a higher temperature, the extent of ionization of water has increased by ~3% and as a result, the "neutral" value for pH is indeed 6.77

C) At a higher temperature, the extent of ionization has increased and a solution with pH = 7 at this temperature is slightly alkaline.

D) At a higher temperature, the extent of ionization of water has increased by ~70% and as a result, the "neutral" value for pH is indeed 6.77

Answer : B

Solution: pH = 7 at 25°C

pH = 6.77 at 40°C

With increasing temperature from 25° to 40°C, the extent of ionization of water increases by ~3% but the nature of pure water is still neutral.

$K_w = [H^+][OH^-]$

$[H^+] = \sqrt{K_w}$

In water $[H^+] = [OH^-]$ at any temperature so it is always neutral irrespective of pH value

22. Three resistors $\frac{R}{3}, R$ and 2 R are connected in such a way that their equivalent resistance is R. The respective electrical power consumed by the resistor are P_1, P_2 *and* P_3. Then choose the correct option/s.

A) P_1 is greater than P_2

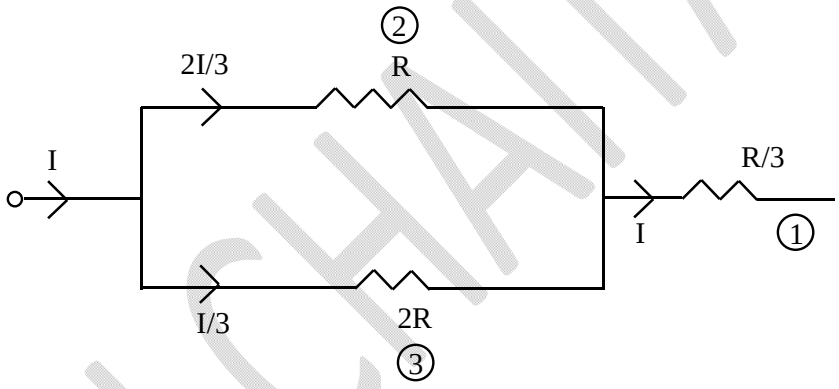
B) P_3 is lesser than P_2

C) P_2 is greater than P_1

D) P_1 is greater than P_3

Answer : B, C, D

Solution:



$$P_1 = I^2\frac{R}{3} = \frac{1}{3}I^2R \equiv \frac{3}{9}I^2R$$

$$P_2 = (\frac{2I}{3})^2 R = \frac{4}{9}I^2R \equiv \frac{4}{9}I^2R$$

$$P_3 = (\frac{I}{3})^2 R = \frac{1}{9}I^2R \equiv \frac{1}{9}I^2R$$

23. Amount of heat H_1 *and* H_2 are supplied respectively to a hollow and a solid metallic sphere of same material and same radius.

A) The volume expansion will be same for both, if $H_1 = H_2$.

B) Hollow sphere will expand more than solid sphere, if $H_1 = H_2$

C) The solid sphere will expand more than hollow sphere if $H_1 = H_2$

D) If they are heated up to the same temperature, amount of expansion will be same for both.

Answer : B, D

Solution: $B)\ H_1 = H_2$

$H = Cm\Delta T$

$H\ \&\ C\ are\ same$

$\Delta T\ \alpha\ \frac{1}{m}$

$\Delta T_1 > \Delta T_2$

$\beta = \frac{\Delta A}{A.\Delta T}$

$D)\ \beta = \frac{\Delta A}{A.\Delta T}$

Hollow Solid

$R, A \rightarrow Same$

$V_1 < V_2$

$m_1 < m_2$

24. Like charges repel and unlike charges attaract magnitude of force (F) between two stationary point charges $Q_1\ and\ Q_2$ separated by a distance r is expressed as $F = \frac{KQ_1Q_2}{T^2}$ (Coulomb's Law) where K is a positive constant. Consider four point charges $Q_1, Q_2, Q_3\ and\ Q_4$ lying in a straight line as shown in the figure beside. The distance between any two consecutive charges is the same. Here $Q_1 - +2mC$ and $Q_3 = +1mC$. If $Q_2\ and\ Q_4$ are in equilibruium option is /are

A) $Q_2 = +\frac{44}{9}mc\ and\ Q_4 = +4mc$

B) $Q_2 = -\frac{44}{9}mc\ and\ Q_4 = +4mc$

C) $Q_2 = +\frac{44}{9}mc\ and\ Q_4 = -4mc$

D) If $Q_2 = 0, Q_4$ cannot be in equilibruim

Answer: B, D

B)

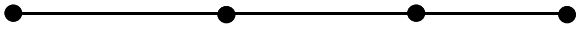
$Q_1 = 2mc \qquad Q_2 = -\frac{44}{9} \qquad Q_3 = 1mc \qquad Q_4 = 4mc$

Here on Q_2 } Resultant force zero

$$F_{Q_2} = \frac{k(1)\frac{44}{9}}{r^2} - \frac{k(4)\left(\frac{44}{9}\right)}{(2r)^2} = 0$$

and $F_{Q_4} = 0$

D)

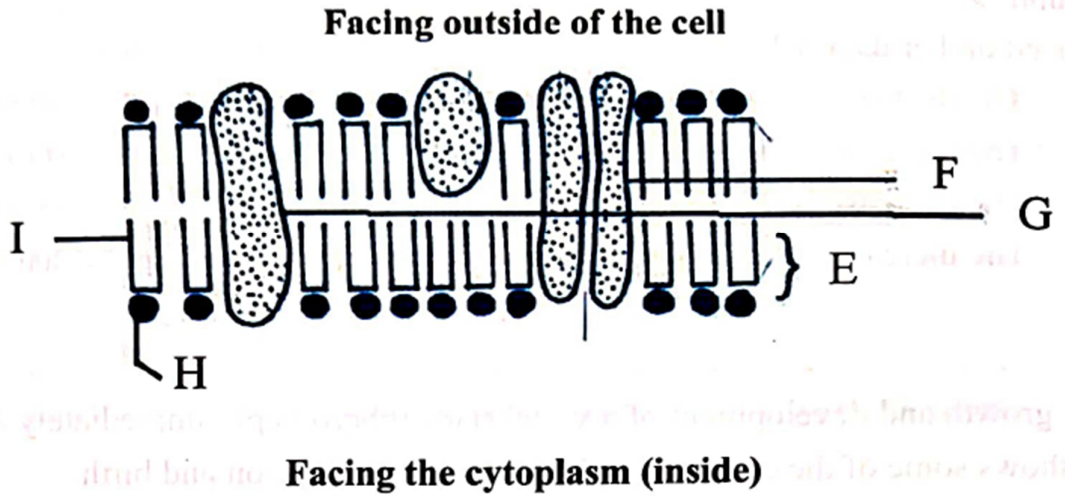


$Q_1 = 2mc \qquad Q = 0 \qquad Q_3 = 1mc \qquad Q_4 = any\ change$

Here on $Q_4 \} \left(F_{Res}\right) \neq 0$

So, equilibrium not exist

25. (a) The structure of an animal cell plasma membrane is shown below. The bi-layered plasma membrane is made up of both proteins & polar lipids along with carbohydrates found attracted to either proteins and /or lipids. Some proteins are embedded in the membrane while other exist more towards the internal surface of the membrane (internal proteins) & or on the external part (surface/external proteins)



Based on above information, identity the label(of each leter) and choose the correct options:

(i) E is a lipid molecule

(ii) F is bi-layered lipid

(iii) G is a trans membrane protein

(iv) H is a the polar part of the molecule

(v) E is entirely polar

(vi) H & I are both non-polar

(vii) I is polar

With respect to nature of plasma membrane, which of the following statement(s) is/are correct?

Answer :

(i) E is a lipid molecule- (True)

(ii) F is bi-layered lipid – (False)

(iii) G is a trans membrane protein – (True)

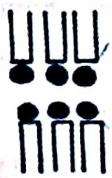
(iv) H is a the polar part of the molecule – (True)

(v) E is entirely polar – (False)

(vi) H & I are both non-polar – (False)

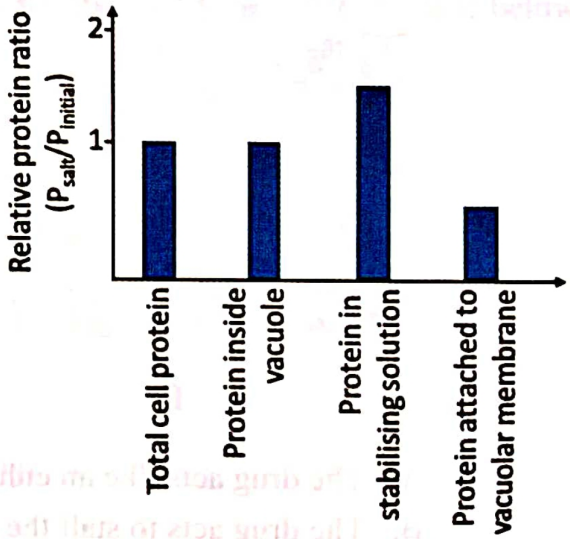
Correct answer – I, III, IV

(b) Wherever a solid food molecule approaches a cell then plasma membrane surround it & engulfs the food practice (phagocytosis) and the food vacuole pinches off into the cytoplasm. As a result the orientation of the membrane proteins get altered as the membrane of the vacuole now faces inside – out. Identified the arrangement of these molecules in the altered plasma membrane of the vacuole and pick the correct one from the options below

A)  B)  C)  D) 

Answer : C

(C) In another experiment, a scientist isolated the food vacuoles from the cell & put them in a solution that increased the stability of the vacuolar membrane. In the second part of the experiment, when she added a small amount of salt to the stabilizing solution, the membrane still seemed to remain intact. To decipher what had happened she perforemed a protein estimation assay on the samples before (P_{intial}) and after addition of the salt (P_{salt}) she divided the values of her salt-treated readings by the corresponding protein reading of the same fraction-type (X-axis) from the original solution (before adding the salt) Her data is depicted in the graph



Based on her data which of the following which of the following interpretation(s) is are true

A) The decrease is due to external proteins that dissociate into the stabilizing solution

B) The increase is due to external proteins that dissociate into the stabilizing solution.

C) The decrease is due to dissociation of transmembrane proteins into the vacuole

D) The increase is due to dissociation of internal proteins the stabilizing solution.

Answer: C

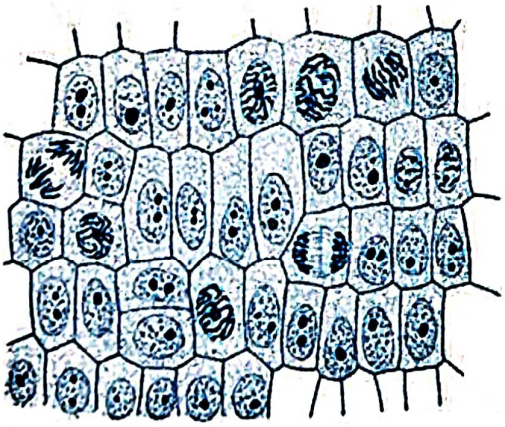
26. **(a)** The growth and development of a vertebrate embryo begin immediately after fertilization the table below shows some of the events (S to Y) between fertilization and birth

S	Development of the heart
T	Placenta forms
U	Hormones are released by the mother to start contractions
V	Implantation of the embryo in the lining of the uterus
W	Embryo forms into a ball of eight cells
X	Development of nervous system
Y	Fertilized ovum divides into two cells by mitosis

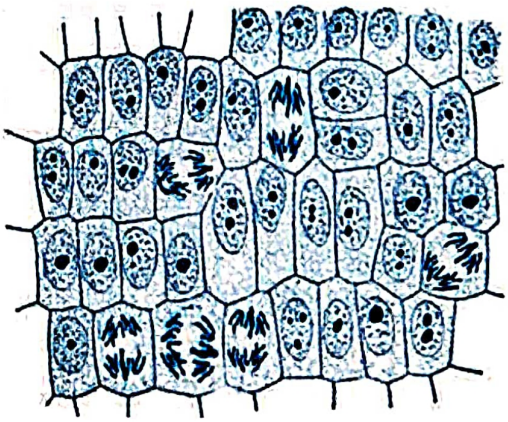
Answer:

Y	Fertilized ovum divides into two cells by mitosis
W	Embryo forms into a ball of eight cells
V	Implantation of the embryo in the lining of the uterus
T	Placenta forms
S	Development of the heart
X	Development of nervous system
U	Hormones are released by the mother to start contractions

b) Cells of a tissue having an average doubling time of 12h were analysed by dye-staining for DNA- chromosomes. In a hypothetical described below, the different phases of the cell cycle were observed among the dividing tissue. One could distinctly observe 1-2 dark stained nucleoli, within each interphase nucleus. Sample P was untreated while sample Q(similar tissue) was treated with a newly discovered drug for 24h, before staining and analysis. Based on your interpretation of the data provided, choose the correct statement(s).



P



Q

A. The drug acts like an enhancer of cell division

B. The drug acts to stall the cells in anaphase.

C. The drug acts to accelerate metaphase in the cells.

D. The drug acts like an enhancer of chromosome disruption.

Answer : B

c) In each of the following stages of the cell cycle of a diploid organism(not provided is sequence), indicate whether the chromosome number is haploid (H), diploid(D) or could be either (E). Also depending on if the chromosome have replicated(R, sister chromatids joined at the kinetochore) or not replicated(N/R), state the corresponding chromosome status in each phase of the cell cycle. interkinesis – phase between Meiosis I and Meiosis II

Chromosome number	Chromosome status	Cell cycle phase
		G2
		Meiotic metaphase I
		Mitotic metaphase
		Meiotic interkinesis
		GI

Answer :

Chromosome number	Chromosome status	Cell cycle phase
2n	N/R	G2
2n	R	Meiotic metaphase I
2n	R	Mitotic metaphase
2n	R	Meiotic interkinesis
2n	N/R	GI

d) Which of the phenomenon can be equated to or most closely represent the corresponding activity associated with a phase of the cell cycle? Choose your options from the following: prophase, metaphase, anaphase, interphase, S phase. Each option can be used only once.

Analogous to the status of DNA in the cell	Phase of cell cycle
Teams when "in-a-tie" at a tug of war	
Transition from a below of cooked noodles to a dehydrated pack	
Serving equal protions of a cake to either two two children	
Noodles in its most relaxed from-cooked noodles in a blow	
Polymerase Chain Reaction(PCR)	

(Note : A " TUG OF WAR" is a game where two groups pull/tug a tight-rope between the two, with the aim of one team tugging the opposing team beyond a midpoint, OR to eventually dragging down the opposing team completely towards one side).

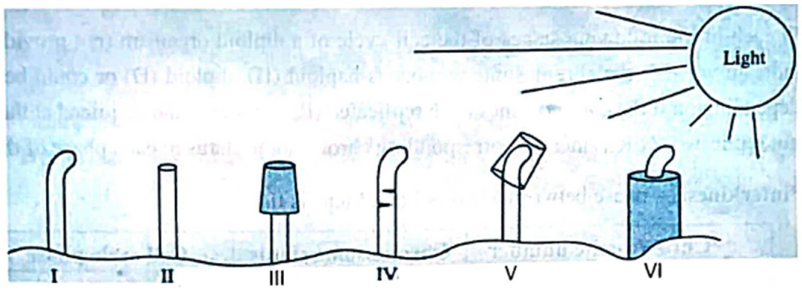
Answer :

Analogous to the status of DNA in the cell	**Phase of cell cycle**
Teams when "in-a-tie" at a tug of war	Metaphase
Transition from a below of cooked noodles to a dehydrated pack	prophase
Serving equal portions of a cake to either two children	Anaphase
Noodles in its most relaxed form-cooked noodles in a blow	Interphase
Polymerase Chain Reaction(PCR)	S-phase

27. An experimenter tried to recapitulate the experiments done by Charles Darwin. He performed a series of experiments on phototropism (growth towards light) of the coleoptile (the cap that covers the first leaves of new seedlings of grass). The treatments they used are described in the first column of the table below:

Treatment	Allowed
I. Coleoptile untreated.	Allowed
II. Tip of coleoptile cut off.	Prevented
III. Opaque cap placed over coleoptile tip.	Prevented
IV. Coleoptile cut halfway through	Allowed
V. Transparent cap placed over coleoptile tip.	Allowed
VI. Opaque sleeve placed over base of coleoptile	Allowed

After the treatment, the plants were allowed to grow (as shown below) for a week and the observations are as in the figure below (corresponding results are tabulated above)



(a) Comparison of treatments I and II shows which of the following options (s)?

A. Growth is promoted by cutting off the tip

B. The tip is the site of auxin synthesis.

C. The tip is necessary for the response to light.

D. There is a range of responses to a single treatment.

Answer: B

(b) The fact that the effect of cutting off the tip (treatment II) is not simply due to wounding of the plant is demonstrated by comparison of which of the treatment? Pick the correct option (s) from below: (1.5 marks)

A. I, II and III

B. I, II and IV

C. II, III and IV

D. IV, V and VI

Answer: C

(c) Comparison of treatment III, V, and VI shows that…..[pick the correct options (s) from below]: (1.5 marks)

A. the tip plays a role in sensing the light

B. the base plays a role in sensing the light

C. confinement of the tip inhibits the response to light

D. confinement of the base facilitates the response to light

Answer: B

(d) To test the hypothesis that the response to light involves differential cell elongation, an experimenter could… [pick the correct option(s) from below]: (1.5 marks)

A. measure the distance between marks made on the seedling after it has bent.

B. count the number of cells visible in a cross section of the coleoptile.

C. compare the length of cells on the sides of the stem towards, and away from the light.

D. repeat the experiment using light of a different wavelength

Answer: C

28. Can a healthy person spend overnight for 8 hours in an airtight room with all the windows and doors closed without ventilation? Let's find out! Consider a closed room of $10\times10\times10$ ft .

I. Find out the volume of the room. Assume about 27 litres is equal to one cubic ft at normal temperature and pressure.

II. Find out the initial total volume of air in the room.

III. Then at the rate of 21% of oxygen in air, calculate the total amount of oxygen present in the closed room.

A normal healthy person at rest or sleeping consumes 250 ml of oxygen per minute. If he is locked in the room for 8 hours.

IV. Calculate the total amount of oxygen utilized by him in 8 hours.

V. Find out the difference in amount of oxygen between the initial and after 8 hours of oxygen content in the room.

VI. State whether the person is dead or alive!!

Write down every step of your calculations clearly for each corresponding step (i – vi), with precise description of what is being calculated with the corresponding formula in words.

Solution:

1. Volume of room $=10\times10\times10$
   $=1000\ ft^3$

   Volume of room $=1000\times27$
   $=27000\,lt$
2. Volume of air = volume of room
   $=27000\,lt$
3. Volume of O_2 in the room $=\dfrac{27000\times21}{100}$
   $=270\times21$
   $=5670\,lt$
4. Volume of O_2 consumed in 8 hours
   $=250\times8\times60$
   $=1,20,000\,ml$
   $=120\,lt$
5. The difference in the initial and final volume of $O_2=120\,lt$
6. Person is alive

29. Airplanes are equipped with emergency slides that are used when an aircraft lands on water. The emergency slide is rolled up and stored underneath the emergency door and is deployed when the emergency exit on an aircraft is opened. This enables people to exit the aircraft and slide out. The aircraft emergency slide must be very quickly inflated and expanded out. Sometimes, this inflation process is carried out by a chemical reaction. The chemical that is commonly used is the thermal decomposition of sodium azide $\left(NaN_3\right)$. When the emergency lever is pulled in the aircraft for

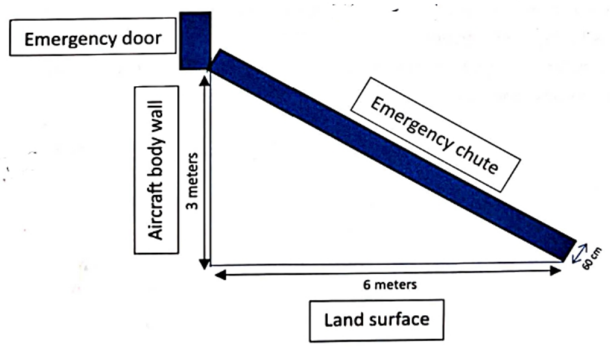
opening the emergency slide, an igniter compound ignites, and the resulting heat degrades sodium azide to form nitrogen gas. This is the same phenomenon that is used in many car air bags.

a) Dry Sodium azide in an inert atmosphere upon heating undergoes a decomposition reaction. One of the products is nitrogen gas. The other is a reactive metal. Write a balanced equation for the decomposition of sodium azide.

b) What is the mass of nitrogen gas released when 100 grams of sodium azide is decomposed?

c) The emergency chute connects the emergency exit with the land surface, as shown below. The width of the chute is 120 cm and the depth is 60 cm. What is the volume of gas that needs to be filled in the chute?

d) To achieve the volume requirement, how much sodium azide should be carried on an aircraft with 6 emergency slides? The pressure inside the chute is 1.3 atm and assume the temperature to be 273K.



High – energy nitrogen compounds are known for their energetic properties, often used as powerful explosives, propellants, or components in pyrotechnics. These compounds contain a significant amount of energy stored within their molecular structure due to the presence of multiple nitrogen atoms, often in a highly strained or unstable configuration. Some high energy nitrogen compounds like TNT (trinitrotoluene) are used as explosives. TNT $\left(C_7H_5N_3O_6\right)$ breaks down to give only nitrogen gas, hydrogen gas, carbon monoxide gas and elemental solid carbon.

e) Write a balanced equation for the decomposition of TNT.

f) How many moles of total gas is released in the decomposition of 1 mole of TNT?

g) If 140 grams of nitrogen gas was obtained from the complete decomposition of TNT, how much TNT was used?

Solution : a) $2NaN_{3(s)} \rightarrow 2Na_{(s)} + 3N_{2(g)}$

b) $2NaN_3 \rightarrow 2Na + 3N_2$

$2\times 65g \longrightarrow \quad 84g$

$100g \longrightarrow \quad ?$

$$\frac{84\times 100}{2\times 65} = \frac{4200}{65} = 64.62\,g$$

c) Width of chute $= 120cm$

Depth of chute $= 60cm$

Length of chute $= \sqrt{3^2+6^2}\times 1000\,cm$

$= 670.8\,cm$

Volume of chute $= 120 \times 60 \times 670.8$

$= 4829760\, cm^3$

$= 4829.76\, lit$

d) Volume of chute $= 4829.76\, lit$

Temperature $= 273K$

Pressure inside chute $= 1.3\, atm$

Moles of N_2 required, $n = \dfrac{PV}{RT}$

$= \dfrac{1.3 \times 4829.76}{0.0821 \times 273} = 280.13\, moles$

$2NaN_3 \rightarrow 2Na + 3N_{2(g)}$

$130g \rightarrow \quad 3\, moles$

$? \quad \rightarrow \quad 3\, moles$

$= \dfrac{280.13 \times 130}{3} = 12139g$

Mass of azide for 1 slide $= 12139g$

Mass of azide required for 6 slides

$= 6 \times 12139\, g$

$= 72834.38\, g$

$= 72.834\, kg$

30. Manufacturing of H_2SO_4: The manufacturing of sulfuric acid (H_2SO_4) is an important process. Content process is an industrial process that involves burning of elemental sulfur in presence of oxygen to sulfur dioxide (SO_2). The sulfur dioxide gas is than purified and cooled to remove impurities and moisture, resulting in a relatively pure SO_2 gas. The purified SO_2 gas is mixed with excess air and passed over a solid catalyst at $450°C$ and 1 – 2 atmospheric pressure to convert the SO_2 into sulfur trioxide (SO_3). Vanadium (V) oxide (V_2O_5) on a solid support is commonly used as the catalyst The sulfur trioxide is then mixed with a carefully controlled amount of water to form sulfuric acid. This is a highly exothermic reaction and must be carefully controlled to prevent overheating and ensure the safety of the process. Sulfuric acid can be further concentrated by dissolving SO_3 in dilute H_2SO_4 results in the formation of oleum $(H_2S_2O_7)$ also known as fuming sulfuric acid.

Concentrated H_2SO_4 is quite often used as a dehydrating agent. It reacts with glucose to give a brittle spongy black mass of carbon. The other organic matter that reacts strongly with concentrated H_2SO_4 include skin , cellulose, plant and animal matter .

Sulfide minerals are one of the major ores that are used for extraction of the different metals. Oxidation of these minerals like iron pyrite (FeS) leads to formation of H_2SO_4 and during rainy

season it forms aqueous solution. The acidic nature of this solution is responsible for dissolution of metal ores and generates highly toxic stream.

a) Write balanced equations for the 4 major reactions in the Contact process leading to formation of olems as described above.

Solution: a) $4FeS + 7O_2 \rightarrow 2Fe_2O_3 + 4SO_2$

$2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3$

$SO_3 + H_2O \rightarrow H_2SO_4$

$H_2SO_4 + SO_3 \rightarrow H_2S_2O_7$

b) IV, V, VI, VII

c) Step 1 $S + O_2 \rightarrow SO_2$

Step – 2 $2SO_2 + O_2 \rightarrow 2SO_3$

Step – 3 $SO_3 + H_2O \rightarrow H_2SO_4$

Step – 1:

$S + O_2 \rightarrow SO_2$

$32kg \rightarrow 1mole$

$1000kg \rightarrow ?$

$= \frac{1000}{32} moles$

$\%\ yield = 95\%$

Moles of SO_2 formed

$= \frac{1000}{32} \times 0.95$

$= \frac{950}{32} moles$

Step – 2 :

$2SO_2 + O_2 \rightarrow 2SO_3$

$2moles \rightarrow 2moles$

$\frac{950}{32} moles \rightarrow ?$

$\frac{950}{32} moles$

$\%\ \text{yield} = 88\%$

Moles of SO_3 formed $= \frac{950}{32} \times 0.88$

$= \frac{836}{32} moles$

Step – 3. $SO_3 + H_2O \rightarrow H_2SO_4$

1 mole 1 mole

$\frac{836}{32} \rightarrow \frac{836}{32} moles$

$\%\ \text{yield} = 99\%$

Moles of H_2SO_4 formed $= \frac{836}{32} \times 0.99 = \frac{827.64}{32}$

Mass of H_2SO_4 formed $= \frac{827.64}{32} \times 98$

$= 2534.65kg$ of H_2SO_4

Overall % yield

$S \rightarrow H_2SO_4$

$32kg$ $98kg$

$1000\,kg \rightarrow \frac{98 \times 1000}{32} = 3062.5kg$

The mass of H_2SO_4 has to get $= 3062.5kg$

The mass of H_2SO_4 obtained $= 2534.65kg$

Overall % yield $= \frac{2534.65}{3062.5} \times 100 = 82.76\%$

d) $H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$

$HSO_4^- + H_2O \rightarrow H_3O^+ + SO_4^{-2}$

31. Titrations are a common laboratory technique used in analytical chemistry to determine the concentration of a substance in a solution. They involve the controlled addition of a reagent (known as the titrant) to a sample (known as the analyte) until a chemical reaction is complete. In a titration it is critical to know the exact concentration of the titrant to determine the concentration of an analyte. In Sahil's industry, the Quality Control department decides to make 1.0 litre of 0.05 M of H_2SO_4 solution for some titration activity and the work is assigned to John. To make this solution, John opens an old bottle of sulfuric acid marked as 98% [by mass] (Density 1.8 g/ml) and takes out 5 ml of the liquid into a beaker. After about 15 minutes he comes back and adds 1.0 litre of water to the concentrated sulfuric acid to dilute it. Then he labels the beaker as 1 litre 0.05 M H_2SO_4.

There are several mistakes that John has made in his preparation. Can you list out at least 3 mistakes that John made, why is it a mistake and what is the remedy for the mistake? **(4 marks)**

Solution:

Con. of given sulphuric acid

$$M = \frac{\frac{w}{w}\% \times d \times 10}{G.m.wt}$$

$$= \frac{98 \times 1.8 \times 10}{98}$$

$= 18\,M$

He took 5 ml of this and now added 1 litre water to the then concentration becomes

$18 \times 5 = 1005 \times M_2$

$M_2 = 0.0895\,M$

This is the concentration of solution

He prepared the mistakes are,

(1) If the concentrated liquid is diluted to 1 litre, then con. Of solution becomes 0.09 M.

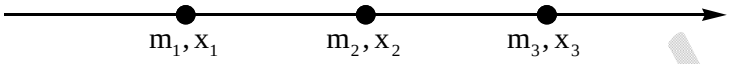
(2) But for making 0.05 M solution, he should add 1770 ml of water to the concentrated H_2SO_4.

(3) He should label the solution as 0.05 M only but not 1 litre 0.05 M.

(4) If H_2SO_4 liquid is left for some time it absorbs moisture.

(5) He should not add water to the concentrated acid.

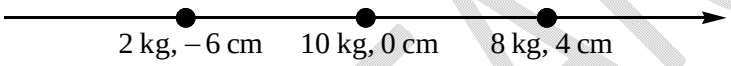
32. The concept of centre of masses plays an important role in analyzing the dynamics of collection of particles and extended objects. The position of centre of mass (CM) represents the point where entire mass can be assumed to be concentrated. In a simple case as shows the position of centre of mass (X_{CM}) can be expressed as (ms and xs are the masses and positions of the respective particles). All positions are measured with respect to same reference point along the same line.



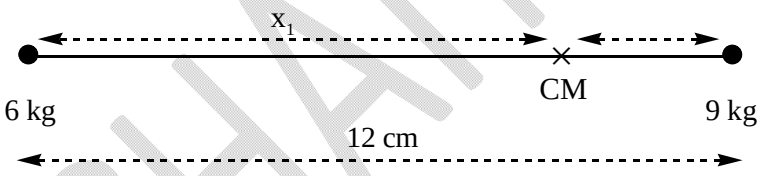
$$X_{CM} = \frac{m_1x_1 + m_2x_2 + m_3x_3 + \cdots}{m_1 + m_2 + m_3 + \cdots}$$

Based on the above information answer the following questions: **(5 marks)**

(a) The centre of mass of the system of three particle given in the figure is given by.



(b) Two particles of mass 6 kg and 9 kg are separated by 12 cm. If the centre of mass is at the origin then find x_1 and x_2.



(c) The 6 kg mass is displaced by 3 cm towards right. By what distance the 9 kg mass be moved in order that the position of CM of the system does not change.

Solution:

(a) $m_1 = 2\text{ kg}, x_1 = -6\text{ cm}$

$m_2 = 10\text{ kg}, x_2 = 0$

$m_3 = 8\text{ kg}, x_3 = 4\text{ cm}$

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

$$= \frac{2(-6) + 10(0) + 8(4)}{2 + 10 + 8}$$

$$= \frac{-12 + 32}{20}$$

$= 1\text{ cm}$ from origin towards right.

(b) Let $m_1 = 6\,kg$

$m_2 = 9\,kg$

Distance of com from 6 kg mass is $x_{cm} = \frac{m_2 d}{m_1 + m_2}$

$= \frac{9 \times 12}{15}$

$= \frac{36}{5}\,cm$

$\therefore x_1 = \frac{-36}{5} = -7.2\,cm$

$x_2 = 12 - 7.2 = 4.8\,cm$

(c) $m_1(\Delta x_1) = m_2(\Delta x_2)$

$6(3) = 9(\Delta x_2)$

$\Delta x_2 = 2\,cm$

33. A ball is thrown up with a velocity 'u' from a tall building of height 'h'. The position of the ball from the ground level is measured with respect to time. The data is provided in the table below:

Time (s)	Position (m)
1	114
3	106
5	50

From the given data find the initial value of 'u', height of building 'h' and acceleration due to gravity 'g'.

Solution:

$S = 114 - h$

$a = -g$

$t = 1\,s$

$u = u$

$114 - h = u - \frac{1}{2}g$

$114 - h = u - \frac{g}{2} \rightarrow (1)$

$S = 106 - h$

$a = -g$

$u = u$

$t = 3$

$106 - h = 3u - \frac{1}{2}g \times 9$

$106 - h = 3u - \frac{9}{2}g \rightarrow (2)$

$S = h - 50$

$a = g$

$u = -u$

$t = 5\,s$

$$h - 50 = -5u + \frac{1}{2}g \times 25$$

$$h - 50 = -5u + \frac{25}{2}g \rightarrow (3)$$

$$(3) \Rightarrow h - 50 = -5u + \frac{25}{2}g$$

$$(1) \Rightarrow 114 - h = u - \frac{9}{2}$$

$$64 = -4u + \frac{24}{2}g$$

$$64 = -4u + 12\,g$$

$$16 = -u + 3g \rightarrow (4)$$

$$106 - h = 3u - \frac{9}{2}g$$

$$h - 50 = -5u + \frac{25}{2}g$$

$$56 = -2u + \frac{16}{2}g$$

$$28 = -u + 4g \rightarrow (5)$$

$$(4) \Rightarrow 16 = -u + 3\,g$$

$$(5) \Rightarrow 28 = -u + 4\,g$$

$$-12 = -g$$

$$\boxed{g = 12}$$

$$(5) \Rightarrow 28 = -u + 4 \times 12$$

$$28 = -u + 48$$

$$u = 48 - 28$$

$$\boxed{u = 20}$$

$$(1) \Rightarrow 114 - h = u - \frac{g}{2}$$

$$114 - h = 20 - \frac{12}{2}$$

$$114 - h = 20 - 6$$

$$114 - h = 14$$

$$h = 114 - 14$$

$$\boxed{h = 100}$$

34. The knowledge of universal law of gravitation and the circular motion helps you to obtain the relation between the period and the radius of the circular orbit. Orbits of solar planets are nearly circular. The following table provides the mean radii of solar planets and the corresponding period. Plot an appropriate graph and hence calculate mass of the Sun. Showcase your skills of approximation techniques and short listing the data. **(10 marks)**

Given: Universal gravitational constant $G = 6.67 \times 10^{-11}\ Nm^2\ kg^{-2}$

	Planet	Mean Radius in AU	Time Period in Earth Years
1	Mercury	0.39	0.24
2	Venus	0.72	0.62
3	Earth	1.00	1.00
4	Mars	1.52	1.88
5	Jupiter	5.20	11.90
6	Saturn	9.58	29.5
7	Uranus	19.22	84.00
8	Neptune	30.05	164.80

Solution:

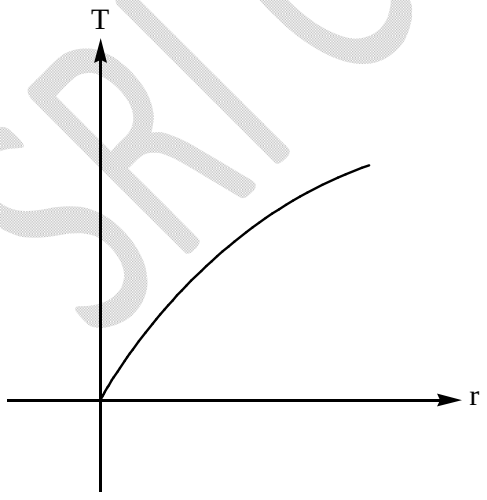
$F = CPF$

$$\frac{GMm}{r^2} = mr\omega^2$$

$$\frac{GM}{r^3} = \frac{4\pi^2}{T^2}$$

$$\Rightarrow T^2 = \frac{4\pi^2}{GM} \times r^3$$

$$T^2 \alpha r^3$$



Mass of Sun $M = \frac{4\pi^2 r^3}{GT^2}$

From given table 'r' for earth $= 1\,AU$

$$= 150 \times 10^6\ m$$

$T = 1$ year

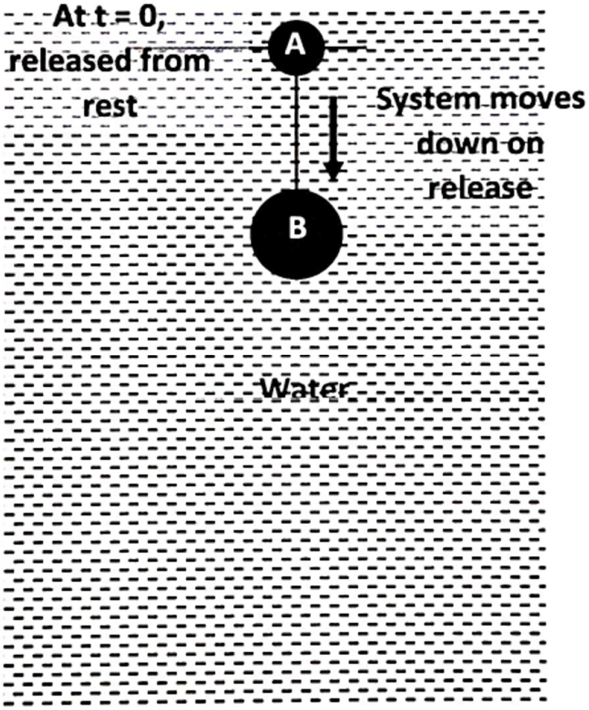
$= 365 \times 86400$ s

$$\therefore M = \frac{4 \times 10 \left(150 \times 10^{6}\right)^{3}}{6.67 \times 10^{-11} \times 365 \times 86400} \text{ kg}$$

$= 2 \times 10^{19} \times 10^{11}$

$M \simeq 2 \times 10^{30}$ kg

35. It is known that when a small spherical ball of radius 'r' moves inside water, water exerts a resistive force F_r on the ball opposite to direction of motion, expressed as $F_r = \left(6\pi \times 10^{-3}\right) rv$ in SI units. Where 'v' is the speed of the ball. Two small solid balls A and B of radius 'r' and 2r respectively, made up of same material, are tied at two ends of a massless thread and the system (Ball B hanging from ball A via thread) is just immersed in a pond filled with water as shown in the adjacent figure. At instant t = 0, the system is released from rest and allowed to fall vertically inside water. At $t = t_1$s , the system attains a constant velocity. Compute



(a) Mass of ball A and ball B

(b) Tension in the thread at t = 0 s

(c) Acceleration of the system at t = 0 s

(d) Tension in the thread at $t >> t_1$ s

(e) Velocity of the system at $t >> t_1$ s

(Given: Density of material of balls = 2.5 g cc^{-1}, Density of water = 1 g cc^{-1}, Radius of Ball A = 1 mm, g = 9.8 m s^{-2}) **(10 marks)**

Solution:

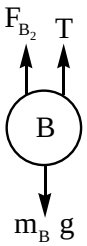
(a) $mA = \left(\frac{4}{3}\pi r^3\right)\rho = \frac{4}{3}\times\frac{22}{7}\times\left(10^{-3}\right)^3\times 2500$

$= 10476.2\times10^{-9}$ kg

$m_B = 8\, m_A$

$= 83,809.5\times10^{-9}$ kg

(b) & (c)



$F_B = \frac{4}{3}\pi(2r)^3\rho\, g$

$= \frac{4}{3}\times\frac{22}{7}\times8\times10^{-9}\times10^3\times9.8$

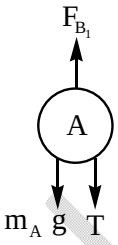
$= 328.53\times10^{-6}$ N

$m_B g = 821.33\times10^{-6}$ N

$F_B = 41.06\times10^{-6}$ N

$m_A g = 102.66\times10^{-6}$ N

For A:



$m_A g + T - F_{B_1} = m_A a$

$m_B g - T - F_{B_2} = m_B a$

$\left(923.99\times10^{-6}\right) - 369.59\times10^{-6} = 94.2857\times10^{-6}\times a$

$a = \frac{554.4}{94.2857} = 5.88\ m/s^2$

and $T = 0$

(d) $T = 0$, because both move with constant velocity

(e) $F_{B_1} + F_{B_2} + F_{v_1} + F_{V_2} = (m_A + m_B)\, g$

$\left(369.59\times10^{-6}\right) + \left(56.57\times10^{-6}\times v\right) = \left(923.99\times10^{-6}\right)$

$56.57\ v = 554.4$

$v = \frac{554.4}{56.57} = 9.8\ m/s$.

* * *