MOVEMENT OF MATERIALS ACROSS THE CELL MEMBRANE:

The plasma membrane functions to isolate the inside of the cell known as protoplasm which includes cytoplasm and nucleus from its extracellular environment. However, such an isolation may not be very complete as very many substances must constantly move btn the protoplasm and extracellular environment across the cell membrane.

For example oxygen must move inside the cell for respiration and Carbondioxide with other waste materials must move out of the cell across the cell membrane. Therefore, the plasma membrane functions as a selectively permeable membrane and allows transport of materials across it.

Transport across the cell membrane takes place by the following fundamental processes;

i) Passive transport: Which is driven by the kinetic energy of the molecules being transported.

ii) Active transport: Which depends upon the expenditure of cellular energy inform of ATP.

Transport/Movement Processes across the Cell membrane:

There are 4 major processes by which materials move in and out of the cells and this include; - Diffusion

- Osmosis
- Active transport
- Cytosis

DIFFUSION:

This is the movement of molecules from a region of high concentration to a region of low concentration until the molecules are spread out evenly or until equilibrium is reached.

Diffusion occurs whenever there is a difference in concentration between the two points or on either sides of the semi-permeable membrane. This is called a concentration gradient or a diffusion gradient.

Diffusion occurs until the particles are evenly /uniformly distributed and there is no more difference in concentration between the two points across the semi-permeable membrane.

Diffusion is a physical process that doesnot need expenditure of energy thus it is a passive process.

Types of diffusion:

Diffusion is sub-divided into two;

(i) Simple diffusion.

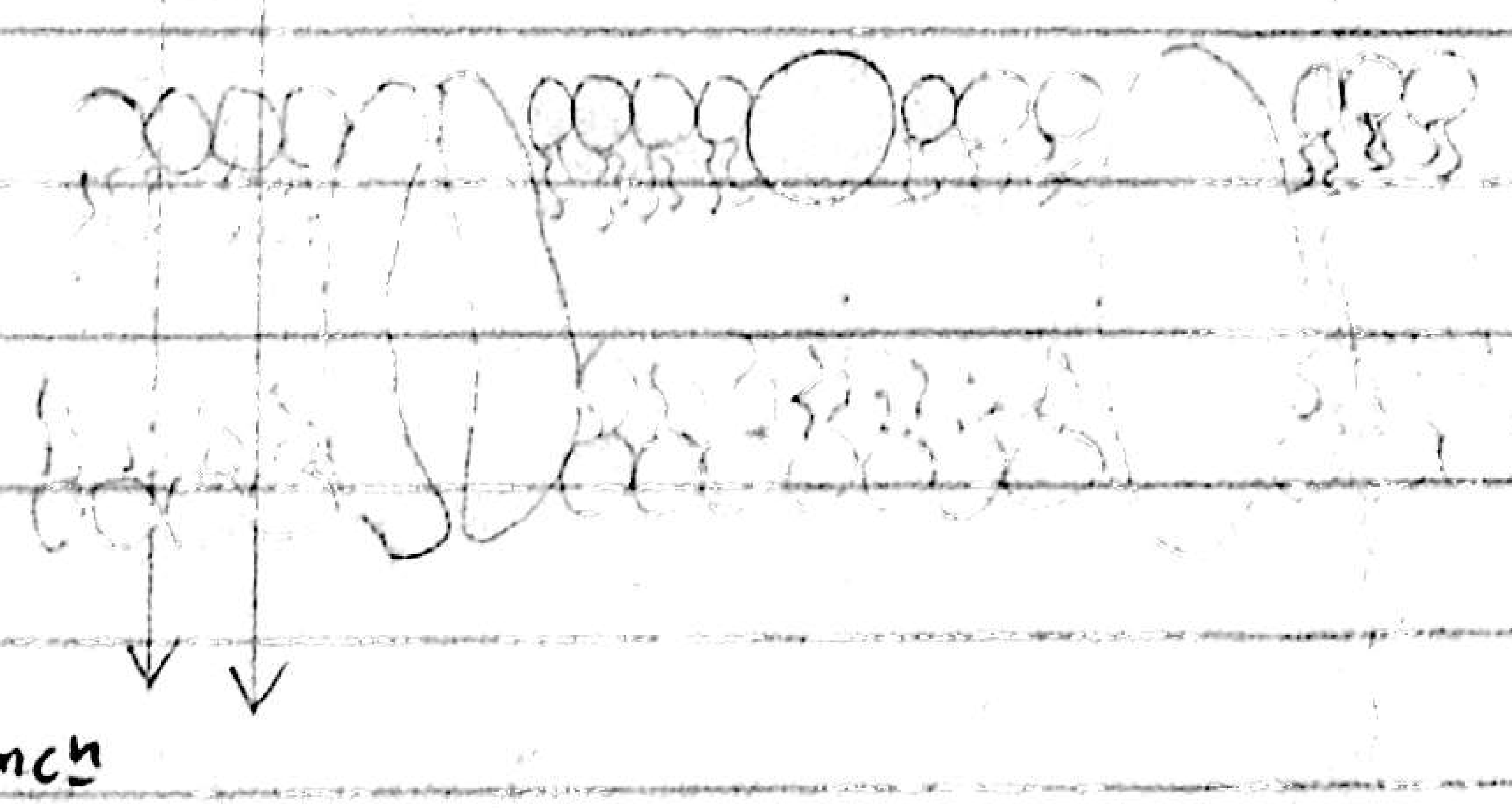
(ii) Facilitated diffusion

SIMPLE DIFFUSION:

This involves movement of very small and **non-polar** substances like oxygen, Carbondioxide and lipid-like substances that can pass through the phospholipid bi-layer with ease. (fat-soluble). These non-polar substances can dissolve through and move in-between the phospholipid molecules that form the bi-layer of the membrane and cross it with ease without the aid of membrane proteins.

Much as water molecules are extremely very small compared to CO_2 and O_2, they are polar molecules and donot move across the cell membrane by simple diffusion. Thus the lipid bi-layer partly accounts for the membrane's selective permeability by preventing polar molecules to move across it

Illustration of how simple diffusion occurs:



Molecules dissolve & moves in btn the phospholipid molecules down concn gradient to the other side of cellmembrane.

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FACILITATED DIFFUSION:

This is transport of molecules across the cell membrane by specific transport proteins (carrier & channel proteins) in a direction of lower concentration of the molecules.

It is faster than simple diffusion and it involves transport of polar substances that cannot be transported by simple diffusion.

The transport protein molecules involved in facilitated diffusion include;

i) Channel proteins.

ii) Carrier proteins.

CHANNEL PROTEINS:

These have pores which are hydrophilic and through these pores, a polar or charged substance passes through it without coming into contact with the lipid bi-layer and move across the cell membrane down a concentration gradient.

Each channel protein in the plasma membrane is specific ie it only lets one type of molecule through. There are two types of channel proteins ie channel proteins that are permanently open and others that are gated.

Gated channel proteins can open and close like gates.

Permanently open channel proteins transport substances like water & other large polar substances like glucose and amino-acids.

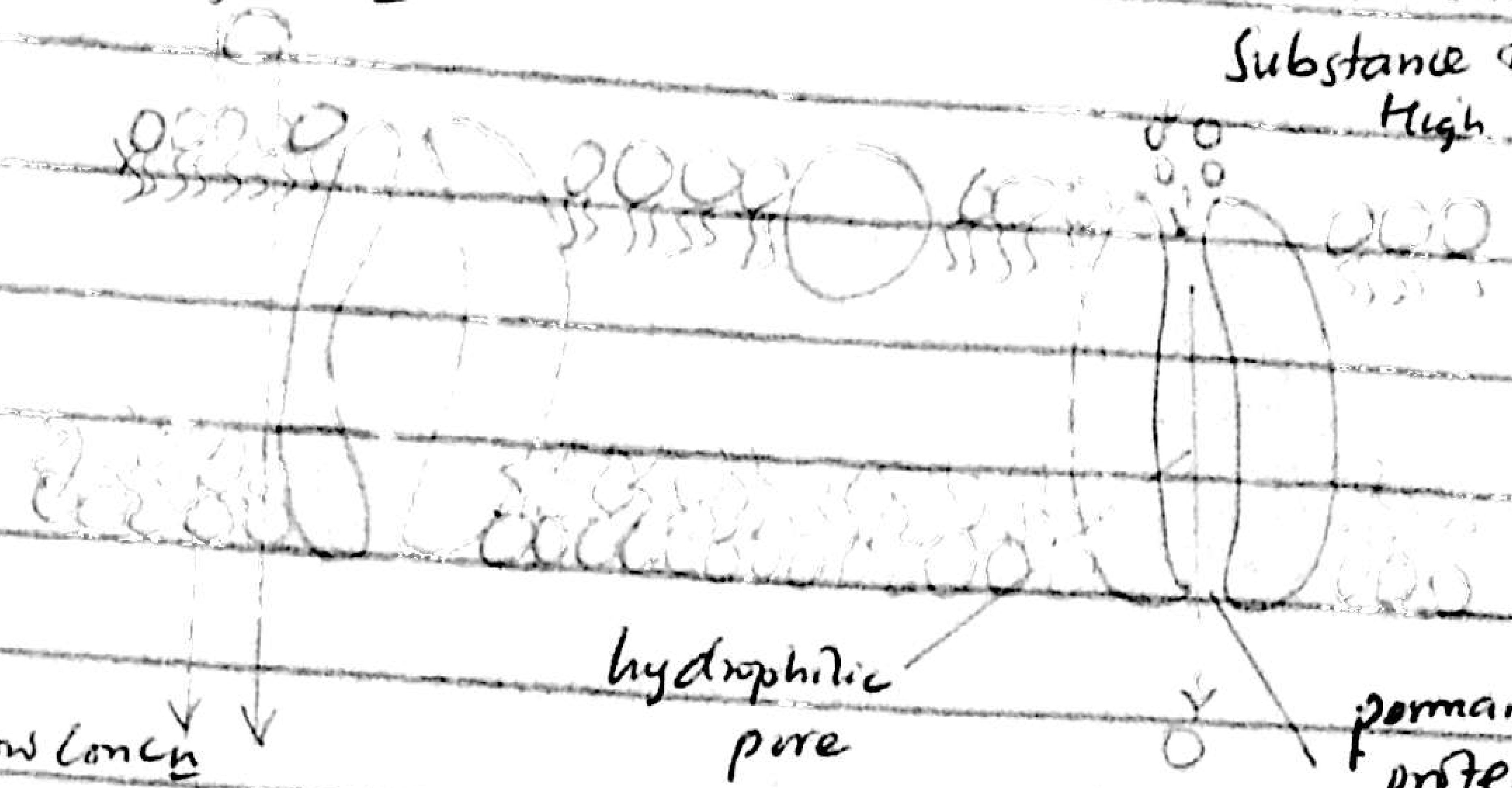
Gated channel proteins mainly transport ions like K^+, Na^+, Ca^{2+} etc. Gated channel proteins open only when they receive an appropriate signal such that ions or any other polar substance is transported across the cell membrane.

Gated channel proteins are important in the conduction of nerve impulses and are usually stimulated to open by electrical or chemical signals. A chemical signal like that of acetylcholine

Channel proteins that transport water molecules are called Aquaporins and these are permanently open.

* Facilitated diffusion of relatively large molecules such as glucose appears to be very specific and may involve a protein, Permease.

ILLUSTRATION OF FACILITATED DIFFUSION BY CHANNEL PROTEINS:

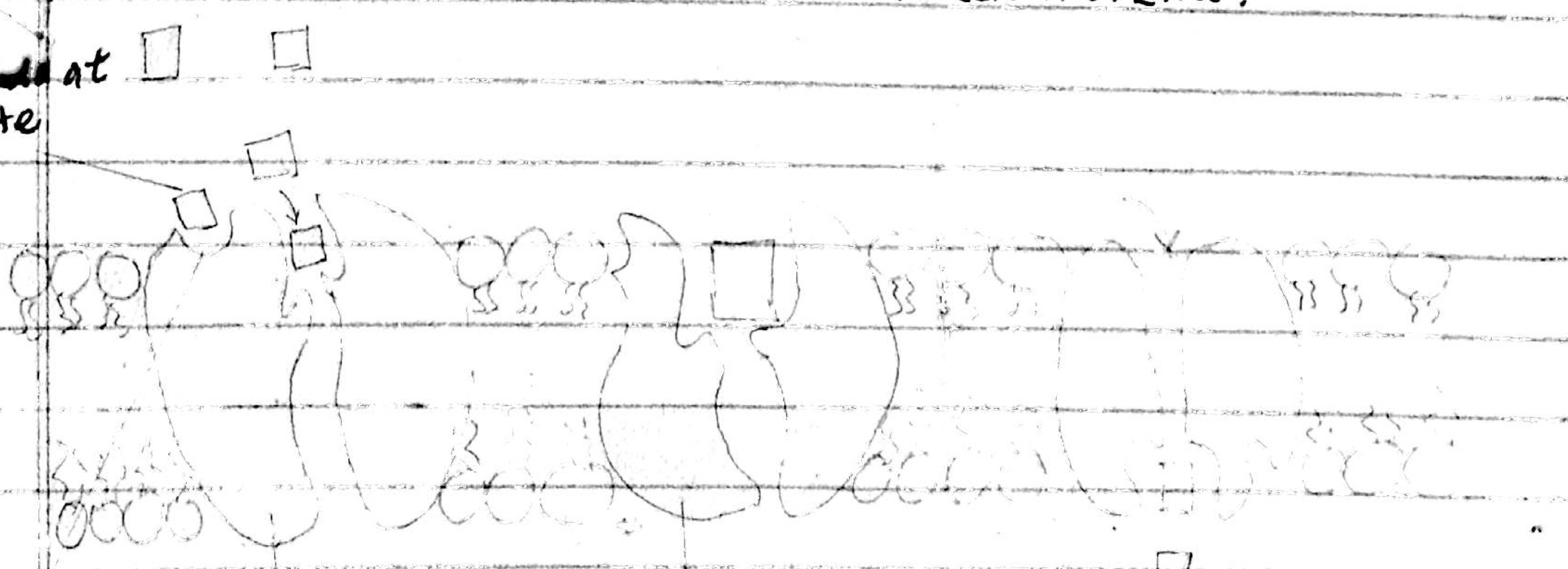


Carrier Proteins:

Carrier proteins ~~call onto~~ hold onto their transport molecules & change shape in a way that allows transport of molecules across the membrane.

Carrier proteins have receptor sites which bind the molecule to be transported. Binding of the molecule at the receptor site causes the carrier protein to undergo change in shape during which it releases the molecule on the other side of the membrane. The process is reversible and passive. Carrier proteins meanwhile usually transport large & polar molecules like amino acids & glucose unlike channel proteins that usually transport small & polar substances like water & ions.

ILLUSTRATION OF TRANSPORT BY CARRIER PROTEINS:



NB: Since facilitated diffusion requires proteins, the proteins may be affected by inhibitors just like enzymes. If it is competitive inhibition, the rate of diffusion lowers but if it's non-competitive inhibition, the rate of diffusion stops.

Features of facilitated diffusion:

i) It is specific whereby each carrier or channel protein transports only certain specific molecules or ions.

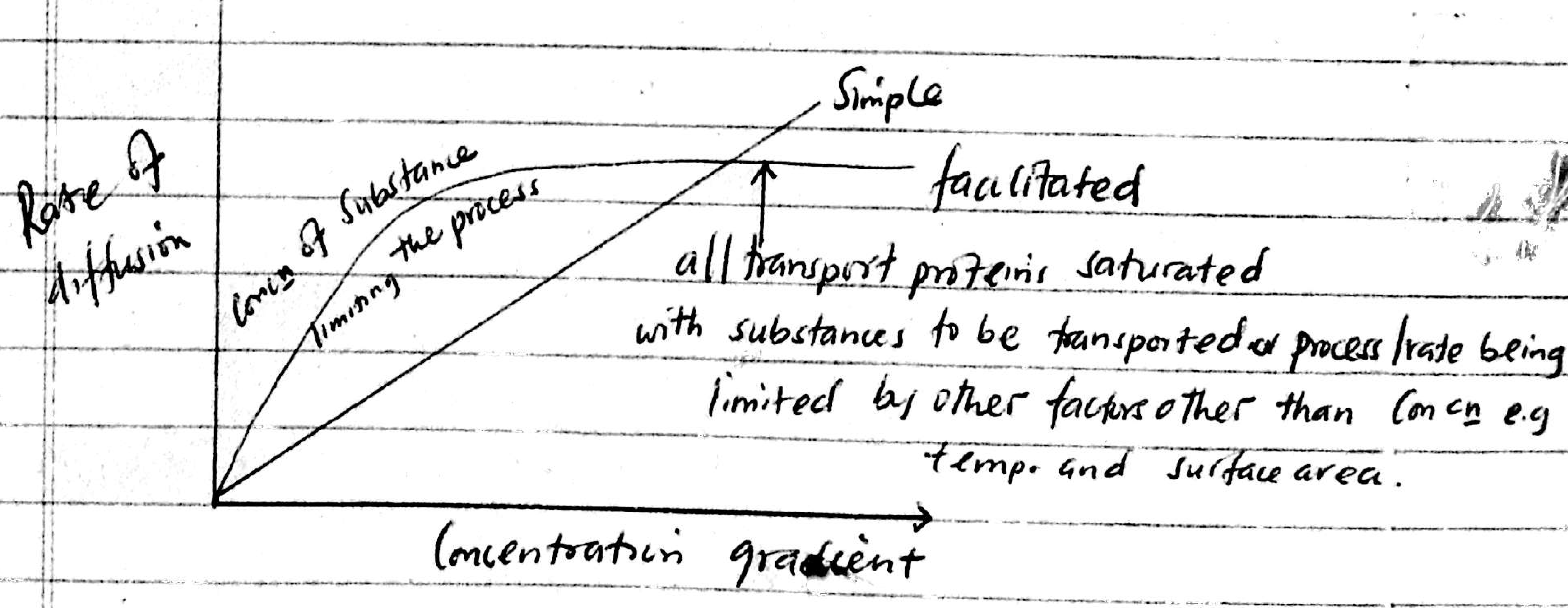
(ii) It is passive and direction of net movement of molecules is determined by relative concentration of substances to be transported inside or outside the cell

iii) It saturates ie if all the relevant channel or carrier proteins are in use, increase in the concentration gradient doesn't increase the rate of diffusion.

Factors that affect the rate of diffusion:

1. The relative concentration of of solute or substance on either side of the membrane; The greater the difference in concentration of the molecules to be transported btn the two points of the membrane the greater the diffusion OR concentration gradient and therefore the faster the rate of diffusion. The rate of diffusion will increase as the concentration of the transport molecules is increased but for facilitated diffusion, it levels off to become constant when all the transport proteins are saturated with molecules to be transported.

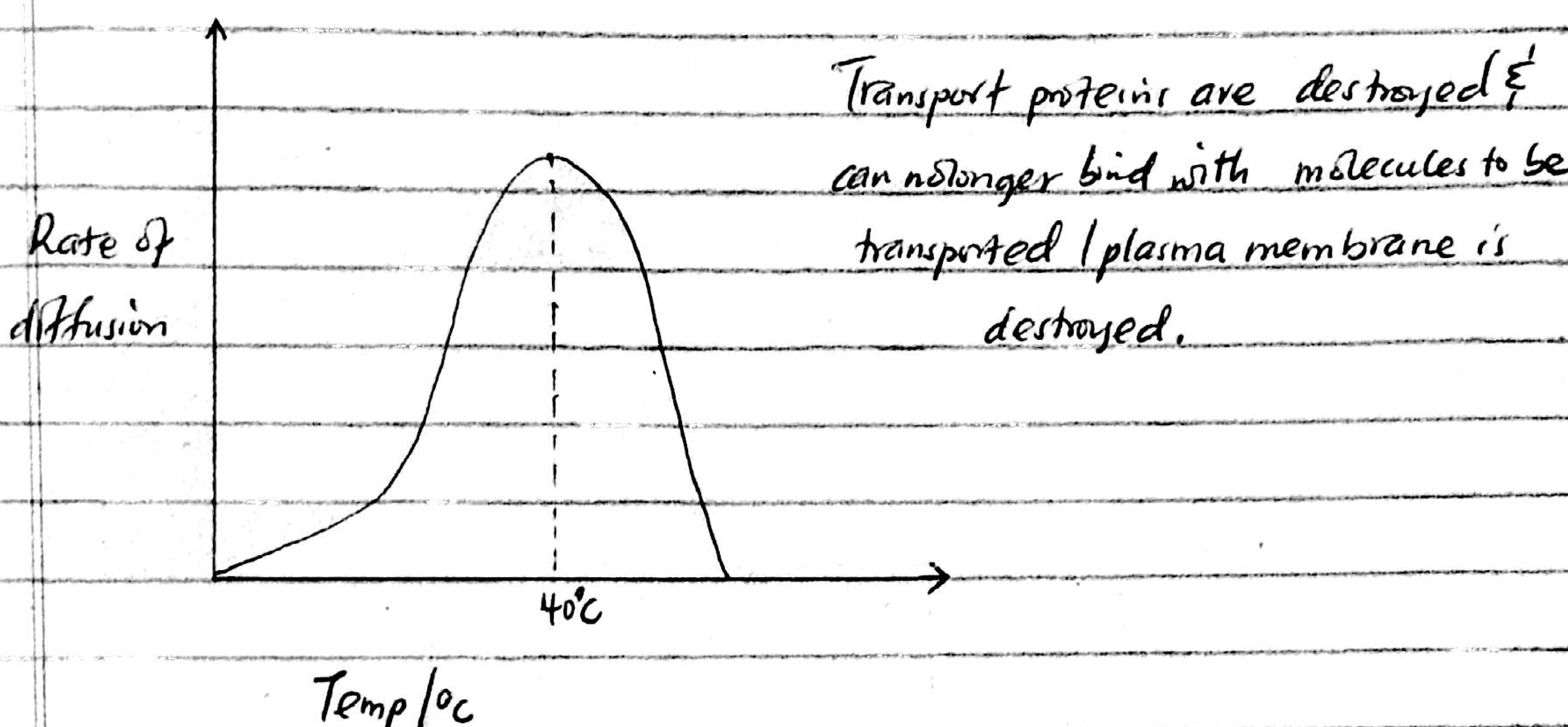
GRAPHIC ILLUSTRATION OF EFFECT OF CONCENTRATION ON RATE OF DIFFUSION:



GAETEC

2. Temperature: A rise in temperature increases the rate of diffusion because all the particles to be transported will have greater kinetic energy which in effect increases the speed of particle movement & at very low temperatures, Kinetic energy is low and speed of particles is very slow hence a low rate of diffusion.

Graphic Illustration of effect of temperature on the rate of diffusion:



3. The distance between the two regions along which the molecules are to travel: The longer the distance, the lower the rate of diffusion and the shorter the distance the higher the rate of diffusion.
Diffusion is fastest through thin membranes because there is a short diffusion distance.
4. The Size of the diffusing particles: Smaller particles diffuse faster than larger particles,
5. The Surface area over which molecules to be transported are exposed to: The larger the surface area, the faster the rate of diffusion.

In Biological membranes, diffusion is fastest if the following are maintained;

i) A steep concentration or diffusion gradient.
ii) A large surface area.
iii) Short diffusion distance.

How organisms maintain a steep concentration gradient at surfaces where diffusion occurs:

i) Transporting away the materials on the other side of the membrane e.g in lungs, absorbed oxygen is transported away so that a steep diffusion gradient is maintained

2) Converting the diffused substance into a new product e.g converting absorbed oxygen into oxy-haemoglobin in the lungs and converting glucose into glycogen.

3) Continuous supply of materials on the membrane with a high concentration of transport materials e.g In lungs, by ventilation & in small intestines by Intestinal wall getting into contact with the food

P.7

How organisms maintain a large surface area over which diffusion takes place:

1. Membranes become folded e.g in the Ileum, the inner lining is folded and in the lungs there are very many alveolar air sacs.
2. The cells of the membrane may have microvilli and in the intestines, there are villi, all these increase the surface area.

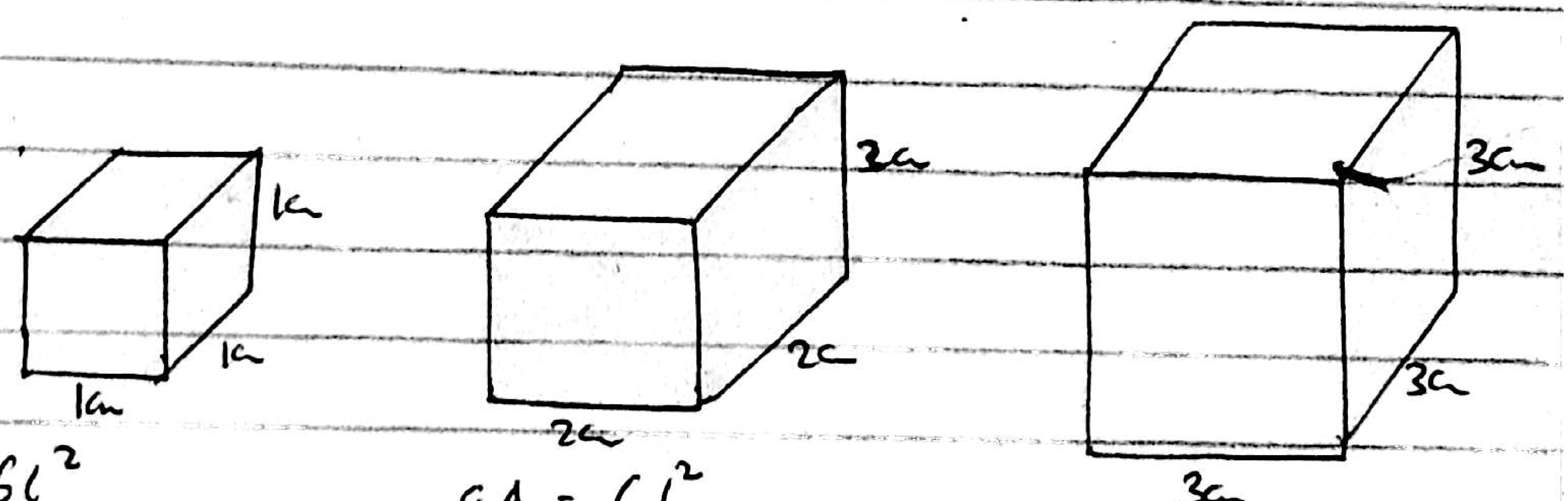
Significance of diffusion:

1. It is a means of gaseous exchange in plants and animals. In plants, It is through the stomata and lenticels and in Vertebrate animals, through gills in fish and lungs in reptiles, amphibians, birds and mammals.
2. Absorption of digested materials like glucose in the Ileum.
3. Excretion of waste products e.g Carbondioxide by the lungs & excretion of ammonia in fresh water fish.
4. Transport of materials within the cell's cytoplasm especially in unicellular organisms like amoeba since they lack transport systems.
5. It is a means of exchange of materials between blood in capillaries and body tissues.
6. Conduction of nerve impulses along neurones is ~~by~~ facilitated by diffusion of Sodium & Potassium ions across the cell membranes

of the neurones and also ~~transports~~ transmission of nerve impulses from one neurone to another across a synapse involves diffusion of the neuro-transmitter substance (acetyCholine)

NB: The phospholipid bi-layer together with the channel and carrier proteins maintain the selective permeability of the molecules across the membrane, This is due to the fact that small and non-polar substances dissolve & move in between the hydrophobic lipid molecules while not allowing any polar substance to move through the hydrophobic bi-layer and the transport proteins only allow transport of specific polar substances.

Surface area to Volume ratio relationship in Organisms:
Consider the following cubes:



$S.A = 6l^2$
$= 6(1)^2$
$= 6cm^2$
$V = l^3$
$= 1cm^3$
$S.A:V.R = 6:1$
$= 6:1$

$S.A = 6l^2$
$= 6 \times (2)^2$
$= 24cm^2$
$V = l^3$
$= 2^3$
$= 8cm^3$
$S.A:V.R = 24:8$
$= 3:1$

$S.A = 6l^2$
$= 6 \times 9$
$= 54cm^2$
$V = l^3$
$= 27cm^3$
$S.A:V.R = 54:27$
$= 2:1$

Implications of this relationship:
As an organism increases in body size, Its surface area to volume ratio decreases and as the body size of an organism decreases, Its surface area to volume ratio increases. In large organisms, the rate of diffusion or body cells will be very slow as the surface area to volume ratio is decreased and this is because the rate of diffusion depends on the surface area. However, other processes like

metabolic rate which depend on volume will be fastest. Therefore, for large organisms to increase the rate of diffusion inside their bodies, they must increase the surface area where diffusion is going to take place e.g by having surface membranes being folded.

This relationship also has implications on rate of heat gain or heat loss from the body of an organism and therefore the need to maintain a constant body temperature e.g small organisms with a large surface area to volume ratio lose quickly body heat while large organisms with small surface area to volume ratio lose body heat very slowly; Therefore the rate of metabolism is fastest in small bodied organisms than large organisms in order to maintain a constant body temperature.

Adaptations of the lungs for faster rate of diffusion:

i) They have very many alveoli to provide a large surface area for fast diffusion.

ii) The bronchi branch into many bronchioles to increase surface area for directing of gases to the different / very many alveoli

iii) The alveolar sacs are surrounded by many blood capillaries which transport to or away the alveoli in order to maintain a steep diffusion gradient between the blood and alveolar air.

iv) The blood vessels contain red blood cells with haemoglobin which combines with the respiratory gases in order to maintain a steep concentration gradient btn blood & alveolar air.

v) The open trachae and bronchi create air passages that constantly ventilate (supply) air to the alveolar surfaces to maintain a steep diffusion gradient

vi) The alveolar epithelial membrane is thin & permeable to reduce on the diffusion distance of the respiratory gases.

vii) The alveolar epithelial membrane and the blood capillaries are in close contact to reduce on the diffusion distance.

Worked examples:

1. Describe the adaptations of the Ileum for faster rate of diffusion of digested food materials.

2. Two molecules

2. 2 molecules that can cross the lipid bi-layer without the help of transport proteins are O_2 and CO_2. What properties allow them to pass the phospholipid bilayer without proteins.

- They are non-polar.

3. Why do water molecules need a transport protein to move rapidly across the plasma membrane

4. How is the selective permeability of materials regulated in the transport by diffusion across the cell membrane.

5. Describe the role of the plasma membrane proteins in bringing about facilitated diffusion.

6a) What is meant by selective permeability of the plasma membrane.

b) Describe how the plasma membrane acts a selective barrier for transport of materials across it.

7. Describe the significance of diffusion in organisms.

8. A rats eats throughout the day while a cow may eat for only a limited few hours of the day. Explain why this two mammals differ in the eating habits.

ACTIVE TRANSPORT

This is the process by which substances move from a region of low concentration to a region of high concentration across a semi-permeable membrane using energy in form of ATP. ie molecules move against a concentration gradient.

Active transport can only take place in a living cell that is producing ATP by respiration. It takes place by means of carrier proteins in the cell membrane and these carrier proteins are specific to the substance to be transported, bringing about selective permeability.

How Active transport occurs:

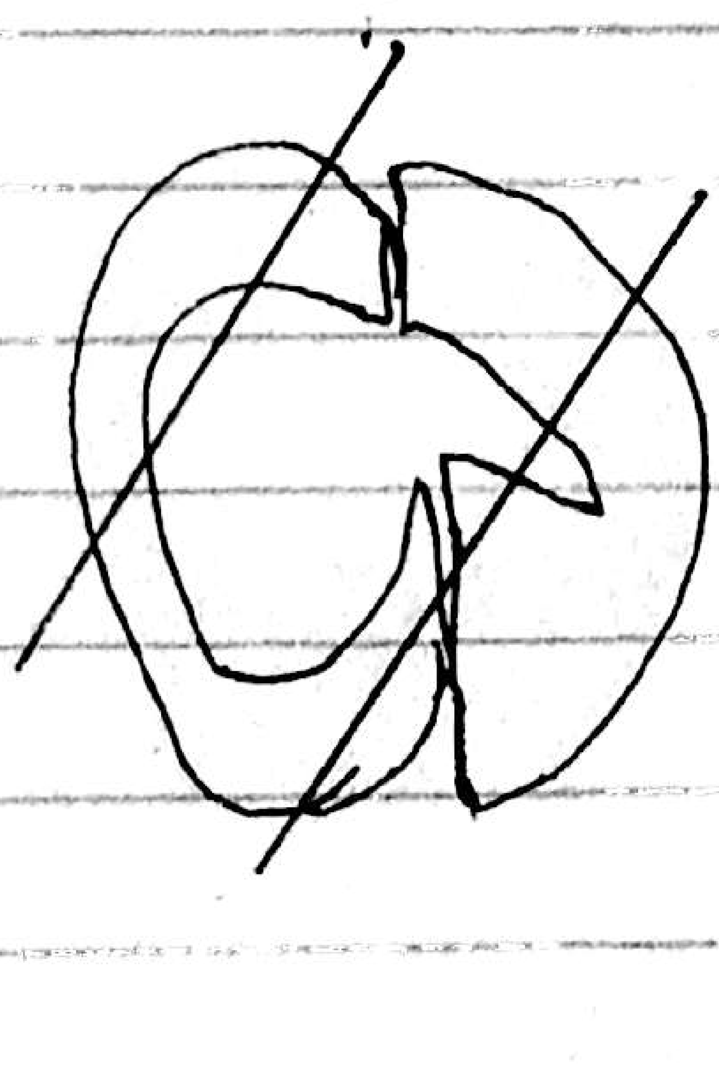
The molecule to be transported combines with a specific carrier protein in the plasma membrane.

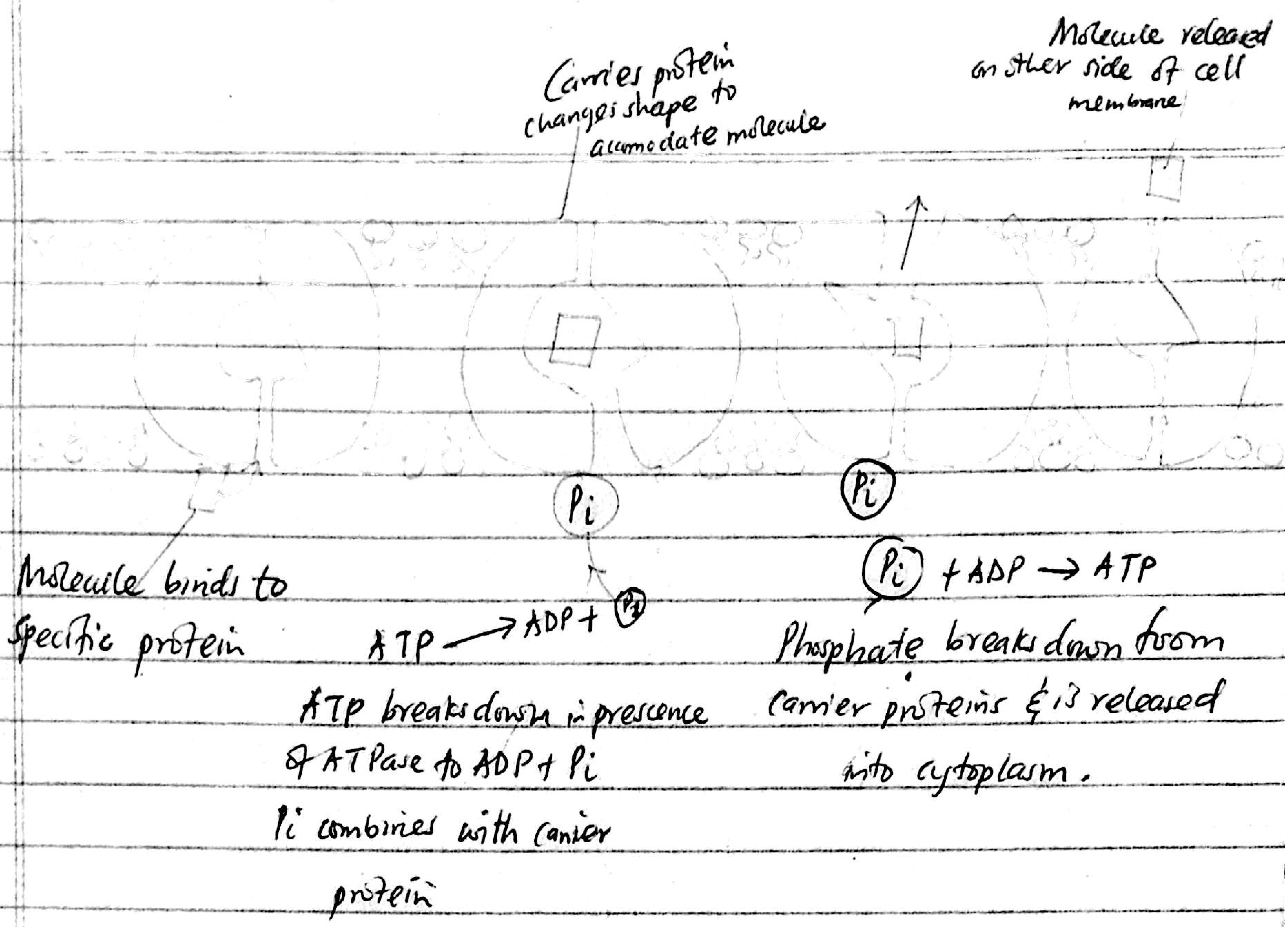
ATP transfers a phosphate molecule to the carrier protein (ATP breaks down to ADP) and inorganic phosphate (Pi) in the prescence of ATPase enzyme & Pi is transferred to the carrier protein

The carrier protein undergoes a change in the shape which can accomodate the molecule and it carries the molecule to the other side of the membrane.

The molecule is released from the other side of the ~~pro~~ membrane and the carrier protein loses a phosphate group and changes to its original shape.

Illustration of Active transport.





The Sodium - Potassium Pump;

Carrier proteins involved in active transport are often called pumps. Some carrier proteins transport two substances in opposite directions across the cell membrane and these are called Antiport carrier proteins. An example of antiport carrier proteins is the Sodium - Potassium pump.

The same carrier protein actively transports/pumps Na^+ out of the cell and K^+ into the cell against a concentration gradient.

However, for every 3 ions of Sodium pumped out, 2 potassium ions are pumped into the cell. This leaves the cytoplasm of the cell to be relatively negative in charge compared to extracellular fluid because of unequal distribution of anions and cations in (charges) creating a voltage across the cell membrane called membrane potential.

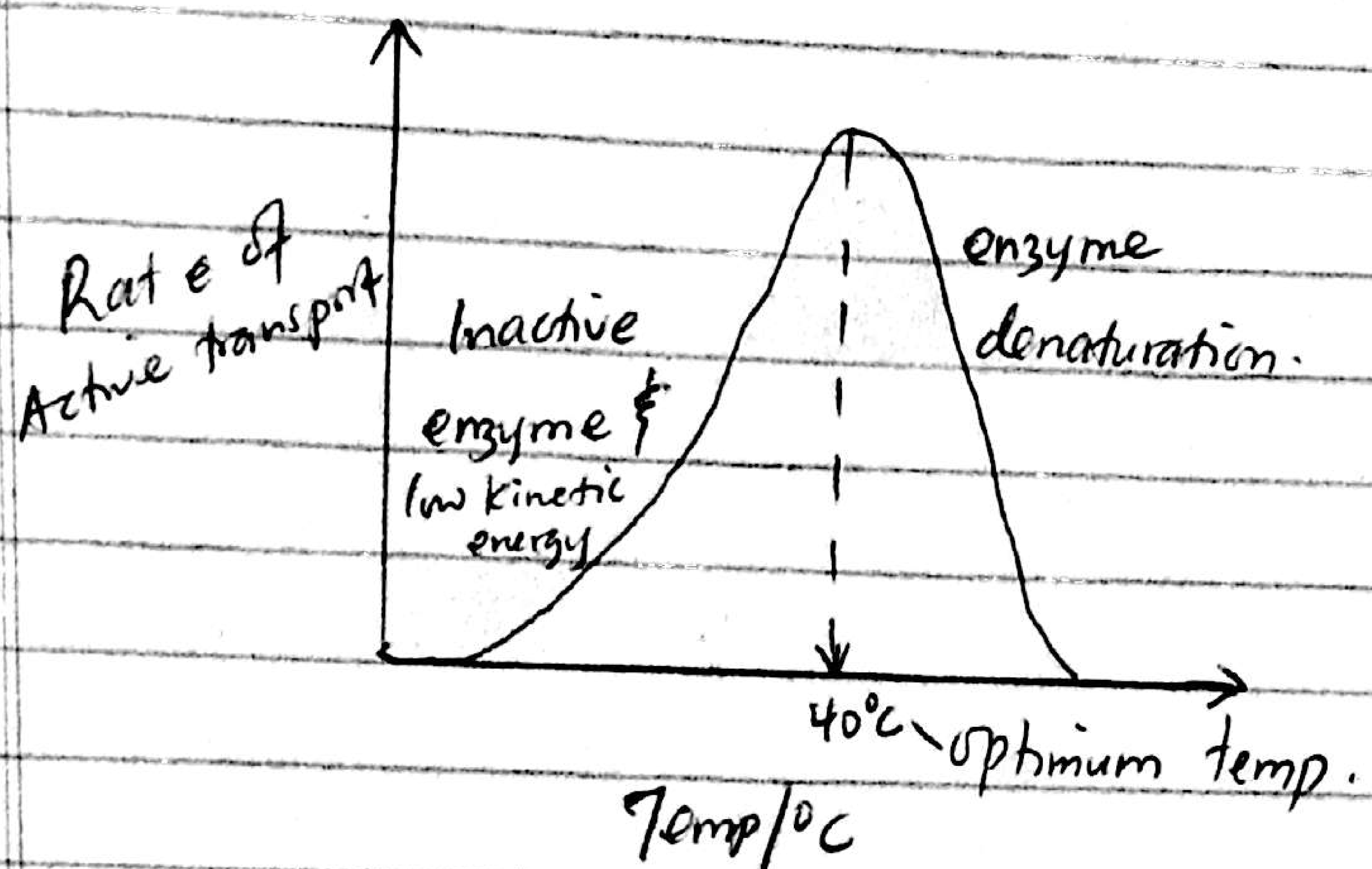
This is important in transmission of nerve impulses when the distribution of Sodium and Potassium ions across the membrane is reversed by facilitated diffusion.

Factors that affect rate of active transport in cells:

1. Temperature:

An increase in temperature will increase the rate of active transport. However, at very high temperatures, enzymes that catalyse the reactions of respiration are denatured and the process of respiration stops resulting in no ATP for active transport and at very low temps, the enzymes are inactive resulting in little or no ATP for active transport. Thereby reducing the rate of active transport.

Illustration of effect of temperature



2. Oxygen Concentration:

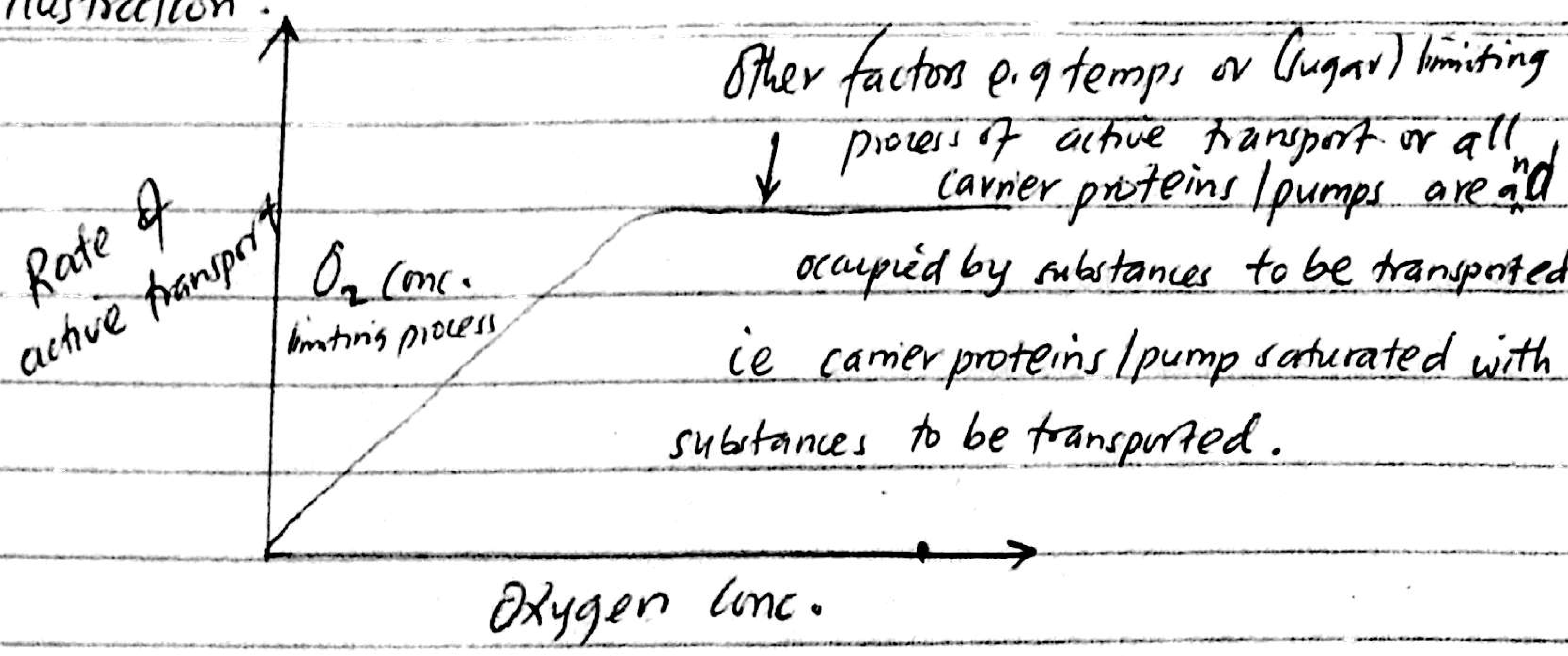
Oxygen is needed for the complete breakdown of food materials to generate ATP during respiration. Increase in oxygen concentration results in increased rate of active transport as more ATP molecules are available for active transport.

Very little or no oxygen concentration reduces or stops the rate of active transport as little or no ATP molecules are available for active transport.

However, the rate of active transport increases up to a certain level and levels off to become constant even when oxygen concentration is further increased.

The levelling off of the rate of active transport will be due to other factors other than oxygen concentration e.g temperature or sugar concentration may become the limiting factors making the rate of active transport level off and become constant.

Illustration:

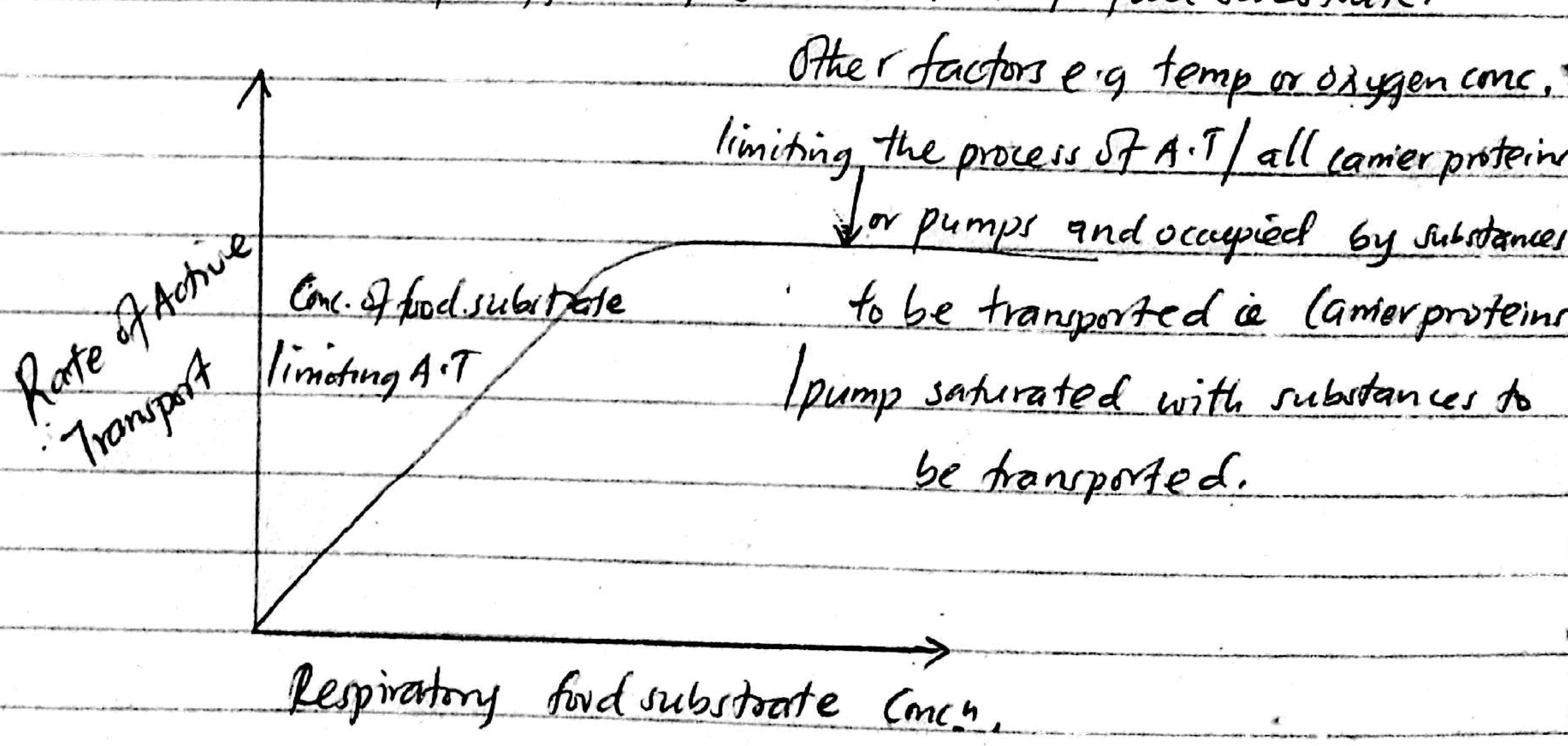


3. Concentration of a respiratory food substrate e.g glucose:

If the concentration of respiratory food substrate is increased, the rate of active transport also increases and if it is lowered, the rate of active transport also lowers. This is because, the food substrate is necessary for ATP generation. However, the rate of active transport will increase until it levels off even when the concentration of food substrate is further increased.

This may be due to other factors e.g temperature, or oxygen concentration limiting the process of active transport and may be also the carrier proteins/pumps in the plasma membrane are all occupied or saturated with substances to be transported.

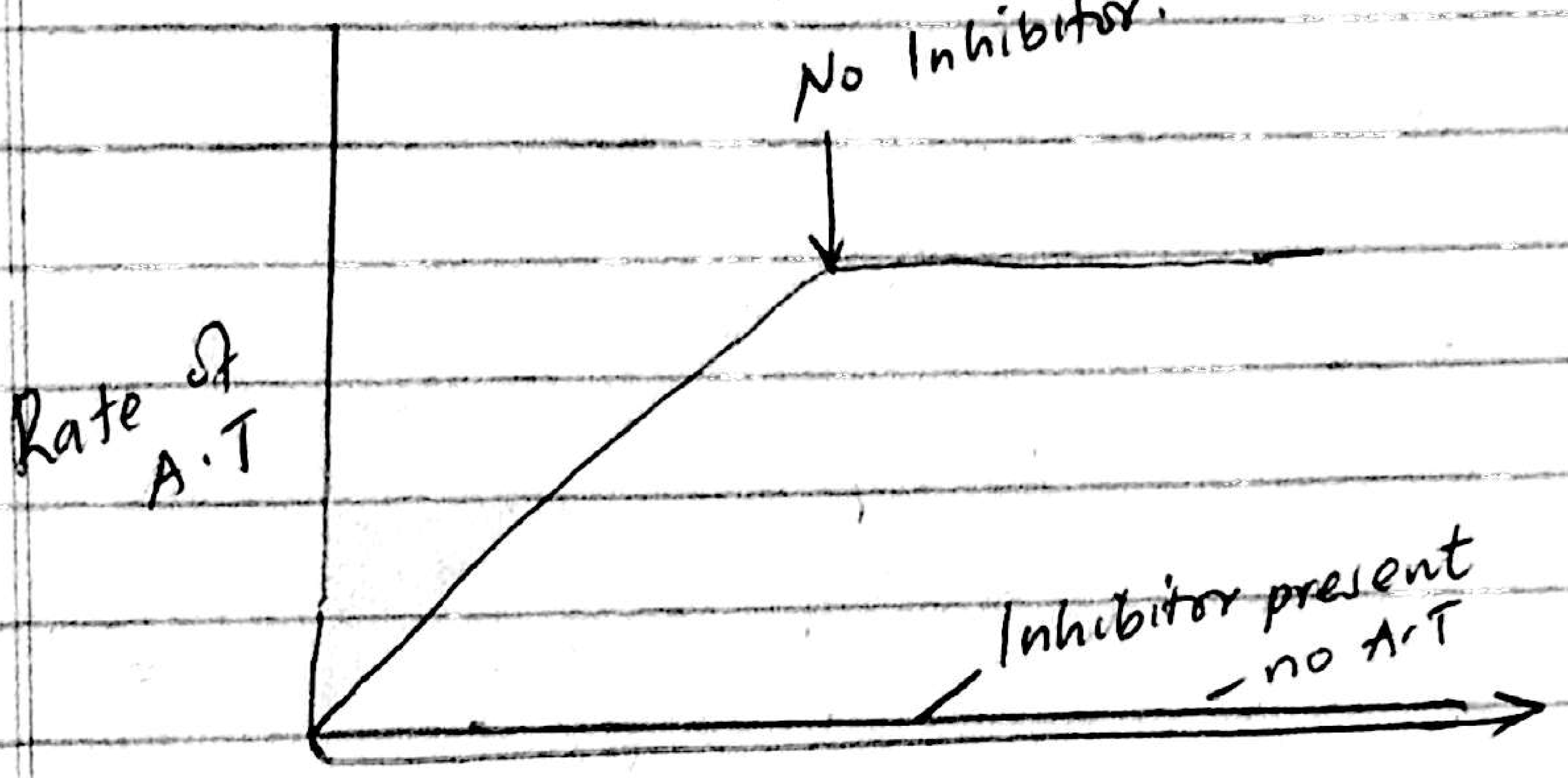
Illustration of effect of concentration of food substrate:



4. Metabolic poison / Inhibitors.

If the metabolic poison is inhibit then enzymes that catalyse the reactions of respiration, they will prevent the generation of ATP which is needed for active transport and thereby active transport stops. However, some inhibitors directly compete for transport with ~~by~~ the molecules to be transported by the carrier proteins and these too reduces active transport.

Illustration of effect of Inhibitors: When increasing the amount of food substrate:



Importance of active transport.

- It creates and maintains a membrane potential across the membrane of nerve cells by active pumping of sodium ions out and potassium ions inside, which when reversed by facilitated diffusion, an impulse (action potential) is generated which is transmitted along nerve cells ie active transport facilitates nerve impulse transmission.
- Active transport results in absorption of mineral salts by plant root hairs & other epidermal cells which form the piliferous layer.
- Active transport is a means of absorption of digested food materials in the mammalian gut.
- It facilitates excretion of waste products from the cells to the extracellular fluids across a concentration gradient e.g excretion of urea by the kidney.
- Active transport facilitates muscular contractions & relaxations by active pumping in & out of Calcium ions in the cytoplasm

of muscle cells.

- Loading & unloading of materials in plant Phloem tissue involves active transport.

REVISION QUESTIONS:

1a) Describe the role of plasma membrane in active transport.

b) Explain the factors that may affect the rate of absorption of mineral ions by plant root hairs

- Temp.
- Inhibitors
- O_2 concn.
- Conc. of metabolic substrates eg glucose

2a) Describe the role of active transport in organisms.

b) How is active transport similar or different from any of the following;

(i) Simple diffusion.

(ii) Facilitated diffusion.

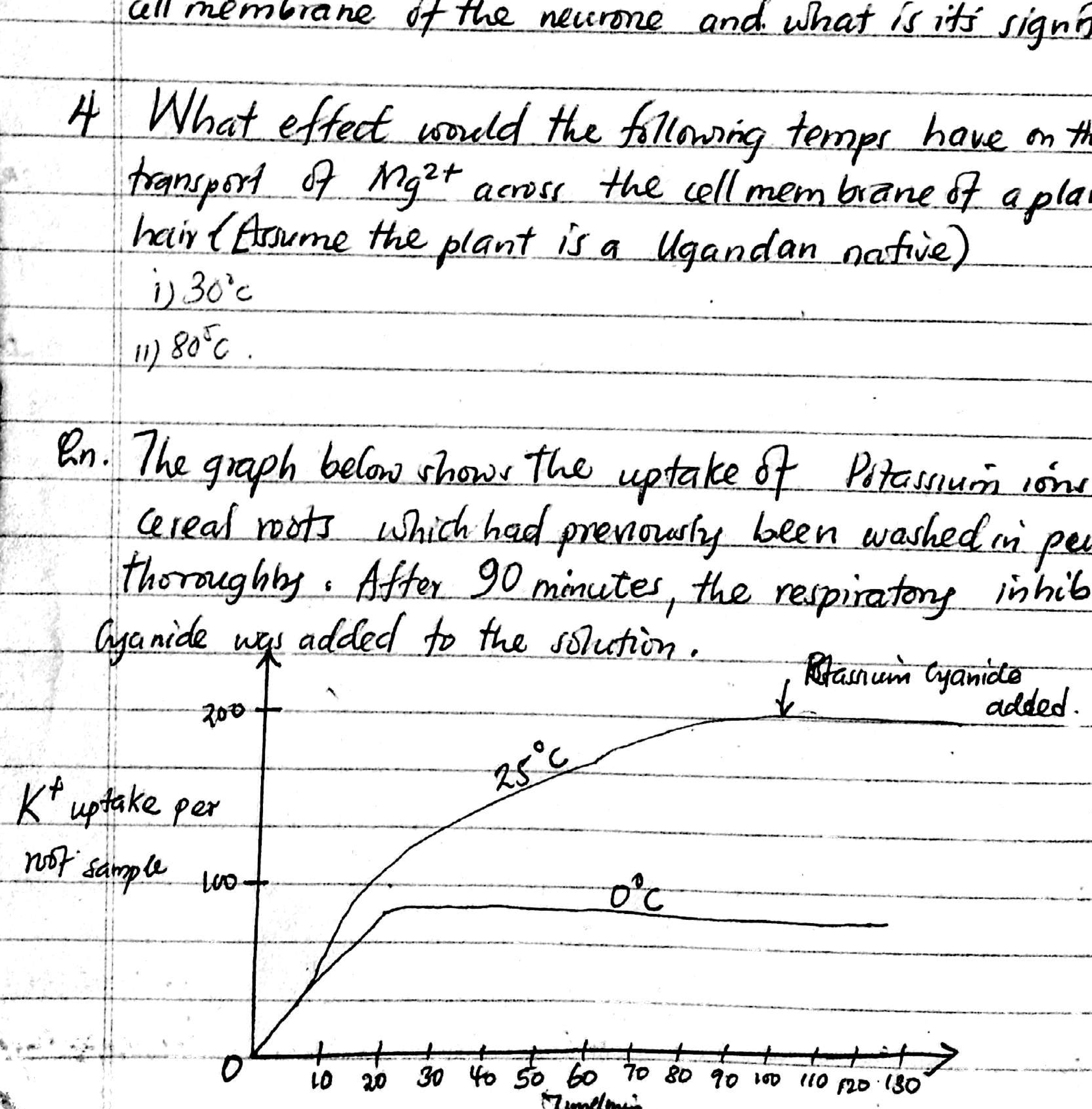
3 Explain how the membrane potential is maintained across the cell membrane of the neurone and what is its significance.

4 What effect would the following temps have on the active transport of Mg^{2+} across the cell membrane of a plant root hair (Assume the plant is a Ugandan native)

i) 30°c

ii) 80°C.

Qn. The graph below shows the uptake of Potassium ions by young cereal roots which had previously been washed in pure water thoroughly. After 90 minutes, the respiratory inhibitor, Potassium Cyanide was added to the solution.



a) Describe the uptake of Potassium ions at 0°c and 25°c & explain
b) Suggest why Potassium Cyanide has the effects it does.
c) Suggest why the roots were thourughly washed before placing them in a solution.

Solns

a) At 0°c.

For the first 20minutes, the rate of Potassium ions uptake is high and eventually levels off or becomes constant

At 25°c.

The rate of Potassium ions uptake increases drastically for the first 20minutes and later increases slowly until 90minutes from where it becomes constant.

b) This is because Potassium Cyanide is an inhibitor and prevents the generation of ATP needed for active transport thus active transport stops hence no more uptake of Potassium ions by the cereal roots.

CORRECTION:

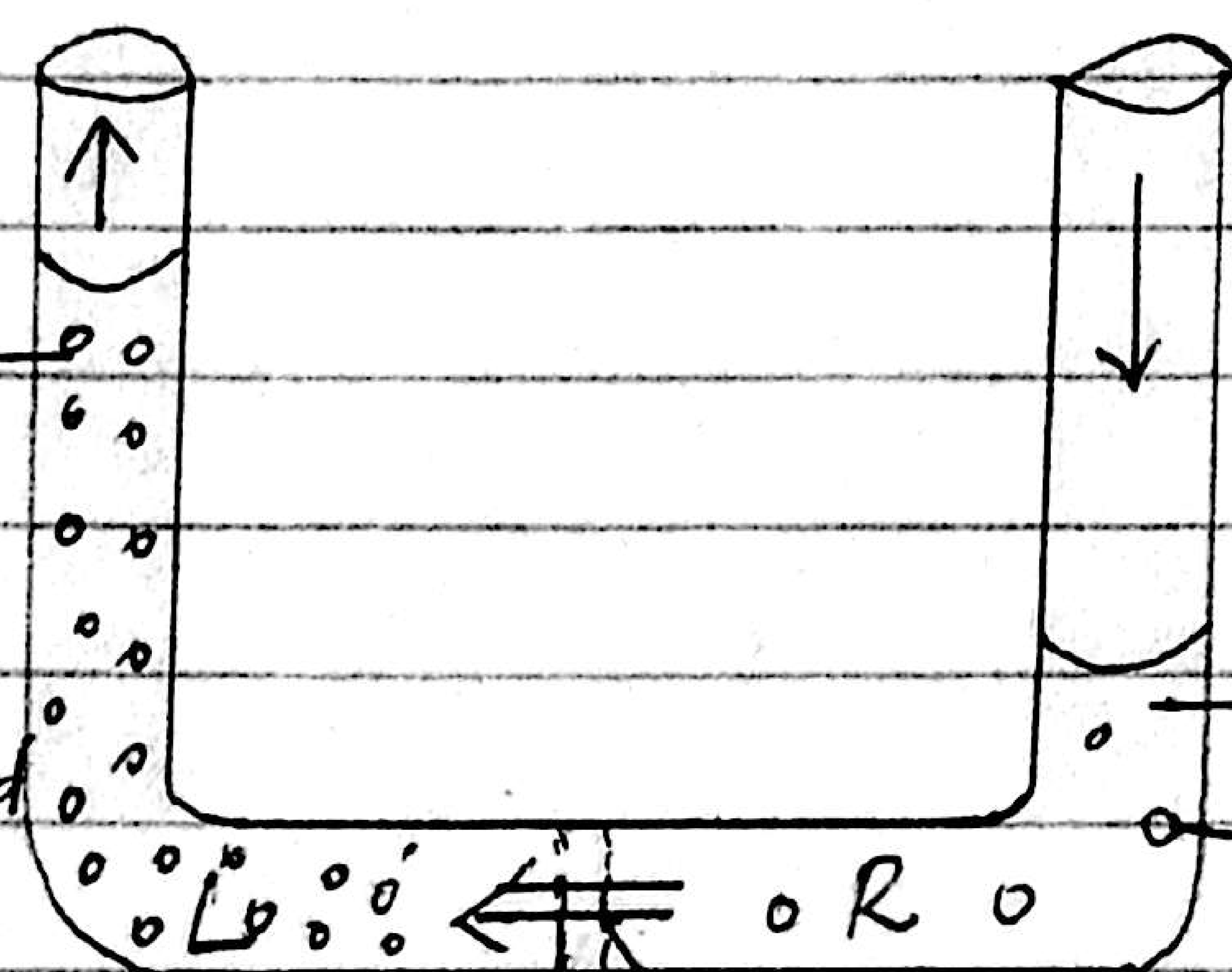
a) Between 0 and 25 minutes, both for 0°c and 25°c, there is a rapid uptake of Potassium ions but the rate of uptake of 25°c is slightly higher. Between 25 and 130minutes, the rate of uptake of Potassium ions for 0°c levels off and becomes constant. Between 25 and 90minutes, the rate of uptake of ions for 25°c is gradual and between 90 and 130minutes, the rate of uptake levels off and becomes constant.

OSMOSIS:

This is the movement of water molecules across a selectively pemeable membrane from a region of low solute concentration to a region of high solute concentration

A selectively pemreable membrane is one that allows an unrestricted passage of water molecules but prevents passage of solute molecules.

Consider the illustration below;



High concn of solute molecules with low concn of free water molecules.

-Water molecules surround solute particles to form hydration shells which make water molecules unfree; therefore maintaining a unidirection flow of water from right to left, Increasing the volume of the contents on the left

Semi-permeable membrane

Low solute concn but with high concn of free water molecules

Solute particle

- Volume of contents on Right reduces due to decrease of water molecules.

Different concentrations of solute molecules lead to different concentrations of free water molecules on either side of a semi-permeable membrane.

The side of the membrane with very many free water molecules will have more water molecules striking the pores in the membrane in a given time interval.

More strikes lead to more water molecules passing through the pores in the membrane. This creates a net flow of free water molecules in one direction as on the side with more solute molecules, water forms hydrogen bonds with the solutes to form hydration shells which make water molecules unfree & unable to flow back across the membrane.

Osmosis & Aquaporins.

In living cells, transport of water across a cell membrane is by facilitated diffusion through channel proteins called Aquaporins, which are specialized channel proteins for water.

Water molecules are small but are polar and therey can not be intact. with the hydrophobic phospholipid bi-layer easily which is non-polar and therey diffusion of water molecules through the phospholipid bi-layer is extremely very slow or not there at all & water molecules can quickly with ease only move through aquaporins in the cell membrane.

Rev. Qn. Explain why water cannot move across the cell membrane by simple diffusion.

THE WATER POTENTIAL:

This is the tendency of water molecules to move from one place to another.

Water potential is denoted by Ψ (Psi - greek).

The higher the water potential, the greater the tendency of the water molecules to leave that system.

Pure water has the highest water potential & If two systems are in contact, Water will move from the system with high water potential to the one with a low water potential

There are two factors which affect water potential ie

(i) Solute concentration.

(ii) Pressure generated when water enters a system/tissue.

Solute Potential:

Is a measure of change in water potential of a system due to the presence of solute molecules.

Dissolving solute molecules in water lowers the concn of free water molecules & hence lowering the water potential. All solutions therey have lower potentials than pure water.

Solute potential is denoted by Ψ_s and it is always a negative value. The more the solute molecules present in a solution, the lower is the ~~value~~ solute potential and therefore the more negative the solute potential value.

Therefore, for a solution, water potential equals to solute potential ie $\Psi = \Psi_s$

Water potential of pure water is zero ie $\Psi = 0$ and if a solute is present, then $\Psi = \Psi_s$

Solute potential (Ψ_s) is always negative because the forces of attraction between the solute molecules and the water molecules reduce the mov't of water molecules.

Pressure Potential:

If Pressure is applied to pure water or a solution, Its water potential increases. This is b'se the pressure tending to force the water from one place to another increases.

When water enters the cell by osmosis, pressure of cytoplasm builds up pushing outwards against the cell membrane. This pressure is called hydro-static pressure.

In plant cells, this pressure builds up pushing the cell membrane against the cell wall; - The cell wall begins to resist the swelling of the cell caused by the influx of water. The pressure that the cell wall develops is called the pressure potential.

Pressure potential is the pressure exerted on the cell contents by the cell wall & Cell membrane.

Pressure potential is denoted by Ψ_p, and it is usually though not always, positive.

At any one time, the water potential, Ψ of a plant cell is the sum of the solute potential & Water potential ie,

Water potential = Solute Potential + Pressure potential.

$$\Psi = \Psi_s + \Psi_p$$

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Osmosis in Plant Cells

Turgidity:

When the external solution is hypotonic, the cell's cytoplasm will have a lower water potential causing an influx of water into the cell.

The water enters into the cell's vacuole causing an internal hydrostatic pressure, developed by the cell wall. This hydrostatic pressure is called the pressure ~~water~~ potential and it opposes the continued uptake of water into the cell by osmosis.

The pressure potential reaches its maximum when the cell wall is stretched to its maximum.

At this point, the plant cell is described as fully turgid or full turgor is reached and the water potential at this point is zero ie $\psi = 0$, no more water can enter the cell.

Turgor pressure plays part in supporting plant organs by maintaining their shape & form.

Herbaceous plants are erect by being filled with fully turgid cells which are tightly packed together and ~~it~~ is also responsible for holding leaves in flat & in horizontal positions

PLASMOLYSIS

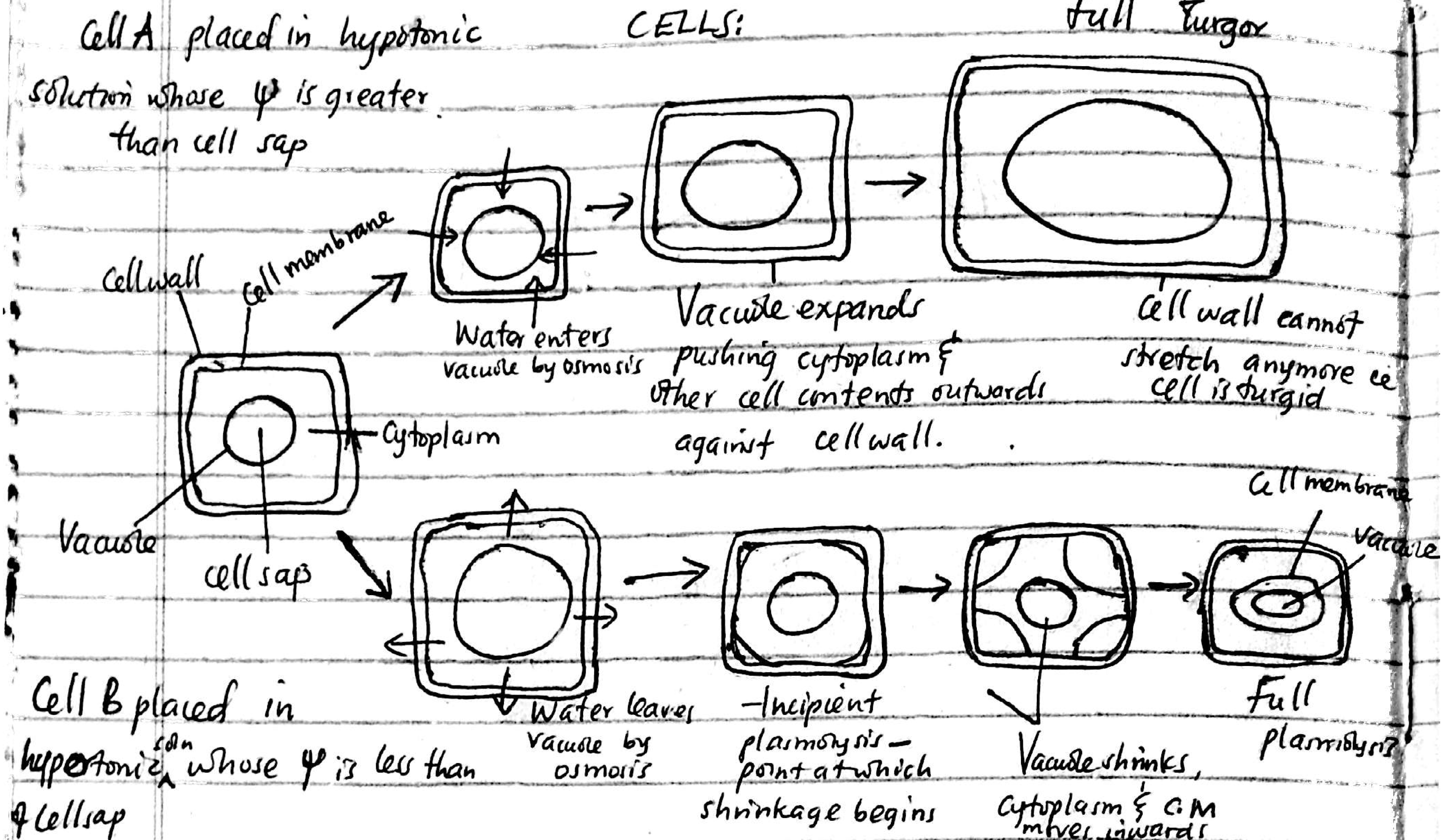
When a plant cell is immersed in a hypertonic solution than its cytoplasm, the cell decreases in volume as water moves out of its vacuole by osmosis.

The protoplasm of the cell shrinks, pulling away from the cell wall & leaving gaps btn the cell wall & the cell membrane.

A cell in this condition is said to be plasmolysed and the cell becomes flaccid.

Plasmolysis is the shrinkage of the plant cells protoplasm away from the cell wall leaving gaps btn the cell wall & plasma membrane.

ILLUSTRATION OF TURGIDITY AND PLASMOLYSIS IN PLANT CELLS:



THE PLANT-WATER RELATIONSHIPS:

Consider a fully plasmolysed cell immersed in pure water, water enters the cell sap by osmosis & the protoplasm begins to expand. As the osmotic influx of water continues, the protoplasm goes on expanding until it comes into contact with the cell wall. When this point is reached, the osmotic influx of water into the cell starts to be opposed by the inward pressure of the cell wall ie pressure potential, ψ_p.

In a plasmolysed cell, the water potential equals the solute potential of the sap vacuole ie

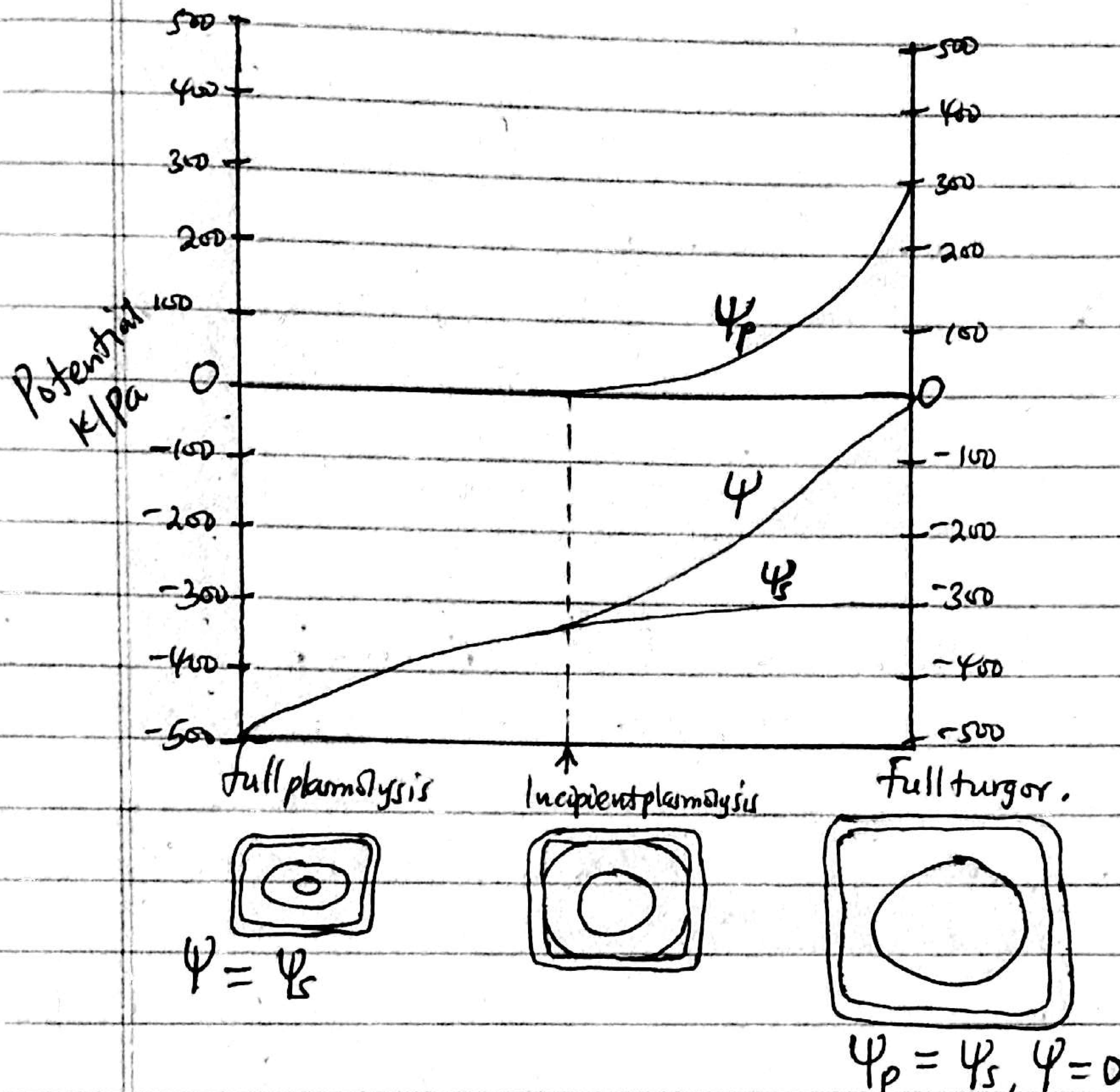
$$\psi_{cell} = \psi_s \text{ of sap}$$

As osmotic influx of water into the cell continues, the water potential of the cell now becomes less negative than the solute potential of the sap by the amount of pressure potential, ψ_p.

As the cell continues to expand, the pressure potential of the cell steadily gets greater & the ψ gets less & less negative.

Eventually, full turgor is reached when the cell can't expand anymore & at this point, the water potential reaches zero (0) and the solute potential is exactly counter balanced by the Ψ_p

Graphical Illustration of the relationship between the Ψ, Ψ_s and Ψ_p of a plant cell at different stages of turgor and plasmolysis:



~~En.~~ ~~Sketch~~ If the solution produces no change in the volume of the cell, It has a solute concentration similar to that of the cell sap or tissue and therefore the water potential of the solution equals to the water potential of the cell or tissue.

In general, $\underset{\text{Usually negative}}{\Psi_{cell}} = \underset{\text{Always negative}}{\Psi_s} + \underset{\text{Usually positive}}{\Psi_p}$

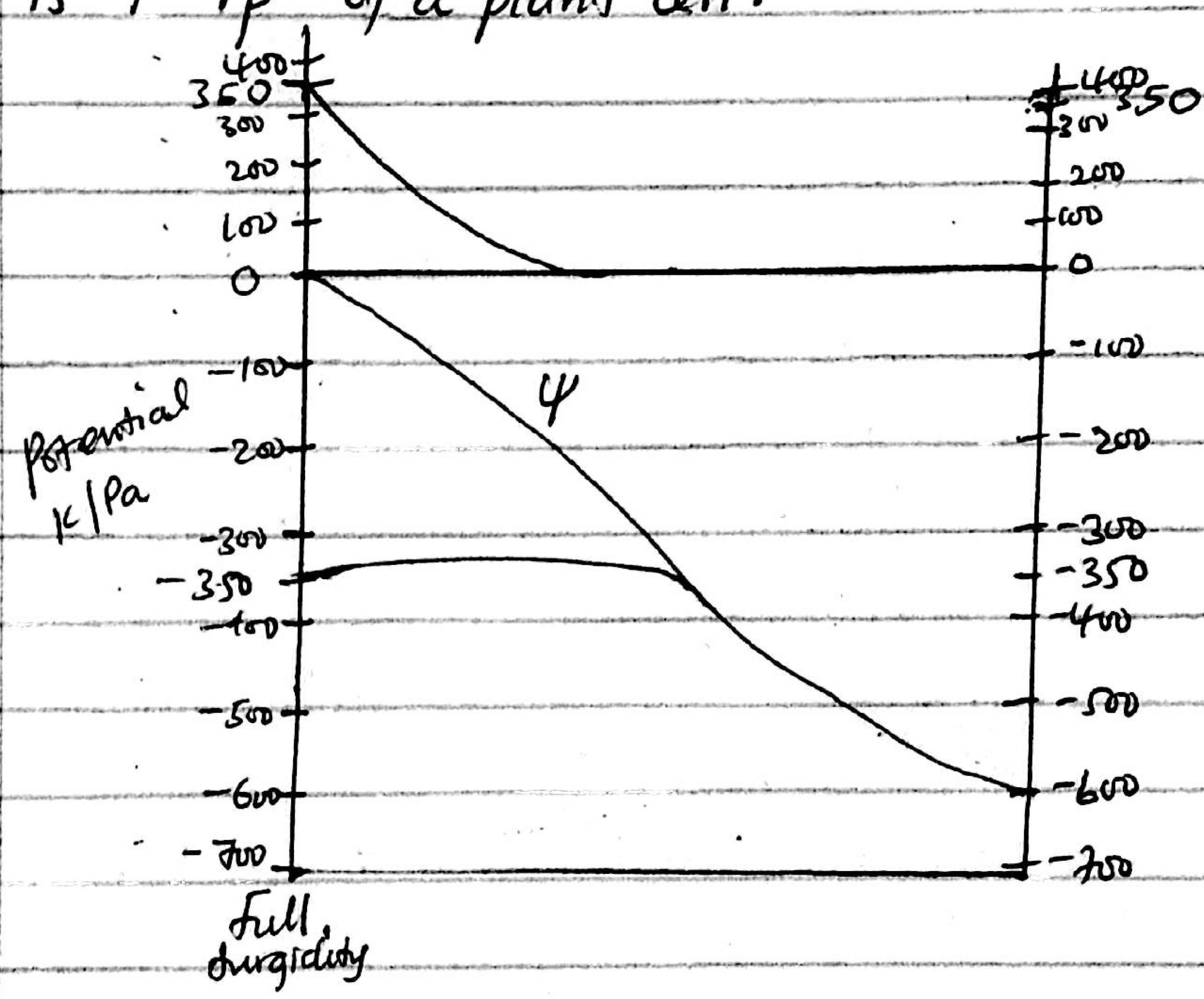
NB:- At full plasmolysis; vacuole almost disappears, cell membrane completely not attached to the cell wall, there is minimum hydrostatic pressure & generally the cell is small &

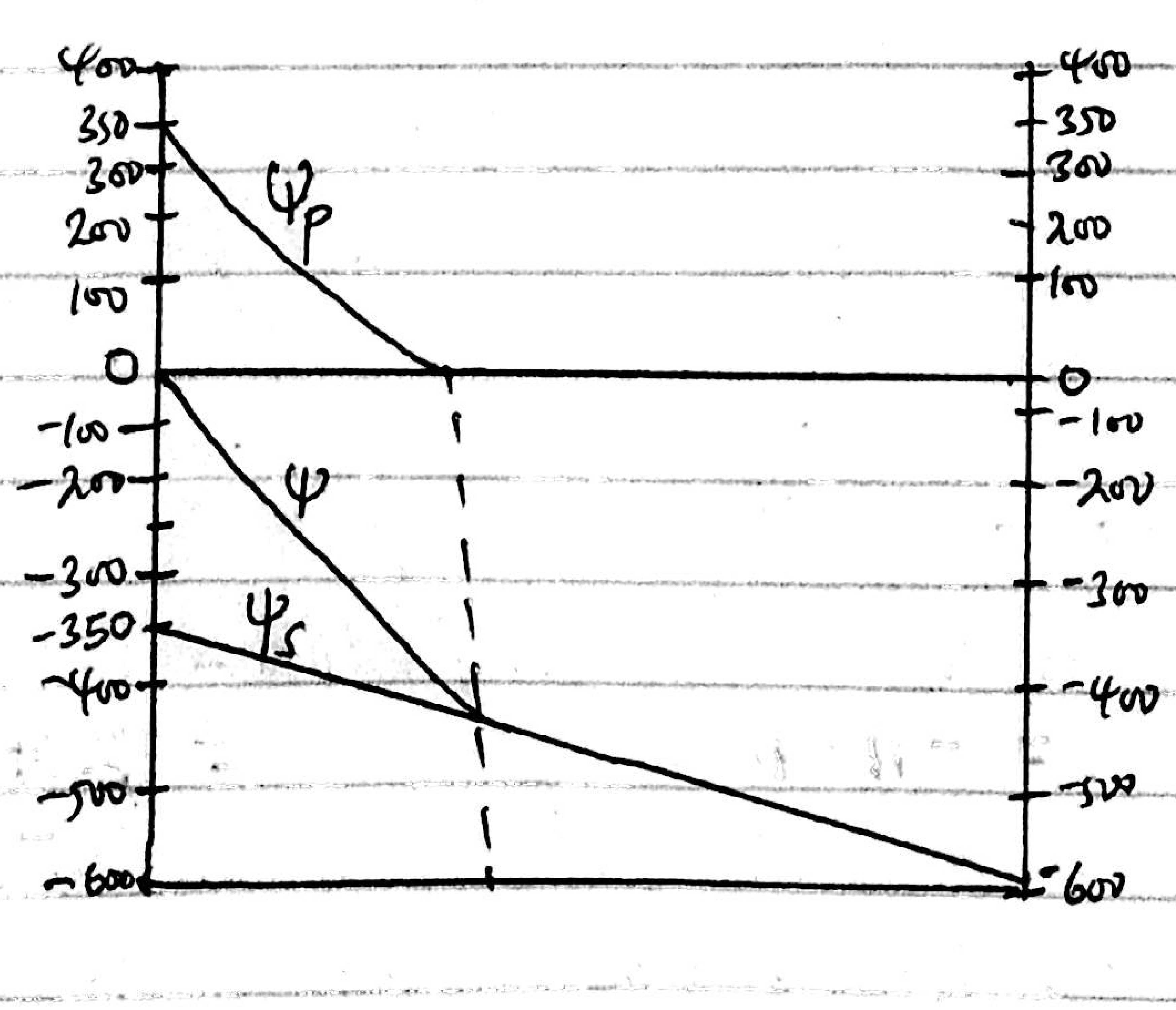
described as flaccid.

- At incipient plasmolysis, cell membrane begins to leave the cell wall.
- At full turgidity, vacuole has maximum volume, no more water enters the cell, there is maximum hydrostatic pressure, the cell membrane is forced against the cell wall.

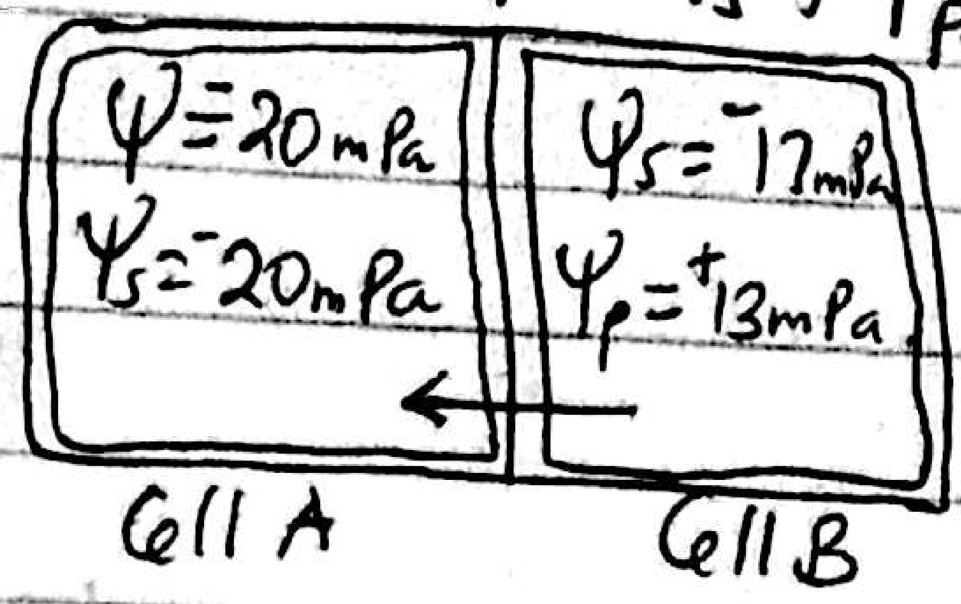
Worked examples:

1. Consider a fully turgid cell whose hydrostatic pressure is positive 350 k/Pa being immersed in a highly concentrated sugar soln whose solute potential is negative, −600 k/Pa. Sketch a graph that shows the relationship btn water potential, Ψ, Ψ_s & Ψ_p of a plant cell.





2. The diagram below two adjacent plant cells A & B. The ψ equation is $\psi = \psi_s + \psi_p$



ψ

a) Calculate the ψ of cell B.

$\psi = \psi_s + \psi_p$

$= -17 + 13$

$= -4$ mPa.

b) Draw an arrow on the diagram to show the direction of flow of water & explain your direction.

Cell A has a more negative water potential than cell B therefore Cell B has a higher ψ than cell A hence water flows from high to low ψ.

c) What is the value of ψ_p of cell A.

$\psi = \psi_s + \psi_p$

$\psi_p = \psi - \psi_s$

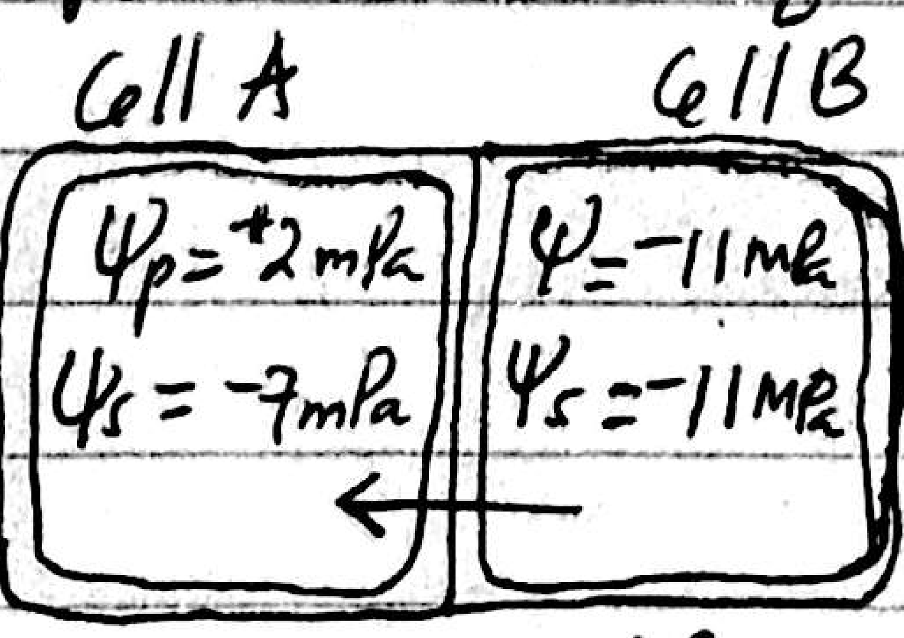
$= 20 - 20$

$= 0$ mPa.

d) Name the condition of the cell when ψ is zero.

- Full turgor. / Fully Turgid

3. Attempt the above qns using the diagram below:



a) ψ of Cell B $= \psi$

$= -11$ mPa

ψ of Cell A $= \psi_s + \psi_p$

$= {}^+2 + {}^-7$

$= {}^-5$ mPa.

Scanned by CamScanner

b) Cell B has a more negative value than cell A therefore cell A has a higher Ψ than Cell B therefore water flows by osmosis from Cell B to Cell A.

c) Ψ_p of Cell B = $\Psi = \Psi_s + \Psi_p$

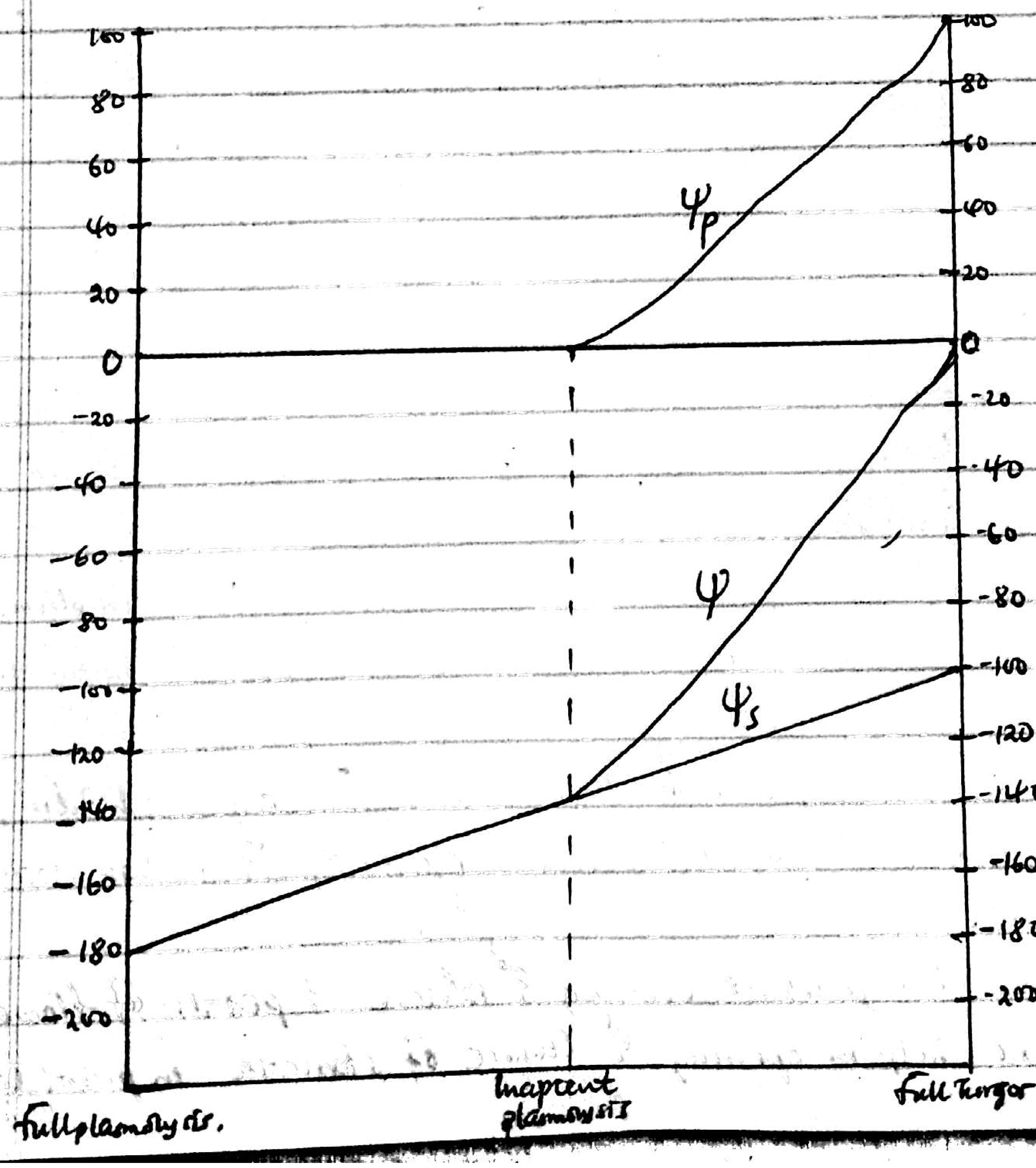
$$\Psi_p = \Psi - \Psi_s$$
$$= -11 - -11$$
$$= 0 \text{ mPa}.$$

Qn 4. A plasmolysed cell from a solution of solute potential −180 kpa was immersed in distilled water. The cell attained full turgor and had a pressure potential of +100 kpa. Sketch a graph that shows how the water potential, solute potential & pressure potential of the cell varies ~~with the~~ until the cell gains full turgor.

Ψ_s = −180 kpa.

Ψ_p = +100 kpa.

$\Psi = \Psi_s + \Psi_p$ = (−180 + 100) kpa = −80 kpa.



OSMOSIS IN ANIMAL CELLS:

If a human red blood cell is placed in an isotonic soln, the cell neither shrinks nor swells. If it is placed in a hypertonic soln, It will shrink & appear crinkled and this is called crenation. If it is placed in a hypotonic soln, It will swell & even burst & this is called haemolysis.

Red blood cells burst (haemolyse) because they lack cellwalls which would prevent the red blood cell from expanding & there4 stop bursting.

PLASMOLYSIS AND WILTING:

When a plant cell is placed in a hypertonic soln, It loses water by exosmosis. The protoplast shrinks & pulls away from the cell wall. Also on dry & hot days, the plant cells lose their water by evaporation & the turgor pressure of the plant cells is reduced with a result that the plant droops. This phenomenon is called wilting.

Wilting is the drooping of leaves & Stems as a result of plant cells becoming flaccid due to exosmotic flow of water out of the plant or by evaporation.

Importance of Osmosis in living organisms:

- Plants absorb water from the soil by Osmosis down a water potential gradient.
- Kidney nephrons reabsorb water back into the blood stream by Osmosis, leading to water conservation in the body hence bringing about osmoregulation.
- In herbaceous plants, Osmosis brings about turgidity in plant cells due to presence of cell walls leading to support & shape in plant organs.
- Osmosis gives plant structures their form e.g by holding the leaf in a flat & horizontal position enabling it to trap maximum sunlight.
- Osmosis brings about opening & closure of petals of flowers.
- Osmosis helps in opening & Closure of stomata in plant leaves

when the guard cells become turgid facilitating gaseous exchange in plants.

CYTOSIS:

This is a form of active transport that involves infolding & outfolding of secretions into vesicles or vacuoles which can be moved.

Cytosis involves contractile proteins in microfilaments & microtubules.

Cytosis results in bulk transport of materials into the cell or outside of the cell.

Types of Cytosis:

1. Endocytosis
2. Exocytosis.

Endocytosis:

This is bulk transport of materials inside the cell. It involves a small area of the plasma membrane folding inwards to surround a material to be taken in by the cell bringing it into the cytoplasm inside a vesicle or vacuole.

The vesicle pinches off the cell membrane & moves deeper inside the cell.

Types of endocytosis:

1. Phagocytosis.
2. Pinocytosis.

Phagocytosis:

This is also called cell eating & it involves the cell taking in large solid substances e.g a whole organism like bacteria.

Phagocytosis involves invagination of cell membrane surrounding the organism or particle & forms a phagocytic vesicle or vacuole which pinches off the cell surface membrane into the cytoplasm.

Lysosomes fuse with the phagocytic vesicle or vacuole & they release hydrolytic enzymes into the vacuole.

The enzymes catalyze breakdown of the ~~surface~~ substance & digestive materials are absorbed into the surrounding cytoplasm across the lining of the membrane or vesicle.

Any indigestable material is got rid of by a vesicle or vacuole moving back to the cell surface membrane fusing with it and release its contents outside of the cell.

Pinocytosis:

This is also called cell drinking. It is similar to phagocytosis only that the infoldings are much smaller. Liquids & large macro molecules such as proteins are taken in via a small pinocytic vesicle.

Pinocytosis is highly specific involving the binding of the molecules with corresponding receptor molecules in the plasma membrane

EXOCYTOSIS:

This involves vesicles or vacuoles moving to the cell membrane & fusing with it & release their contents to the outside of the cell.

Exocytosis provides a means by which enzymes, hormones, antibodies & other substances are removed from the cell.

Importance of cytosis:

- Secretory cells use exocytosis to export their products eg the pancreatic cells make insulin & secrete it into blood by exocytosis.

3:30
2:30
5:00

- Exocytosis facilitates synaptic transmission during which neuro transmitter substances in synaptic vesicles of synaptic knobs fuse with pre-synaptic membrane to release neuro transmitters into synaptic cleft of the synapse
- Exocytosis delivers cell wall materials to the outside of the cell from golgi vesicles.
- Exocytosis leads to replenishment of ē plasma membrane as ē veside membrane becomes part of the plasma membrane after discharge of their contents to the outside of the cell.
- Endocytosis forms a basis of feeding in protoctists like amoeba as they engulf their food material by help of pseudopodia.
- Endocytosis is a defensive mechanism in which pathogens are