Question 41

Of the 27 known human blood group systems, the ABO and Rhesus (Rh) systems are clinically the most important. Each person is one of the four ABO groups, O, A, B, and AB, and is either Rh +ve or Rh–ve. The frequencies in the New Zealand population of are (to nearest whole number) as follows:

O+ = 38%
O– = 9%
A+ = 32%
A– = 6%
B+ = 9%
B– = 2%

The frequencies of AB+ and AB– have been omitted from the list. The frequency of AB+ is approximately

A. 2%
B. 3%
C. 4%
D. 6%

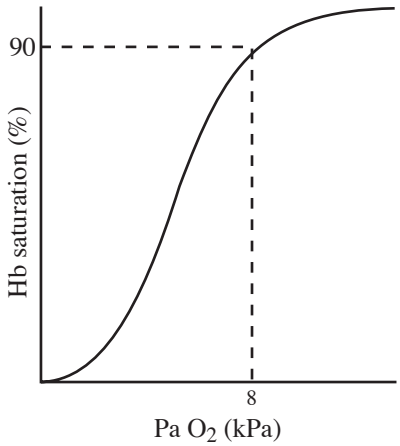
Question 42

The osmotic concentration of a solution is proportional to the number of dissolved particles (molecules or ions) per unit volume of solution. A molar (1M) solution contains the molecular mass of solute in each dm^3 ('litre') of solution. The molecular mass of glucose is 180, so a dm^3 of molar glucose solution contains 180 g of dissolved glucose. Given that the molecular mass of sucrose is 342, which of the following pairs of solutions would have the most nearly equal osmotic concentration (percentages refer to percentage by mass)?

A. 10% glucose and 10% sucrose
B. 0.4 M glucose and 0.2 M sucrose
C. 10% sucrose and 5% glucose
D. 5% sucrose and 10% glucose

Question 43

In mammals, a haemoglobin molecule consists of four subunits, each of which can bind to an oxygen molecule.

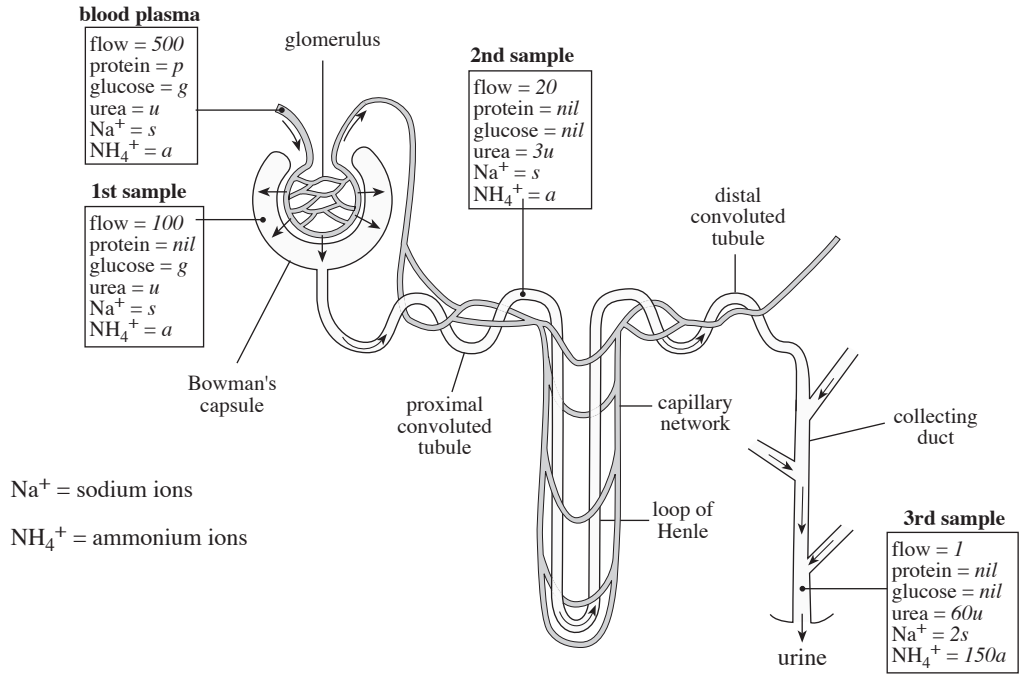


The sigmoid shape of the oxygen dissociation curve at left indicates that when a fully saturated haemoglobin molecule loses oxygen from one subunit:

A. it becomes easier to lose the second and third oxygen molecules.
B. it becomes difficult to lose the second and third oxygen molecules
C. the haemoglobin binds CO_2.
D. the haemoglobin binds HCO_3^-.

The following information relates to Questions 44– 46

The kidneys play an important part in regulating the composition of the blood. Each human kidney consists of about a million nephrons, one of which is shown diagrammatically below. Each nephron is a blind-ending renal tubule beginning as a cup-shaped Bowman's capsule. Into Bowman's capsule dips a cluster of capillaries called a glomerulus. Liquid is forced under blood pressure from the glomerulus into the capsule, and as it passes along the renal tubule some substances are reabsorbed into the network of blood vessels and others are secreted from the blood into the tubule.



The working of the kidney has been studied by taking samples of fluid from various points using a micropipette, and analysing the rate of flow (volume per minute) and composition. Flow rates and concentrations are expressed as relative values and are indicated in the boxes. Thus in the 3rd sample the urea concentration is 60 times as high as in the plasma, and 20 times as high as in the 2nd sample.

Question 44

These data show that between the points where the first and second samples are taken,

A. none of the water and 4/5 of the Na+ are reabsorbed from the tubular fluid into the blood.
B. none of the water and none of the Na+ are reabsorbed from the tubular fluid into the blood
C. 4/5 of the water and none of the Na+ are reabsorbed from the tubular fluid into the blood.
D. 4/5 of the water and 4/5 of the Na+ are reabsorbed from the tubular fluid into the blood.

Question 45

These data suggest that between the points where the second and third samples are taken,

A. there is no movement of urea between tubule and blood.
B. some urea moves passively from tubule to blood.
C. some urea moves passively from blood to tubule.
D. some urea moves by active transport from blood into the tubule.

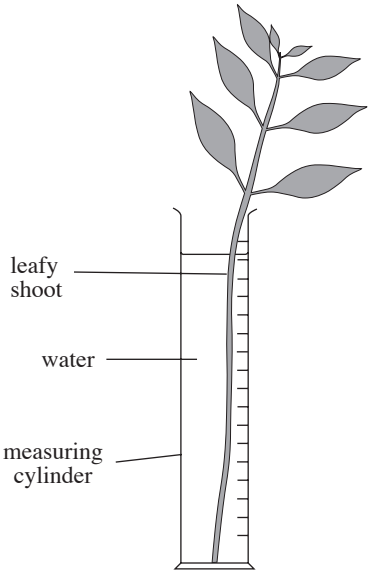
Question 46

The data show that between the points where samples 1 and 3 are taken, the total quantity of NH_4^+ ions

A. does not change.
B. increases 150 times.
C. increases 7.5 times.
D. increases 15 times.

The following information applies to Question 47 and 48

In an investigation to compare water loss with water uptake by a shoot, Winston set up the apparatus shown. He first cut the shoot from the plant at 7.00 am and immediately made a second cut under water. He recorded the volume of water in each measuring cylinder, and also the total mass of each apparatus. He then placed both pieces of apparatus in a windowsill and left them for 4 days, with air freely circulating. 1 cm^3 of water has a mass of 1 g.



The table below shows the results after four days, during which the shoot grew in length by 0.2 cm.

	Apparatus A (with shoot)		Apparatus B (control)	
	Volume (cm^3)	Mass (g)	Volume (cm^3)	Mass (g)
First	76.2	262.0	94.0	248.3
After 4 days	65.9	251.8	93.8	248.1
Change	10.3	10.2	0.2	0.2

Question 47

The volume of water used (i.e. absorbed and retained) by the plant was:

A. 10.3 cm^3
B. 10.2 cm^3
C. 0.2 cm^3
D. 0.1 cm^3

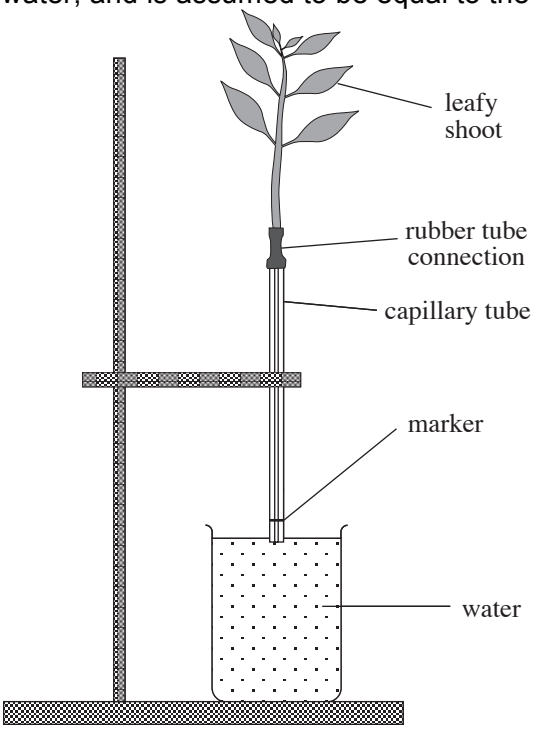
Question 48

The water that had been retained by the plant was mainly used for:

A. respiration.
B. photosynthesis.
C. cell enlargement.
D. osmosis.

The following information applies to Questions 49 and 50

Helen and Michael set up identical bubble potometers as shown, with the intention of comparing the transpiration rates of sun-adapted and shade-adapted karaka shoots. The capillary tube is briefly raised above the water level in the beaker for long enough for an air bubble to enter the tube, and is then lowered back into the water. The rate at which the bubble moves is a measure of the rate at which the plant absorbs water, and is assumed to be equal to the rate of loss.



Helen used sun-adapted and Michael used shade-adapted shoots, and both sets of apparatus were set up on the same windowsill. The distance moved by the bubble in a known period of time was recorded, and is shown in the table.

	Distance moved by bubble (mm)	Time (min)	Total leaf area (cm^2)	Cross section area of tube
Sun-adapted shoot	30	2	240	2 mm^2
Shade-adapted shoot	45	6	360	2 mm^2

Question 49

If Helen wanted to obtain a comparative value (i.e. how many more times faster one shoot transpired than the other), which of he following data would she ***not*** need?

A. the cross section area of the tube
B. the distance moved by the bubble
C. the time taken
D. the total leaf area

Question 50

Which shoot transpired the faster, and by how many times?

A. The shade-adapted shoot transpired 1.5 times faster than the sun shoot.
B. The shade-adapted shoot transpired 3 times faster than the sun shoot.
C. The sun-adapted shoot transpired 3 times faster than the shade shoot.
D. The sun-adapted shoot transpired 1.5 times faster than the shade shoot.

Question 51

The tricuspid valve is in the right side of the heart and separates the right ventricle, which pumps blood to the lungs, from the right atrium, which receives blood from the rest of the body. The ***reason*** why the tricuspid valve closes is:

A. to stop the blood flowing backwards.
B. there is a difference in pressure on either side of it.
C. it stops oxygenated blood mixing with deoxygenated blood.
D. it gives the blood time to enter the atrium.

Question 52

The following sequence of reactions occurs in respiration:

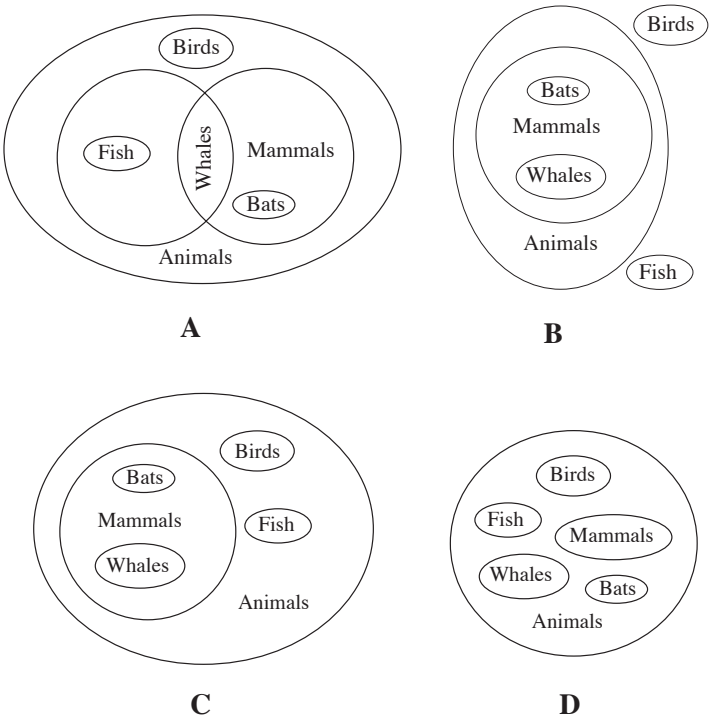
oxoglutarate —*enzyme 1*→ succinate —*enzyme 2*→ fumarate —*enzyme 3*→ malate

The addition of malonic acid results in no change in the concentration of oxoglutarate, an accumulation of succinate, and a near absence of fumarate and malate. Further addition of fumarate results in the formation of malate. What does this information indicate about malonate?

A. It is an inhibitor of enzyme 1.
B. It catalyses the formation of succinic acid.
C. It is an inhibitor of enzyme 2.
D. It inhibits enzyme 3.

Question 53

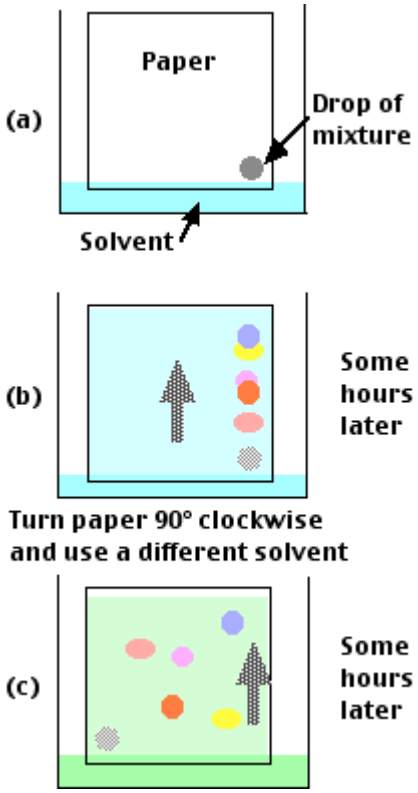
Which of the following correctly shows the relationships between the groups of organisms shown?



The following information relates to Questions 54 to 57

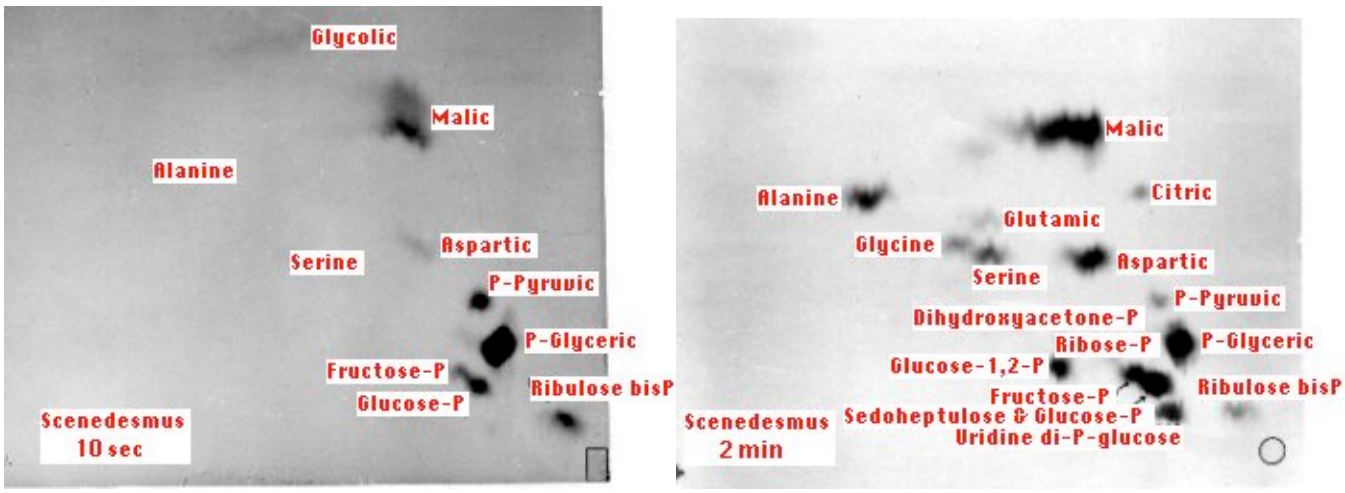
Paper chromatography is a process that separates a mixture of compounds by allowing them to be soaked up by a piece of absorbent paper.

- A drop of mixture is placed in one corner of a square of absorbent paper.
- One edge of the paper is immersed in a solvent. (a)
- The solvent migrates up the sheet by capillary attraction.
- As it does so, the substances in the drop are carried along at different rates. (b)
- Each compound migrates at a rate that reflects the size of its molecule and its solubility in the solvent.
- After a second run at right angles to the first (often using a different solvent), the various substances will be spread out at distinct spots across the sheet, forming a chromatogram. (c)
- The identity of each spot can be determined by comparing its position with the position occupied by known substances under the same conditions.
- In many cases, a fragment of the paper can be cut away from the sheet and chemical analysis run on the tiny amount of substance in it.



If the mixture contains molecules that have been labelled with a radioactive tracer, these can be located by placing the chromatogram next to a sheet of X-ray film. The location of dark spots on the developed film (because of radiation emitted by the tracer) can be correlated with the position of the substances on the chromatogram.

Examine the autoradiograms below (courtesy of Dr. James A. Bassham) that were essential in working out the dark reactions of photosynthesis. The dark spots show the radioactive compounds produced after 10 secs (left) and 2 minutes (right) of photosynthesis by the green alga *Scenedesmus*. The alga was supplied with carbon dioxide labelled with ^{14}C, a radioactive isotope of carbon. The small rectangle and circle (lower right-hand corners) mark the spots where the cell extract was applied.



Question 54

At 10 seconds, where is most of the radioactivity found?

A. in ribulose bisphoshate (Ribose bisP).
B. in 3-phosphoglycerate ("P-Glyceric").
C. in phosphorylated glucose (Glucose-P).
D. in phosphorylated pyruvic acid (P-Pyruvic).

Question 55

Which of the following most correctly describes the substances that have been synthesised by 2 minutes?

A. phosphorylated 6-carbon sugars (such as Glucose-1,2-P and Fructose-P).
B. glucose and fructose.
C. phosphorylated 6-carbon sugars and a number of amino acids (such as alanine and serine).
D. a number of amino acids (such as alanine and serine).

Question 56

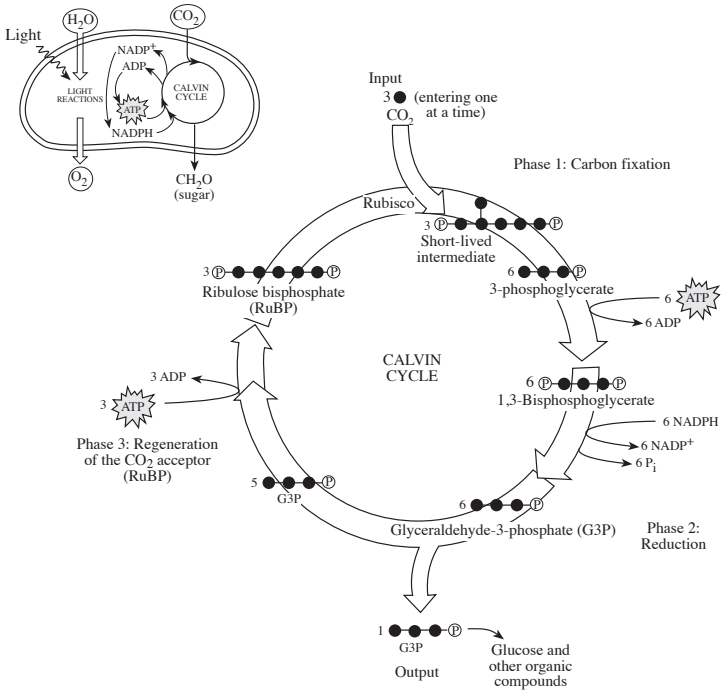
The distance that a compound moves up the paper from the starting point divided by the distance that the solvent moves up from the starting point is called the R_f value of the compound. The R_f value applies to a particular compound being carried by a particular solvent on a particular type of paper. Distances are measured between the centres of the spots.

$$R_f = \frac{\text{distance that the compound moves up the paper from the starting point}}{\text{distance that the solvent moves up the paper from the starting point}}$$

Referring back to the autoradiograms above: which substance has the largest R_f value in the second solvent used? (assume the same orientation as in the 'model' chromatogram diagrams shown before the 'real' ones).

A. alanine
B. glycolic acid (Glycolic)
C. glycine
D. malic acid (Malic)

Question 57



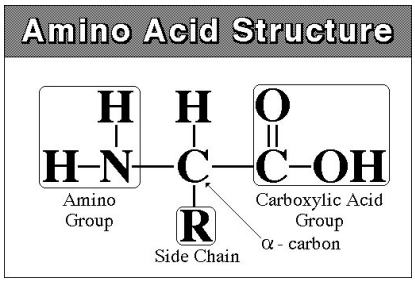
The Calvin cycle is the second part of photosynthesis and occurs in the stroma of the chloroplast. In the Calvin cycle CO_2 is incorporated into organic molecules which are converted to sugar. For the net synthesis of one molecule of the 3 - carbon sugar glyceraldehyde-3-phosphate (G3P) the cycle must take place 3 times, fixing 3 molecules of CO_2. The G3P produced in the Calvin cycle is later converted to glucose and other organic compounds.

To produce a molecule of glucose ($C_6H_{12}O_6$) from carbon dioxide and water would require the expenditure of how many molecules of ATP and NADPH?

A. 6 molecules of ATP and 6 molecules of NADPH
B. 9 molecules of ATP and 6 molecules of NADPH
C. 18 molecules of ATP and 12 molecules of NADPH
D. 36 molecules of ATP and 24 molecules of NADPH

Question 58

Proteins are all polymers constructed from a set of 20 amino acids. The general structure of amino acids is shown below:



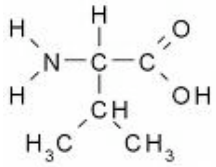
Amino acids consist of a central carbon atom joined to an amino group, a carboxyl group, a hydrogen atom and a variable group symbolised by R. The R group, or side chain, differs with each amino acid and amino acids are grouped according to the properties of their side chains.

Amino acids may be either:

- non -polar – the electrons in the bonds of the side chain are shared equally.
- polar – the electrons in the bonds of the side chain are **NOT** shared equally.
- acidic – the side chain is characterised by a negative charge.
- basic - the side chain is characterised by a positive charge.

Consider the diagram of the structure of the amino acid, valine at right below. Is valine:

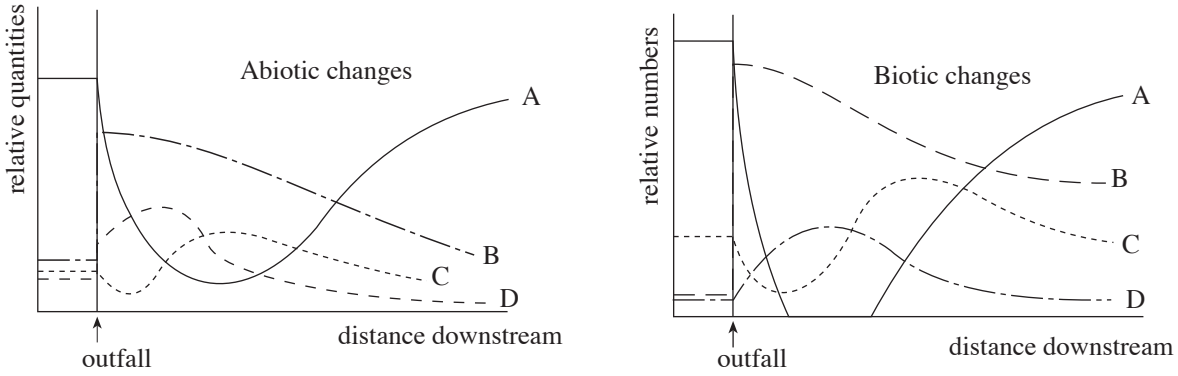
A. non -polar.
B. polar.
C. acidic.
D. basic.



The following information relates to Questions 59 and 60

Domestic sewage is rich in bacteria and decomposable organic matter, and when discharged into a river, it results in drastic physical and chemical changes in the water and in the organisms living in the river. The presence of large numbers of bacteria increases demand for oxygen. The sewage discharge is usually very turbid and reduces algal growth but once turbidity decreases the enrichment of the waters with nitrogen from the sewage may result in an explosive increase in the density of photosynthetic organisms. As these organisms die, and organic material accumulates in the sediments, detritivores increase and consume oxygen in the waters, negatively affecting the populations of oxygen sensitive species such as fish. The graphs below show the abiotic and biotic changes in a river with a large sewage outfall.

The abiotic changes shown are suspended organic matter, ammonia, nitrate, and dissolved oxygen. The biotic changes shown are the numbers of fish, bacteria, ciliates (single-celled organisms that feed on bacteria), and algae (plant-like organisms).



Question 59

In the left hand graph, give the letter of the curve that is most likely to represent dissolved oxygen.

Question 60

In the right hand graph, give the letter of the curve that is most likely to represent algae.

Question 61

Considering the graph at right, a peak of estrogen production occurs during:

A. the flow phase of the menstrual cycle.
B. the beginning of the follicular phase of the ovarian cycle.
C. the period just before ovulation.
D. the beginning of the luteal phase of the ovarian cycle.