SOLUTIONS

3.1: Mode of action of enzymes

1. **C**
   The diagram suggests molecule P is an enzyme, and molecules R and S fit into its active site, indicating that they are likely substrates interacting with P during an enzyme-catalyzed reaction.
2. **C**
   The enzyme catalyzes the hydrolysis of sucrose into fructose, a reducing sugar. This explains why the honey sample tested positive (orange) while the nectar did not (blue).
3. **A**
   Enzymes facilitate reactions by bringing reacting molecules closer (statement 1), lowering the activation energy needed (statement 2), and allowing reactions to occur at lower temperatures (statement 3).
4. **D**
   Statement 3 is correct because the induced fit model explains that the substrate binds to the enzyme's active site and is converted to product via interactions with specific R-groups.
5. **A**
   The substrate for CYP3A4 are toxins. Furanocoumarins are potential inhibitors of CYP3A4. However, the question doesn't specify whether furanocoumarins are competitive or non-competitive inhibitors since it did not mention whether increasing the concentration of substrate (toxin) overcomes the enzyme inhibition or not.
   Option A is correct for any enzyme as they increase the rate of reaction by lowering the activation energy
   Option B is incorrect as the question states that the substrates are toxins found in some fruits not the fruits themselves
   Option C is incorrect as it is not specified in the question that furanocoumarins is a non-competitive inhibitor.
   Option D is incorrect as it is not specified in the question that furanocoumarins is a competitive inhibitor
6. **B**
   The activation energy of a reaction is the minimum energy that must be overcome for reactants to be transformed into products. Enzymes work by lowering this activation energy, making the reaction proceed more quickly at lower temperatures. On the graph, the region indicating the activation energy for the enzyme-catalyzed reaction is represented by the peak height of the curve labeled "with enzyme." This peak is lower than that of the curve labeled "without enzyme," illustrating the reduced amount of energy required to initiate the reaction due to the presence of the enzyme.
7. **A**
   All the statements suggest that the modified protein's altered structure, shape, or properties prevent it from being effectively recognized and degraded by protein-digesting enzymes. This is due to:
   1. Changes in tertiary structure, making it harder for enzymes to break it down.
   2. Loss of shape complementary with the enzyme's active site, reducing susceptibility to digestion.
   3. Inability to induce a proper fit with the protein-digesting enzyme, resisting degradation.
   The statements highlight the importance of protein structure and shape in enzyme-substrate interactions, and how modifications can lead to resistance to degradation.
8. **A**
   Amylase in saliva is indeed an enzyme that works outside of cells to catalyze the breakdown of starch into sugars in the mouth, making it extracellular. The other enzymes listed (carbonic anhydrase, DNA polymerase, and RNA polymerase) function within the cells. Carbonic anhydrase operates in red blood cells, DNA polymerase and RNA polymerase work inside cells during DNA replication and transcription, respectively.
9. **B**
   According to the lock-and-key model, the enzyme's active site is already the correct shape to fit the substrate, like a key fits a specific lock, which means there is no change in shape as the enzyme-substrate complex forms. Enzymes are also known to catalyze reactions by lowering the activation energy required.

10. A

Based on the observation where the concentration of one solution decreased while the other remained the same after mixing, it is supported that P may break down over time, Q may be a biological catalyst, and P may be the substrate for Q.

11. C

The lock and key hypothesis and the induced fit hypothesis of enzyme action are addressed. The substrate fitting into the enzyme's active site without a change in shape is a characteristic of the lock and key hypothesis. The substrate is held in the active site by temporary bonds in both models. The induced fit hypothesis posits that the enzyme and substrate undergo conformational changes for increased compatibility.

12. A

The addition of serine and indole to tryptophan synthase, altering fluorescence intensity, indicates their interaction with the enzyme's active site, influencing the enzyme's conformation and function.

13. A

Option A is the correct answer as hydrogen bonds, disulfide bridges and hydrophobic interactions are all involved in maintaining the tertiary structure of a protein.

14. B

Option B is the correct answer as the greater the concentration of the protein is the greater the absorbance is that result in a linear increasing graph.

15. B

A colorimeter is used to measure the absorbance of certain wavelengths of light by a particular solution. In this case experiments 1 and 2 involve the measures of absorbance making the use of colorimeter justified. Hence, option B is the correct answer.

16. D

Option D is the correct answer as the number of enzyme substrate complexes formed are dependent on the number of enzymes in the solution which assuming are constant means that the complexes formed are constant as well.

17. D

Statements 1 and 2 are incorrect as enzymes can function outside cells and some of them are also involved in anabolic reactions meaning they build up molecules. Hence, option D is the correct answer as all enzymes forms temporary bonds with the substrate and have a tertiary structure.

18. A

Option A is the correct answer as the chlorine atoms in sucralose have no interactions so they do not change the structure in any possible way. Options B, C and D are incorrect as these are all possible reasons for why sucrase cannot break down sucralose.

19. B

Option B is the correct answer as the question asks for the reduction in the activation energy meaning the difference between the non-enzyme catalyzed and the enzyme catalyzed reactions.

20. B

Statement 1 is correct as PHBA is similar to catechol meaning that it occupies the active site where catechol is supposed to bind. Statement 2 is incorrect as similar shape means that PHBA acts as a competitive inhibitor. Statement 3 is incorrect as at high enough concentrations the competitive inhibitors do not affect the Vmax of the reaction. Hence, option B is the correct answer.

21. D

Option D is the correct answer as the activation energy with the presence of enzymes is smaller than without the enzyme and the energy of the reactants is greater than the products.

22. A

Statement 1 is correct as according to the induced fit model enzymes hold substrate to allow for maximum effectiveness. Statements 2 and 3 are correct since enzymes lower the activation energy meaning more molecules can react and that too at a lower temperature. Hence, option A is the correct answer.

23. B

Initially when there is a large amount of substrate the enzymes are saturated since they are actively taking part in reaction, so the number of free active sites decrease rapidly. However, as the concentration of products starts to increase, and the substrate starts to decrease the number of active sites that are free once again starts to increase. This is shown by the line in option B which is the correct answer.

24. D

An appropriate control for this experiment would be to test the substrate only at all the different temperatures. Hence, option D is the correct answer.

25. D

Option A is incorrect since enzymes change shape when a substrate fits into an active site. Option B is incorrect since enzymes lower the activation energy of the reactants and not the products. Option C is incorrect as enzymes do form chemical bonds which are broken later on. Hence, option D is the correct answer as the sequence of amino acids determines the shape of the active site of the enzyme.

26. B

The hydrolysis of triglycerides produces glycerol and fatty acids. Fatty acid lower the pH of the reaction mixture which may lead to the denaturation of the enzyme. Hence, the pH must be maintained. Option B is the correct answer.

27. A

The purpose of producing zymogen is because if the active enzyme was produced it would not distinguish between the target proteins and digest proteins of the cell that produced it. Hence, it is produced in an inactive form making option A the correct reasoning.

28. D

1 represents the product since they gradually increase as time progresses. 2 represents the number of unbound enzymes that decrease at first but start to increase again due to lack of substrate. 3 represents the substrate since it gradually decreases over time and 4 represents the enzyme-substrate complex that increases at first but then starts to decrease due to lack of substrate. Hence, option D is the correct answer.

29. D

The concentration of the product increases with time to a point where it remains constant. This shows that there are no more products being product which suggests that the substrate molecules for the enzymes were used up. Hence, option D is the correct answer.

30. A

All 3 statements can be proven as the reaction goes on the substrate decreases which means that the product made is also decreasing. However, the overall product made increases and since fatty acids are produced they gradually lower the pH and cause lipase to denature. The pH changes rapidly initially due to the high concentration of the substrate but decreases gradually as the substrate starts to decrease. Hence, option A is the correct answer.

31. A

When the pH of an environment is decreases below the optimum pH of an enzyme, the hydrogen and ionic bonds between the adjacent R groups, holding the tertiary structure are broken. Hence, option A is the correct answer.

32. C

Most of these time related experiments measure time directly in seconds to standardize the results. The hundredths of a seconds is not needed since this is mostly dependent on the reaction time. Converting into seconds and rounding off gives 94 seconds which is an appropriate unit. Hence, option C is the correct answer.

33. A

Option B is incorrect as the shape is not complementary initially. Option C is incorrect as the substrate forming bonds does not explain how the substrate can fit into the active site. Option D is incorrect as the tertiary structure changes before the enzyme-substrate complex forms as seen in the diagram not after it. Hence, option A is the correct answer since as soon as the substrate comes into contact with the enzyme, the enzyme alters its shape to allow the substrate to fit into it.

34. C

Statement 1 is incorrect as folding is not necessary for the formation of active sites. Statements 2, 3 and 4 are correct as the enzyme according to the induced fit model changes its shape to incorporate the substrate and the substrate while in the active site forms temporary bonds with the enzyme. At optimum temperature more complexes are formed as the substrate molecules fit into the enzymes. Hence, option C is the correct answer.

35. C

Option A is incorrect as W is the difference it the activation energies. Option B is incorrect as X is the reaction without the enzyme. Option D is incorrect as Z is the energy release and W is the difference in activation energies. Hence, option C is the correct answer as Y is the reaction with the enzyme and W is the difference in activation energies.

36. C
Statement 1 is correct as the bonding between the R groups of the polypeptide result in the shape of the active site of the enzyme which grants it its specificity. Statements 2, 3 and 4 are incorrect since the pH does not affect specificity. Polypeptide chains are not linked by peptide bonds and shape of the substrate molecule does not affect the enzyme's specificity. Hence, option C is the correct answer.

37. B
2 represents the activation energy of the reaction with the enzyme. Hence, option B is the correct answer.

38. D
Statement 1 is incorrect as the active site does not need to be complementary to the substrate since it can change to fit the substrate. Statement 2 is incorrect as the likelihood of non-competitive inhibition is not less since all enzymes work through the same model. Statement 3 is correct as the interactions of the substrate with the R groups of the amino acids cause conversion into the product. Hence, option D is the correct answer.

39. B
Option A is incorrect since the Y enzyme is active at lower temperatures as well but it shows inactivity up till 50 degrees. Option C is incorrect as the concentration of the product should decrease after the enzyme denatures but it shows that it remains constant which is not possible. Option D is incorrect since this graph shows no signs of the product decreasing rather it shows exponential increase even after denaturation. Hence, option B is the correct answer as it shows for X that the concentration decreases as the enzyme denatures above the optimum temperature. The same is the case for Y where the concentration is low at low temperatures but increases and then finally decreases as the enzyme denatures.

40. C
The main difference between the induced fit and the lock and key hypothesis is that in the induced fit model the enzyme changes shape in the presence of the substrate to get a better fit. Hence, option C is the correct answer.

41. C
According to the induced fit model the substrate causes a change in the active site of the enzyme in order for the active site to bind to the substrate. Hence, option C is the correct answer.

3.2: Factors that affect enzyme action

1. A
Malonate is a competitive inhibitor; increasing substrate (succinate) concentration can outcompete it, allowing V_{max} to still be reached.

2. D
Non-competitive inhibitors bind to an enzyme at a site other than the active site, reducing overall reaction rate regardless of substrate concentration. Graph D shows a lower maximum rate, confirming the inhibitor's effect.

3. C
Statement C is correct because a non-competitive inhibitor binds away from the active site, reducing V_{max} by inactivating enzymes, but Michaelis-Menten constant (K_m) remains unchanged as substrate binding is unaffected.

4. C
Increasing enzyme concentration speeds up the reaction, leading to a faster increase in absorbance initially. However, the final absorbance remains the same, as all substrate is eventually converted. Graph C best represents this effect.

5. B
Non-competitive inhibitors bind to a site other than the active site, altering enzyme shape and reducing activity regardless of substrate concentration. Competitive inhibitors, in contrast, bind to the active site.

6. B
Enzyme P has peak activity in acidic conditions (low pH), while enzyme Q functions best in slightly alkaline conditions. Graph B correctly shows P's optimum at low pH and Q's at a slightly alkaline pH.

7. D
A competitive inhibitor increases the substrate concentration at K_m (K_m increases), but does not change the maximum velocity (V_{max}) because the inhibition can be overcome by adding more substrate.

8. A
The Michaelis-Menten constant (K_m) is the substrate concentration at half the maximum reaction rate (V_{max}). From the graph, V_{max} is approximately 36 mol dm^{-3} s^{-1}, so half of V_{max} is 18 mol dm^{-3} s^{-1}. By locating this rate on the y-axis and tracing it to the curve, the corresponding substrate concentration on the x-axis is 12 mol dm^{-3}, confirming option A.

9. B
Enzyme X reaches a high rate of reaction at low substrate concentration, indicating the highest affinity. Enzyme Z has a moderate affinity, and enzyme Y requires a much higher substrate concentration, indicating the lowest affinity.

10. D
A low K_m value indicates high enzyme affinity for the substrate. K_m measures enzyme-substrate affinity and is defined as the substrate concentration where the enzyme works at half its maximum rate. Hence, statements 2 and 3 are correct, but statement 1 is false.

11. A
Curve 1 shows the highest rate of reaction without an inhibitor. Curve 2 shows the effect of a competitive inhibitor, which can be overcome by increasing substrate concentration. Curve 3 represents the non-competitive inhibitor, which reduces the maximum rate of reaction regardless of substrate concentration.

12. C
The graph shows how enzyme activity changes with pH (*x*-axis) and how this affects the rate of reaction (*y*-axis). The reaction rate increases with optimal pH and decreases as pH moves away from the optimum.

13. B
The Michaelis–Menten constant (K_m) measures the substrate concentration at which an enzyme works at half its maximum rate, reflecting the enzyme's affinity for its substrate.

14. B
The absorbance in test-tube Y decreases as the reaction progresses, indicating that the product in Y has a lower absorbance than the substrate, consistent with the reaction data shown.

15. A
At point X, the rate of reaction is limited by enzyme concentration, as substrate concentration is no longer the limiting factor, and further increase in substrate does not increase the reaction rate.

16. D
The uncatalyzed reaction (X) has a higher activation energy, while the catalyzed reaction (Y) lowers the energy barrier. Z represents the overall energy released during the reaction.

17. B
K_m represents the substrate concentration when the enzyme is working at half its maximum rate, and at this value, half the active sites are occupied. A high K_m value indicates the enzyme binds substrate weakly, slowing the reaction. Hence, statements 1, 2, and 4 are correct.

18. A
Line A shows the reaction with the enzyme added. The enzyme speeds up the reaction, increasing the rate of product formation, reaching a higher total product faster than without the enzyme.

19. C
In region X, as temperature increases, the rate of the enzyme-controlled reaction increases until it reaches an optimum point, beyond which high temperatures cause enzyme denaturation.

20. C
Removing a non-competitive inhibitor restores enzyme activity, increasing the V_{max} as more active enzyme is available. However, K_m remains unchanged because the substrate's affinity for the enzyme is not affected by non-competitive inhibition.

21. C
Immobilised papain is more stable at higher temperatures, as shown by the graph where it remains active at a higher temperature compared to free papain.

22. C
At the start of an enzyme-substrate reaction the rate of reaction is the greatest since the substrate concentration is high and all the active sites of the enzymes are saturated. However, as the reaction proceeds the rate of reaction decreases because substrate concentration decreases. There are less successful collisions between enzymes and substrates and less enzyme-substrate complexes are formed. This corresponds with graph C.

23. D

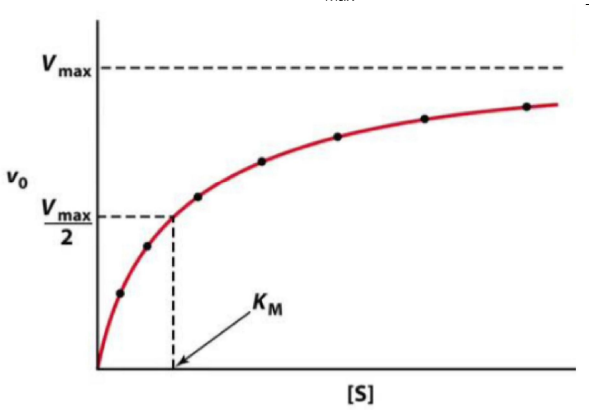
Line Q shows a decreased reaction rate, suggesting the presence of inhibitors. Competitive inhibitors (option 2) resemble the substrate and would reduce the rate by competing with the substrate for the active site. Non-competitive inhibitors (option 3) bind to a different site and change the enzyme's shape, affecting its activity. The correct influences leading to a reaction rate like that in Line Q are therefore competitive and non-competitive inhibition.

24. C

K_m value is that concentration of the substrate at which half of the active sites of the enzyme are occupied by the substrate.

K_m value determines the binding capacity or affinity of the enzymes towards a particular substrate.

K_m is the concentration of substrate at which half of the V_{max} is attained.



25. A

At point X on the graph, the enzyme is saturated with substrate and operating at maximum rate. pH, substrate concentration, and temperature can all affect enzyme activity. Changes in pH and temperature can alter the enzyme's structure, impacting its activity.

26. A

If enzyme Z is inhibited by the end-product, the effect on the quantities of intermediate 1 and the end-product would be as follows:

Quantity of Intermediate 1: This would likely increase. When enzyme Z is inhibited, it will result in the accumulation of intermediate 1 since it can't be converted further in the pathway. Quantity of End-Product: The quantity of the end-product might decrease. Since enzyme Z is inhibited, it cannot convert intermediate 2 into the end-product. This could lead to a reduction in the production of the end product.

In summary, inhibiting enzyme Z with the end-product would likely result in an increased concentration of intermediate 1 and a decreased concentration of the end-product in the pathway.

27. C

A low Michaelis-Menten constant (K_m) value indicates a high affinity of the enzyme for its substrate. It means the enzyme reaches half-maximal activity at a low substrate concentration.

28. A

The Michaelis-Menten constant (K_m) relates inversely to the enzyme's affinity for its substrate, affecting the rate at which the enzyme reaches half of its maximum activity.

29. B

Line 1 shows the highest rate of breakdown of hydrogen peroxide, which likely represents the condition with only substrate and enzyme present, as this would show the maximum rate of reaction without any inhibitors.

Line 2 shows a lower rate than line 1 but still increases with substrate concentration, suggesting competitive inhibition is occurring. With competitive inhibition, increasing substrate concentration can overcome the inhibition to some extent, because substrate and inhibitor compete for the active site of the enzyme.

Lines 3 and 4 represent the slowest rates. Line 3 seems to plateau at a lower rate than line 1 despite increasing substrate concentration, which is characteristic of non-competitive inhibition, where the inhibitor binds to an allosteric site, not the active site, and increasing substrate concentration does not affect the inhibition.

Line 4 is flat, which suggests that no reaction is occurring at all – this would be the control with only substrate and no enzyme present.

30. D
The decreasing volume of oxygen released over time indicates the gradual conversion of the substrate (hydrogen peroxide) into product, reducing the reaction rate.

31. B
Understanding the effects of a non-competitive inhibitor on enzyme activity involves recognizing that such inhibitors decrease the overall number of active enzyme molecules without affecting the affinity for the substrate. The correct graph would show a reduced maximum rate of enzyme activity with an unchanged substrate concentration required to reach half the maximum enzyme activity.

32. A
Option A is the correct answer as K_m is inversely proportional to the affinity an enzyme has for its substrate and this also means that the enzyme reached the V_{max} at a high substrate concentration.

33. B
Option B is the correct answer as competitive inhibitors attach to the active site of an enzyme and with a high enough concentration of the substrate they can be displaced resulting in an increase in the rate of the reaction.

34. C
Option C is the correct answer as in the presence of an enzyme the activation energy is lower meaning that the hump is a little lower. The final energy of the products is always the same.

35. B
Option B is the correct answer as in the presence of a competitive inhibitor the V_{max} remains the same but the K_m increase since it is inversely proportional to the affinity the enzyme has for its substrate. Since competitive inhibitors decrease this affinity the K_m increases.

36. C
Option C is the correct answer as the K_m is inversely proportional to the affinity the enzyme has for a substrate meaning that enzyme F has the greatest affinity for its substrate.

37. B
Statement 1 is incorrect as even if the enzymes denature according to this statement the cell membrane is still intact which means that the pigment should remain inside the cell. Statements 2 and 3 are correct as increasing the temperature cause the enzymes in the cell membrane to denature and the phospholipid molecules move around as well which increases the fluidity and permeability of the membrane allowing the pigment to diffuse out more.

38. A
Option A is the correct answer as outside the cell and inside the cell the amino acids will be hydrophilic while in the region inside the membrane the amino acids will be hydrophobic.

39. D
Option D is the correct answer as K_m is inversely proportional to the affinity that an enzyme has for its substrate. Hence, substrate 4 has the lowest K_m meaning it has the highest affinity.

40. C
The non-immobilised enzyme at 37 ^oC (slid line) shows the steepest decrease in pH, indicating the highest activity and thus the highest product yield. Non-immobilised enzymes tend to have higher activity at optimal temperatures compared to immobilised ones. Hence, C is correct.

41. D
Statement 1 is incorrect as if enzyme concentration was a limiting factor the pH would continue to decrease at a constant rate. Statement 2 is correct as the reaction proceeds the substrate concentration decreases making it the limiting factor. Statement 3 is incorrect as if all the sites were occupied the pH would still continue to decrease. Statements 4 and 5 are correct since the fatty acids produced lower the pH and may cause denaturation or the products of the reaction act as competitive inhibitors slowing down the reaction. Hence, option D is the correct answer.

42. B
Since the ibuprofen occupies the active site of the enzyme this means that this is competitive inhibition since the actual substrate can no longer bond to the active site since it is already occupied. Hence, options C and D are incorrect as well as option A since this is reversible reaction. Hence, option B is the correct answer.

43. D
Statement 1 is incorrect since there is an inverse relationship between the K_m value and the affinity the enzyme has for a substrate. In non-competitive inhibition the affinity decreases meaning that the K_m value should increase not decrease. Statements 2 and 3 are correct as non-competitive inhibition can halt the

reaction reducing the product concentration as well as reduce the rate of the reaction by binding irreversibly with the enzyme. Hence, option D is the correct answer.

44. B

Competitive inhibitions bind reversibly to the enzymes and do not affect the V_{max} value. Hence, option B is the correct answer.

45. B

Option A is incorrect since enzyme 2 would be completely denatured. Option C is incorrect as substance Y will be formed but in low concentrations. Option D is incorrect since the initial reactant will still be metabolized since it is not affected. Hence, option B is the correct answer as non-competitive inhibition of enzyme 2 will cause substance X to increase in concentration since it is not metabolized.

46. D

Options A and B are incorrect as the enzymes will not use equal amounts not will they not use the substrate altogether. Option C is incorrect since V_{max} is directly proportional to the K_m and Km is inversely proportional to the affinity enzyme has for its substrate. For the enzyme with the lower V_{max} the K_m will also be lower which means that enzyme has greater affinity for the substrate and hence will use more of it. Hence, option D is the correct answer.

47. B

Since K_m is inversely proportional to the affinity an enzyme has for its substrate the modified enzyme will have a higher affinity for the substrate. Hence, option B is the correct answer.

48. A

In the presence of a non-competitive inhibitor, the rate of reaction is influenced by enzyme concentration, inhibitor concentration, and substrate concentration. While non-competitive inhibitors affect enzyme activity regardless of substrate levels, substrate and enzyme concentrations still impact the overall reaction rate. Hence, A is correct.

49. A

Experiment X will have a line that will initially have a constant slope since the temperature is constant but eventually the slope will start decreasing as the substrate concentration decreases. For Y initially the slope will be constant but it will plateau since at high temperatures human enzymes denature. Hence, option A is the correct answer as it shows graphs corresponding to the explanation.

50. B

Competitive inhibitors do not affect V_{max} but increase the K_m which results in lowered affinity of the enzyme for the substrate. Hence, option B is the correct answer.

51. D

Option A is incorrect as an enzyme with a high Km value would require higher substrate concentration to reach its V_{max}. Option B is incorrect as enzymes with high K_m have lower affinity. Option C is incorrect as an enzyme with a low K_m would require less substrate concentration to reach V_{max}. Hence, option D is the correct answer as enzymes with low K_m have higher affinity.

52. C

The tertiary structure of the immobilized enzyme changes at higher concentrations since it the solution there are ionic attractions as well which are not present in the gel resulting in the enzyme denaturing at a higher pH. Hence, option C is the correct answer.

53. D

Competitive inhibitors do not affect V_{max} but increase the K_m which results in lowered affinity of the enzyme for the substrate. Hence, option D is the correct answer.

54. D

K_m is the substrate concentration that give half V_{max}. Hence, option D is the correct answer.

55. A

The enzyme has the lowest affinity for the substrate with the highest K_m value. In this case the highest value is in option A making it the correct answer.

56. B

Statements 1 and 3 are correct as competitive inhibitors occupy the same site as the substrate and can be used to control the rate of reaction of an enzyme. Statements 2 and 4 are incorrect as competitive inhibitors have similar shape to substrates not exactly the same and they do not bind to any other site other than the active site. Hence, option B is the correct answer.

57. B
X displays competitive inhibition since it occupies the active site of the enzyme whereas Y exhibits non-competitive inhibition since it occupies a site other than the active site of the enzyme. Hence, option B is the correct answer.

58. D
Since aspirin reacts with an amino acids that forms an essential part of the 3D structure it changes it and the binding strongly suggests irreversible binding. This suggests that the inhibition is non-competitive only. Hence, option D is the correct answer.

59. C
Options A and B are incorrect as between R and S substrate concentration is the limiting reactant. Option D is incorrect as between S and T number of enzyme molecules is inhibiting the rate of reaction. Hence, option C is the correct answer.

60. C
Statement 1 is correct as increased affinity for an inhibitor can decrease the rate of reaction. Statement 3 is incorrect as a change in the shape of the active site would stop the reaction completely since the substrate cannot fit into the active site anymore. Statement 3 is correct as the activation energy for the modified enzyme might be greater which slows down the rate of reaction. Hence, option C is the correct answer.

61. B
An enzyme with a low Michaelis-Menten constant has high affinity for its substrate and requires a low concentration of substrate to reach the maximum reaction rate in the shortest period. Hence, option B is the correct answer.

62. D
Option A is incorrect as competitive inhibitors bind to active sites of enzymes. Option B is incorrect as competitive inhibitors are like substrate but not exactly like them. Option C is incorrect as non-competitive inhibitors can be used to stop a reaction altogether. Hence, option D is the correct answer as competitive inhibitors do not alter V_{max} but non-competitive inhibitors decrease it.

63. B
From one glance it is visible that option B is the correct answer as within 30 seconds 5 grams of the product was formed meaning that within 60 seconds 10 grams could form.

64. B
Both the competitive and non-competitive inhibitors alter with the specificity of the enzyme with competitive inhibitors occupying the active site and non-competitive inhibitors changing it altogether. Statement 2 is applicable to competitive inhibitors only and statement 3 for non-competitive inhibitors. Hence, option B is the correct answer.

65. D
As the temperature increase the substrate concentration decreases as the rate of reaction increases but once the temperature crosses the optimum temperature the enzymes start of denature and as a result let go of the substrates resulting in an increase in concentration. Hence, option D is the correct answer.

66. C
0.38 is the V_{max} dividing it by 2 gives 0.19 and looking at the substrate concentration for this value we find K_m to be 1.5. Hence, option C is the correct answer.

67. D
Option A is incorrect as competitive inhibitors bind to the active site of the enzyme. Option B is incorrect as X is a competitive inhibitor since the V_{max} is the same. Option C is incorrect as Y is a non-competitive inhibitor since it decreases the V_{max}. Hence, option D is the correct answer as Y is a non-competitive inhibitor that binds to a site other than the active site of the enzyme.

68. B
Enzymes decrease the activation energy and have no effect on the energy yield. Hence, option B is the correct answer.

69. A
The appearance of the product and disappearance of the substrate can be used to measure the rate of reaction but not the K_m. Hence, option A is the correct answer.

70. A
Option B is incorrect as at high concentration of competitive inhibitor increasing the substrate concentration can displace the inhibitor. Option C is incorrect as non-competitive inhibitors are not affected by the substrate concentration. Option D is incorrect as concentration of substrate is not linked with the rate of

reaction. Hence, option A is the correct answer as at a certain concentration of substrate all the enzymes are saturated meaning that the rate of reaction is maximum.

71. D

The hydrolysis of triglycerides product fatty acids and glycerol which decrease the pH of the reaction mixture. Eventually the decrease in pH causes the enzyme lipase to denature by breaking down its tertiary structure. Hence, option D is the correct answer.

72. D

Option A is incorrect as increasing the Kinetic energy means increasing the temperature which is also happening for the free enzyme. Option B is incorrect as the enzyme still is active till 90 degrees. Option C is incorrect as the optimum temperature for the free and the immobilized enzymes is the same. Hence, option D is the correct answer as immobilizing stabilizes the enzymes against denaturation.

73. A

Statements 1, 2 and 3 are all correct as the inhibitor can bind in the presence of a substrate since it binds at alternative sites and it can prevent product formation. Hence, option A is the correct answer.

74. A

Increasing the substrate concentration will lead to a point where all the active sites of the enzyme are saturated meaning that the rate of reaction is maximum. Hence, option A is the correct answer.

75. A

Competitive inhibitors bind to the active site of the enzyme. They do not change the shape of the enzyme and are similar in shape to the substrate. He concentration of inhibitor does affect the rate of reaction of the enzyme. Hence, option A is the correct answer.

76. B

Statement 1 is correct as the higher the concentration of inhibitor X the more the enzyme is inhibited meaning that less sucrose is broken down. Statement 2 is incorrect as production of glucose ad fructose using inhibitor Y is less that when using inhibitor Z. Statement 3 is incorrect as well as at 2 concentration all the enzymes produce more glucose and fructose due to less inhibition. Hence, option B is the correct answer.

77. B

The Km is used to compare the affinity that enzymes have for their substrates. Hence, option B is the correct answer.

78. C

Statements 1, 3 and 4 are correct as increase in temperature cause the bonds between the R groups of the amino acids to break which causes the change in the tertiary structure of the enzyme that makes the active site no longer complementary to the substrate. Hence, option C is the correct answer.

79. C

Option A is incorrect as at the optimum temperature the rate of reaction is the fastest which is not in this case. Option B is incorrect as at 60 degrees it is possible that the enzyme denatures which results in a plateau. Option D is incorrect as the rate of reaction is faster at 70 degrees due to the steeper slope. Hence, option C is the correct answer as at 70 degrees the amylase denatures before the hydrolysis is complete.

80. A

An appropriate control for this experiment would be to replace the enzyme with water. Hence, option A is the correct answer.

81. C

Option A is incorrect as if the shape was altered the activity would decrease which it does not. Option B is incorrect as immobilizing increases the activity at higher temperatures according to the graph. Option D is incorrect as reducing the collision decreases the activity which is not the case. Hence, option C is the correct answer as immobilizing increases the stability of the enzyme at higher temperatures.

82. C

Option A is incorrect as it is possible that the rate of reaction is greater at 42 or 43 degrees. Option B is incorrect as the data is fine since it indicates that the optimum temperature has been crossed. Option D is incorrect as between 40 and 50 degrees the activity starts to decrease. Hence, option C is the correct answer as the optimum temperatures lies somewhere between 30 and 50 degrees.

83. D

Since there is a small excess of the substrate initially the concentration will be constant due to saturation but as the substrate starts to decrease the enzyme-substrate complexes will also start to decrease. Hence, option D is the correct answer.

84. D
Statement 1 is incorrect as at the optimum temperature the rate of reaction is the fastest which is not the case in this situation. Statements 2 and 3 are correct as the initial rate of reaction is the fastest at 70 degrees and the higher the temperature is the more quickly the enzyme denatures. Hence, option D is the correct answer.

85. A
Option B is incorrect as they show specificity for toxins in the human digestive system. Options C and D are incorrect since there is not enough information to suggest whether this is competitive or non-competitive inhibition. Hence, option A is the correct answer as the enzyme lowers the activation energy for the toxin breakdown process.

86. D
Only the increase in enzyme concentration would always lead to an increase in the rate of reaction as more substrate molecules can be acted upon. Increases in temperature and pH do not always increase the rate of reaction. Hence, option D is the correct answer.

87. A
Experiment X will have a line that will initially have a constant slope since the temperature is constant but eventually the slope will start decreasing as the substrate concentration decreases. For the other graph initially the slope will be constant but it will plateau since at high temperatures human enzymes denature. Hence, option A is the correct answer as it shows graphs corresponding to the explanation.

88. C
In competitive inhibition if the substrate concentration exceeds the inhibitor concentration it displaces it and this leads to an increase in the rate of reaction. In non-competitive inhibition the substrate concentration does not have any effect. Hence, option C is the correct answer.

89. D
Option A is incorrect as this is a similarity not a difference. Option B is incorrect as saturation with glucose is once again a similar activity. Option C is incorrect as hexokinase phosphorylates more glucose molecules than glucokinase. Hence, option D is the correct answer as hexokinase has greater affinity for glucose since it requires a smaller concentration to reach the maximum rate of reaction.

90. C
At 1 and 2 the substrate and enzyme concentration are acting as the limiting reactants respectively as increasing their concentration leads to an increase in the rate of reaction. In 3 and 4 the concentration of competitive and non-competitive inhibitors are acting as the limiting factors respectively. Hence, option C is the correct answer.

91. A
Change in enzyme and substrate concentration as well as the product acting as the inhibitor all regulate the rate of reaction. Hence, option A is the correct answer.

92. D
Competitive inhibitors bind to the active site, and they do not decrease the activation energy of the reaction. Hence, option D is the correct answer.

93. A
Option B is incorrect as the graph does not show the Kinetic energy so it cannot be assumed that they will be maximum. Option C is incorrect as at R the enzyme is still functional so disulfide bonds cannot break. Option D is incorrect as at S there is still enzyme activity as seen by the rate of reaction. Hence, option A is the correct answer as at P the enzyme forms hydrogen bonds with the substrate in the active site.

94. C
Option A is incorrect as if the enzymes were denatured the mass of the products formed would be different. Option B is incorrect as non-competitive inhibitor would also cause less product to be formed. Option D is incorrect as higher concentration of substrate would mean that greater product would form. Hence, option C is the correct answer as the substrate concentration is the same only the enzyme concentration differs which results in different times taken for the reaction to reach the final mass.

95. C
Options A, B and D are incorrect since competitive inhibitors bind reversibly, do not change the active site and do not lower the activation energy. Hence, option C is the correct answer as competitive inhibitors limit the formation of complexes lowering the rate of reaction.

96. A
Statements 1 and 2 are correct as competitive inhibitors are similar to the substrate and they bind to the active site of the enzyme. Statement 3 is correct as well since non-competitive inhibitors alter the shape of

the enzyme they attach to. Statement 4 is incorrect as non-competitive inhibitors bind to allosteric sites on the enzymes. Hence, option A is the correct answer.

97. A
The graph indicates the enzyme concentration since the enzymes remain the same in the reaction unless more are added. Hence, option A is the correct answer.

98. D
The decreased substrate concentration cannot give line Y as even if the molecules are less in number they will all react eventually. Increase pH and lowered temperature can cause an increase in the number of unreacted molecules by denaturing the enzymes or decreasing its activity. Hence, option D is the correct answer.

99. C
Only statement 1 is correct as at the optimum temperature the enzyme works best. Not all enzymes have this temperature between 35 and 40 degrees and above optimum temperature enzymes still continue to work until denatured. Hence, option C is the correct answer.

100. D
In cases of both competitive and non-competitive inhibition the tertiary structure is the one that is always modified. Hence, option D is the correct answer.

101. D
Only statement 3 is correct as all inhibitors cause a decrease in the rate of reaction. Hence, option D is the correct answer.

102. C
Option A is incorrect as it shows that they enzyme activity is constant beyond 50 degrees which is not possible. Options B and D are incorrect since they show the enzyme having an optimum temperature of 50 degrees which is not possible since the enzyme is adapted to function optimally between 85 and 95 degrees.Hence, option C is the correct answer as it shows the rate of reaction gradually increasing.

103. C
This type of inhibition is non-competitive since the inhibitor will bind to an allosteric site. Statement 1 is incorrect as the complex has already formed. Statement 4 is incorrect as the Vmax decreases. Statements 2 and 3 are correct as the inhibitor is non-competitive and the initial rate of reaction is reduced. Hence, option C is the correct answer.

104. B
At low concentration of inhibitor it takes less concentration of substrate to increase the rate of reaction. At high concentrations it takes more to increase the rate back up to the point where it was without the inhibitors. Hence, option B is the correct answer.

105. B
Option B is the correct answer as competitive inhibitors bind to the active site of the enzyme and if the substrate concentration is high enough the effect of the inhibitor decreases.

106. A
Statements 1 and 2 are correct as increases in temperature of pH cause hydrogen and ionic bonds to break that change the 3D structure of the enzyme. Statement 3 is incorrect as none of these factors cause an increase in hydrophobic interactions. Hence, option A is the correct answer.

107. A
As the reactions starts the enzyme-substrate complex increases in concentration up to the point where the enzyme is saturated after which it starts to decrease as the concentration of the substrate decreases. Hence, option A is the correct answer as it shows exactly this.

3.3: Multiple topics

1. D
A bacterial protease digests proteins but does not act as an antibody. Non-competitive inhibition cannot be overcome by increasing substrate concentration. Proteases break peptide bonds using water in hydrolysis, making statement 3 correct.

2. D
Between 20–30 s: rate = (50–40)/10 = 1cm^3 / s; Between 30–40 s: rate = (55–50)/10 = 0.5 cm^3 / s;
Thus, the rate from 20–30 s is twice the rate from 30–40 s.

3. **A**
Allopurinol is a competitive inhibitor because it has a similar shape to hypoxanthine, allowing it to bind to the active site of xanthine oxidase, reducing uric acid production, option A.

4. **C**
Catalase has a turnover number of 2,800,000, and phosphatase has 971. Now $\frac{2,800,000}{971} \approx 2884$, meaning catalase converts substrate to product 2884 times faster than phosphatase.

5. **C**
As the substrate (lipid) concentration decreases, the reaction slows down (statement 1). The high concentration of products can eventually cause enzyme denaturation (statement 3). However, the pH of the reaction mixture would decrease rather than increase due to fatty acid release.

6. **C**
Lysosomes are present inside the cell and at the telophase spindle these are also inside a cell meaning that these are involved in intracellular hydrolysis. Lumen of the stomach and the mucus in the trachea perform their function extracellularly. Hence, option C is the correct answer.

7. **A**
Options B, C and D are incorrect as ATP synthase, DNA polymerase and RNA polymerase are all intracellular enzymes meaning they act inside a cell. Option A is the correct answer as amylase is an extracellular enzyme as it is secreted by the salivary glands into the mouth.

8. **A**
The blocks with the greatest volume become yellow most quickly. By multiplying the dimension we can see that option A has the greatest volume meaning it gets yellow the fastest.

9. **C**
Option A is incorrect as we cannot assume that phosphorylase converts glucose phosphate into starch. Option B is incorrect as the maximum rate of reaction is seen at 30 and 35 mg dm^3. Option D is incorrect as the substrate concentration acts the limiting factor since increases in that result in the rate of reaction increasing. Hence, option C is the correct answer.

10. **D**
Statement 1 describes translation which occurs inside the cell and statement 3 describes the function of the mitochondria which is also present inside the cell. Statement 2 is the correct as enzymes are secreted into the small intestine for digestion. Hence, option D is the correct answer.

11. **D**
Option A is incorrect as alpha helix refers to the secondary structure. Option B is incorrect as single polypeptide refers to the primary structure. Option C is incorrect as this once again refers to the primary structure. Hence, option D is the correct answer as the active sites are formed as a result of the tertiary structure.

12. **D**
Statement 1 is incorrect as ribozymes are RNA molecules not proteins. Statement 2 is correct as the specific sequence of nucleotides forms the active site of the ribozymes. Statement 3 is correct as ribozymes form since RNA has specific structures that are responsible for the active sites of the ribozyme. Hence, option D is the correct answer.

13. **C**
Competitive inhibitors increase K_m and non-competitive inhibitors decrease it. Hence, option C is the correct answer.

14. **C**
Sterilizing the blood plasma will cause the enzyme to denature and using an inhibitor would decrease the rate of reaction which is not required. Incubating with the appropriate substrate allows us to measure the rate of reaction and hence monitor the activity of the enzyme. Hence, option C is the correct answer.

15. **A**
Option B is incorrect as at 10 degrees more black colored rabbits are produced not less. Option C is incorrect as is tyrosine is switched off at 10 degrees there would be no black rabbits which is not the case. Option D is incorrect as at 30 degrees there are less black fur rabbits indicating that the enzyme's activity decreases. Hence, option A is the correct answer as at 30 degrees there must be an inhibitor that binds to the rabbit skin cells preventing the production of melanin.

16. **D**
Between 50 and 60 minutes the pH remains constant meaning that the either the substrate has run out meaning it acts as a limiting factor or the low pH has causes the enzymes denature or the products are

causing enzyme inhibition preventing it from carrying out the reaction. Hence, option D is the correct answer.

17. D

The drugs are required to be specific to the viral protease meaning that they should only affect it and not any other substances in the body. Hence, option D is the correct answer.

18. D

Since the enzyme in the body is suited to catalyze ethanol this means the ethylene glycol acts as a competitive inhibitor. This means that if a large quantity of ethanol of used the substrate will displace the inhibitor since it is more likely to bind to the active site. Hence, option D is the correct answer.