

THE UNIVERSITY OF AUCKLAND

INCOURSE TEST 2018

BIOLOGICAL SCIENCES

**Foundations of Biochemistry
BIOSCI.106SC**

Friday, 14 September 2018 6.30 - 8.30 P.M.

(Time Allowed: TWO hours)

VERSION 1021135

Student Identification Form

PLEASE COMPLETE THE FOLLOWING:

Family Name: _____

First Name: _____

ID Number: _____

Signature: _____

Submit this page to supervisors at the beginning of the test.

(Failure to do this may result in non-assessment of your script!)

PLEASE NOTE: QUESTIONS HAVE BEEN REMOVED FROM THE ORIGINAL VERSION AS THE CONTENT WAS NOT COVERED IN 2020- so the questions are not completely in numerical sequence

THE UNIVERSITY OF AUCKLAND

BIOLOGICAL SCIENCES

Foundations in BiochemistryIn-course Assessment TestFriday, 14 September 2018 6.30 - 8.30 p.m.**GENERAL INSTRUCTIONS****Roll Slip:**

- Fill this in and pass it to the nearest aisle seat.

Multiple Choice Questions:

- Use the Teleform Sheet.
- Use **pencils** only. Shade the rectangle completely.
- Do not cross out mistakes. ERASE them completely.
- Complete family name, first name, initial and ID Number. Do not complete your stream. Fill spaces from left to right.
- Your code is **1021135**.
Check this is correct on your teleform.
- Failure to enter the version code or other details correctly will mean your MCQ cannot be marked.

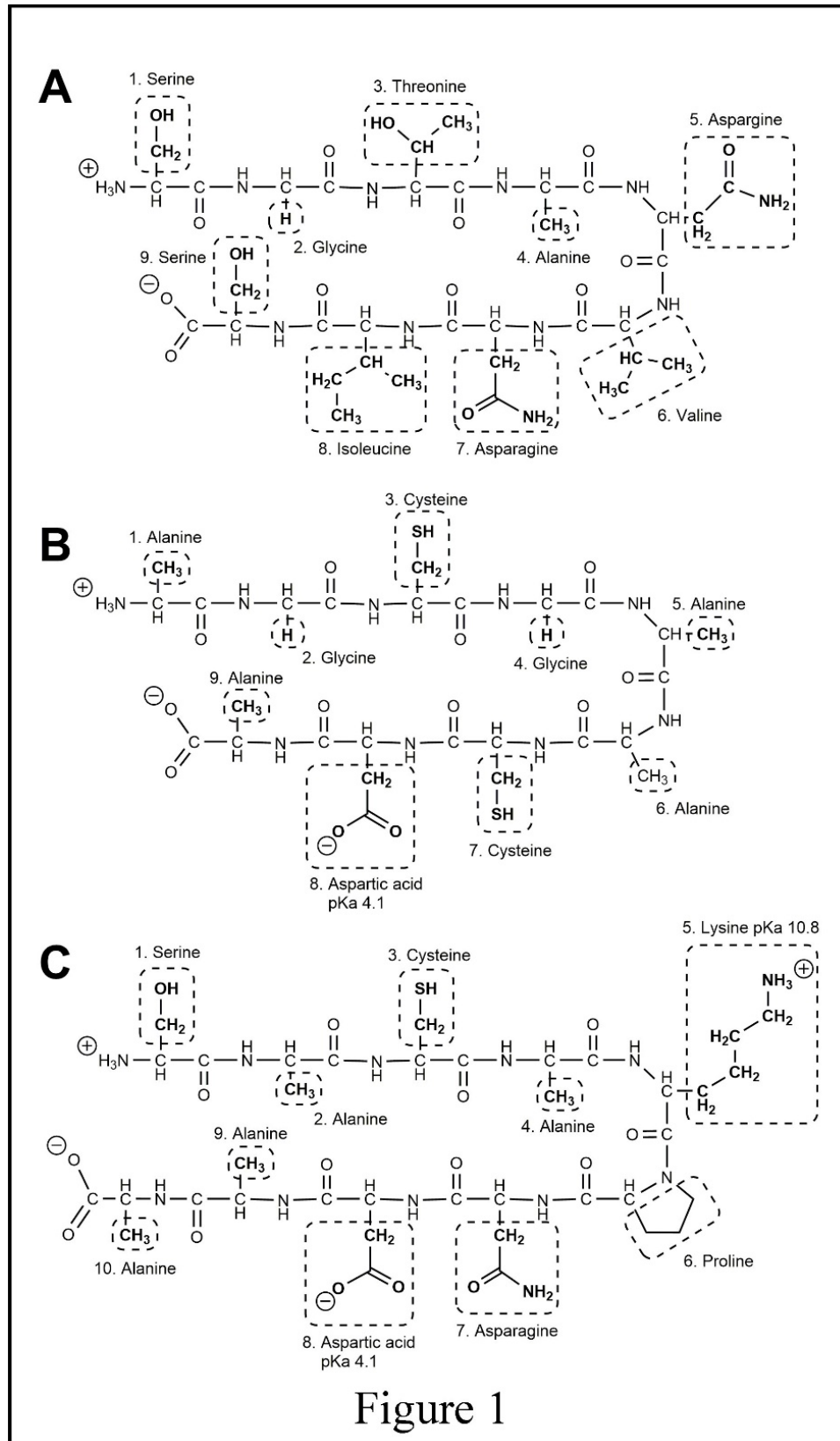
Test Format:

(Total marks = 90)
ALL QUESTIONS SHOULD BE ATTEMPTED.

All test scripts will be collected at the end of the exam.

MULTIPLE CHOICE QUESTIONS**Test Version Code 1021135****Choose THE BEST answer from the alternatives provided.**

Three short polypeptide chains are illustrated in Figure 1 with acid/base side chains in the appropriate form at pH 7. Use these images to help you to answer Questions 1-5.



1. Refer to the three polypeptides illustrated in Figure 1. Which statement below is CORRECT?
 1. If polypeptide B folds up correctly it will have an overall neutral charge.
 2. If polypeptide C formed an α -helix it would be kinked or interrupted near the middle of the structure.
 3. Polypeptide A has a mixture of non-polar, polar, and electrically-charged side chains.
 4. Polypeptide B could form a silk/fibroin type structure because it has a high alanine content.
2. Refer to the three polypeptides illustrated in Figure 1. One of the polypeptides forms a dimer through side chain interactions. This dimer can be changed back into monomers by a change in pH. Which polypeptide is described?
 1. Polypeptide B forms a coiled-coil dimer structure. At pH 2, the hydrophobic side chains are protonated and the dimer structure is disrupted.
 2. Polypeptide C forms a dimer through a salt bridge. At pH 2, the salt bridge is broken and the dimer structure disrupted.
 3. Polypeptide A forms a dimer through the hydrogen bonding of polar side chains. These interactions can be disrupted by a change in pH.
 4. Polypeptide B and C both form dimers following the formation of disulfide bonds. The disulphide bond is broken by an increase in pH.
3. Refer to the three polypeptides illustrated in Figure 1. Which of these polypeptides can form a β -sheet which has one side entirely hydrophobic and the other side entirely hydrophilic?
 1. None of the polypeptides are capable of forming the structure described.
 2. polypeptide A
 3. polypeptide B
 4. polypeptide C
4. Refer to the three polypeptides illustrated in Figure 1. How many of these polypeptides have an overall neutral charge at pH 7?
 1. none of the polypeptides
 2. two of the polypeptides
 3. only one of the polypeptides
 4. all three of the polypeptides
5. Refer to the three polypeptides illustrated in Figure 1. At pH 9, how many of the polypeptides now have an overall neutral charge?
(note: ignore the potential effect of pH on the terminal amino and carboxyl groups - consider only side chains)
 1. All three of the polypeptides
 2. two of the polypeptides
 3. None
 4. only one of the polypeptides
6. Blood pH is tightly regulated and is important for the release of oxygen from haemoglobin. Which statement is **CORRECT**?
 1. A change in blood pH at the tissues helps carbonic acid to bind to haemoglobin to replace the oxygen that is released. This promotes a conformational change in the haemoglobin protein.
 2. A lowering of the pH at the tissues protonates a histidine that can then form a salt-bridge (electrostatic interaction). The new interaction alters the conformation of the haemoglobin protein.
 3. The formation of a salt-bridge (electrostatic interaction) between the side chains of two lysines (a di-lysine bond) promotes oxygen release by altering the conformation of the haemoglobin protein.
 4. The lowering of the pH at the tissues to 7.2 protonates an aspartic acid side chain that can then form a salt bridge (electrostatic interaction) with a lysine side chain.

Refer to Figure 2 below to answer questions 7, 8 and 9.

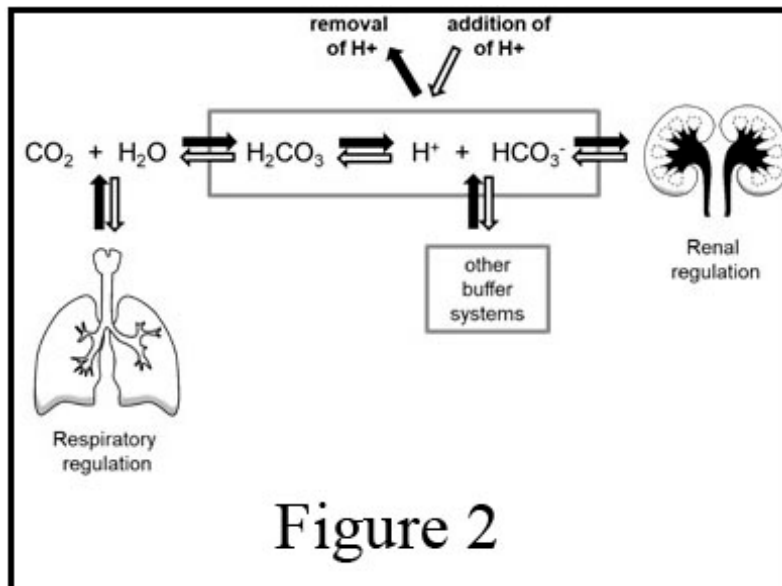


Figure 2

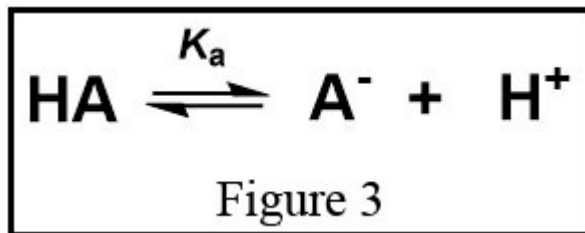
7. Jane has a chronic bacterial infection that affects her blood pH. Her condition can be described as chronic acidosis with her blood pH lower than the normal range. Jane's blood pH is tested daily for one week and shows some improvement each day. Refer to Figure 2 to explain why her blood pH has risen over the period of several days.
 1. Her cellular metabolism has adjusted to retain more carbon dioxide in her tissues and blood stream and this increase has lowered the blood pH.
 2. The renal system has adjusted the bicarbonate and hydrogen ion concentrations in the bloodstream over a period of hours and days.
 3. The bicarbonate, phosphate, and protein buffering systems have all acted together to reduce the hydrogen ion concentration in the blood.
 4. Her body has produced more lipids in her bloodstream to act as buffering agents.

8. After some months of suffering with chronic acidosis, Jane is being treated with a new drug that increases her respiratory rate by approximately 25%. Refer to Figure 2.

The new treatment has returned her blood pH to the normal range because the increased respiratory rate:

1. produces an increase of CO_2 in the bloodstream. Increased levels of the enzyme carbonic anhydrase produce more carbonic acid, which lowers the hydrogen ion concentration.
 2. removes more CO_2 from the bloodstream signalling the brain to release more acetic acid.
 3. provides more oxygen in her blood stream. Dissolved oxygen combines with hydrogen ions (H^+) to give water molecules and in this process the blood pH is returned to normal.
 4. removes more CO_2 from her bloodstream. The carbonic acid equilibrium is shifted and consequently, the hydrogen ion concentration is reduced.
9. Refer to Figure 2, choose the **CORRECT** statement.
 1. The dissociation of carbonic acid to hydrogen ions and bicarbonate occurs spontaneously but not completely.
 2. Exercise produces CO_2 in the tissues. This increases the carbonic acid concentration in the blood while at the same time reducing the hydrogen ion concentration.
 3. The fastest physiological response to the addition of a small amount of strong acid to the blood stream is an increase in the respiratory rate.
 4. The addition of a small amount of strong acid to the blood stream will decrease the concentration of carbonic acid because of a chemical equilibrium.

10. The pK_a value of an amino acid side chain describes the propensity of an amino acid side chain to dissociate. Acidic side chains have low pK_a values and basic side chains have high pK_a values. How is pK_a defined from the generic chemical equilibrium for weak acids shown below in Figure 3?



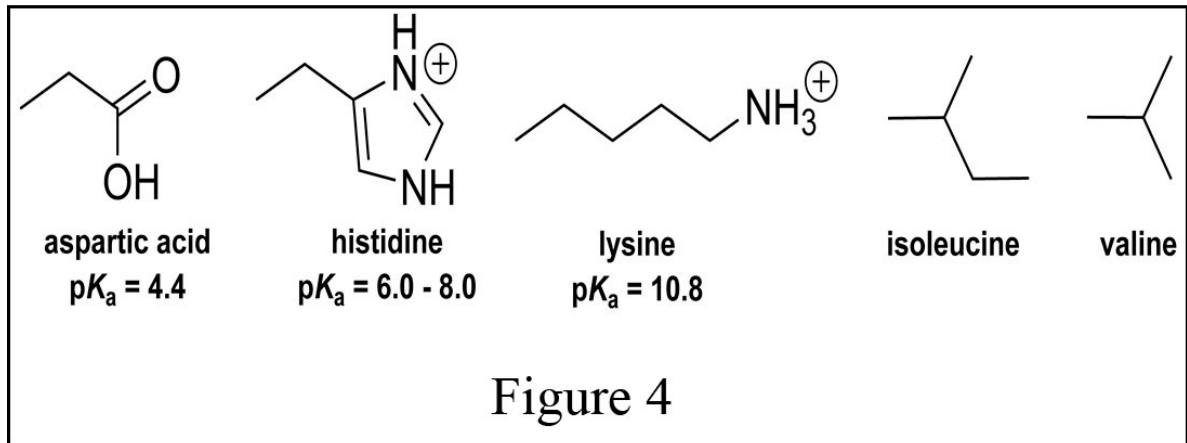
1. $pK_a = -\log_{10}[H^+]$

2. $pK_a = -\log_{10}[A^-][H^+]$

3. $pK_a = -\log_{10} \frac{[A^-][H^+]}{[HA]}$

4. $pK_a = -\log_{10} \frac{[HA]}{[A^-][H^+]}$

11. Consider a negatively charged and a positively charged amino acid forming an electrostatic interaction at a physiological pH of 7.4. The potential side chains involved are shown in figure 4 below in their protonated forms:

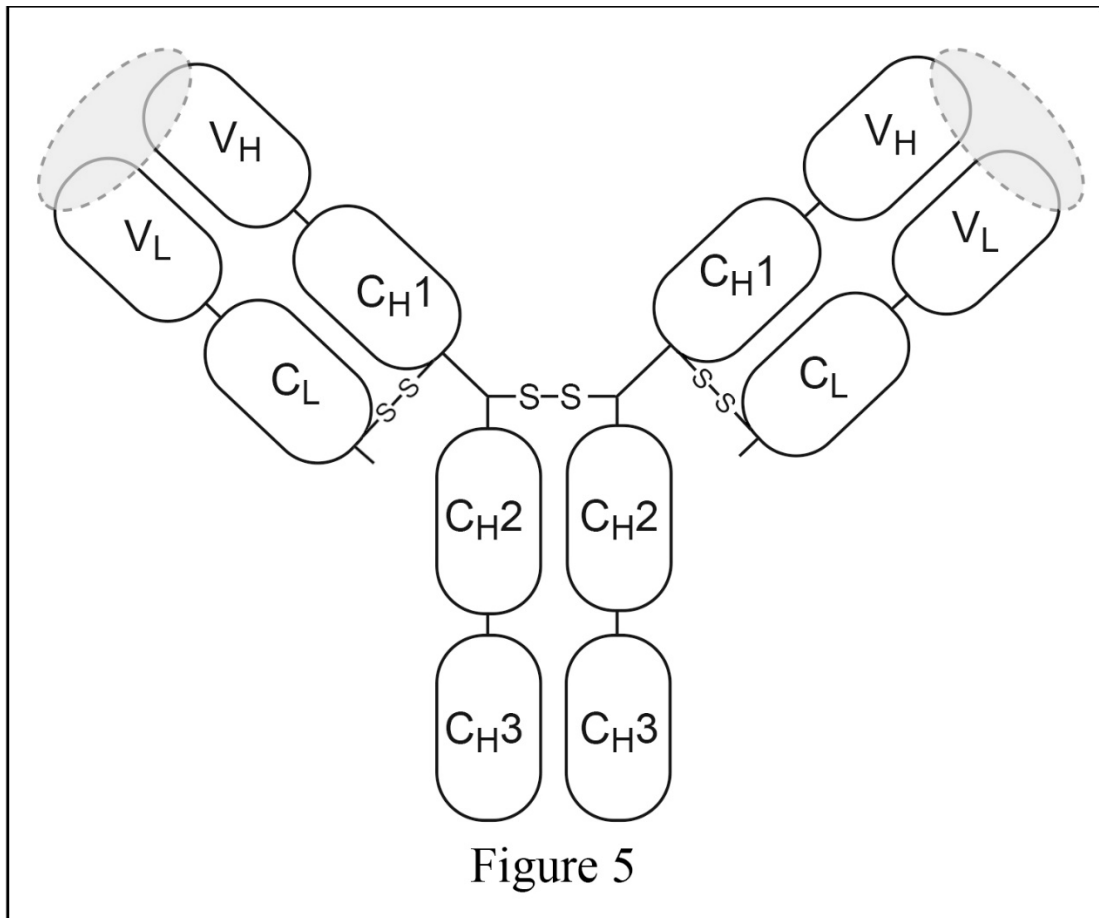


If we increase the pH to 8.5, the electrostatic interaction will be broken. Why does this happen?

1. The paired amino acids are aspartic acid and lysine. On changing the pH to 8.5 the lysine loses its positive charge and becomes neutral.
 2. The paired amino acids are aspartic acid and histidine. The histidine pKa is 8.0 and the pH change to 8.5 deprotonates the histidine.
 3. The paired amino acids are valine and isoleucine. On changing the pH to 8.5 both the valine and isoleucine become negatively charged and repel each other.
 4. The paired amino acids are aspartic acid and lysine. On changing the pH to 8.5, the aspartic acid becomes protonated and has a neutral charge.
12. Which statement is **CORRECT**?
1. β -sheets and α -helices are defined by their backbone hydrogen bonding.
 2. α -helices can be either right-handed or left-handed.
 3. α -helices are defined by their side chain hydrogen bonding that is along the helical axis.
 4. β -sheets cannot form barrel shapes because their hydrogen bonding pattern holds them flat.
13. Fibrous proteins:
1. with β -sheet secondary structures usually have rigid, coiled and compact structures.
 2. with α -helices rarely contain disulphide bonds.
 3. have highly repetitive amino acid sequences and highly regular secondary structures.
 4. are defined by secondary structure with specific patterns of side chain hydrogen bonding.
14. The fibroin (silk) structure:
1. contains right-handed α -helices with 3.6 amino acids per turn.
 2. contains β -sheets with glycine side chains covering one entire side of each sheet.
 3. has a pattern of basic amino acids every 3rd amino acid of the primary sequence.
 4. has a pattern of acidic amino acids every 3rd amino acid of the primary sequence.

15. A bioengineering student wants to design a new fibre using spider silk as their inspiration. What molecular features should the student's new fibre contain?
1. The new fibre should have extensive layers of β -sheets. These sheets are flexible and would wrap around upon themselves to form barrel-shaped protein structures.
 2. The new fibre should contain a mixture of amorphous (unstructured) sections and highly regular smaller sections of nano-crystalline β -sheet.
 3. The new fibre should contain regions of α -helical secondary structure held together by hydrogen bonds, electrostatic interactions, and covalent disulphide bonds.
 4. The new fibre should contain a random sequence of amino acids. Random sequences produce a fluid and sticky material just like spider silk that can be extruded to form a man-made fibre.
16. .
17. Which statement is **CORRECT**?
1. The normal form of the prion protein is much lower in energy compared to the high energy fibril form of the protein.
 2. The prion protein is considered infectious because it is delivered to the human body by an infectious agent, for example, a bacterium or a virus.
 3. Prion amyloid fibrils cause neuron death. The action of astrocytes then produces cavities in brain tissue.
 4. The disease form of the prion protein can easily convert back to the normal form of the protein in an equilibrium process.
18. Which statement is **INCORRECT**?
1. In amyloid disease fibres, small sections of the extended polypeptide chain associate to form large β -sheet assemblies.
 2. Protein folding is rapid and stabilised by partly correctly folded intermediates.
 3. Proteins fold rapidly by sampling every possible conformation of the polypeptide backbone starting from the N-terminus and ending at the C-terminus.
 4. Amyloid diseases are driven by the misfolding of a normal protein.
19. Globular proteins are:
1. defined by their overall size and shape.
 2. usually insoluble.
 3. usually very stable unless they are enzymes.
 4. driven to fold up by the "hydrophobic effect".
20. Which statement is **CORRECT**?
1. A 1500-amino acid long protein is likely to be folded into domains.
 2. Antibodies bind antigens with high affinity but low selectivity.
 3. Domain structure always makes a protein rigid and inflexible.
 4. A tetrameric protein structure contains six different protein chains.

21. How would you best describe the antibody structure shown below in Figure 5?



1. A single protein chain forming a Y-shaped molecule with disulphide bonds providing stability. Two antigen binding domains are formed at the top of the Y-shape.
 2. A tetrameric quaternary structure with two heavy chains and two light chains. Each heavy chains is folded into four domains and each light chains is folded into two domains.
 3. An assembly of two proteins chains held together by disulphide bonds. There are a total of two antigen binding sites per antibody.
 4. An oligomer of four individual protein chains. All of the protein chains have the same number of domains.
22. You have been asked to engineer a new type of antibody. Your boss wants to name it a "superbody" that binds with high affinity to multiple antigen binding sites simultaneously. Which one of the following options describes how you would design this molecule.
1. A flexible multi-armed molecule with antigen binding sites on several of the arms.
 2. A very rigid X-shaped molecule with antigen binding sites at the ends of the X-shaped arms.
 3. A large flexible molecule with one high affinity antigen binding site.
 4. A large rigid molecule with a single high-affinity antigen binding site located at one end of the molecule.

23.

24.

25. The sialic acid recognised by hemagglutinin is:

1. a specially modified amino acid located at the surface of a host cell membrane protein.
2. located at the top of a carbohydrate chain attached to a host cell membrane protein.
3. attached to DNA molecules imbedded in the host cell membrane.
4. only found in membrane proteins in the lungs of humans.

26. The concept of host range describes which animals will be infected with a particular subtype of influenza A virus. Which statement about host range is **CORRECT**?

1. Humans have bird-type receptors in their lungs. It is therefore relatively easy for a bird virus to be passed directly between birds and humans.
2. Pigs have both types of receptor (bird and human) throughout their respiratory tracts. Pigs can therefore become infected with both bird-type and human-type viruses.
3. It is difficult for humans to be directly infected by birds because bird influenza recognises the modified sugar sialic acid and human receptors use the sugar galactose instead of sialic acid.
4. Birds have both human-type and bird-type receptors in their upper respiratory tract. Human viruses can therefore be passed easily to chickens.

Figure 6 below shows four antigen molecules attached to a surface, they are labelled A1, A2, A3, and A4. Five antigen binding sites are shown below the antigens. They are labelled BS1, BS2, BS3, BS4, and BS5. The shaded areas indicate hydrophobic regions.

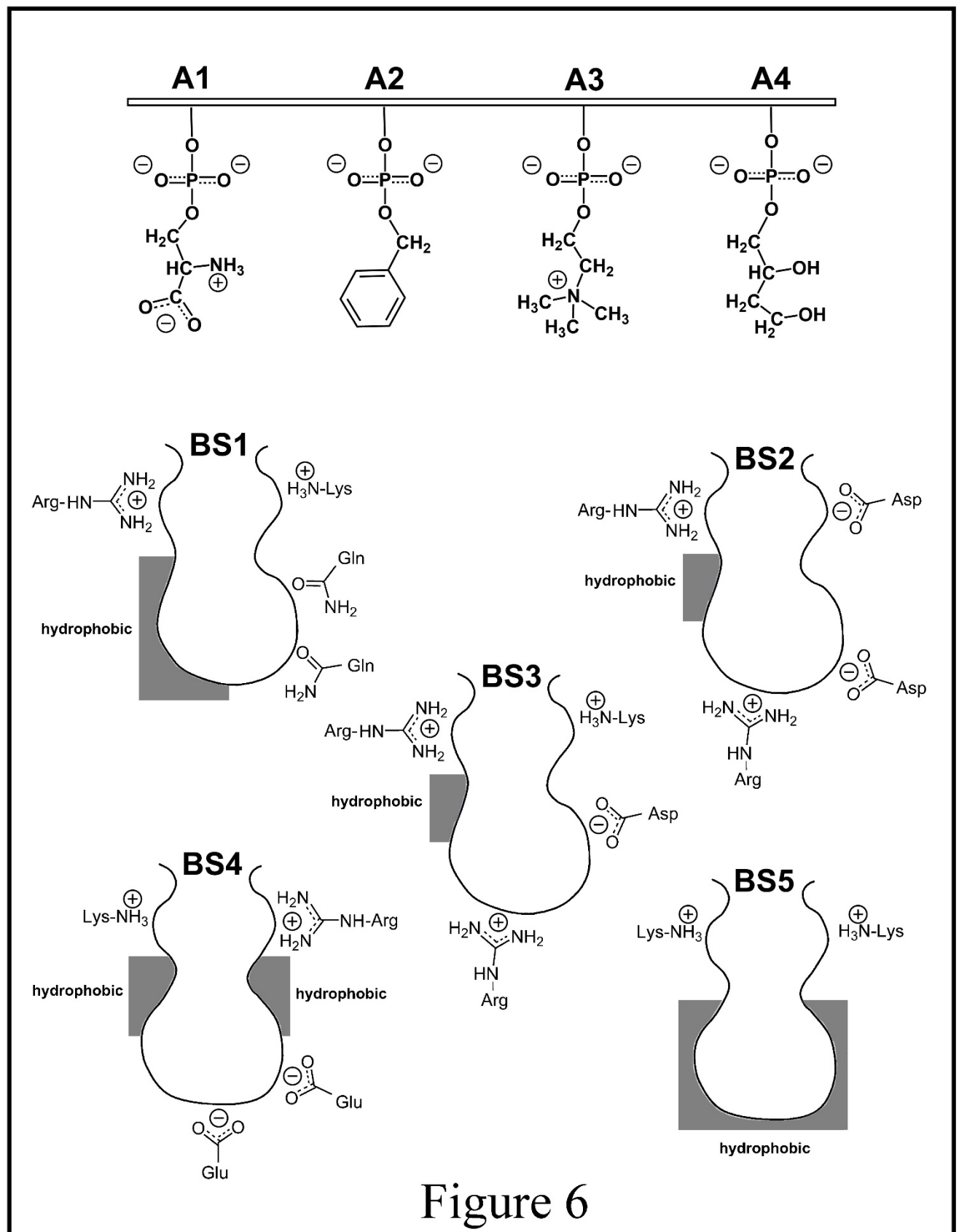
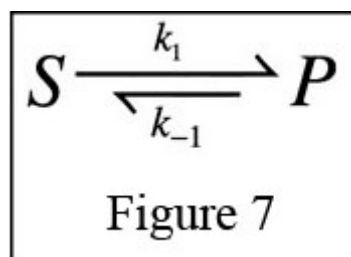


Figure 6

To answer questions 27, 28, 29, and 30 you should match one antigen with one antigen binding site using the rules of molecular recognition you learnt in class and which you practised in post lecture quizzes.

27. Which antigen binding site would recognise and bind to antigen A1?
1. BS4
 2. BS1
 3. BS3
 4. BS2
28. Which antigen binding site would recognise and bind to antigen A2?
1. BS5
 2. BS1
 3. BS4
 4. BS3
29. Which antigen binding site would recognise and bind to antigen A3?
1. BS1
 2. BS4
 3. BS2
 4. BS5
30. Which antigen binding site would recognise and bind to antigen A4?
1. BS2
 2. BS4
 3. BS1
 4. BS3

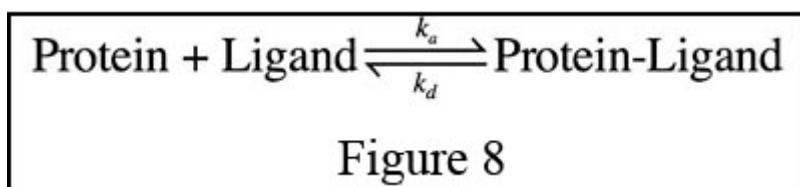
Questions 31 and 32 refer to the effects of an enzyme on the general reaction shown in Figure 7 below:



31. Which of the following statements is **CORRECT**?
1. The activation energy $\Delta G^\ddagger$ for the reaction is decreased.
 2. The concentration of the product is increased.
 3. The reaction equilibrium is shifted away from the substrate.
 4. The free energy change, ΔG , for the reaction is increased.
32. Refer to Figure 7. Which of the following statements is **CORRECT**?
1. The reaction rates (k_1 and k_{-1}) are unchanged
 2. The reverse reaction rate (k_{-1}) is increased
 3. The forward reaction rate (k_1) is decreased
 4. The reverse reaction rate (k_{-1}) is decreased

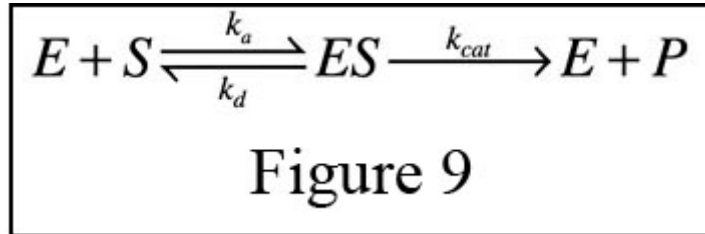
33. For an enzyme-catalysed reaction, when the substrate concentration is equal to the Michaelis constant, i.e. $[S] = K_M$,
1. 50% of the active sites are occupied by substrate.
 2. increasing $[S]$ by 50% will have little effect on the reaction rate.
 3. less than 10% of the active sites are occupied by substrate.
 4. about 90% of the active sites are occupied by substrate.
34. In reference to the transition state of an enzyme-catalysed reaction, the
1. interactions between enzyme and substrate are maximised.
 2. binding between the enzyme and substrate is weak.
 3. substrate is in its most stable form.
 4. transition state is long-lived.
35. Which of the following statements is **INCORRECT**?
1. Organic enzyme co-factors are often derived from vitamins.
 2. Enzymes can only be composed of protein.
 3. Many enzymes require metal ions as co-factors.
 4. RNA molecules can act as enzymes.

Question 36 relates to the binding equilibrium, shown in Figure 8 below, between protein and ligand, where k_a and k_d are the rates for association and dissociation respectively:



36. When the concentration of the ligand is equivalent to the equilibrium constant K_D :
1. further increases in ligand concentration will not significantly change the fraction of protein binding sites occupied by ligand.
 2. 50% of the protein binding sites will be occupied by ligand.
 3. 10% of the protein binding sites will be occupied by ligand.
 4. 90% of the protein binding sites will be occupied by ligand.

The following question refers to the Michaelis-Menten model of enzyme activity, which considers the conversion of substrate, S, to product, P, as a two-step process as shown in Figure 9:



37. Which of the following is **NOT** an assumption of the Michaelis-Menten model of enzyme action?
1. The concentration of substrate, [S], is much greater than the concentration of enzyme [E]
 2. Product is converted back to substrate at a significant rate.
 3. k_{cat} is the rate-limiting step in the conversion of substrate to product.
 4. The concentration of the enzyme-substrate complex, [ES], is constant over the time of the measurement.
38. When the initial rate, v , of an enzyme-catalysed reaction is at half its maximum possible rate, V_{max} , the concentration of substrate [S], is equal to:
1. K_M
 2. $\frac{K_M}{V_{max}}$
 3. k_a
 4. k_d

39. When the substrate concentration $[S]$, is much smaller than the Michaelis-Menton constant K_M , which of the following statements is **INCORRECT**?
1. The initial reaction rate, v , is directly proportional to $[S]$.
 2. Increasing $[S]$ will not increase the initial reaction rate, v .
 3. Almost all of the active sites of the enzyme are empty.
 4. The concentration of free enzyme is higher than the concentration of enzyme-substrate complex, $[ES]$.
40. The initial rate, v , of an enzyme-catalysed reaction, is related to the substrate concentration, $[S]$, by the Michaelis-Menten equation. Which of the following expressions **CORRECTLY** states that equation?

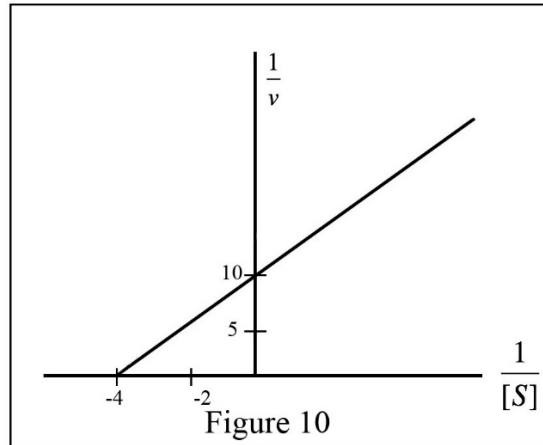
1.
$$v = \frac{V_{\max}[S]}{K_M + [S]}$$

2.
$$v = \frac{V_{\max}[S]}{K_M - [S]}$$

3.
$$v = \frac{V_{\max} + [S]}{K_M [S]}$$

4.
$$v = \frac{V_{\max}[S]}{K_M [S]}$$

Questions 41, 42 and 43 all relate to the graph shown in Figure 10 below, which was produced in an experiment to determine the kinetic analysis of a new enzyme. The substrate concentration $[S]$ was measured in μM , and the rate of the enzyme was measured using a photometric assay as $\Delta\text{mAU}/\text{min}$. Please study the graph carefully and answer the questions below.



41. The Michaelis-Menten constant, K_M , of an enzyme-catalysed reaction:
 1. is the substrate concentration required to produce half the maximum reaction rate.
 2. is a measure of how quickly the enzyme can release the substrate.
 3. None of the other answers are correct.
 4. has a higher numerical value if the enzyme has a high affinity for the substrate.

42. This graph in Figure 10 shows a graphical representation of the:
 1. Michaelis-Menton equation, where the K_M of the enzyme can be calculated from this graph to be $0.25 \mu\text{M}$.
 2. Michaelis-Menton equation, where the K_M of the enzyme can be calculated from this graph to be $-0.25 \mu\text{M}$.
 3. Lineweaver-Burke equation, where the K_M of the enzyme can be calculated from this graph to be $0.25 \mu\text{M}$.
 4. Lineweaver-Burke equation, where the K_M of the enzyme can be calculated from this graph to be $-0.25 \mu\text{M}$.

43. In Figure 10, the $V_{\max}$ of the enzyme can be calculated from the graph to be:
 1. $10 \Delta\text{mAU}/\text{min}$.
 2. $4 \Delta\text{mAU}/\text{min}$.
 3. $0.1 \Delta\text{mAU}/\text{min}$.
 4. $0.25 \Delta\text{mAU}/\text{min}$.

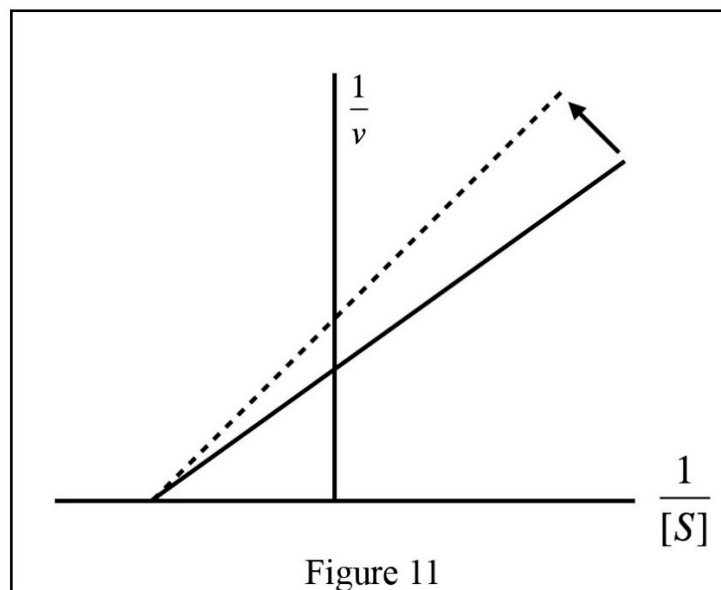
44. A reversible non-competitive enzyme inhibitor can bind to:
 1. only the free enzyme.
 2. both the free enzyme and the enzyme-substrate complex.
 3. only the enzyme-substrate complex.
 4. only the free substrate.

45. The K_i for an enzyme inhibitor is equal to:

1. The K_M^{app} for substrate in the presence of the inhibitor.
2. The V_{max}^{app} in the presence of the inhibitor.
3. The k_a for the binding of inhibitor to enzyme.
4. The K_d for the binding of inhibitor to enzyme.

Questions 46, 47, 48, 49 and 50 relate to the scenario below. Please consider the scenario carefully and then answer the questions that follow. You are called in to assist the investigation into the murder of the head research scientist at a biomedical institute, Professor Slott. There is evidence that Prof. Slott has been killed using one of the enzyme inhibitors that have been developed at the institute. The main project at the institute is an investigation into a respiratory enzyme, referred to as Respiratory Enzyme X, and three separate laboratories within the institute have each developed a potential inhibitor. Each inhibitor has a different mechanism of action.

The detectives want you to figure out which inhibitor has been used to kill Prof. Slott as this may identify the killer. The inhibitor that is purified from the deceased Prof. Slott is used in an enzyme inhibitor assay. The results given in Figure 11 are for a reversible inhibitor, where the black line refers to the activity of the enzyme alone and the dotted line refers to the activity of the enzyme in the presence of the inhibitor, I. The arrow highlights the change that has occurred in the presence of the inhibitor.



46. What type of inhibition is being exhibited in Figure 11?
1. Uncompetitive
 2. Allosteric homotropic
 3. Non-competitive
 4. Competitive
47. By what factor does the Michaelis-Menton constant, K_M , appear to have been changed in Figure 11?

$$\frac{K_M}{V_{\max}}$$

1. It has increased by $\frac{K_M}{V_{\max}}$
2. It has decreased by $\left(1 + \frac{[I]}{K_i}\right)$
3. None, K_M has remained constant in the presence of inhibitor.
4. It has increased by $\left(1 + \frac{[I]}{K_i}\right)$

48. By what factor does the $V_{\max}$ appear to have been changed in Figure 11?

$$\left(1 + \frac{[I]}{K_i}\right)$$

1. It has increased by $\left(1 + \frac{[I]}{K_i}\right)$
2. It has decreased by $\left(1 + \frac{[I]}{K_i}\right)$
3. None, $V_{\max}$ has remained constant in the presence of inhibitor.

$$\frac{K_M}{V_{\max}}$$

4. It has decreased by $\frac{K_M}{V_{\max}}$

49. To determine the K_i of this inhibitor, a secondary graph could be drawn, plotting the slopes from Lineweaver-Burke plots in the presence of increasing concentrations of inhibitor on the y-axis, against inhibitor concentration on the x-axis. The K_i could then be read from:

1. The y-intercept
2. The x-intercept
3. The negative of the y-intercept
4. The negative of the x-intercept

50. If the inhibitor that killed Prof Slott had a different mechanism to the mechanism shown in Figure 11 above, Which of the following statements is **CORRECT**?

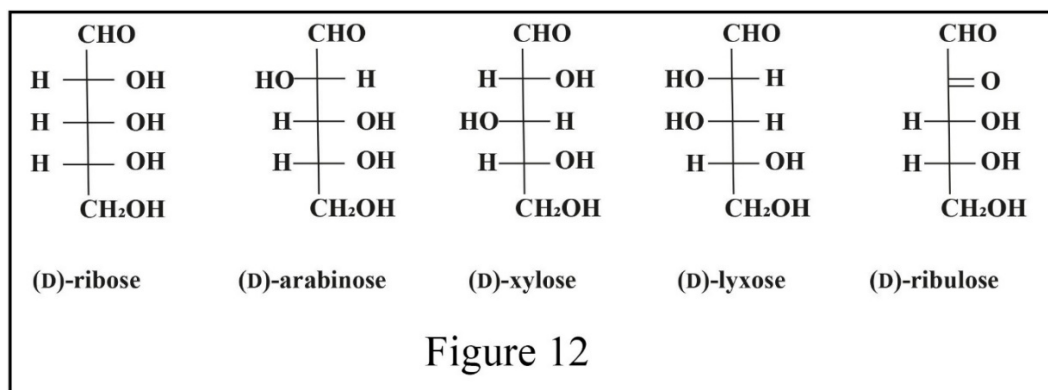
1. In uncompetitive inhibition, the measured value of K_M would change, but $V_{\max}$ would be unchanged.

$$\left(1 + \frac{[I]}{K_i}\right)$$

2. In competitive inhibition, the K_M would appear to increase by $\left(1 + \frac{[I]}{K_i}\right)$
3. In non-competitive inhibition, the K_M would appear to decrease by $\frac{K_M}{V_{\max}}$
4. In allosteric inhibition, it would be impossible to measure a value for $V_{\max}$.

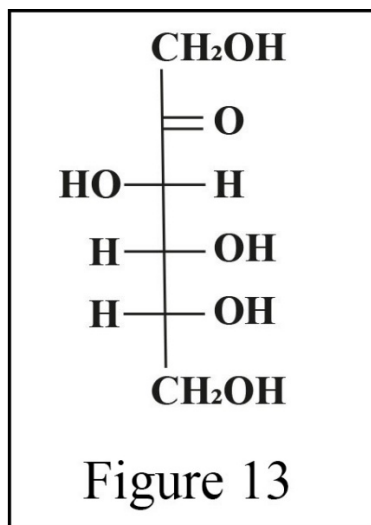
51. Which of the following statements about allosteric enzymes is **INCORRECT**?
1. They obey Michaelis-Menten kinetics.
 2. They show a sigmoidal dependence on substrate concentration.
 3. They are multi-subunit proteins.
 4. They may have binding sites for non-substrate modulators.
52. For a multimeric enzyme showing homotropic allostery, which of the following statements is **INCORRECT**?
1. The binding of substrate to one enzyme subunit causes a conformational change in that subunit.
 2. The binding of substrate to one enzyme subunit increases the K_M of other enzyme subunits for substrate.
 3. The binding of substrate to one enzyme subunit causes a conformational change in other enzyme subunits.
 4. The binding of substrate to one enzyme subunit decreases the K_M of other enzyme subunits for substrate.
53. Energy released by ATP hydrolysis in the cell:
1. cannot make an energetically unfavourable reaction occur.
 2. can be coupled to an unfavourable reaction to alter its equilibrium ratio.
 3. can only be used to change the rate of a reaction and cannot alter its equilibrium ratio.
 4. can only be used to influence chemical reactions, not protein conformations.
54. A common mechanism for the regulation of biosynthetic pathways in the cell is that:
1. the final product of the pathway inhibits the first committed step in the pathway by negative heterotropic feedback.
 2. the first committed step in the pathway is always unregulated, but subsequent steps are allosterically controlled.
 3. the final product of the pathway inhibits the final step in the pathway by negative heterotropic feedback.
 4. the pathway can only be regulated by the availability of precursors in the cell.
55. Which of the following statements about catabolic metabolism is **INCORRECT**?
1. It converts small compounds into larger ones.
 2. It converts large compounds into smaller ones.
 3. The reactions involved are generally energetically favourable.
 4. ATP is generated as a result.

56. Considering the structures below in figure 12, which statement is **INCORRECT**?



1. D-ribose and D-arabinose are enantiomers.
2. D-ribulose has 2 chiral carbons.
3. ribose and arabinose are epimers.
4. ribose and lyxose are diastereomers.

Consider the sugar in the Figure 13 below and answer questions 57 and 58.



57. For the sugar below, which statement is **CORRECT**?

1. This sugar is an L-isomer.
2. This sugar is one of the monosaccharides that join to make sucrose.
3. This sugar can irreversibly cyclise to form a 5-membered ring.
4. This sugar does not occur in nature.

58. Refer to the sugar in the Figure 13.

In the form illustrated, how many stereoisomers are possible?

1. 8
2. 3
3. 12
4. 6

59. Comparing amylopectin and glycogen, which of the following statements is **INCORRECT**?
1. The branch-points in glycogen are more frequent than those in amylopectin.
 2. Both polysaccharides contain branch points formed *via* α -1,6 glycosidic bonds.
 3. Amylopectin contains glucose monomers joined *via* β -1,4 glycosidic bonds.
 4. Glycogen contains glucose monomers joined *via* α -1,4 glycosidic bonds.
60. Which of the following is an example of a monosaccharide?
1. lactose
 2. sucrose
 3. mannose
 4. maltose
61. During aerobic respiration, which of the following molecules directly donates electrons to the electron transport chain at the highest energy level?
1. ATP
 2. ADP
 3. NADH
 4. FADH_2
62. Substrate-level phosphorylation accounts for what percentage of the ATP formed **DIRECTLY** by the reactions of glycolysis?
1. 6.25 %
 2. 100 %
 3. 50 %
 4. 0 %
63. During anaerobic respiration in skeletal muscle, pyruvate is converted to:
1. lactate
 2. acetyl CoA
 3. oxaloacetate
 4. ethanol
64. Which of the following **DO NOT** result in the release of CO_2 ?
1. Conversion of α -ketoglutarate to succinyl CoA.
 2. Conversion of pyruvate to oxaloacetate.
 3. Conversion of isocitrate to α -ketoglutarate.
 4. Conversion of pyruvate to acetyl CoA.
65. The process of chemiosmosis:
1. is essential for ATP production.
 2. refers to the movement of electrons through the electron transport chain.
 3. drives ATP production *via* the ATP synthase complex.
 4. occurs through complex I of the electron transport chain.
66. The electron transport chain:
1. takes place in the cytoplasm of prokaryotic cells.
 2. is a series of substitution reactions.
 3. utilises ubiquinone/co-enzyme Q to shuttle electrons between complexes I and III.
 4. produces ATP *via* substrate-level phosphorylation.

67. A poison reacts with complex I of the electron transport chain. Which of the following is **CORRECT**?

1. The cell will be unable to oxidise FADH_2 .
2. NADH will accumulate.
3. The cell will be unable to reduce ubiquinone.
4. No protons can be pumped across the mitochondrial inner membrane.

68. For the reaction in Figure 14 below, which statement **CORRECT**?

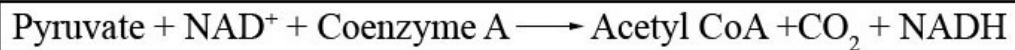
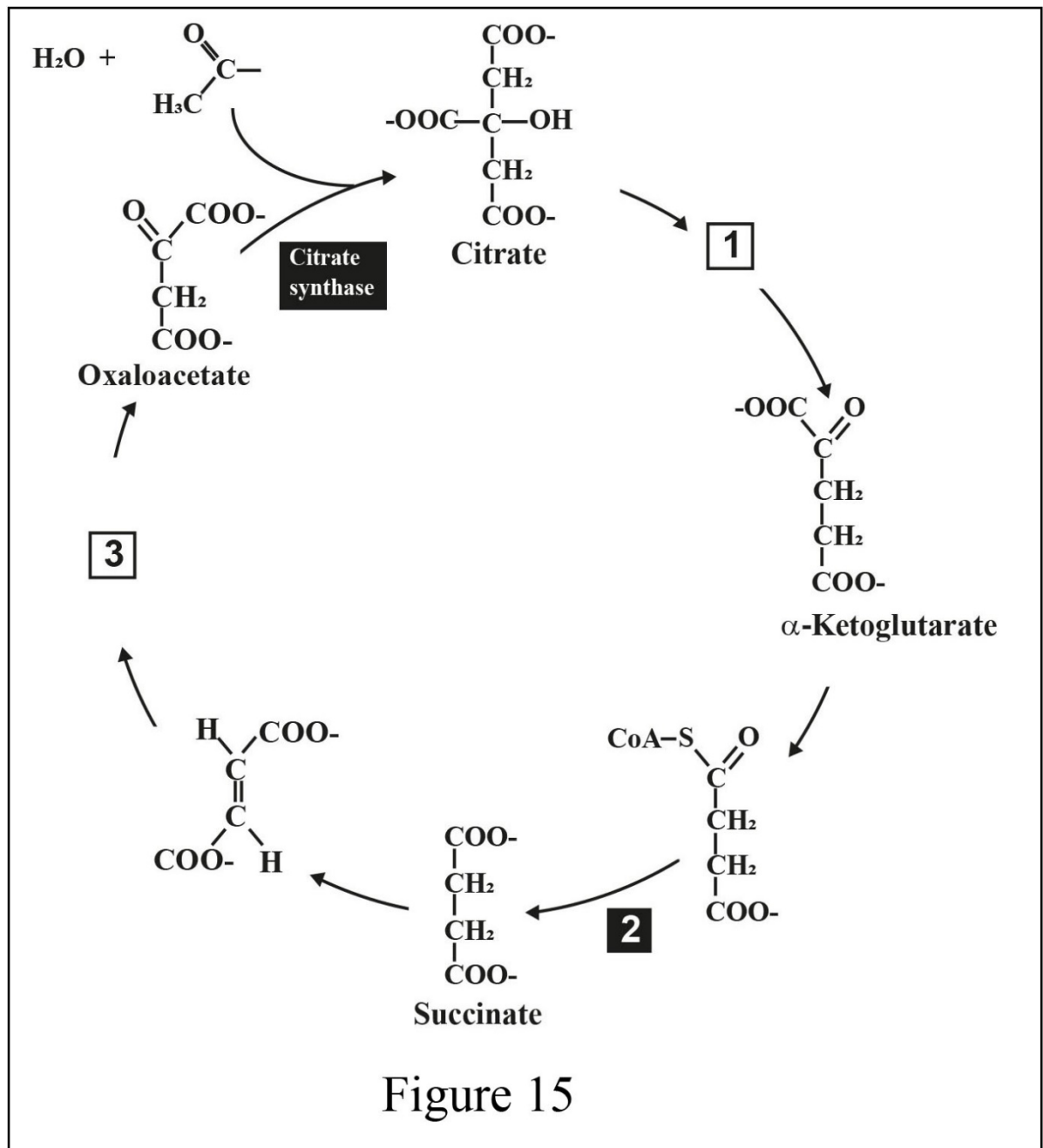


Figure 14

1. Pyruvate is coupled to a lipoamide group, CO_2 is released and the remaining carbons are transferred to coenzyme A.
 2. Pyruvate is first decarboxylated, followed by transfer to a lipoamide group before being transferred to coenzyme A.
 3. Pyruvate is coupled to coenzyme A, decarboxylation is catalysed by a lipoamide group, and acetyl CoA is released.
 4. Pyruvate is coupled to coenzyme A resulting in the release of CO_2 .
69. Which of the following enzymes produces NADH in the citric acid cycle?
1. Aconitase
 2. Malate dehydrogenase
 3. Succinate dehydrogenase
 4. Pyruvate dehydrogenase
70. An experiment is set up to perform a part of glycolysis. Glyceraldehyde 3-phosphate is added as a substrate, along with the enzymes enolase, phosphoglycerate kinase, and pyruvate kinase. What else would you add to the experiment in order to form pyruvate as the end-product?
1. ADP, NAD^+ , phosphoglycerate mutase, glyceraldehyde 3-phosphate dehydrogenase
 2. ADP, NAD^+ , aldolase, pyruvate dehydrogenase
 3. ATP, NAD^+ , phosphoglycerate mutase, glyceraldehyde 3-phosphate dehydrogenase
 4. ATP, NADH, triose phosphate isomerase, pyruvate dehydrogenase
71. The rate of conversion of fructose 1-phosphate to fructose 1,6-bisphosphate is measured in an experiment containing an optimal concentration of ATP. The experiment is repeated but fructose 2,6-bisphosphate is also added. Which statement best describes what happens in the second experiment?
1. The rate is the same since fructose 2,6-bisphosphate is not on the glycolytic pathway.
 2. The rate is decreased since fructose 2,6-bisphosphate inhibits phosphofructokinase.
 3. The rate is increased since fructose 2,6-bisphosphate activates phosphofructokinase.
 4. It is impossible to know without knowing the source of the enzyme used in the reaction.
72. Which of the following effects are likely to be observed following a session of intense exercise?
1. Lactate will be transported to the liver as part of the Cori cycle.
 2. All the other options are correct.
 3. Gluconeogenesis will occur in the liver.
 4. Alanine will be transported to the liver.

73. Figure 15 below depicts the citric acid cycle but only some of the compounds and enzymes are shown.



Pick the answer that matches the correct compound or enzyme to the corresponding number.

1. A = malate; B = aconitase; C = fumarate
2. A = isocitrate; B = succinylCoA synthase; C = malate
3. A = succinyl CoA; B = malate dehydrogenase; C = malate
4. A = isocitrate; B = succinate dehydrogenase; C = fumarate

74. How many ATP molecules can a cell synthesise from one molecule of acetyl CoA oxidised to CO_2 and water through cellular respiration? Assume 2.5 ATP per NADH and 1.5 ATP per FADH_2 .
1. 12.5
 2. 10
 3. 7.5
 4. 9
75. Glucagon:
1. stimulates glycolysis in skeletal muscle.
 2. All other options are correct.
 3. stimulates gluconeogenesis in the liver.
 4. is secreted in response to high blood glucose levels.
76. The R-state of muscle phosphorylase b is:
1. inactive.
 2. formed by phosphorylation at a serine.
 3. favoured by high AMP concentrations.
 4. activated by ATP.
77. Which of the following enzymes is **NOT** involved in bypassing one of the irreversible steps of glycolysis?
1. phosphoenolpyruvate carboxykinase
 2. phosphoglucose isomerase
 3. pyruvate carboxylase
 4. fructose 1,6-bisphosphatase
78. An experiment is performed to purify different organelles from cells. The cell contents are separated into five different fractions. Only one of these fractions contains the mitochondria. How would you determine which fraction contains the mitochondria?
1. By measuring the activity of the enzyme glyceraldehyde 3-phosphate.
 2. By measuring the activity of the enzyme succinate dehydrogenase.
 3. By measuring the activity of the enzyme enolase.
 4. By measuring the glucose concentration.
79. During intense exercise, glycolysis is stimulated by:
1. activation of phosphofructokinase by AMP.
 2. phosphorylation of pyruvate kinase.
 3. activation of pyruvate carboxykinase by acetyl CoA.
 4. conversion of pyruvate to oxaloacetate.
80. Glycogen synthesis is stimulated by which of the following mechanisms?
1. a switch to the R-state of glycogen phosphorylase
 2. cleavage of 10 amino acids from the N-terminus of glycogen synthase
 3. a reduction in the extent of phosphorylation of glycogen synthase
 4. dimerisation of glycogen phosphorylase

81. How many more moles of ATP/GTP are required to make one mole of glucose *via* gluconeogenesis compared to the number of moles of ATP generated by one mole of glucose metabolised by glycolysis?

1. 2
2. 6
3. 4
4. 8

82. Consider the following reaction found in glycolysis:



The standard free energy change for this reaction is -18.8kJ / mol. Which of the following options is **CORRECT**?

1. Under standard conditions this reaction will proceed in the opposite direction to that shown.
2. This reaction is an important step at which glycolysis is regulated.
3. Under cellular conditions, the free energy change is significantly different to the standard free energy change so the reaction can participate in both glycolysis and gluconeogenesis.
4. The large standard free energy change means that the reaction must be bypassed with a separate reaction in order for gluconeogenesis to proceed.

83. Glucokinase is expressed in the liver. Which of the following is **INCORRECT**?

1. Glucokinase has a lower affinity for glucose than muscle hexokinase.
2. Glucokinase is an isoform of hexokinase.
3. Glucokinase is not inhibited by glucose-6-phosphate.
4. Glucokinase is required for glycogen degradation.

84. In the liver after a carbohydrate-rich meal, which of the following does **NOT** occur?

1. Circulating insulin levels increase.
2. Glycolysis is inhibited.
3. The amount of fructose 2,6-bisphosphate in the liver is increased.
4. Glycogenolysis is inhibited.

85. Which of the following enzyme activities is **NOT** involved in glycogen breakdown?

1. phosphorylase
2. phosphatase
3. transferase
4. α -1,6-glucosidase

86. Which of the following statements about gluconeogenesis is **INCORRECT**?

1. Free fatty acids can be used as a carbon source.
2. Alanine from muscle can be used as a carbon source.
3. Lactate from muscle can be used as a carbon source.
4. Glycerol can be used as a carbon source.

87. In cellular respiration, oxygen is consumed during:
1. Substrate-level phosphorylation.
 2. the citric acid cycle.
 3. the electron transport chain.
 4. the Cori cycle.
88. Why does the liver possess an enzyme that specifically cleaves glucose-6-phosphate to form glucose and inorganic phosphate?
1. to supply glucose for glycogen synthesis
 2. to allow glucose to be released into the blood
 3. to ensure adequate phosphate availability
 4. to supply glucose for oxidation by glycolysis
89. Conversion of pyruvate to ethanol is required to:
1. prevent lactic acidosis.
 2. generate acetyl CoA in yeast.
 3. regenerate NAD^+ under anaerobic conditions.
 4. bypass one of the irreversible steps of glycolysis.
90. Which of the following **DOES NOT** regulate the activity of pyruvate kinase?
1. ATP
 2. fructose 1,6-bisphosphate
 3. fructose 2,6-bisphosphate
 4. phosphorylation in response to hormone signalling