

THE UNIVERSITY OF AUCKLAND

INCOURSE TEST 2019

BIOLOGICAL SCIENCES

Foundations of Biochemistry
BIOSCI.106SC

Thursday 19 September 2019 6.30 - 8.00 P.M.

(Time Allowed: 90 minutes)

VERSION 1021672

Student Identification Form

PLEASE COMPLETE THE FOLLOWING:

Family Name: _____

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

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

THE UNIVERSITY OF AUCKLAND**BIOLOGICAL SCIENCES****Foundations in Biochemistry****In-course Assessment Test****Thursday, 19 September 2019 6.30 - 8.00 p.m.****GENERAL INSTRUCTIONS****Roll Slip:**

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

Multiple Choice Questions:

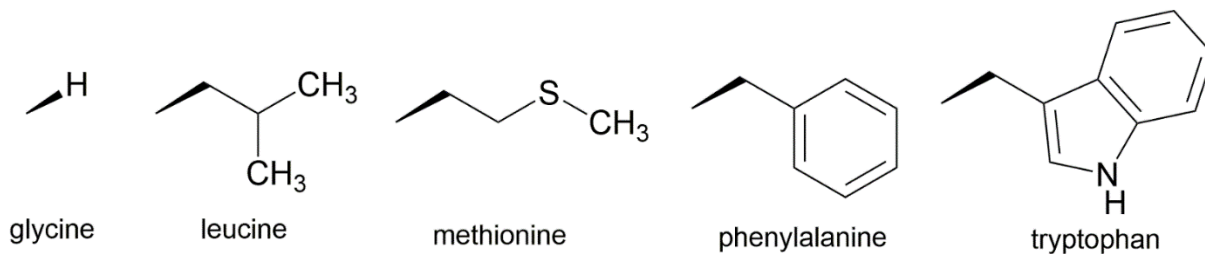
- Use the Teleform Sheet.
- Use **pencils** only. Shade the rectangle completely.
- Do not cross out mistakes. ERASE them completely.
- Complete family name, first name, initial and ID Number. Do not complete your stream. Fill spaces from left to right.
- Your code is **1021672**.
Check this is correct on your teleform.
- Failure to enter the version code or other details correctly will mean your MCQ cannot be marked.

Test Format:

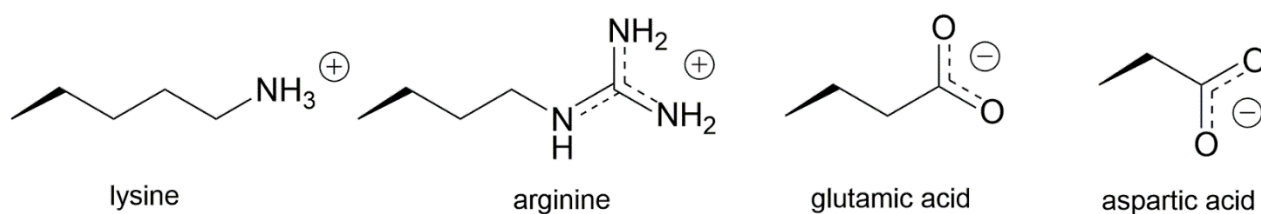
(Total marks = 66)
ALL QUESTIONS SHOULD BE ATTEMPTED.

CHEMICAL STRUCTURES SHEET

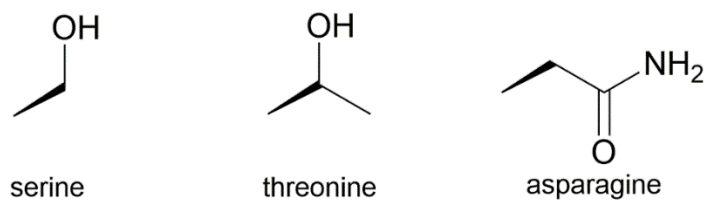
non-polar amino acid side chains



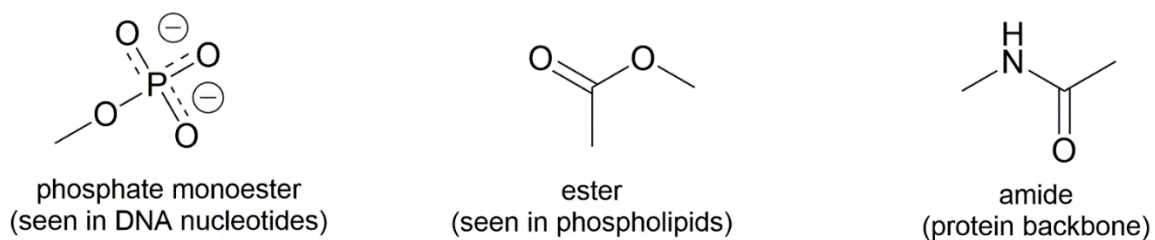
charged amino acid side chains



polar amino acid side chains



other functional groups



MULTIPLE CHOICE QUESTIONS
Test Version Code 1021672

Choose **THE BEST** answer from the alternatives provided.

1. The Periodic Table of Life contains the elements C, H, N, O, P and S. This mixture of so-called first and second tier elements are abundant in biological molecules because:
 1. they have the largest number of electrons of all the elements making them reactive.
 2. they all favour the formation of covalent bonds.
 3. they are chemically unreactive, stable and cannot form non-covalent bonds.
 4. this mixture of atoms makes exclusively hydrophobic molecules.

2. Which of the following statements is **INCORRECT**?
 1. The heavier chemical elements present throughout the Universe were produced by fusion in first-generation stars.
 2. The formation of simple chemicals on primordial Earth required an oxygen-rich atmosphere.
 3. Water supports all life and was required on primordial Earth for molecules to form.
 4. The chemical composition of biological molecules across life on Earth reflects a common evolutionary ancestry.

3. Why does the element carbon form the basis of all biological molecules?
 1. All of the other statements are correct.
 2. Carbon can form polarised covalent bonds with more electronegative elements.
 3. It has only four (4) electrons in its outer electron orbital; electrons can be shared in making new bonds and fill these empty places.
 4. Carbon can form single, double, and triple bonds, providing a diversity of chemical compounds.

4. Consider all the molecules shown in the "Chemical structures sheet" on page 5.

Which statement about these molecules is **CORRECT**?

1. Amide groups form the backbone of DNA.
2. The phosphate monoester group interacts unfavourably with water because of its highly negative charge.
3. The ester group can only function as a hydrogen bond donor.
4. The amide group can simultaneously function as a hydrogen bond donor and hydrogen bond acceptor.

5. Consider all the molecules shown in the "Chemical structures sheet" on page 5.

Which subset of the functional groups can only form dispersion interactions (van der Waals) or interactions involving induced dipoles?

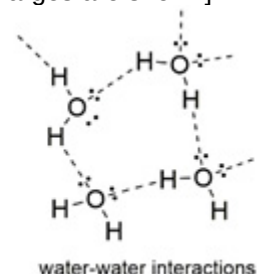
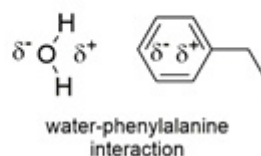
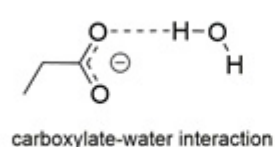
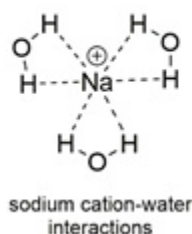
1. polar amino acid side chains
2. both polar and non-polar amino acids
3. charged amino acids
4. non-polar amino acid side chains

6. Consider all the molecules shown in the "Chemical structures sheet" on page 5.

Which of the molecules listed below could form a charge-dipole interaction with a water molecule?

1. both lysine and phosphate monoester
2. both tryptophan and glutamic acid
3. All of the non-polar amino acid side chains; water will induce a full charge in side chains such as phenylalanine.
4. both serine and threonine

7. Which of the arrangements shown between waters molecules and other functional groups below includes unfavourable contacts? [note: only some lone pairs and partial charges are shown]

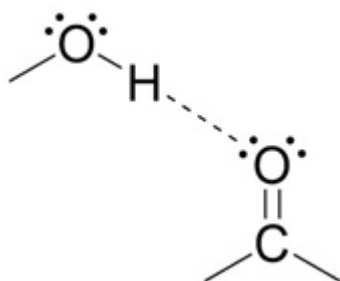


1. sodium cation-water interactions
2. water-water interactions
3. carboxylate-water interaction
4. water-phenylalanine interaction

8. Weak interactions:

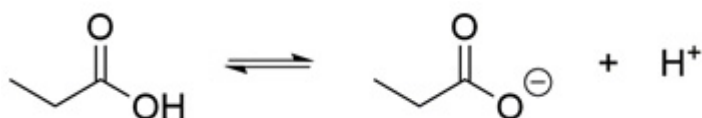
1. provide a stabilising effect when proteins fold up into their functional three-dimensional shapes.
2. are covalent bonds that join atoms together into molecules.
3. are only formed between different molecules.
4. are difficult to break.

9. Which statement about the serine-carbonyl hydrogen bond shown below is **CORRECT**?



1. Carbonyl groups can only form a single hydrogen bond.
2. Hydroxyl groups can only form a single hydrogen bond.
3. The hydrogen bond distance (between H and O) is longer than the sum of the hydrogen and oxygen van der Waals radii.
4. Hydrogen bonds make use of lone pair electrons on oxygen atoms.

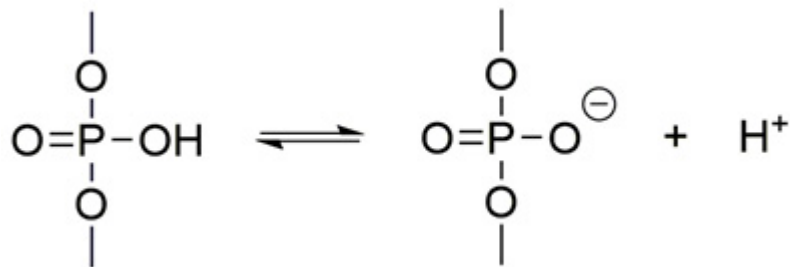
10. The amino acid side chain glutamic acid is a weak acid and has a pKa value of ~4.1. Its dissociation reaction is shown below:



Which statement is **CORRECT**?

1. If a strong acid is added, the glutamic acid buffer system will produce a higher concentration of the conjugate base.
2. Below pH 3.0, the side chain will be protonated.
3. Between pH 4.1 and 7.0, the side chain will most likely be protonated.
4. At a neutral pH of 7.0, the glutamic acid side chain has an equal probability of being in the protonated or deprotonated form.

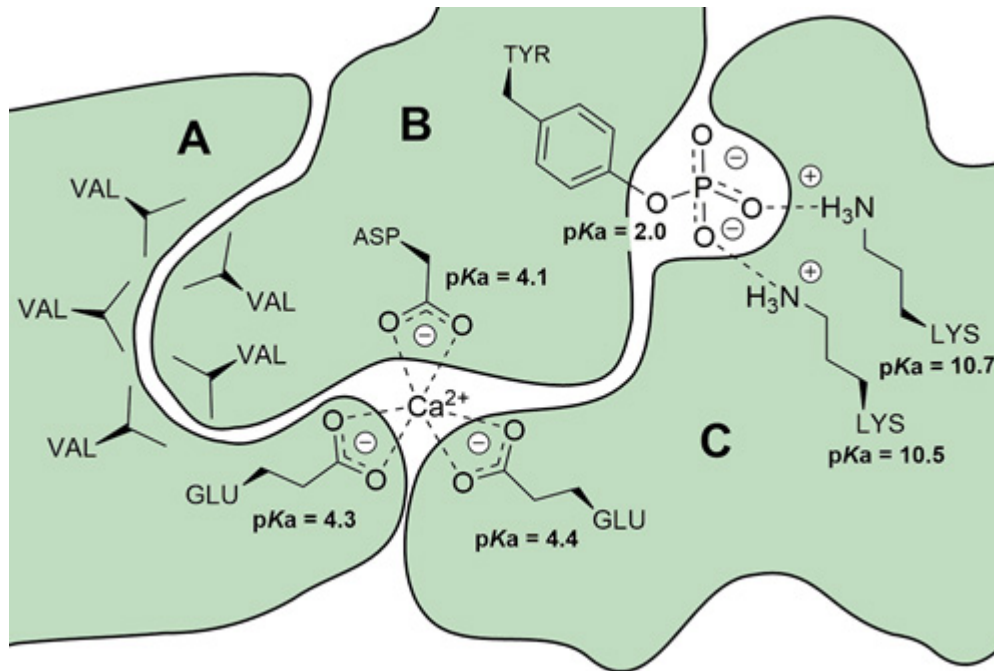
11. The DNA in our bodies is strongly associated with proteins called histones through charge-charge interactions. Histones are small, positively charged molecules. The DNA backbone contains phosphate groups that have a pK_a value of ~ 2 :



Which of the following statements is **CORRECT**?

1. The DNA-histone charge-charge interactions will only occur over a pH range between 2.0 and 7.4. Above pH 7.4 the charges on the DNA backbone will change from negative to positive.
2. At physiological pH (~ 7.4) the DNA phosphates will be in the protonated (uncharged) form and will interact strongly with the positive charges of the histones.
3. Above pH 2, the DNA backbone will carry negative charges to interact with positive charges on the histones.
4. The pK_a value is determined by the rate of enzymatic conversion of the weak acid to produce the conjugate base.

12. The diagram below shows a complex of three proteins **A**, **B**, and **C**. Some important intermolecular interactions that hold the three-protein complex (**A-B-C**) together are shown. The pKa values of the charged side chains are indicated.



The phosphorylation of the tyrosine in protein **B** is part of a cell signalling process. The signalling is regulated by the delivery of the **A-B-C** protein complex to the lysosome (pH < 4.0), where the complex dissociates into separate proteins before each is degraded by proteolysis.

Why does the complex dissociate?

1. At pH 4.0, the phosphorylated tyrosine (TYR) will be protonated and the **B-C** interactions disrupted.
 2. At pH 4.0 or below, the glutamic (GLU) and aspartic (ASP) acids will become protonated and their interaction with the calcium ion disrupted.
 3. The non-polar interface between **A** and **B**, involving valine side chains (VAL), will be disrupted by the change in pH.
 4. At pH 4.0 or below, the lysine (LYS) side chains will be deprotonated and this will disrupt the **B-C** interface.
13. Carbon dioxide:
1. concentrations in the body are influenced by the respiratory rate: the faster you breathe, the more CO₂ is retained in the tissues.
 2. dissolves in the blood to produce hydrochloric acid.
 3. combines with water and is enzymatically converted to carbonic acid.
 4. is produced in the tissues where it is converted to oxygen.

14.

15. Which statement is **INCORRECT**? When DNA folds up spontaneously into a double helix:

1. the overall change in Gibbs Free Energy is positive.
2. specific patterns of hydrogen bonding form between A and T bases, and between G and C bases.
3. the hydrophobic effect induces the relatively hydrophobic base pairs to be hidden in the centre of the molecule. The hydrophilic phosphate groups form hydrogen bonds with water molecules.
4. there is an "energy gain" in forming both hydrogen bonds and base pair stacking (van der Waals) interactions.

16. Which of the following statements is **CORRECT**?

1. Prions are difficult to destroy but lose their infectious properties after a long period of time.
2. Amyloid diseases can be inherited, occur spontaneously, or they can be contracted from ingestion of contaminated food.
3. All amyloid diseases are caused by the same protein.
4. Amyloid fibrils are removed from brain tissue by astrocytes.

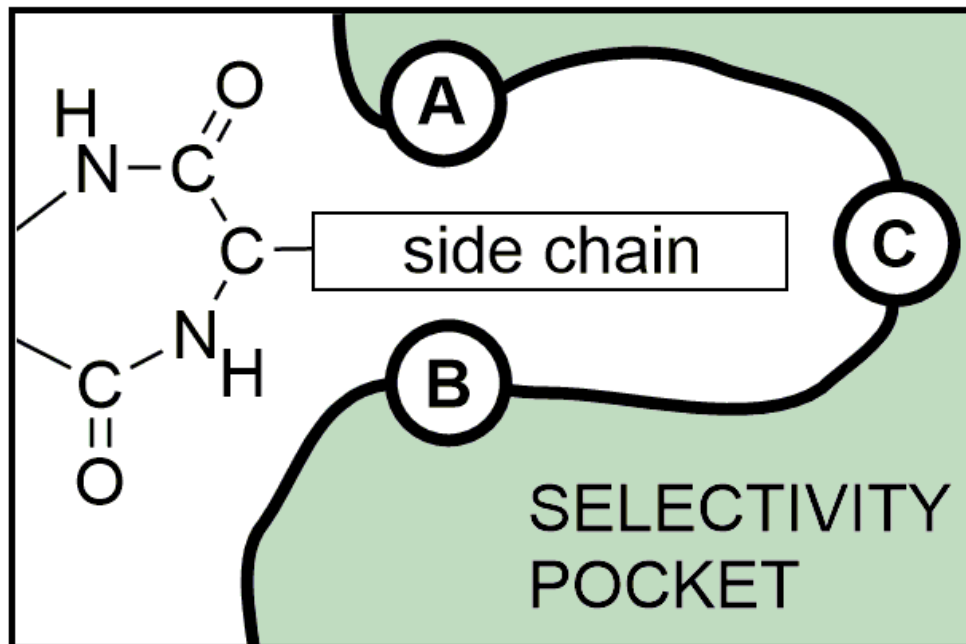
17. Consider the image of a fibril provided below:



Which of the following statements is **CORRECT**?

1. There is no energy barrier for the non-disease form of a protein to convert into the disease forms.
 2. Fibrils are low energy because their structures are stabilised by intermolecular hydrogen bonding between protein monomers.
 3. In amyloid disease: oligomers, aggregates, and fibril structures are dominated by α -helical secondary structure
 4. The detailed mechanism by which a prion converts a normal protein to a disease protein is well known.
18. The serine protease enzyme, trypsin, is involved in digestion. This enzyme cuts its substrate, a protein, into two pieces at specific amino acid sequences. Trypsin has a binding pocket that selectively recognises either a lysine or an arginine side chain.

Consider the figure below and the images provided of amino acid side chains (separate "Chemical structures sheet" on page 5) to answer the question below.

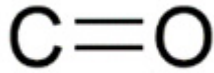


Which amino acids located at positions **A**, **B**, and **C** allow the selectivity pocket to **best** recognise a lysine or arginine side chain binding deeply in the selectivity pocket?

1. A=leucine, B=phenylalanine, C=any amino acid
2. None of the other combinations would be suitable.
3. A=glycine, B=glycine, C=phenylalanine
4. A=glycine, B=glycine, C=aspartic acid

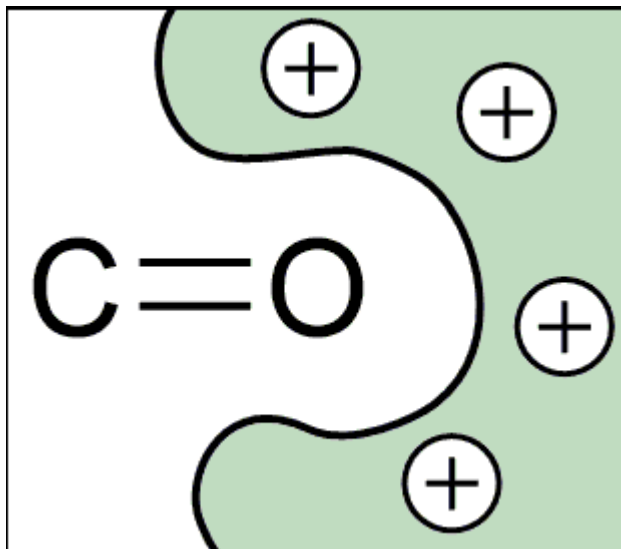
19. Carbonyl groups are often reactive in biology. Some enzymes catalyse the formation of a new covalent bond to the carbonyl carbon of the substrate.

Consider the carbonyl group below to answer the question.



What are the charges on the carbonyl carbon and oxygen respectively?

1. carbon = uncharged, oxygen = full negative charge
 2. carbon = full positive charge, oxygen = full negative charge
 3. carbon = partial positive charge, oxygen = uncharged
 4. carbon = partial positive charge, oxygen = partial negative charge
20. The formation of a new covalent bond in the substrate can occur at an oxyanion site in the enzyme, shown in the figure below. Binding of the carbonyl group at the oxyanion site makes the carbon atom more reactive to bond formation



How does the oxyanion site of the enzyme make the carbon atom more reactive?

1. The C=O bond becomes more polarised and the carbon more positively charged.
 2. None of the other options is correct.
 3. The C=O bond becomes more polarised and the carbon more negatively charged.
 4. A charge-charge interaction between the carbonyl oxygen and the oxyanion site makes the C=O bond less polarised.
21. Which of the following statements about influenza is **CORRECT**?
1. The "H" and "N" nomenclature refers to the host organism either "human" or "non-human".
 2. Hemagglutinin recognition of sialic acid allows the influenza virus to enter the host cell.
 3. Neuraminidase recognises the sugar galactose and cleaves it from the host cell receptors.
 4. Pandemic influenza mostly kills children and the elderly; young adults have robust immune systems and will not become infected.

22. Why is it difficult for humans to contract bird type influenza?
1. Humans have bird type sialic acid receptors in the upper respiratory tract.
 2. Humans have too high a body temperature for bird influenza to survive.
 3. Humans have bird type sialic acid receptors only deep in their lungs.
 4. Birds can only share influenza with other birds.
23. Which of the following statements is **CORRECT**?
1. Enzymes slow down the rate at which a reaction reaches equilibrium, but do not change the position of its equilibrium.
 2. Enzymes change the position of the reaction equilibrium but do not change the rate at which equilibrium is reached.
 3. Enzymes do not change either the position of the reaction equilibrium or the rate at which equilibrium is reached.
 4. Enzymes speed up the rate at which a reaction reaches equilibrium, but do not change the equilibrium position.
24. The transition state of an enzyme-catalysed reaction:
1. contains the least stable form of the substrate.
 2. is long-lived.
 3. inhibits the enzymatic reaction.
 4. contains the most stable form of the substrate.
25. The function of an enzyme is to:
1. reduce both the overall free energy change and the activation energy of a reaction.
 2. reduce the overall free energy change of a reaction.
 3. reduce the activation energy of a reaction.
 4. increase the activation energy of a reaction.

26. In the biological sciences, the affinity of binding between a protein (P) and a ligand (L) to form a protein-ligand complex (P-L) is conventionally described by:

1. the dissociation rate constant, k_d

2. the dissociation equilibrium constant, $K_d = \frac{[P][L]}{[P-L]}$

3. the association equilibrium constant, $K_a = \frac{[P-L]}{[P][L]}$

4. the association rate constant, k_a

27. Which feature do heterotropic allosteric and non-competitive enzyme inhibitors share?

1. They always bind covalently to the enzyme.
2. They bind to a site on the enzyme that is different from the active site.
3. They compete with substrate for binding to the active site.
4. They only bind to the enzyme-substrate complex.

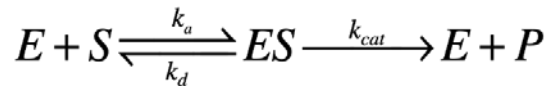
28. A reversible, competitive enzyme inhibitor can bind to:

1. only the enzyme-substrate complex.
2. both the free enzyme and the enzyme-substrate complex.
3. only the free substrate.
4. only the free enzyme.

29. Professor Xavier notices that an enzyme's maximum rate of conversion of substrate to product (V_{max}) is reduced in the presence of Compound X. Has Professor Xavier conclusively proven in this experiment that Compound X is a non-competitive inhibitor and why?

1. No, the result does not prove that Compound X is a non-competitive inhibitor because non-competitive inhibitors increase V_{max} .
2. No, the result is inconclusive because both non-competitive and uncompetitive inhibitors decrease V_{max} .
3. No, the result does not prove that Compound X is a non-competitive inhibitor because non-competitive inhibitors never alter V_{max} .
4. Yes, the result conclusively shows that compound X is non-competitive inhibitor because non-competitive inhibitors decrease V_{max} .

30. The following question refers to the Michaelis-Menten model of enzyme activity. This model considers the conversion of substrate, S , to product, P , by the enzyme, E , to be a two-step process as shown in the equation below:



Which of the following is **NOT** an assumption of the Michaelis-Menten model of enzyme action?

1. The concentration of the enzyme-substrate complex, $[ES]$, is constant over the time of the measurement.
 2. The conversion of the enzyme-substrate complex, ES , to $E + P$ is the rate-limiting step in the conversion of substrate to product.
 3. The binding of S to E to form the enzyme-substrate complex, ES , is the rate-limiting step in the conversion of substrate to product.
 4. The concentration of substrate, $[S]$, is much greater than the concentration of enzyme, $[E]$.
31. 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 options is the Michaelis-Menten equation?

1.
$$v = \frac{V_{\max} [S]^n}{K + [S]^n}$$

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

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

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

32. Which of the following options describing the Michaelis-Menten constant, K_M , is **INCORRECT**?

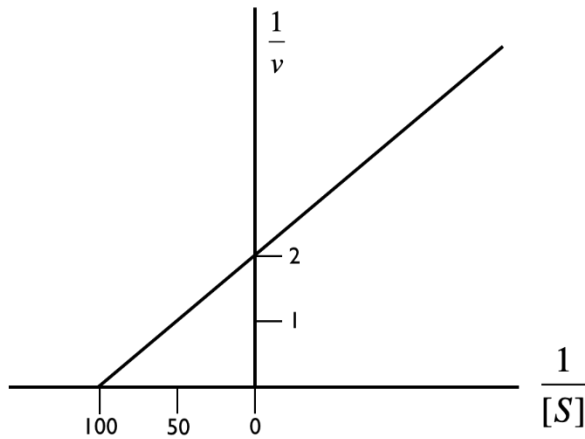
1. The K_M represents the concentration of substrate, S , at which half the active sites of the enzyme, E , are occupied.

2.
$$K_M = \frac{k_d + k_{cat}}{k_a}$$

3.
$$K_M = \frac{[E][S]}{[ES]}$$

4. The K_M represents the concentration of substrate, S , at which the enzyme is working at its maximal rate.

An experiment to determine the kinetics of a new enzyme was performed. The substrate concentration $[S]$, measured in μM , was varied, 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 Questions 33 to 35.**



33. The graph shows a graphical representation of the:

1. Second Law of Thermodynamics
2. Hill Equation
3. Michaelis-Menten equation
4. Lineweaver-Burke equation

34. The K_M of the enzyme, as read from this graph, is:

1. $100 \mu\text{M}$
2. $0.01 \mu\text{M}$
3. $-0.01 \mu\text{M}$
4. $-100 \mu\text{M}$

35. The V_{max} of the enzyme, as read from this graph, is

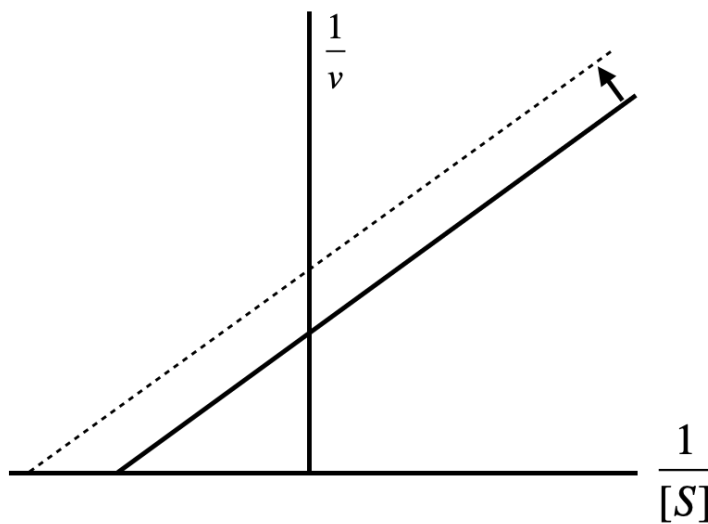
1. $-2 \Delta\text{mAU}/\text{min}$
2. $1 \Delta\text{mAU}/\text{min}$
3. $0.5 \Delta\text{mAU}/\text{min}$
4. $2 \Delta\text{mAU}/\text{min}$

Please consider the following scenario to answer Questions 36 to 39.

Avocados turn brown due to the presence of an enzyme, polyphenol oxidase (PPO) that in the presence of oxygen catalyses the conversion of phenols into polyphenols (which are brown in colour).

Professor Jeremy discovers an enzyme inhibitor that once sprayed on avocados, inhibits the enzyme PPO and therefore prevents avocados from turning brown when cut open. Before he can sell his research (and make lots of money from smashed-avocado-on-toast fans), he needs to determine the mechanism of action for this inhibitor.

The results of his experiment with the PPO enzyme and the inhibitor are shown in the graph below. The results given in the graph below 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 I



36. What type of inhibition is being exhibited?

1. Non-competitive
2. Allosteric homotropic
3. Uncompetitive
4. Competitive

37. By what factor does the Michaelis-Menten constant K_M , appear to have been changed?

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

38. By what factor does the $V_{\max}$ appear to have been changed?

1. None, it has remained constant.

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

3. It has increased by $\left(1 + \frac{[I]}{K_i}\right)$

4. It has decreased by $\left(1 + \frac{[I]}{K_i}\right)$

39. The enzyme inhibitor identified in this experiment can bind to:

1. only the free substrate.
2. both the free enzyme and the enzyme-substrate complex.
3. only the enzyme-substrate complex.
4. only the free enzyme.

40. Which of the following statements about allosteric enzymes is **CORRECT**?

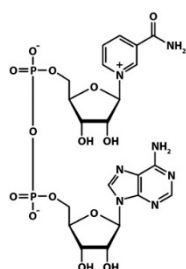
1. A graph of the reaction velocity, v , against the substrate concentration, $[S]$, is a sigmoidal curve.
2. The reaction velocity, v , reaches a maximum value at very low substrate concentration, $[S]$.
3. Their behaviour is fully explained by the Michaelis-Menten model.
4. All of the other options are incorrect.

41. Which statement given below regarding the hydrolysis of ATP to ADP is **INCORRECT**?

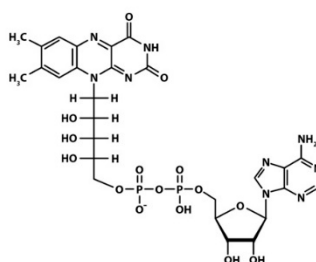
1. There is a special 'high energy' characteristic in the O-P bond that is hydrolysed.
2. Water can more effectively hydrate free phosphate compared to ATP.
3. There is greater resonance stabilisation of free mono-phosphate compared to the tri-phosphate in ATP.
4. Electrostatic repulsion within ATP is energetically unfavourable.

42. The first committed step in a biosynthetic pathway is often catalysed by:
1. an allosteric enzyme stimulated by the final product of the pathway.
 2. an unregulated enzyme obeying Michaelis-Menten kinetics.
 3. a pro-enzyme regulated by proteolysis.
 4. an allosteric enzyme inhibited by the final product of the pathway.
43. The standard redox potential ($\Delta E'_0$) for a redox reaction involving the transfer of two electrons is +0.1 V. What is the standard free energy change ($\Delta G^{\circ'}$) for this reaction? (You should assume that the standard free energy change is defined by: $\Delta G^{\circ'} = -nF \Delta E'_0$; the Faraday constant is 100 kJ/molV, and that the reaction is taking place at pH 7 and 25°C.)
1. -10 kJ/mol
 2. -20 kJ/mol
 3. +40 kJ/mol
 4. +20 kJ/mol
44. Would you expect the reaction in Question 43 to be coupled to the energetically favourable oxidation of FADH₂ to FAD?
1. There is not enough information provided to determine the answer.
 2. No, because the negative value for $\Delta G^{\circ'}$ indicates that the reaction is spontaneous.
 3. Yes, because the positive value for $\Delta G^{\circ'}$ indicates that the reaction is spontaneous.
 4. Yes, because the positive value for $\Delta E'_0$ indicates that the reaction is not spontaneous.
45. Which of the following features was **NOT** likely present in LUCA?
1. proton gradients
 2. iron sulphur clusters
 3. the ability to breakdown glucose by glycolysis
 4. the production of ATP through ATP synthase

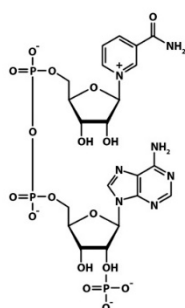
46. Consider the image below:



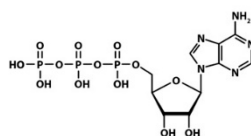
Compound A



Compound B



Compound C



Compound D

Which of the compounds is **NOT** involved in electron transfer reactions (redox reactions)?

1. compound C
2. compound A
3. compound B
4. compound D

47. Which statement **BEST** describes the role of ferredoxin in LUCA?

1. It transfers electrons to H^+ to produce H_2 .
2. Its active site contains copper.
3. It becomes permanently oxidised and excreted from the cell.
4. It shuttles electrons from the protein called Energy Converting Hydrogenase (Ech) to CO_2 .

48. Which of the following features was **NOT** available in significant quantities within alkaline hydrothermal vents at the time LUCA evolved?

1. iron sulphur complexes
2. hydrogen
3. oxygen
4. carbon dioxide

49. Which statement must be **CORRECT** for an electron transfer reaction (i.e. a redox reaction) to be energetically spontaneous?
1. The change in reduction potential ΔE° must be negative.
 2. The reaction must proceed with a positive ΔG value.
 3. The change in reduction potential ΔE° must be positive.
 4. The two groups involved in the transfer must be in direct contact.

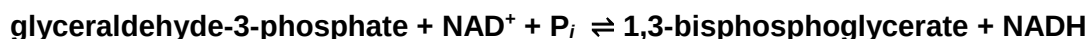
Please refer to the table below to answer Question 50:

Half reaction	E'° (V)
$\text{Fumarate}^{2-} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{Succinate}^{2-}$	0.03
$\text{Oxaloacetate}^{2-} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{Malate}^{2-}$	-0.17
$\alpha\text{-ketoglutarate}^{2-} + \text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{Citrate}^{2-}$	-0.38
$\text{Succinate} + \text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \alpha\text{-ketoglutarate}^{2-} + \text{H}_2\text{O}$	-0.67
$\text{NAD}^+ + \text{H}^+ + 2\text{e}^- \rightarrow \text{NADH}$	-0.32
$\text{FAD} + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{FADH}_2$	-0.22

50. The table above shows standard reduction potentials of some biological important reactions at 25°C and pH 7.

Which of the following reactions proceeds spontaneously in the indicated direction?

1. $\text{Oxaloacetate}^{2-} + \text{NADH} \rightarrow \text{Malate}^{2-} + \text{NAD}^+$
 2. $\alpha\text{-ketoglutarate}^{2-} + \text{CO}_2 + \text{NADH} \rightarrow \text{Citrate}^{2-} + \text{NAD}^+$
 3. $\text{Succinate}^{2-} + \text{FAD} \rightarrow \text{Fumarate}^{2-} + \text{FADH}_2$
 4. $\text{Succinate} + \text{CO}_2 + \text{NADH} \rightarrow \alpha\text{-ketoglutarate}^{2-} + \text{H}_2\text{O} + \text{NAD}^+$
51. The following reaction occurs in glycolysis and is catalysed by the enzyme glyceraldehyde-3-phosphate dehydrogenase. Under standard conditions the free energy change (ΔG) is + 6.3 KJ/Mol.



Which of the following statements about this reaction is **INCORRECT**?

1. Increasing the NADH concentration could potentially drive the reaction in the reverse direction (i.e. to the left).
2. Increasing the concentration of NAD^+ could potentially drive the reaction in the forwards direction (i.e. to the right).
3. The reaction does not proceed in the direction indicated under standard conditions (i.e. to the right).
4. Changing the enzyme concentration will change the ΔG value.

52. Which of the following statements is **INCORRECT** about carbohydrate polymers composed of D-glucose?
1. Glycogen can be broken down in skeletal muscle by glycolysis.
 2. Cellulose is composed of repeating β -1,4-glycosidic linkages.
 3. Starch and glycogen are composed of α -1,4-glycosidic linkages.
 4. Both cellulose and glycogen contain branch points comprising α -1,6- and β -1,6 linkages.

53. Which of the following enzymes does **NOT** catalyse a reaction in glycolysis that is considered irreversible?

1. pyruvate kinase
2. phosphofructokinase
3. glyceraldehyde-3-phosphate dehydrogenase
4. hexokinase

54. The breakdown/processing of one glucose molecule by glycolysis generates a total of four (4) ATP molecules. However, overall there is only a net gain of two (2) ATP for each glucose that enters the pathway.

Why does the metabolism of glucose through glycolysis only result in a net production of two (2) ATP molecules?

1. Two (2) ATP molecules are used to synthesise two (2) NADH molecules in the second phase of glycolysis.
2. Two (2) ATP molecules are used in the initial phase of glycolysis thereby reducing the net gain to two (2) ATP molecules.
3. Two (2) ATP molecules are used to convert pyruvate to a form that can enter the citric acid cycle
4. Two (2) ATP molecules are generated by each of the pyruvate molecules produced by glycolysis.

55. Identify the statement which describes the role of mitochondria in cells.

1. Mitochondria transform the energy captured by NADH into cellular energy in eukaryotic cells.
2. The only role of mitochondria is to protect all the DNA in eukaryotic cells
3. Glucose is converted into pyruvate in the matrix of the mitochondria.
4. None of the other options are correct.

56. Which of the following components or processes is **NOT** part of the electron transport chain?

1. iron sulphur clusters
2. oxidation of NADH and FADH₂
3. oxygen
4. generation of ATP from ADP

57. Oligomycin is an inhibitor of ATP synthase and inhibits cellular respiration when incubated with mitochondria. However, if mitochondria express uncoupling protein-1 (UCP-1) then some respiration still occurs (as measured by oxygen consumption).

Which of the following statements describes how this occurs?

1. UCP-1 increases the levels of ATP synthase and components of the electron transport chain to overcome oligomycin's inhibitory effect.
 2. UCP-1 overcomes the effect of oligomycin by increasing the number of mitochondria.
 3. UCP-1 provides an alternative route for protons to enter the mitochondrial matrix.
 4. UCP-1 prevents oligomycin from binding to ATP synthase so that respiration can still proceed.
58. If skeletal muscles work to the point of fatigue, the muscle cells may not have sufficient oxygen to carry out aerobic respiration. Which process(es) can muscle cells use to continue working if oxygen is not available?
1. converts pyruvate to alanine
 2. oxidation of pyruvate via pyruvate dehydrogenase and the TCA cycle (Krebs cycle)
 3. lactic acid fermentation
 4. ethanol fermentation
59. In eukaryotic cells, each process of cellular metabolism generates a different net amount of ATP. Which process below directly metabolises the greatest number of ATP molecules for each glucose molecule?
1. glycolysis
 2. lactic acid fermentation
 3. the electron transport chain and ATP synthase
 4. TCA cycle (Krebs cycle)
60. One function of both alcohol fermentation and lactic acid fermentation is to:
1. oxidise FADH_2 to FAD
 2. reduce NAD^+ to NADH
 3. reduce FAD to FADH_2
 4. oxidise NADH to NAD^+

61. Which of the following options defines a correct sequence of the electron transport chain?
1. Complex I $\rightarrow$ Complex II $\rightarrow$ Complex III $\rightarrow$ Complex IV
 2. Complex II $\rightarrow$ Cytochrome c $\rightarrow$ Complex III $\rightarrow$ Coenzyme Q $\rightarrow$ Complex IV
 3. Complex III $\rightarrow$ Coenzyme Q $\rightarrow$ Complex IV $\rightarrow$ ATP synthase
 4. Complex II $\rightarrow$ Coenzyme Q $\rightarrow$ Complex III $\rightarrow$ Cytochrome c $\rightarrow$ Complex IV

62. Which of the following statements about ATP synthase is **INCORRECT**?
1. It contains a stator protein component.
 2. Hydrogen ions diffuse back into the matrix through ATP synthase.
 3. It is the final component of the electron transport chain.
 4. It is located within the inner mitochondrial membrane.
63. Futile cycles are avoided in glycolysis and gluconeogenesis because these pathways:
1. occur in completely different cellular compartments.
 2. occur in different tissues.
 3. have key metabolic steps that use different enzymes.
 4. are completely distinct pathways involving different enzymes.
64. High concentrations of ATP inhibit the enzyme activities of both phosphofructokinase and pyruvate kinase. What is the metabolic significance of this inhibition?
1. Inhibition enables two separate bypass enzymes to catalyse the reverse reactions.
 2. It enables the cell to decrease glycolysis and ATP production when the cell's energy status is high.
 3. It favours the conversion of pyruvate to lactate.
 4. It promotes the movement of pyruvate into the mitochondria and oxidation through aerobic respiration
65. Although glycolysis can occur in most cells, the major site of gluconeogenesis is limited to certain tissues. Which tissue is **NOT** a major site of gluconeogenesis?
1. All three tissues are major site of gluconeogenesis.
 2. Kidney
 3. Liver.
 4. Muscle
66. Which of the following is the liver enzyme that cleaves the phosphate from glucose-6-phosphate to form glucose?
1. fructose-1,6-bisphosphatase
 2. hexokinase
 3. glucokinase
 4. glucose-6-phosphatase