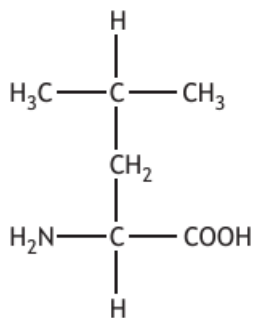


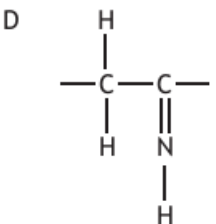
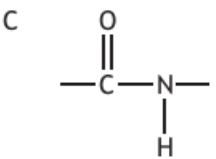
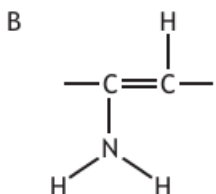
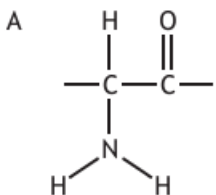
1. The diagram shows the structure of the amino acid leucine.



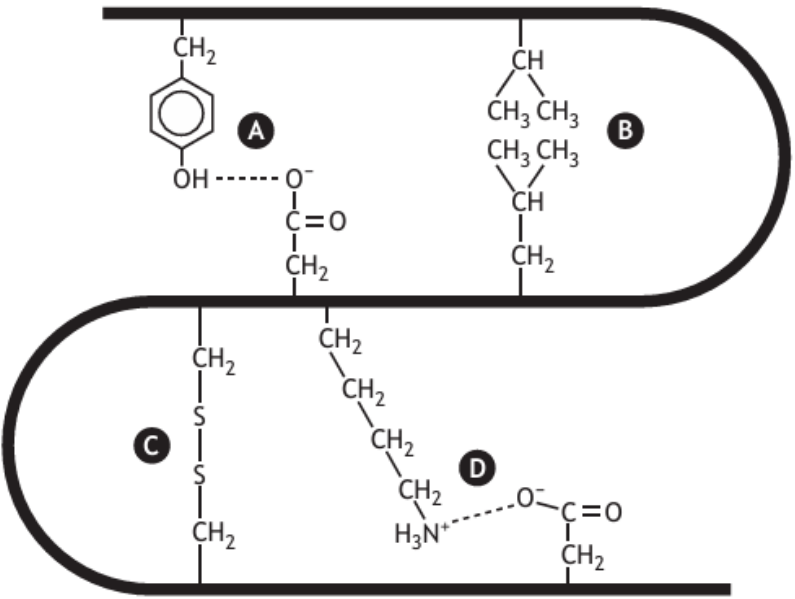
To which class of amino acids does leucine belong?

- A Polar
- B Hydrophobic
- C Acidic
- D Basic

2. Which of the following diagrams illustrates a peptide bond?



3. The diagram shows some interactions between amino acid R-groups in a polypeptide chain. Which letter shows hydrophobic interactions?



Which of the following is a covalent bond that stabilises the tertiary structure of a protein?

- A Disulphide bridge
- B Hydrogen bond
- C Ionic bond
- D Hydrophobic interactions

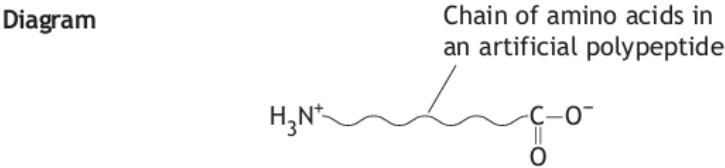
4. A hydrophobic amino acid has an R group that is

- A negatively charged
- B positively charged
- C not polar
- D polar.

5. The table below shows the charges on the R groups of four amino acids at a certain pH. An artificial polypeptide consisting of a chain of only 24 of these amino acids has the ratio 3glycerates:2asparates:2lysines:1glycine and is shown in the diagram below. The charge on each chain terminus is also shown.

Table

Charge on R Group = +1	Charge on R Group = -1
glycerate	lysine
aspartate	glycine



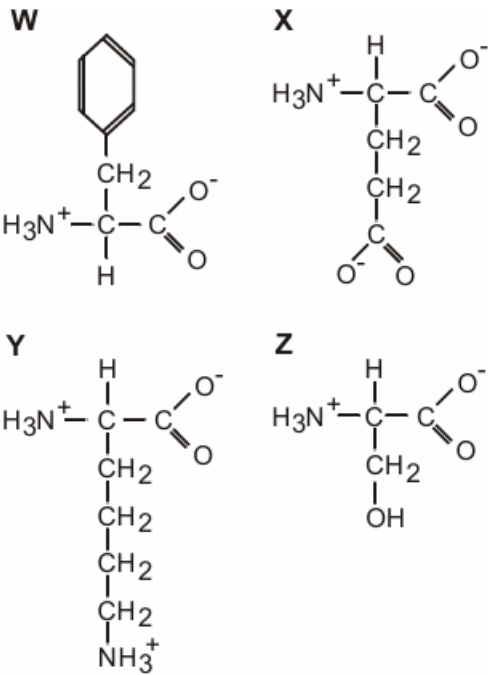
From the information given, what is the overall net charge on this polypeptide at this pH?

- A -6
- B -3
- C +3
- D +6

6. R groups of amino acids, which are polar, acidic and basic, are attracted to water molecules in the cytoplasm of cells and are therefore described as

- A charged
- B hydrophilic
- C ionised
- D hydrophobic.

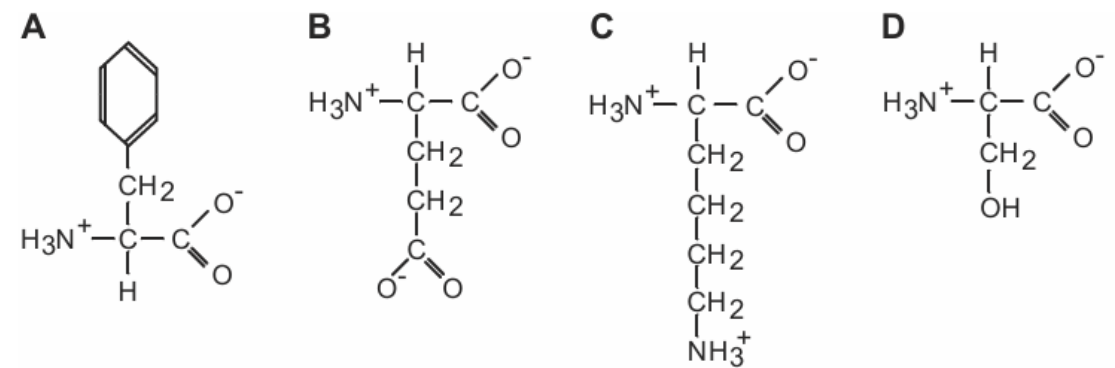
7. The figure below represents the structure of four amino acids.



Which row in the table shows the classification of the four amino acids?

	Basic	Polar	Hydrophobic	Acidic
A	Y	Z	W	X
B	Z	W	X	Y
C	W	X	Y	Z
D	X	Y	Z	W

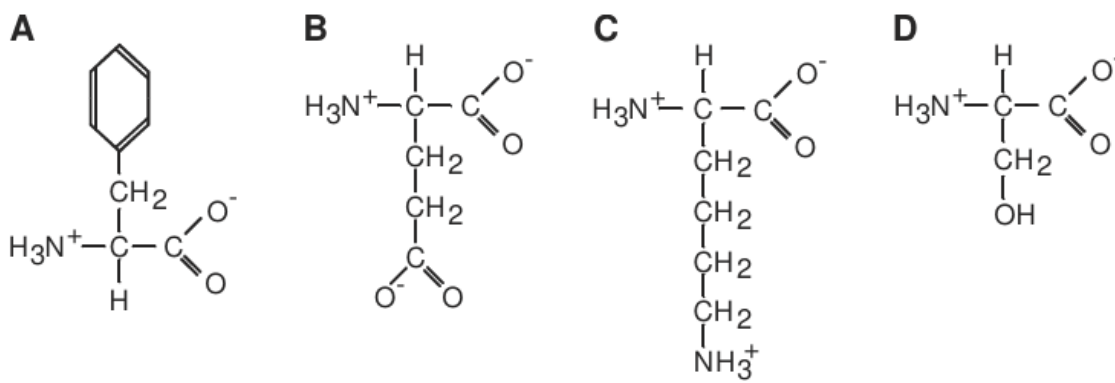
8. Which amino acid represented below is hydrophobic?



9. Which row in the table shows the enzymes that could phosphorylate or dephosphorylate a protein during post-translational modification?

	<i>Phosphorylate</i>	<i>Dephosphorylate</i>
A	ATPase	caspase
B	phosphatase	ATPase
C	ATPase	kinase
D	kinase	phosphatase

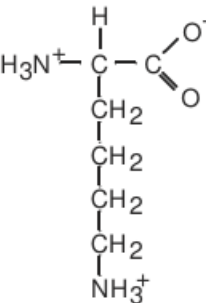
10- Which amino acid represented below is acidic?



11. Each molecule of oxygen that binds to a haemoglobin subunit has the effect of increasing the affinity for the next oxygen molecule. This type of interaction is known as

- A positive modulation
- B induced fit
- C facilitated transport
- D cooperativity.

12. The diagram below represents an amino acid.



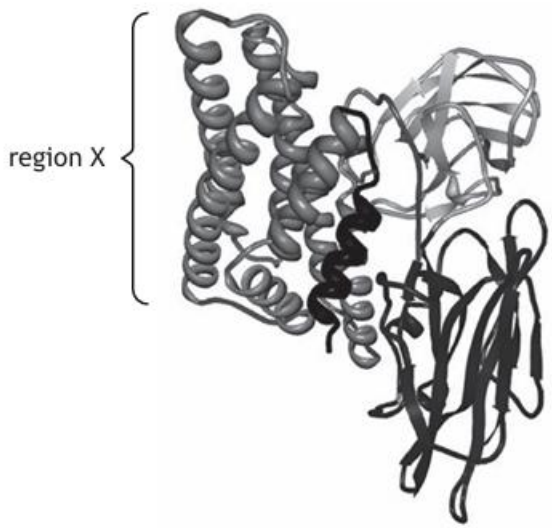
It has an R group that is

- A Basic
- B polar
- C hydrophobic
- D acidic.

13. Which of the following maintain the structure of an α -helix?

- A Hydrogen bonds
- B London dispersion forces
- C Ionic bonds
- D Disulphide bridges

14. The three-dimensional structure of a protein is shown.



Which row in the table describes region X?

	Type of secondary structure	Bonding that stabilises secondary structure
A	β -sheet	peptide
B	α -helix	peptide
C	β -sheet	hydrogen
D	α -helix	hydrogen

15. Alpha helices in proteins are stabilised by

- A hydrogen bonds
- B ionic bonds
- C disulphide bridges
- D hydrophobic interactions.

16. The table shows the number of amino acids in a particular protein and the charge of each amino acid at a certain pH.

Amino acid	Charge	Number
Arginine	positive	13
Aspartate	negative	9
Cysteine	negative	2
Histidine	positive	2
Glutamate	negative	20
Lysine	positive	19
Tyrosine	negative	7

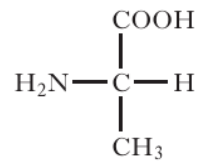
Assuming that each amino acid carries a single positive or negative charge, what is the protein's net charge at this pH?

- A -4
- B -38
- C +4
- D +38

17. Each molecule of oxygen that binds to a subunit of haemoglobin has the effect of increasing the affinity of the remaining subunits to oxygen. This type of interaction is known as

- A cooperativity
- B facilitated transport
- C induced fit
- D positive modulation.

18 The diagram below represents the structure of the amino acid alanine.

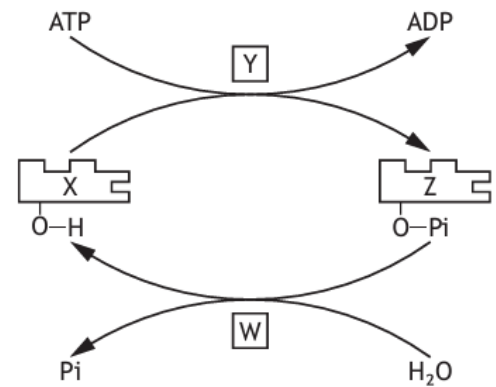


- In the diagram, the R group has the composition
- A —H
 - B —NH₂
 - C —CH₃
 - D —COOH.

19 Which line in the table below correctly represents an allosteric enzyme binding with a positive modulator?

	Modulator binding site		Affinity of enzyme for substrate	
	active site	secondary site	increased	decreased
A	✓		✓	
B		✓		✓
C		✓	✓	
D	✓			✓

20 The diagram shows how phosphate is used to modify the conformation of an enzyme, phosphorylase, and so change its activity.

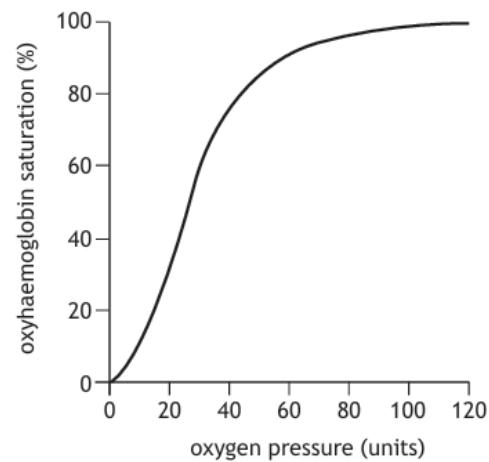


Which row in the table identifies the labels?

	Kinase	Phosphatase	Phosphorylase
A	Y	Z	W
B	W	Y	Z
C	X	Y	W
D	Y	W	Z

- 21 . An amino acid that has a hydrophobic R group is
- A polar
 - B non-polar
 - C positively charged
 - D negatively charged.

22 The figure shows the normal oxygen dissociation curve for haemoglobin.



Which row in the table shows the direction of shift in the oxygen dissociation curve as a result of changes in pH and temperature?

	Shift of curve	Change in pH	Change in temperature
A	left	decrease	increase
B	right	increase	increase
C	left	increase	decrease
D	right	decrease	decrease

23 Which row in the table describes the effects of an increase in temperature on haemoglobin and oxygen delivery to cells?

	Affinity of haemoglobin for oxygen	Oxygen delivery to tissue
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

24 Which row in the table describes features of a positive modulator binding to an enzyme?

	Binding	Affinity for substrate
A	allosteric site	increases
B	active site	increases
C	allosteric site	decreases
D	active site	decreases

25 The binding of oxygen to haemoglobin is affected by small changes in temperature or pH. Which of the following changes would **decrease** haemoglobin’s affinity for oxygen?

- A increased temperature, decreased pH
- B increased temperature, increased pH
- C decreased temperature, decreased pH
- D decreased temperature, increased pH

26 An enzyme-controlled reaction is taking place in optimum conditions in the presence of a large surplus of substrate.

Conditions can be altered by

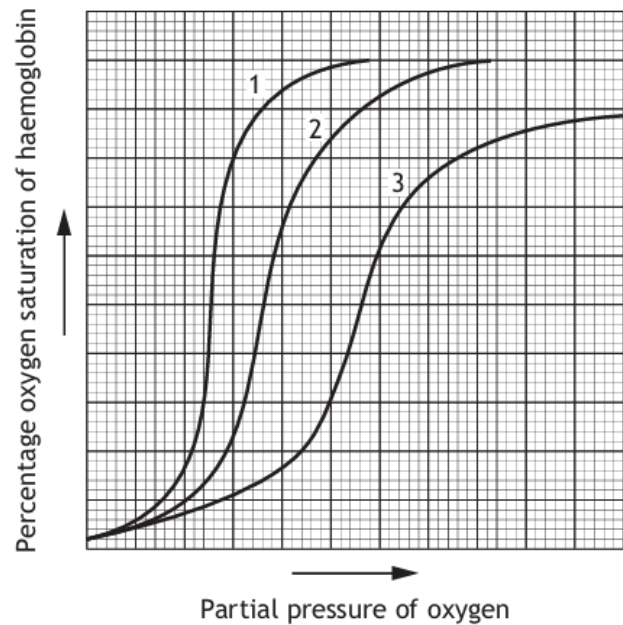
- 1 increasing the temperature
- 2 adding a positive modulator
- 3 increasing enzyme concentration
- 4 increasing substrate concentration.

Product yield would be increased by

- A 1 and 2
- B 2 and 3
- C 2 and 4
- D 3 and 4.

27 Temperature influences the binding and release of oxygen molecules by haemoglobin.

The graph below shows the percentage oxygen saturation of haemoglobin at three different temperatures: 34°C, 37°C and 42°C.

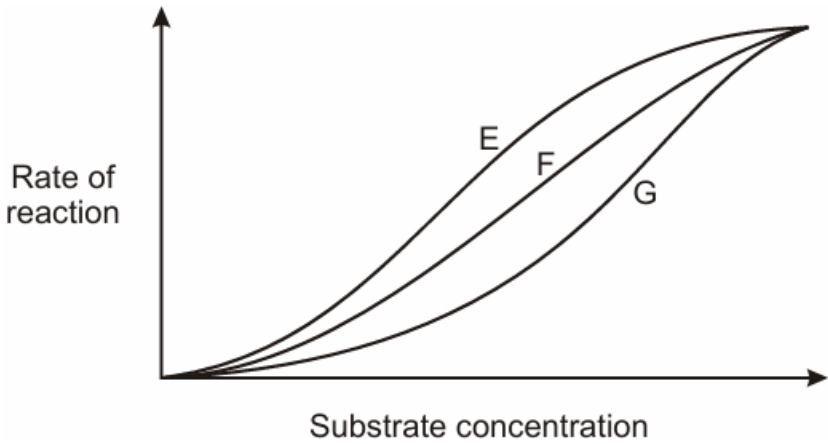


Which line in the table below identifies these temperatures?

	Graph 1	Graph 2	Graph 3
A	34°C	37°C	42 °C
B	37°C	42 °C	34 °C
C	34°C	42 °C	37 °C
D	42°C	37°C	34°C

28

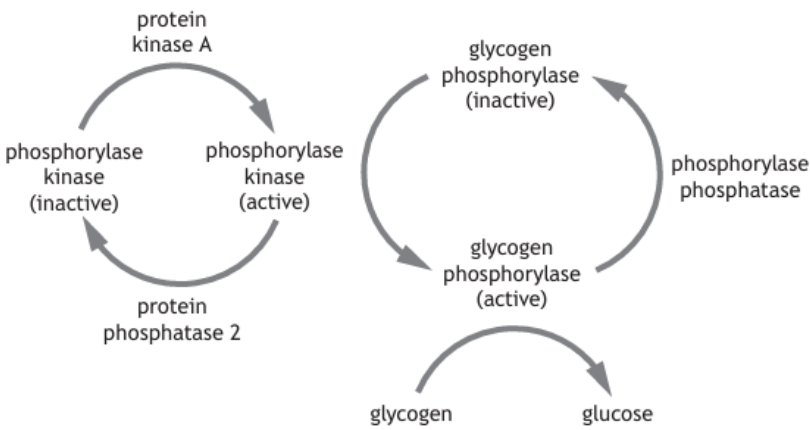
The following graph shows the effect of increasing substrate concentration on the activity of an allosteric enzyme, with and without the presence of modulators.



Which row in the table correctly identifies the plotted lines?

	No modulator	Positive modulator	Negative modulator
A	E	F	G
B	F	E	G
C	G	E	F
D	F	G	E

29 The figure gives information about enzymes involved in glycogen metabolism in humans.



Which row in the table describes events when the enzyme protein kinase A is activated?

	Phosphate group attached to glycogen phosphorylase	Glycogen converted to glucose
A	yes	yes
B	yes	no
C	no	no
D	no	yes

30 In the post-translational modification of a protein, which of the following enzymes would remove a phosphate?

- A proteinase
- B ATPase
- C phosphatase
- D kinase

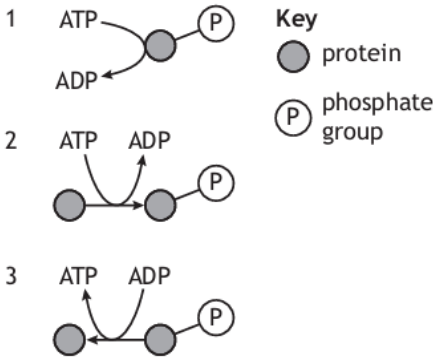
31 Transcription of gene Z only occurs when its transcription factor is dephosphorylated. The distribution of the transcription factor together with the activities of a protein kinase and protein phosphatase specific to this transcription factor are shown in the table.

Tissue	Transcription factor present	Protein kinase activity	Protein phosphatase activity
Muscle	–	–	+
Heart	+	+	–
Brain	+	–	+

Gene Z is transcribed in the

- A brain only
- B heart only
- C muscle and brain only
- D heart and brain only.

32 The diagrams below represent the general actions of enzymes involved in the transfer of phosphate groups in cells.



Which line in the table below identifies the enzymes involved in each diagram?

	Phosphatases	ATP-ases	Kinases
A	1	2	3
B	3	1	2
C	2	3	1
D	1	3	2

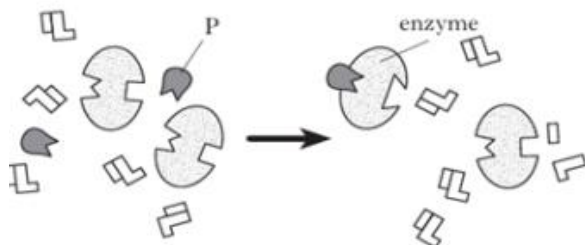
33

Which line in the table below describes correctly the bonds that create the shape of a protein at a particular stage of its formation?

	Stage of formation	Shape of protein	Bonds
A	primary structure	chain	hydrogen
B	secondary structure	helix	hydrogen
C	primary structure	helix	peptide
D	secondary structure	chain	peptide

34

The diagram below shows an enzyme-catalysed reaction.

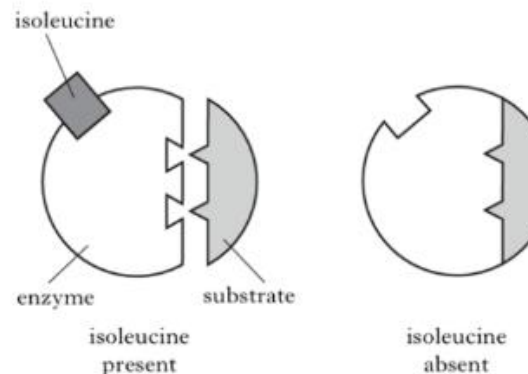


Which of the following correctly identifies the role of molecule P?

- A Substrate
- B Negative modulator
- C Competitive inhibitor
- D Positive modulator

35

The diagram below shows the effect of isoleucine on the enzyme threonine deaminase.

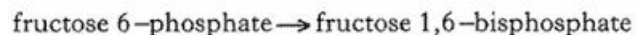


In high concentrations, isoleucine acts as

- A an allosteric inhibitor
- B an allosteric activator
- C a competitive inhibitor
- D a positive modulator.

36

The following reaction occurs in glycolysis.



Which type of enzyme would catalyse this reaction?

- A Protease
- B Polymerase
- C ATPase
- D Kinase

37

Covalent modification of enzymes is used to control their activity.

Which of the following processes involves the covalent modification of an enzyme?

- A The conversion of trypsinogen into trypsin.
- B The end-product inhibition of phosphatase.
- C The allosteric inhibition of glycogen phosphorylase.
- D The conversion of sucrose into glucose and fructose.

38

Covalent modification can be used to regulate enzyme activity.

Which of the following is an example of covalent modification?

- A Allosteric modulation
- B End product inhibition
- C Binding of an inhibitor to the active site
- D Addition of a phosphate group by a kinase enzyme

A protein's net charge is equal to the number of positively charged amino acids minus the number of negatively charged amino acids.

Table 1 shows the charge of amino acids at a certain pH.

Table 1

<i>Positively charged</i>	<i>Negatively charged</i>
arginine	tyrosine
lysine	cysteine
histidine	glutamate
	aspartate

Table 2 shows the number of each amino acid in a protein.

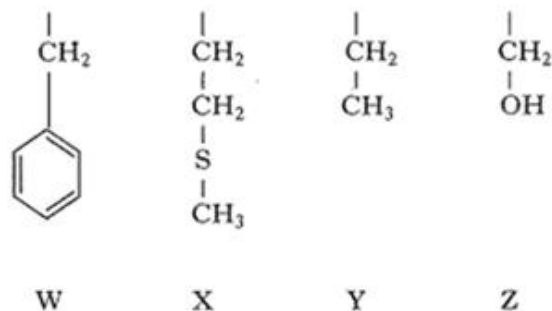
Table 2

<i>Amino acid</i>	<i>Number</i>
arginine	3
lysine	19
histidine	2
tyrosine	7
cysteine	2
glutamate	20
aspartate	2

Assuming that each amino acid carries a single positive or negative charge, what is the protein's net charge at the same pH?

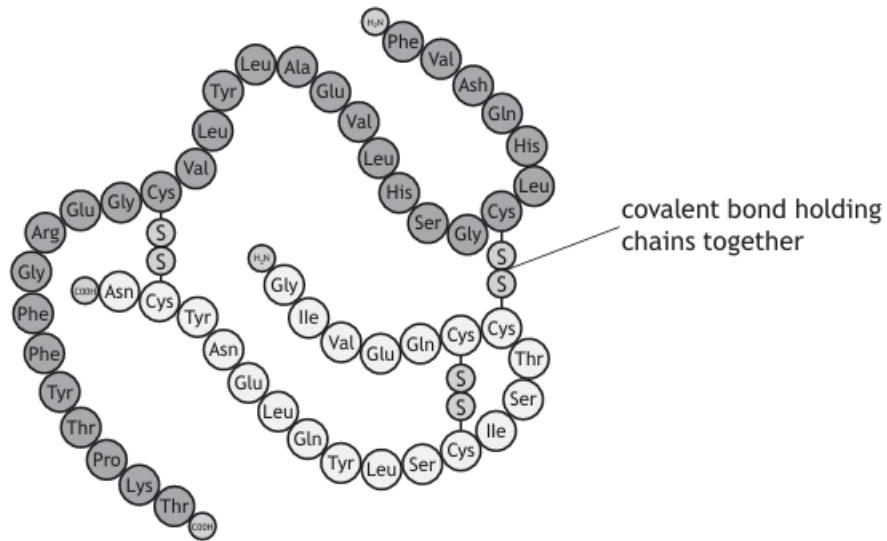
- A + 20
- B + 7
- C - 7
- D - 20

The side chains of four amino acids are shown below.



A polar side chain is present in

- A W and X
- B Y and Z
- C Z only
- D W, X and Z.



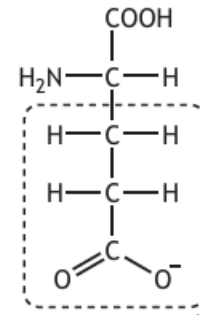
1. Name the type of covalent bond that holds the two chains of insulin together. 1

2. Within each haemoglobin subunit, a high proportion of the amino acids in the polypeptide form α -helices.
State the main force stabilising these regions. 1

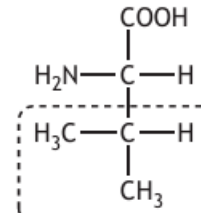
3. Explain why haem is described as a prosthetic group. 1

4. Name the level of protein structure describing several connected polypeptide subunits. 1

Glutamic acid



Valine



R group

5. State the class of amino acids to which valine belongs. 1

6. Molecules of sickle cell haemoglobin clump together preventing access to oxygen binding sites.

Suggest why this is a result of the substitution of glutamic acid by valine. 1

Alpha-helix turn

7. Explain why haem is described as a prosthetic group.

8. Name the process whereby binding of oxygen to one subunit of haemoglobin alters the affinity of the remaining subunits.

1

9. Tissues with higher metabolic rates require more oxygen. These tissues produce more carbon dioxide, which dissolves in tissue fluids to form carbonic acid.
Explain how this increases oxygen delivery at these tissues.

1

10. Haem is a non-protein component important in the function of haemoglobin.
State the term used to describe such a component.

1

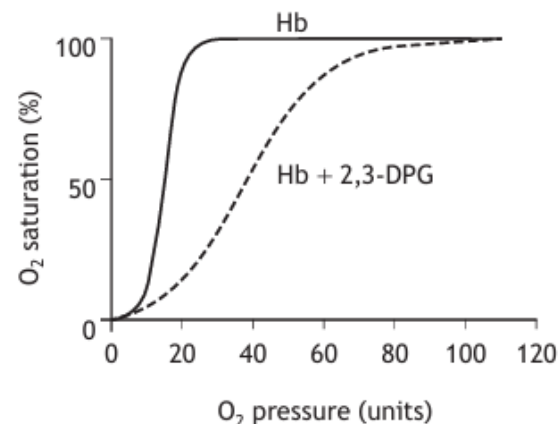
11. Explain the term cooperativity in relation to oxygen binding to haemoglobin.

1

12. Haemoglobin is affected by a number of allosteric interactions. Allosteric interactions between the oxygen-binding sites result in co-operativity.

Explain what is meant by co-operativity in haemoglobin.

1



13. Explain how the data show that 2,3-DPG is acting as a negative modulator.

14. The concentration of 2,3-DPG in the blood is normally 5 mmol per litre, but this rises to approximately 8 mmol per litre in individuals living at high altitude.

Explain how this increase in 2,3-DPG concentration at high altitude would help oxygen delivery to tissue.

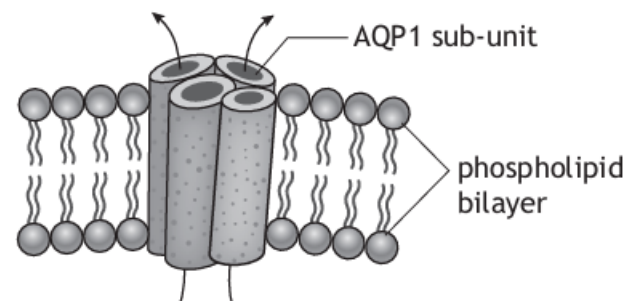
1

15. The drug diazepam increases the effect of GABA molecules by binding to a secondary (allosteric) binding site on GABA_A receptors.
State the term used to describe the effect of diazepam on GABA_A receptors.

1

16. . Aquaporin 1 (AQP1) is a membrane protein which channels the movement of water molecules. AQP1 has four sub-units, each of which acts as a water channel, as shown in Figure 1 below.

Figure 1: A fragment of membrane containing AQP1



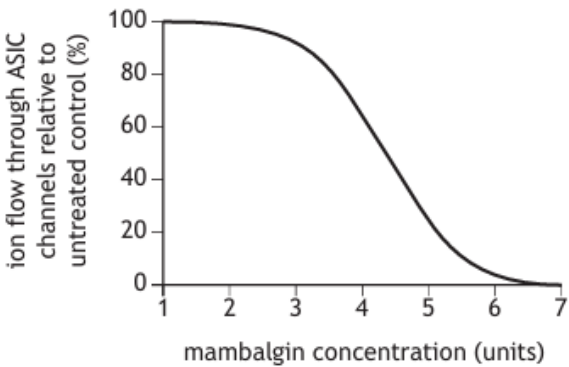
With reference to AQP1, describe what is meant by the quaternary structure of a protein.

1

17. Explain why the rate of uptake by GLUT transporters levels off at high glucose concentrations.

1

18. Acid sensing ion channels (ASICs) are involved in the perception of pain and are activated by small changes in the pH of the surrounding cellular environment. Mambalgin is another toxin found in black mamba venom, which is known to be able to bind to ASICs.
The graph shows the effect of increasing the dose of mambalgin on the activity of ASIC ion channels.



Suggest the mechanism by which mambalgin might work as a painkiller by preventing the generation of a nerve impulse.

1

19. What name is given to a molecule that binds to a protein?

1

20. Describe the reaction catalysed by a kinase enzyme.

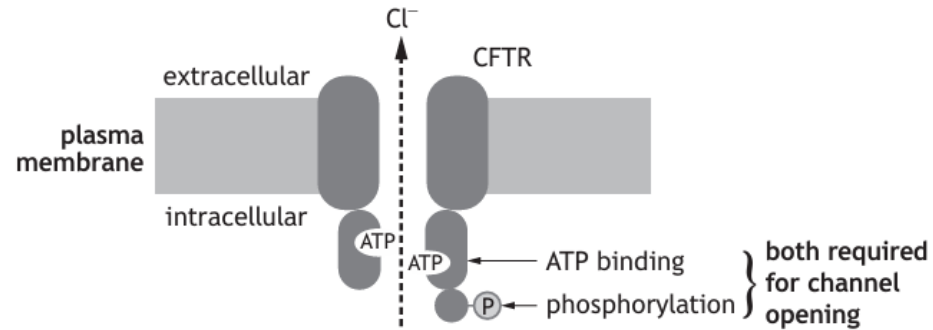
1

21. Suggest what happens to the receptor protein when GABA binds to it.

1

22. The protein CFTR is involved in the regulation of water content of extracellular mucus in the lungs and digestive system.

The figure represents the action of CFTR. It regulates the passage of chloride ions (Cl^-) across membranes of epithelial (lining) cells. In order for this ion channel to open, the protein must bind two ATP molecules, as well as a phosphate group. The increased concentration of Cl^- outside the cell draws water out of the epithelial cells into the mucus, maintaining its fluidity.

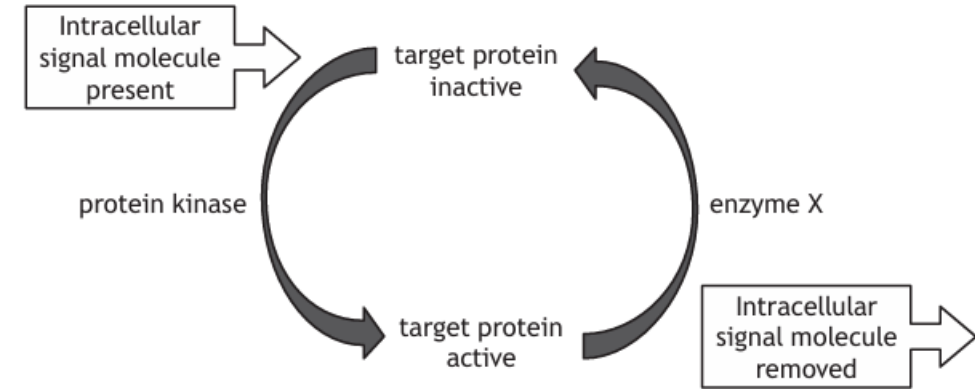


Cholera is a disease caused by the bacterium *Vibrio cholerae*. It causes severe watery diarrhoea, which can lead to dehydration and even death. The bacterium produces *cholera toxin* which interferes with the control of the CFTR protein channel by constantly activating a kinase enzyme.

Explain how the production of cholera toxin by *Vibrio cholerae* can lead to more water being drawn out of the epithelial cells.

2

23. The diagram shows how two types of enzyme can be involved in controlling the activity of a protein in response to the presence of a signalling molecule within the cell (intracellular signal molecule). Intracellular signalling molecules are often produced as a result of extracellular signals received by cell-surface receptors.



24. Name the type of enzyme represented by enzyme X.

1

Explain how the action of protein kinase can switch a target protein from inactive to active.

1

Explain the importance of the system being able to return the target protein to its inactive state.

1

24. The eukaryotic organism *Candida albicans* is one of the most common fungal pathogens of humans. One treatment for *C.albicans* infection is a compound called *sordarin*, which is isolated from a different fungus. Sordarin works by binding to highly specific sites on a protein called eukaryotic elongation factor 2 (eEF-2). eEF-2 causes the elongation of polypeptide chains during translation, by binding to a section of the ribosome.

a (i) Explain why sordarin can be described as a ligand. 1

(ii) Explain why binding of sordarin to eEF-2 would change the function of the protein. 1

The gene for the protein eEF-2 is highly conserved across eukaryote species.

b))(i) Suggest what concerns there may have been in treating *C.albicans* infections in humans with sordarin. 1

(ii) Describe what happens in a phosphorylation cascade.

MARI

25



Oxyhaemoglobin

a) State the level of protein structure shown by haemoglobin.

b) Give the biological term for the iron-containing haem group embedded in each globin subunit.

c) Give the biological term for the reduced affinity of haemoglobin for the second oxygen once the first has been released.

26 Some of the proteins in secretory vesicles are inactive precursors of digestive enzymes. Give the reason for them to be kept in an inactive form before secretion.

State how the precursors of digestive enzymes are activated after being released from the cell.

1

1

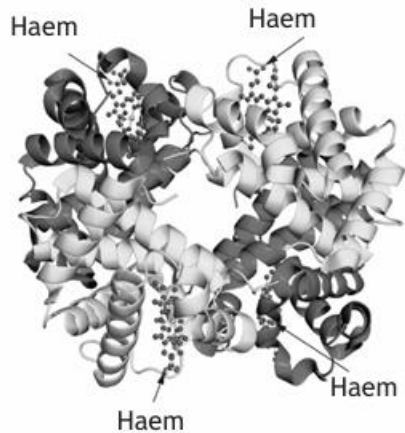
27 a) Some of the proteins in secretory vesicles are inactive precursors of digestive enzymes. Give the reason for them to be kept in an inactive form before secretion. 1

So it does not digest the cell (that produced them)

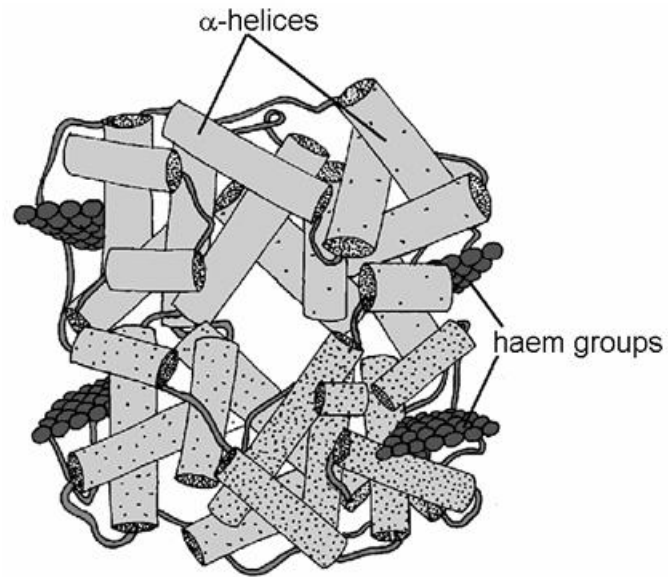
b) State how the precursors of digestive enzymes are activated after being released from the cell. 1

Proteolytic cleavage/covalent modification

28 Identify **one** type of secondary structure shown in the haemoglobin molecule in the figure below. 1



29 The diagram represents a haemoglobin molecule composed of four polypeptide subunits held together by inter molecular bonds.



(i) Name another secondary structure in a haemoglobin subunit.

Turns/beta pleated sheet 1

(ii) Give an example of a type of bond that gives haemoglobin this conformation.

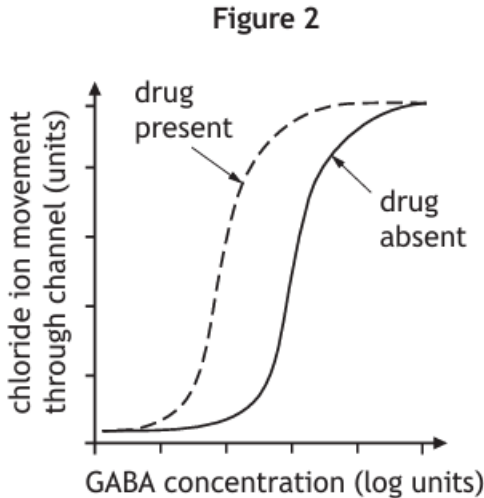
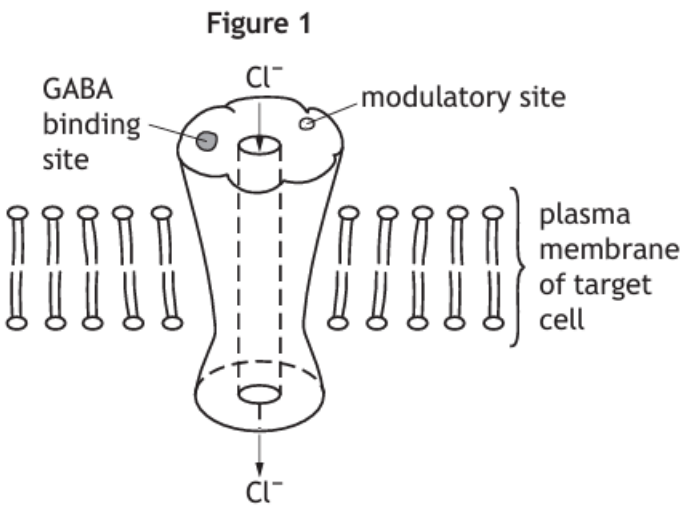
Hydrogen/LDF's/Disulfide bridge/hydrophobic interactions/ionic 1

(iii) State the level of protein structure shown by haemoglobin.

quaternary 1

30 Gamma-aminobutyric acid (GABA) is a neurotransmitter that functions as a signalling molecule in the central nervous system. GABA binds to a receptor protein located in the plasma membrane of target cells as shown in **Figure 1**. Binding of a GABA molecule opens a channel that allows chloride ions (Cl^-) to enter the cell.

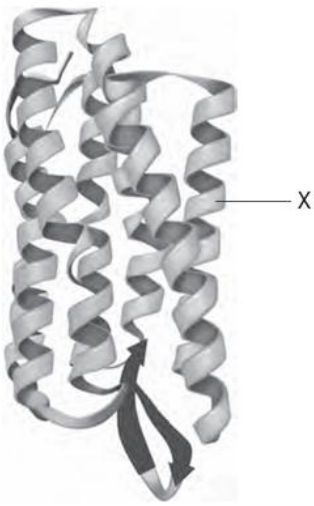
Benzodiazepines are sedative drugs that bind to the receptor protein and increase its affinity for GABA. These drugs act as allosteric modulators by binding at a site that is distinct from the GABA-binding site. **Figure 2** shows the movement of chloride ions through the channel as GABA is increased with and without the drug being present.



a) Describe the information in **Figure 2** that shows that the affinity of the receptor for GABA has been increased by the benzodiazepine. 1

b) Explain why the affinity of the receptor for GABA increases when the drug binds to the modulatory site. 1

31 The diagram below represents part of a molecule of bacteriorhodopsin, a protein found in *Archaea*.



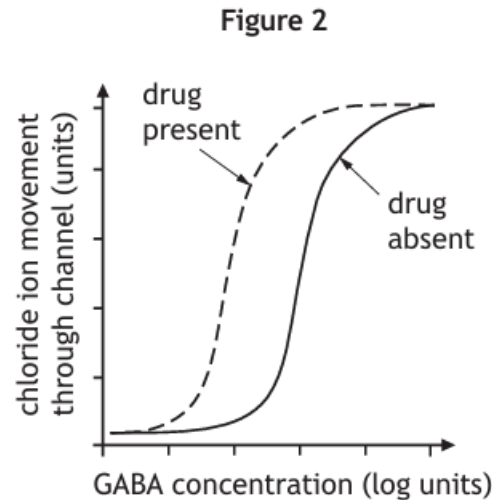
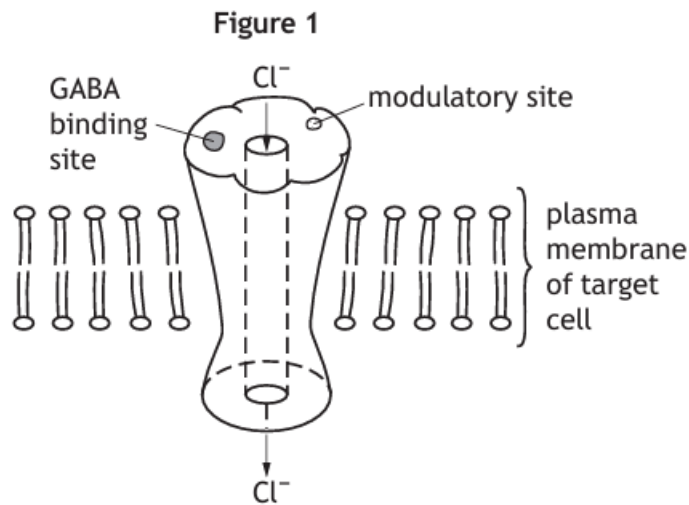
The ribbons in the diagram represent the primary and secondary structures of the protein.

(i) Describe what is meant by the primary structure of a protein. 1

(ii) Name the secondary structural feature shown at X in the diagram and describe how this feature is formed from the primary structure of the protein. 2

- 30 Gamma-aminobutyric acid (GABA) is a neurotransmitter that functions as a signalling molecule in the central nervous system. GABA binds to a receptor protein located in the plasma membrane of target cells as shown in **Figure 1**. Binding of a GABA molecule opens a channel that allows chloride ions (Cl^-) to enter the cell.

Benzodiazepines are sedative drugs that bind to the receptor protein and increase its affinity for GABA. These drugs act as allosteric modulators by binding at a site that is distinct from the GABA-binding site. **Figure 2** shows the movement of chloride ions through the channel as GABA is increased with and without the drug being present.



- a) Describe the information in **Figure 2** that shows that the affinity of the receptor for GABA has been increased by the benzodiazepine.

1

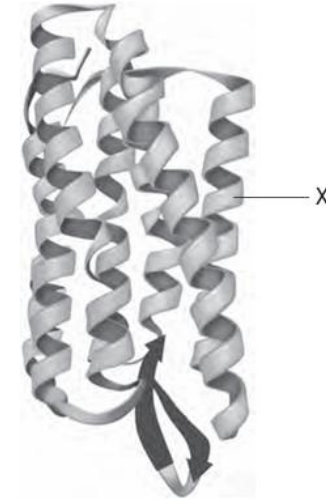
Chloride movement is (generally) greater at any GABA concentration if drug present

- b) Explain why the affinity of the receptor for GABA increases when the drug binds to the modulatory site.

1

Changes the conformation of the GABA site

- 31 The diagram below represents part of a molecule of bacteriorhodopsin, a protein found in *Archaea*.



The ribbons in the diagram represent the primary and secondary structures of the protein.

- (i) Describe what is meant by the primary structure of a protein.

1

Amino acid sequence

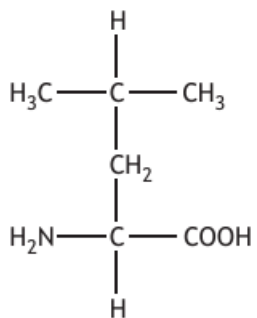
- (ii) Name the secondary structural feature shown at X in the diagram and describe how this feature is formed from the primary structure of the protein.

2

X = Alpha helix (1)

Hydrogen bonding along the BACKBONE

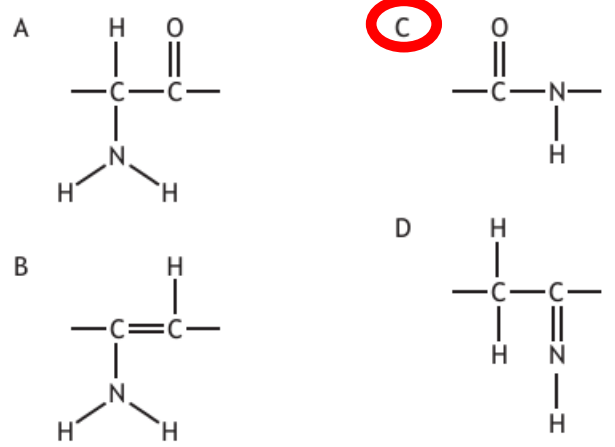
1. The diagram shows the structure of the amino acid leucine.



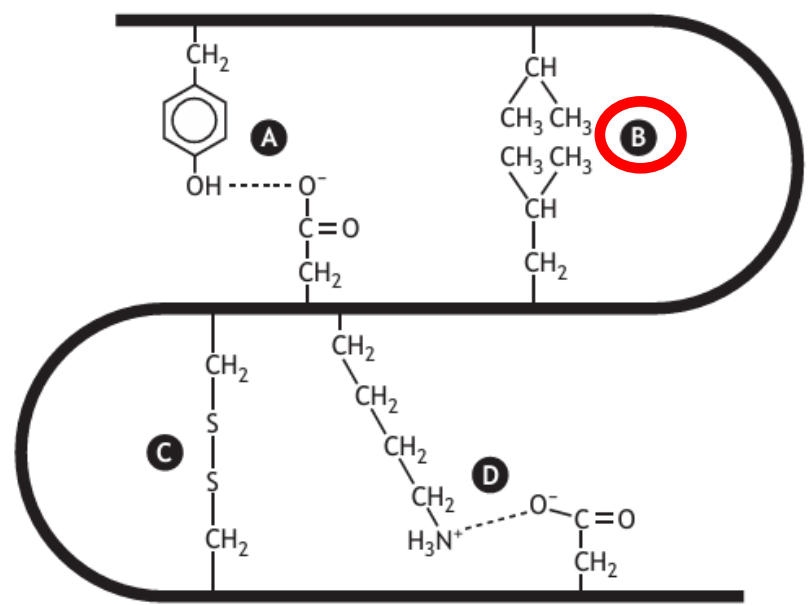
To which class of amino acids does leucine belong?

- A Polar
- B Hydrophobic**
- C Acidic
- D Basic

2. Which of the following diagrams illustrates a peptide bond?



3. The diagram shows some interactions between amino acid R-groups in a polypeptide chain. Which letter shows hydrophobic interactions?



Which of the following is a covalent bond that stabilises the tertiary structure of a protein?

- A Disulphide bridge**
- B Hydrogen bond
- C Ionic bond
- D Hydrophobic interactions

4. A hydrophobic amino acid has an R group that is

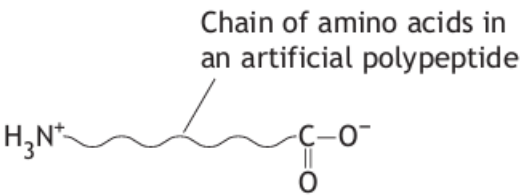
- A negatively charged
- B positively charged
- C not polar**
- D polar.

5. The table below shows the charges on the R groups of four amino acids at a certain pH. An artificial polypeptide consisting of a chain of only 24 of these amino acids has the ratio 3glycerates:2asparates:2lysines:1 glycine and is shown in the diagram below. The charge on each chain terminus is also shown.

Table

Charge on R Group = +1	Charge on R Group = -1
glycerate	lysine
aspartate	glycine

Diagram



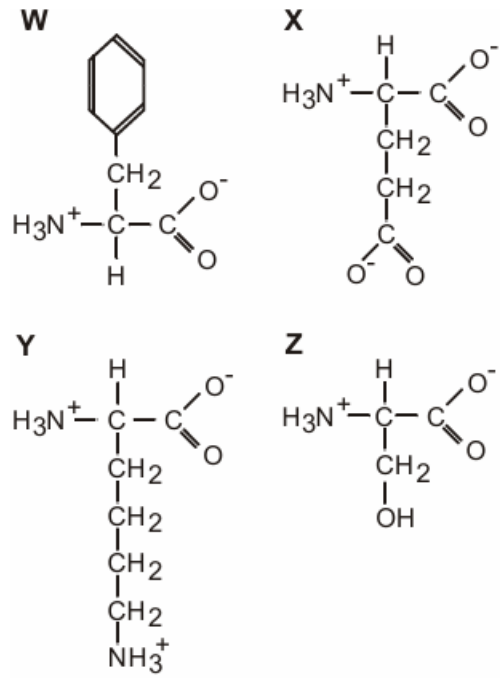
From the information given, what is the overall net charge on this polypeptide at this pH?

- A -6
- B -3
- C +3
- D +6**

6. R groups of amino acids, which are polar, acidic and basic, are attracted to water molecules in the cytoplasm of cells and are therefore described as

- A charged
- B hydrophilic**
- C ionised
- D hydrophobic.

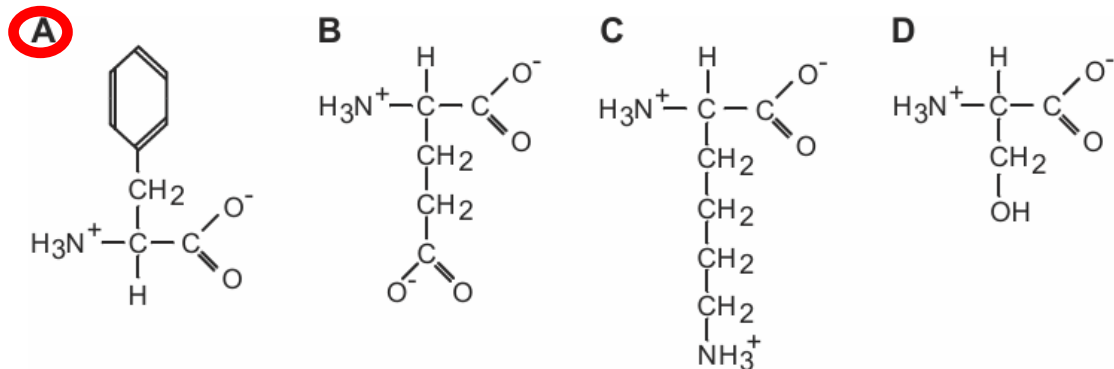
7. The figure below represents the structure of four amino acids.



Which row in the table shows the classification of the four amino acids?

	Basic	Polar	Hydrophobic	Acidic
A	Y	Z	W	X
B	Z	W	X	Y
C	W	X	Y	Z
D	X	Y	Z	W

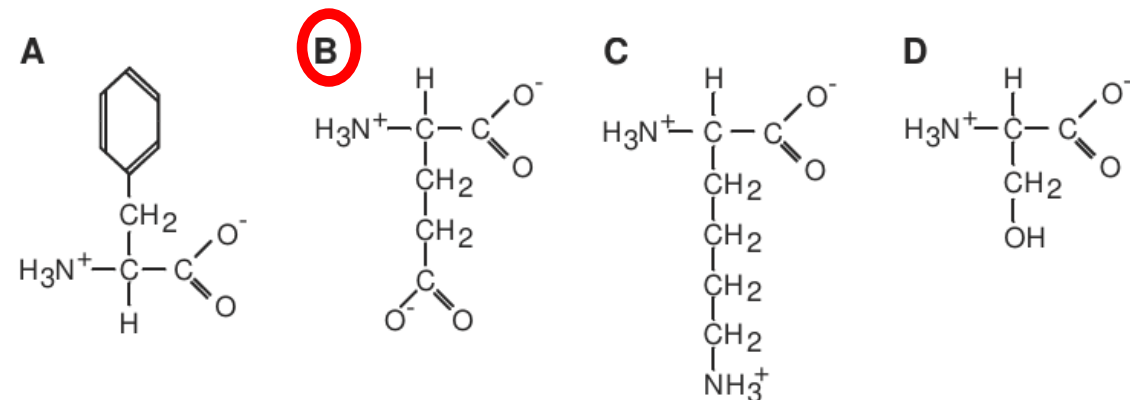
8. Which amino acid represented below is hydrophobic?



9. Which row in the table shows the enzymes that could phosphorylate or dephosphorylate a protein during post-translational modification?

	<i>Phosphorylate</i>	<i>Dephosphorylate</i>
A	ATPase	caspase
B	phosphatase	ATPase
C	ATPase	kinase
D	kinase	phosphatase

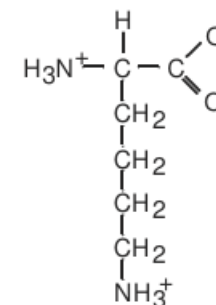
10. Which amino acid represented below is acidic?



11. Each molecule of oxygen that binds to a haemoglobin subunit has the effect of increasing the affinity for the next oxygen molecule. This type of interaction is known as

- A positive modulation
- B induced fit
- C facilitated transport
- D cooperativity.**

12. The diagram below represents an amino acid.



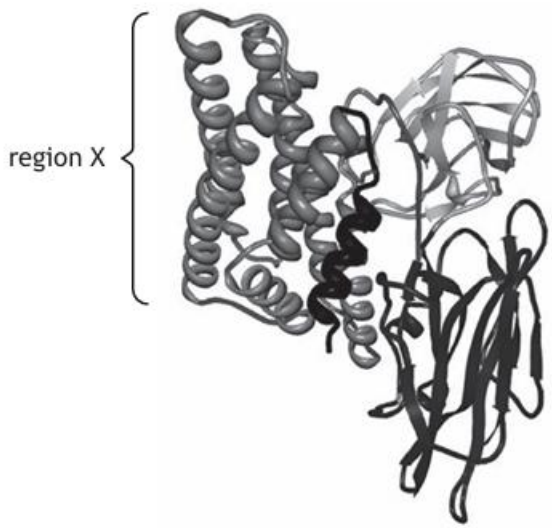
It has an R group that is

- A Basic**
- B polar
- C hydrophobic
- D acidic.

13. Which of the following maintain the structure of an α -helix?

- A Hydrogen bonds**
- B London dispersion forces
- C Ionic bonds
- D Disulphide bridges

14. The three-dimensional structure of a protein is shown.



Which row in the table describes region X?

	Type of secondary structure	Bonding that stabilises secondary structure
A	β -sheet	peptide
B	α -helix	peptide
C	β -sheet	hydrogen
D	α -helix	hydrogen

15. Alpha helices in proteins are stabilised by

- A** hydrogen bonds
- B ionic bonds
- C disulphide bridges
- D hydrophobic interactions.

16. The table shows the number of amino acids in a particular protein and the charge of each amino acid at a certain pH.

Amino acid	Charge	Number
Arginine	positive	13
Aspartate	negative	9
Cysteine	negative	2
Histidine	positive	2
Glutamate	negative	20
Lysine	positive	19
Tyrosine	negative	7

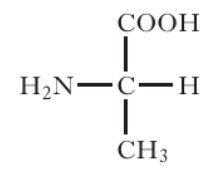
Assuming that each amino acid carries a single positive or negative charge, what is the protein's net charge at this pH?

- A** -4
- B -38
- C +4
- D +38

17. Each molecule of oxygen that binds to a subunit of haemoglobin has the effect of increasing the affinity of the remaining subunits to oxygen. This type of interaction is known as

- A** cooperativity
- B facilitated transport
- C induced fit
- D positive modulation.

18 The diagram below represents the structure of the amino acid alanine.



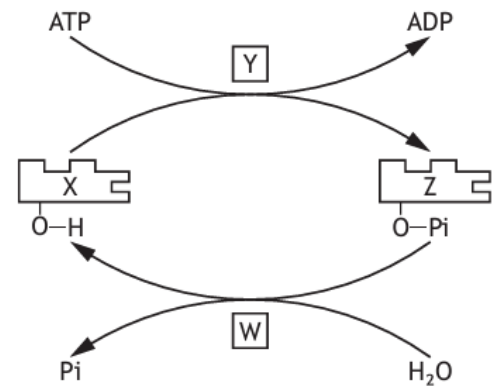
In the diagram, the R group has the composition

- A —H
- B —NH₂
- C —CH₃**
- D —COOH.

19 Which line in the table below correctly represents an allosteric enzyme binding with a positive modulator?

	Modulator binding site		Affinity of enzyme for substrate	
	active site	secondary site	increased	decreased
A	✓		✓	
B		✓		✓
C		✓	✓	
D	✓			✓

20 The diagram shows how phosphate is used to modify the conformation of an enzyme, phosphorylase, and so change its activity.



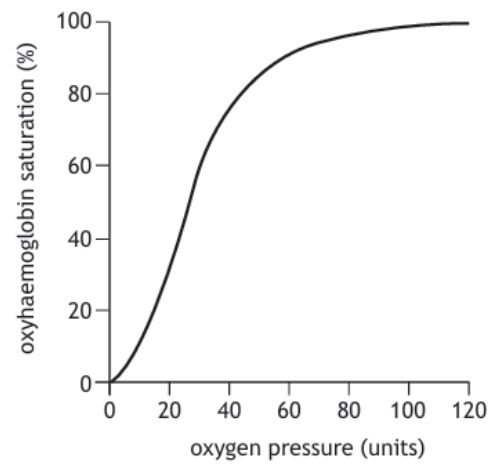
Which row in the table identifies the labels?

	Kinase	Phosphatase	Phosphorylase
A	Y	Z	W
B	W	Y	Z
C	X	Y	W
D	Y	W	Z

21 . An amino acid that has a hydrophobic R group is

- A polar
- B non-polar**
- C positively charged
- D negatively charged.

22 The figure shows the normal oxygen dissociation curve for haemoglobin.



Which row in the table shows the direction of shift in the oxygen dissociation curve as a result of changes in pH and temperature?

	Shift of curve	Change in pH	Change in temperature
A	left	decrease	increase
B	right	increase	increase
C	left	increase	decrease
D	right	decrease	decrease

23 Which row in the table describes the effects of an increase in temperature on haemoglobin and oxygen delivery to cells?

	Affinity of haemoglobin for oxygen	Oxygen delivery to tissue
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

24 Which row in the table describes features of a positive modulator binding to an enzyme?

	Binding	Affinity for substrate
A	allosteric site	increases
B	active site	increases
C	allosteric site	decreases
D	active site	decreases

25 The binding of oxygen to haemoglobin is affected by small changes in temperature or pH. Which of the following changes would **decrease** haemoglobin's affinity for oxygen?

- A increased temperature, decreased pH
- B increased temperature, increased pH
- C decreased temperature, decreased pH
- D decreased temperature, increased pH

26 An enzyme-controlled reaction is taking place in optimum conditions in the presence of a large surplus of substrate.

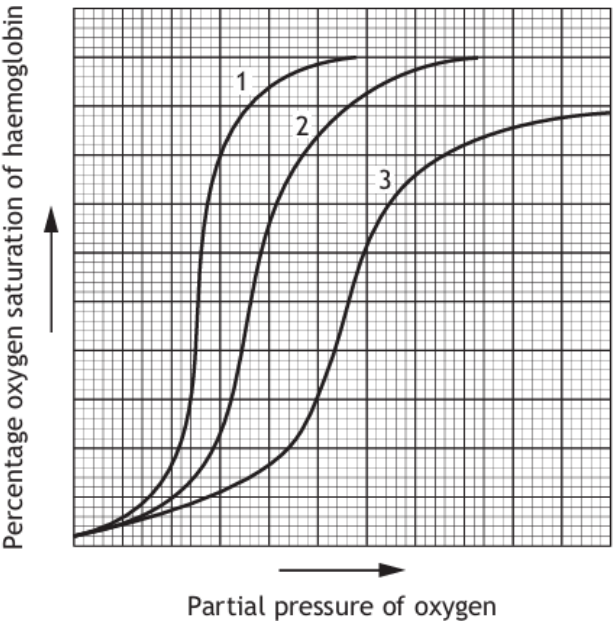
Conditions can be altered by

- 1 increasing the temperature
- 2 adding a positive modulator
- 3 increasing enzyme concentration
- 4 increasing substrate concentration.

Product yield would be increased by

- A 1 and 2
- B 2 and 3
- C 2 and 4
- D 3 and 4.

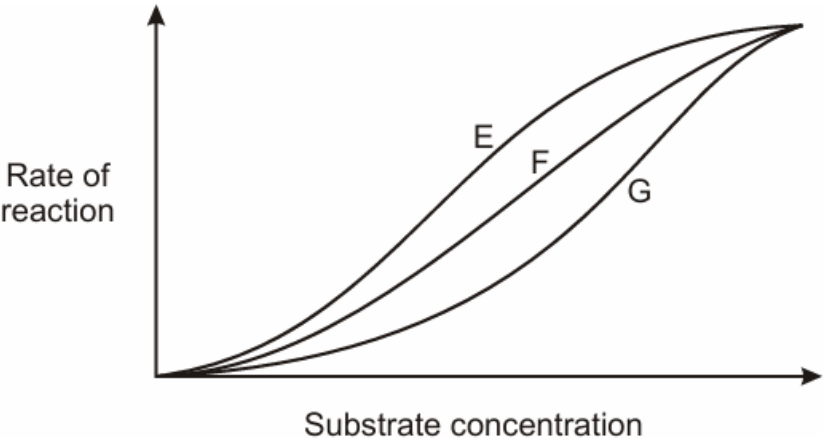
27 Temperature influences the binding and release of oxygen molecules by haemoglobin. The graph below shows the percentage oxygen saturation of haemoglobin at three different temperatures: 34°C, 37°C and 42°C.



Which line in the table below identifies these temperatures?

	Graph 1	Graph 2	Graph 3
A	34°C	37°C	42 °C
B	37°C	42 °C	34 °C
C	34°C	42 °C	37°C
D	42°C	37°C	34°C

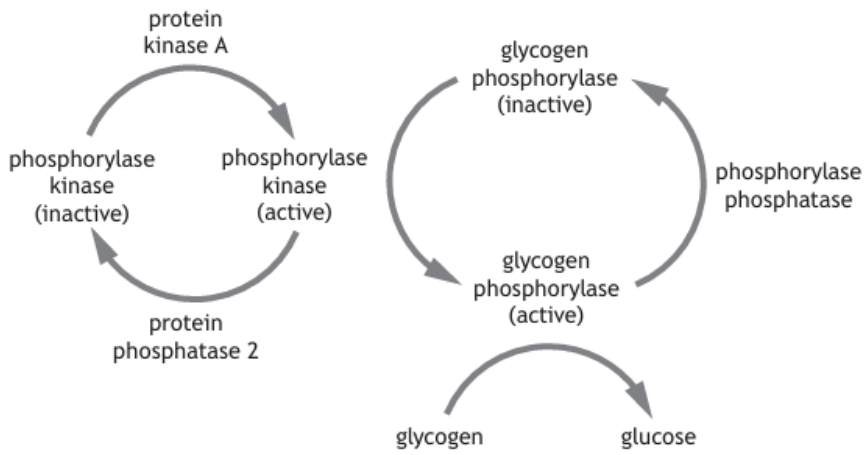
28 . The following graph shows the effect of increasing substrate concentration on the activity of an allosteric enzyme, with and without the presence of modulators.



Which row in the table correctly identifies the plotted lines?

	No modulator	Positive modulator	Negative modulator
A	E	F	G
B	F	E	G
C	G	E	F
D	F	G	E

29 The figure gives information about enzymes involved in glycogen metabolism in humans.



Which row in the table describes events when the enzyme protein kinase A is activated?

	Phosphate group attached to glycogen phosphorylase	Glycogen converted to glucose
A	yes	yes
B	yes	no
C	no	no
D	no	yes

30 In the post-translational modification of a protein, which of the following enzymes would remove a phosphate?

- A proteinase
- B ATPase
- C phosphatase
- D kinase

31 Transcription of gene Z only occurs when its transcription factor is dephosphorylated.

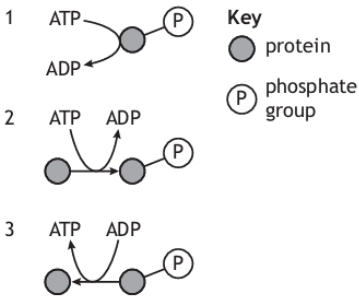
The distribution of the transcription factor together with the activities of a protein kinase and protein phosphatase specific to this transcription factor are shown in the table.

Tissue	Transcription factor present	Protein kinase activity	Protein phosphatase activity
Muscle	—	—	+
Heart	+	+	—
Brain	+	—	+

Gene Z is transcribed in the

- A brain only
- B heart only
- C muscle and brain only
- D heart and brain only.

32 The diagrams below represent the general actions of enzymes involved in the transfer of phosphate groups in cells.



Which line in the table below identifies the enzymes involved in each diagram?

	Phosphatases	ATP-ases	Kinases
A	1	2	3
B	3	1	2
C	2	3	1
D	1	3	2

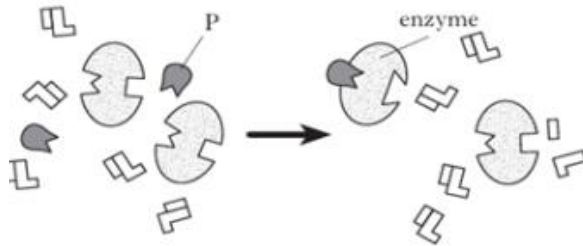
33

Which line in the table below describes correctly the bonds that create the shape of a protein at a particular stage of its formation?

	Stage of formation	Shape of protein	Bonds
A	primary structure	chain	hydrogen
B	secondary structure	helix	hydrogen
C	primary structure	helix	peptide
D	secondary structure	chain	peptide

34

The diagram below shows an enzyme-catalysed reaction.

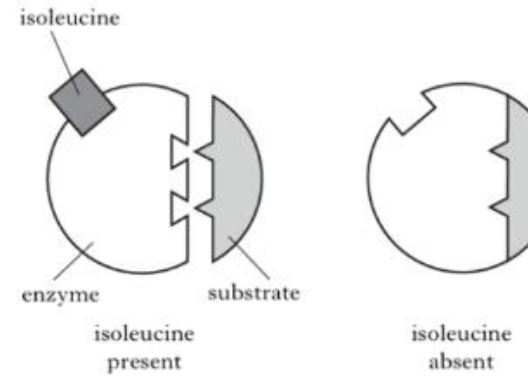


Which of the following correctly identifies the role of molecule P?

- A Substrate
- B Negative modulator**
- C Competitive inhibitor
- D Positive modulator

35

The diagram below shows the effect of isoleucine on the enzyme threonine deaminase.

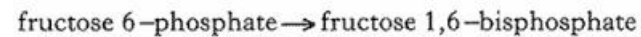


In high concentrations, isoleucine acts as

- A an allosteric inhibitor**
- B an allosteric activator
- C a competitive inhibitor
- D a positive modulator.

36

The following reaction occurs in glycolysis.



Which type of enzyme would catalyse this reaction?

- A Protease
- B Polymerase
- C ATPase
- D Kinase**

37

Covalent modification of enzymes is used to control their activity.

Which of the following processes involves the covalent modification of an enzyme?

- A The conversion of trypsinogen into trypsin.**
- B The end-product inhibition of phosphatase.
- C The allosteric inhibition of glycogen phosphorylase.
- D The conversion of sucrose into glucose and fructose.

38

Covalent modification can be used to regulate enzyme activity.

Which of the following is an example of covalent modification?

- A Allosteric modulation
- B End product inhibition
- C Binding of an inhibitor to the active site
- D Addition of a phosphate group by a kinase enzyme**

A protein's net charge is equal to the number of positively charged amino acids minus the number of negatively charged amino acids.

Table 1 shows the charge of amino acids at a certain pH.

Table 1

<i>Positively charged</i>	<i>Negatively charged</i>
arginine	tyrosine
lysine	cysteine
histidine	glutamate
	aspartate

Table 2 shows the number of each amino acid in a protein.

Table 2

<i>Amino acid</i>	<i>Number</i>
arginine	3
lysine	19
histidine	2
tyrosine	7
cysteine	2
glutamate	20
aspartate	2

Assuming that each amino acid carries a single positive or negative charge, what is the protein's net charge at the same pH?

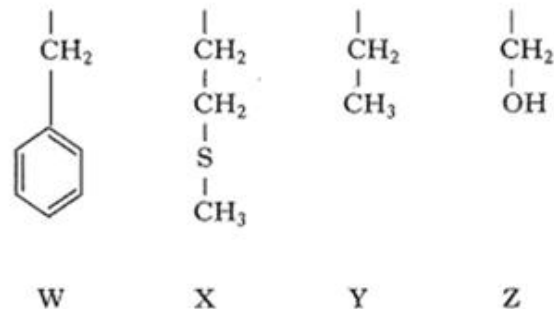
A + 20

B + 7

C - 7

D - 20

The side chains of four amino acids are shown below.



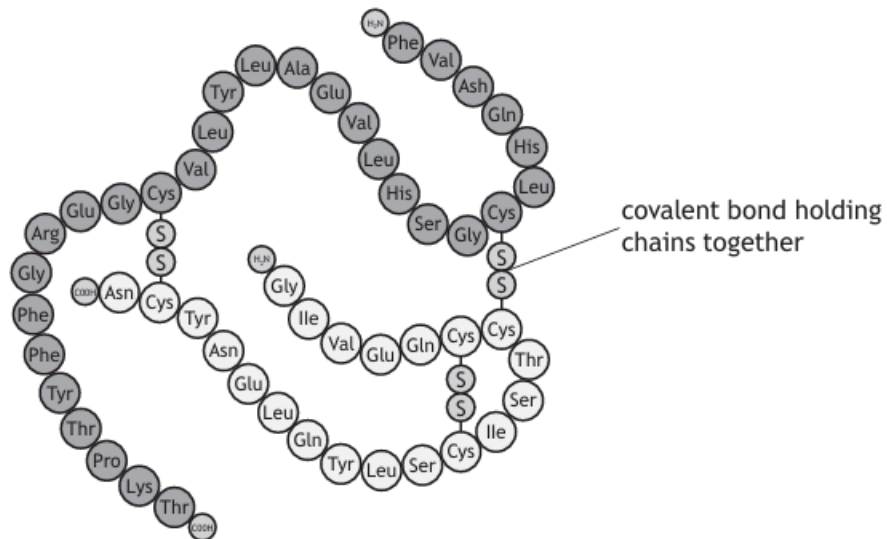
A polar side chain is present in

A W and X

B Y and Z

C Z only

D W, X and Z.



1. Name the type of covalent bond that holds the two chains of insulin together. 1

disulphide

2. Within each haemoglobin subunit, a high proportion of the amino acids in the polypeptide form α -helices.
State the main force stabilising these regions. 1

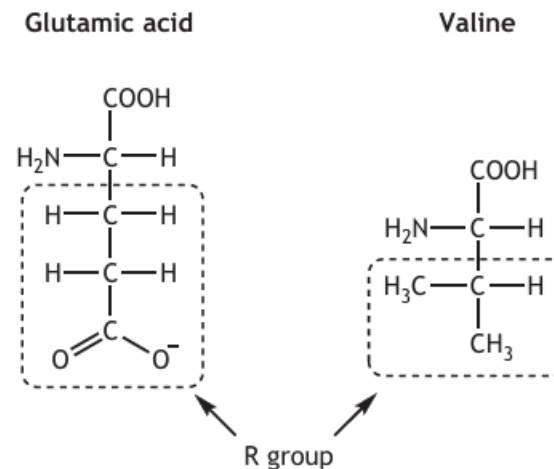
Hydrogen bonds.

3. Explain why haem is described as a prosthetic group. 1

Non-protein group essential for function/binding oxygen

4. Name the level of protein structure describing several connected polypeptide subunits. 1

Quaternary



5. State the class of amino acids to which valine belongs. 1

Hydrophobic/Non-polar

6. Molecules of sickle cell haemoglobin clump together preventing access to oxygen binding sites.

Suggest why this is a result of the substitution of glutamic acid by valine. 1

Valine has no charge so
haemoglobin molecules don't repel

7. Explain why haem is described as a prosthetic group.

Non-protein group essential for function/binding oxygen

8. Name the process whereby binding of oxygen to one subunit of haemoglobin alters the affinity of the remaining subunits.

1

Cooperativity

9. Tissues with higher metabolic rates require more oxygen. These tissues produce more carbon dioxide, which dissolves in tissue fluids to form carbonic acid.

Explain how this increases oxygen delivery at these tissues.

1

Lower affinity of haemoglobin for oxygen

So greater release

10. Haem is a non-protein component important in the function of haemoglobin.

State the term used to describe such a component.

1

Prosthetic group

11. Explain the term cooperativity in relation to oxygen binding to haemoglobin.

1

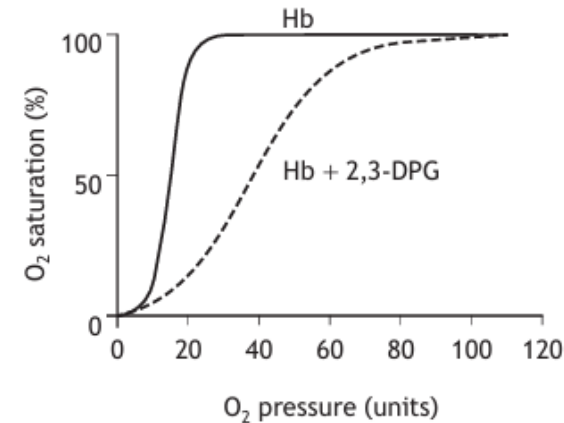
Binding to one subunit of one oxygen
makes the binding of other oxygen more likely.

12. Haemoglobin is affected by a number of allosteric interactions. Allosteric interactions between the oxygen-binding sites result in co-operativity.

Explain what is meant by co-operativity in haemoglobin.

1

Changes in binding of oxygen at one site affects the
binding of oxygen at the remaining subunits.



13. Explain how the data show that 2,3-DPG is acting as a negative modulator.

Requires a higher O₂ pressure to reach 100% saturation

As haemoglobin's affinity for oxygen decreased

14. The concentration of 2,3-DPG in the blood is normally 5 mmol per litre, but this rises to approximately 8 mmol per litre in individuals living at high altitude.

Explain how this increase in 2,3-DPG concentration at high altitude would help oxygen delivery to tissue.

1

Higher concentration would further reduce affinity for oxygen
enabling haemoglobin to release oxygen more easily

15. The drug diazepam increases the effect of GABA molecules by binding to a secondary (allosteric) binding site on GABA_A receptors.

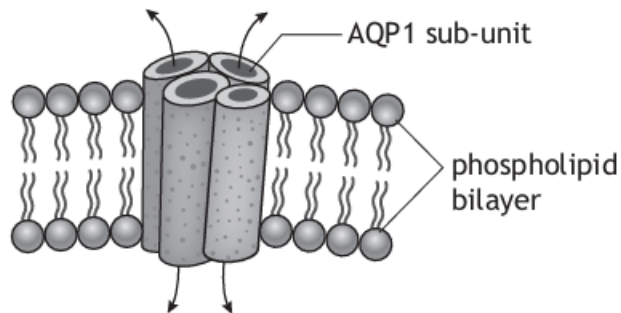
State the term used to describe the effect of diazepam on GABA_A receptors.

1

Positive modulator

16. . Aquaporin 1 (AQP1) is a membrane protein which channels the movement of water molecules. AQP1 has four sub-units, each of which acts as a water channel, as shown in Figure 1 below.

Figure 1: A fragment of membrane containing AQP1



With reference to AQP1, describe what is meant by the quaternary structure of a protein.

1

Contains 4 protein sub units

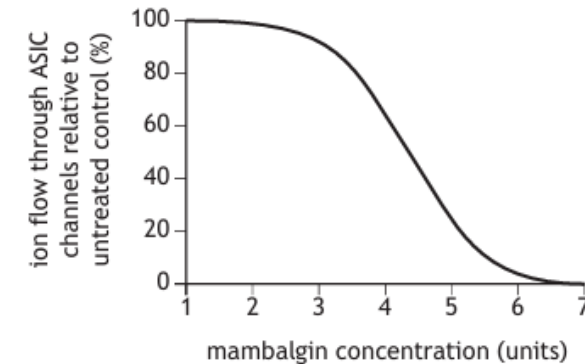
17. Explain why the rate of uptake by GLUT transporters levels off at high glucose concentrations.

1

most GLUT transporters filled

18. Acid sensing ion channels (ASICs) are involved in the perception of pain and are activated by small changes in the pH of the surrounding cellular environment. Mambalgin is another toxin found in black mamba venom, which is known to be able to bind to ASICs.

The graph shows the effect of increasing the dose of mambalgin on the activity of ASIC ion channels.



Suggest the mechanism by which mambalgin might work as a painkiller by preventing the generation of a nerve impulse.

1

Mambalgin acts as an antagonist

Cannot sufficiently depolarise the membrane/initiate action potential

19. What name is given to a molecule that binds to a protein?

1

ligand

20. Describe the reaction catalysed by a kinase enzyme.

1

phosphorylation

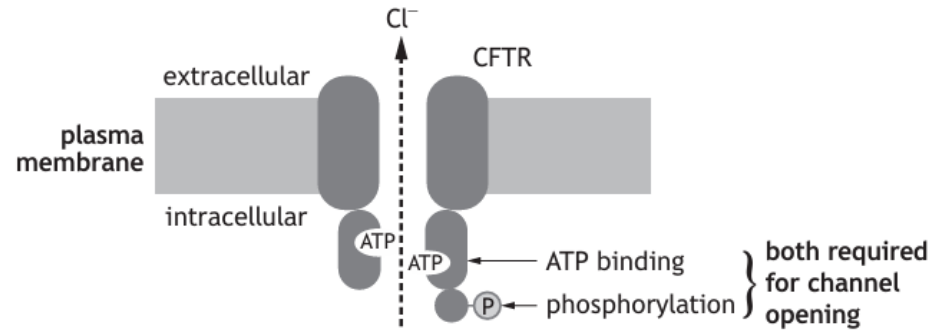
21. Suggest what happens to the receptor protein when GABA binds to it.

1

changes conformation

22. The protein CFTR is involved in the regulation of water content of extracellular mucus in the lungs and digestive system.

The figure represents the action of CFTR. It regulates the passage of chloride ions (Cl^-) across membranes of epithelial (lining) cells. In order for this ion channel to open, the protein must bind two ATP molecules, as well as a phosphate group. The increased concentration of Cl^- outside the cell draws water out of the epithelial cells into the mucus, maintaining its fluidity.



Cholera is a disease caused by the bacterium *Vibrio cholerae*. It causes severe watery diarrhoea, which can lead to dehydration and even death. The bacterium produces *cholera toxin* which interferes with the control of the CFTR protein channel by constantly activating a kinase enzyme.

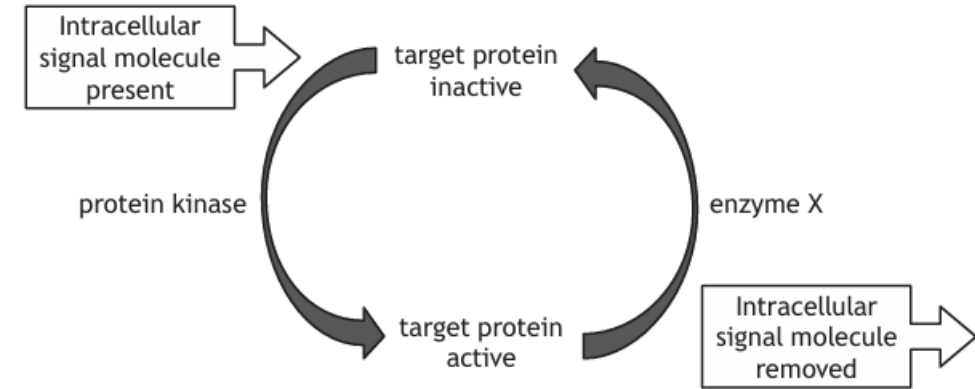
Explain how the production of cholera toxin by *Vibrio cholerae* can lead to more water being drawn out of the epithelial cells.

2

Constantly active kinase leads to constant phosphorylation of CFTR

ion channel constantly open

23. The diagram shows how two types of enzyme can be involved in controlling the activity of a protein in response to the presence of a signalling molecule within the cell (intracellular signal molecule). Intracellular signalling molecules are often produced as a result of extracellular signals received by cell-surface receptors.



24. Name the type of enzyme represented by enzyme X.

1

phosphatase.

Explain how the action of protein kinase can switch a target protein from inactive to active.

1

Kinase phosphorylates target protein changing its conformation

Explain the importance of the system being able to return the target protein to its inactive state.

1

So that the target protein can respond again.

24. The eukaryotic organism *Candida albicans* is one of the most common fungal pathogens of humans. One treatment for *C. albicans* infection is a compound called *sordarin*, which is isolated from a different fungus. Sordarin works by binding to highly specific sites on a protein called eukaryotic elongation factor 2 (eEF-2). eEF-2 causes the elongation of polypeptide chains during translation, by binding to a section of the ribosome.

a (i) Explain why sordarin can be described as a ligand.

1

Binds to a protein.

(ii) Explain why binding of sordarin to eEF-2 would change the function of the protein.

1

Causes conformational change

The gene for the protein eEF-2 is highly conserved across eukaryote species.

b))(i) Suggest what concerns there may have been in treating *C. albicans* infections in humans with sordarin.

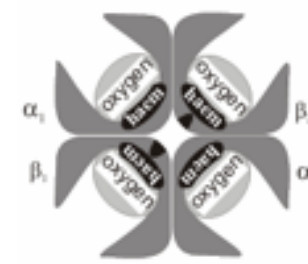
1

Drug could have a similar effect in humans.

(ii) Describe what happens in a phosphorylation cascade.

Series of kinases phosphorylating the next in the sequence activating it

25.



Oxyhaemoglobin

a) State the level of protein structure shown by haemoglobin.

Quaternary

b) Give the biological term for the iron-containing haem group embedded in each globin subunit.

Prosthetic group

c) Give the biological term for the reduced affinity of haemoglobin for the second oxygen once the first has been released.

Co operativity

d) State a changed condition in an exercising muscle that influences the reduced affinity of haemoglobin for oxygen.

Reduced pH/increased temperature

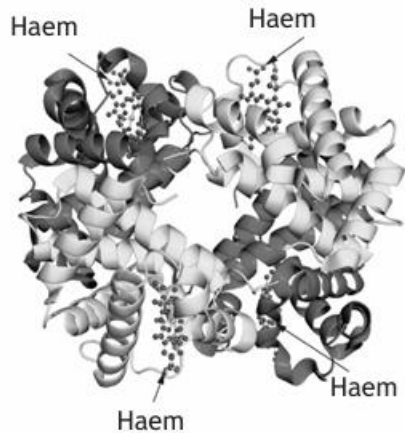
27 a) Some of the proteins in secretory vesicles are inactive precursors of digestive enzymes. Give the reason for them to be kept in an inactive form before secretion. 1

So it does not digest the cell (that produced them)

State how the precursors of digestive enzymes are activated after being released from the cell.

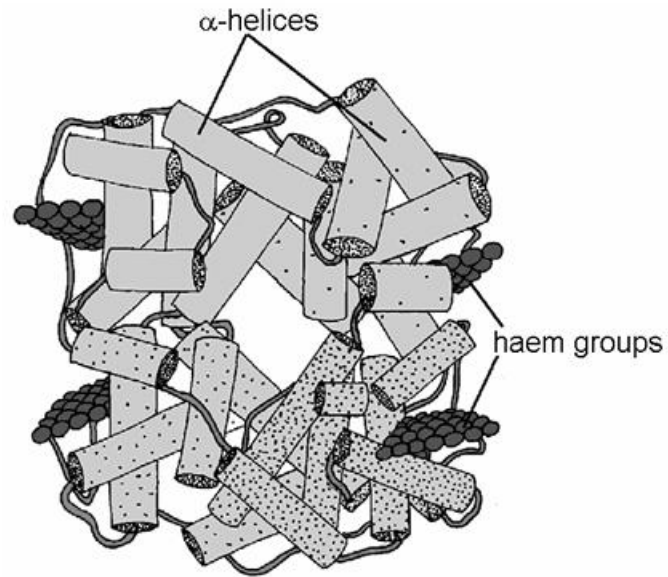
b) Proteolytic cleavage/covalent modification 1

28 Identify **one** type of secondary structure shown in the haemoglobin molecule in the figure below. 1



Alpha helix/turns

29 The diagram represents a haemoglobin molecule composed of four polypeptide subunits held together by inter molecular bonds.



(i) Name another secondary structure in a haemoglobin subunit.

Turns/beta pleated sheet 1

(ii) Give an example of a type of bond that gives haemoglobin this conformation.

Hydrogen/LDF's/Disulfide bridge/hydrophobic interactions/ionic 1

(iii) State the level of protein structure shown by haemoglobin.

quaternary 1

- | | |
|---|--|
| <p>1. Diagram/description of generalised structure of an amino acid.</p> <p>2. (Amino acids only) differ in (structure of) R group.</p> <p>3. TWO from:
Types of R groups are acidic/basic/polar/hydrophobic</p> <p>4. (Different) R groups give different hydrogen-bonding capacity/chemical reactivity</p> | <p>12. TWO from:</p> <ul style="list-style-type: none">• Hydrophobic interactions• Ionic bonds• London dispersion forces• Hydrogen bonds• Disulphide bridges |
|---|--|

MAX 2 from Pts 1 to 4

5. Primary structure (of a protein) is the order of amino acids (in a polypeptide/protein)
6. (Amino acids) linked by peptide bonds

OR
Diagram showing peptide bond

7. Secondary structure from hydrogen bonding (between amino acids)
8. Along backbone

OR
not between R groups

9. α -helix, β (–pleated) sheet and turns are types of secondary structure
10. Tertiary structure is folding of polypeptide/3-D shape of protein
11. Tertiary structure stabilised by interactions between R groups