# 2. Biological molecules

NOTE:

- Monosaccharides = glucose, fructose, galactose, ribose, deoxyribose
- Reducing sugars = monosaccharides + maltose
- Non-reducing sugar = sucrose
- Glucose = hexose
- Ribose & deoxyribose = pentose

1.

What enables triglycerides to perform their functions in living organisms?

1 Triglycerides have hydrophobic and hydrophilic regions.

2 Triglycerides have a high ratio of carbon–hydrogen bonds to carbon atoms.

3 Hydrolysis of triglycerides releases metabolic water.

**A** 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 2 only

Ans: D

- Option 1 applies to phospholipids NOT triglycerides.
- Option 2 is true, because this allows a lot of energy to be released.
- Option 3 is not true, because hydrolysis requires water. Hydrolysis of triglycerides produces glycerol and 3 fatty acids.

2.

Samples of glucose, sucrose, and a mixture of glucose and sucrose were divided into two halves **M** and **N**.

**M** was then tested with Benedict's solution.

**N** was boiled with dilute hydrochloric acid, neutralised and then tested with Benedict's solution.

The colour of the solution was compared to colour standards.

Which table identifies the correct colour changes for these samples?

**A**

| sample | **M** | **N** |
|---|---|---|
| glucose | blue | blue |
| sucrose | blue | yellow |
| mixture | blue | yellow |

**B**

| sample | **M** | **N** |
|---|---|---|
| glucose | yellow | yellow |
| sucrose | blue | yellow |
| mixture | blue | yellow |

**C**

| sample | **M** | **N** |
|---|---|---|
| glucose | yellow | yellow |
| sucrose | blue | yellow |
| mixture | yellow | red |

**D**

| sample | **M** | **N** |
|---|---|---|
| glucose | yellow | red |
| sucrose | blue | red |
| mixture | yellow | red |

Ans: C

3.

Some foods contain hydrogenated vegetable fats. These are unsaturated fats that have been converted to saturated fats.

Which property of the fats will have changed?

**A** Their hydrocarbon chains will fit together more closely.

**B** Their solubility in water will increase.

**C** They will have more double bonds in their molecules.

**D** They will remain liquid at room temperature.

Ans: A

4.

A polypeptide contains a specific number of amino acids, n.

How many peptide bonds are present in this polypeptide?

**A** n – 1 **B** n **C** n + 1 **D** n + 2

Ans: A

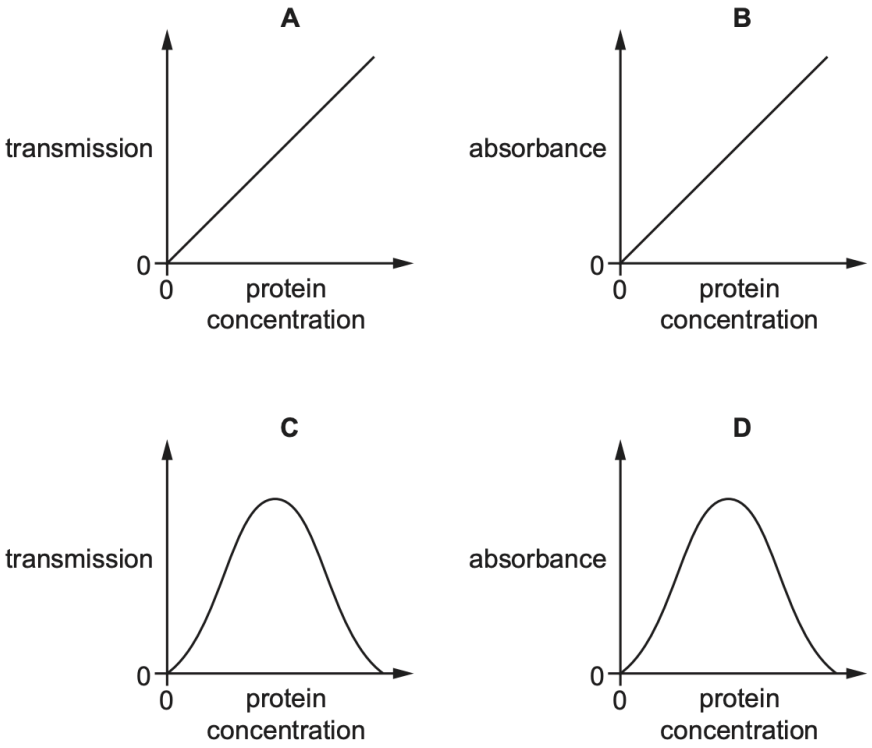
5.

A student used colorimetry to monitor the hydrolysis of a protein by a protease enzyme.

The student used biuret solution to determine the concentration of protein in the hydrolysis reaction.

The student produced a calibration curve using known concentrations of protein.

Which diagram shows the calibration curve?




Ans: B

6.

Which have properties that are dependent on hydrogen bonds?

1 cellulose

2 a molecule of haemoglobin

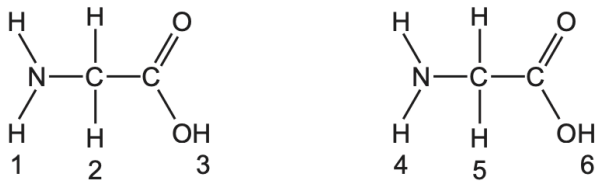
3 water

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

Ans: A

7.

The diagram shows two amino acids. Some of the hydrogen atoms are numbered 1 to 6.




Which two numbered hydrogen atoms could contribute to the production of a molecule of water when a peptide bond forms between these two amino acids?

**A** 1 and 4 **B** 1 and 6 **C** 3 and 5 **D** 2 and 4

Ans: B

- Peptide bond = CONH
- To form the peptide bond, the COOH group loses OH and the NH2 groups loses an H
- Thus the 2 H for the water molecule come from hydrogens 1 and 6

8.

A student wrote four statements about water.

1 Water has a high specific heat capacity which maintains the temperature of water within cells.

2 Mammals rely on water having a relatively low latent heat of vaporisation to keep them cool.

3 When a negatively charged ion is added to water, the $\delta^+$ charge on the hydrogen atom is attracted to the ion.

4 When surrounded by water, non-polar molecules tend to be pushed apart from one another.

Which statements are correct?

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **A** | ✓ | ✗ | ✓ | ✓ |
| **B** | ✓ | ✗ | ✓ | ✗ |
| **C** | ✗ | ✓ | ✗ | ✓ |
| **D** | ✗ | ✓ | ✗ | ✗ |

key
✓ = correct
✗ = not correct

Ans: B

9.

Typical enzymes are large globular proteins with a specific tertiary shape.

Which molecular interactions are directly involved in maintaining the tertiary shape?

1 hydrogen bonding

2 disulfide bridges

3 hydrophobic interactions

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

Ans: A

10.

Long chain, saturated fatty acids change from solid to liquid at higher temperatures compared with short chain, unsaturated fatty acids.

Which fatty acids would be more likely to form triglycerides in mammals that live in cold climates?

**A** long chain saturated

**B** long chain unsaturated

**C** short chain saturated

**D** short chain unsaturated

Ans: D

- Fatty acids need to be in liquid form in order to form triglycerides.
- Short chain, unsaturated fatty acids change from solid to liquid at lower temperatures, so are more suitable for forming triglycerides in low temperatures

11.

ATP molecules are synthesised in mitochondria.

Which sugar is found in these ATP molecules?

**A** deoxyribose

**B** fructose

**C** glucose

**D** pentose

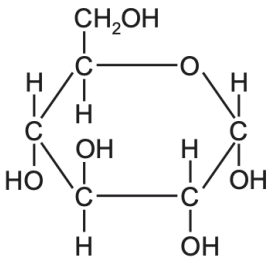
Ans: D

NOTE: components of ATP

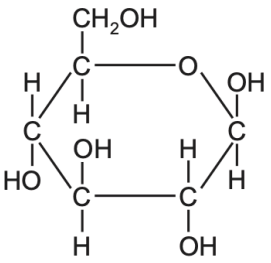
- Nitrogenous base = adenine
- Sugar = ribose
- 3 phosphate groups

12.

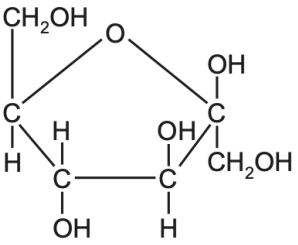
The diagram shows three hexose sugars.



1



2



3

Which row correctly shows examples of carbohydrates in which these three hexose sugars occur?

| | sucrose | cellulose | amylopectin |
|---|---|---|---|
| **A** | 1 | 2 | 3 |
| **B** | 1 | 3 | 2 |
| **C** | 2 | 3 | 1 |
| **D** | 3 | 2 | 1 |

Ans: D

- 1 = α–glucose
- 2 = β–glucose
- 3 = fructose

13.

Trehalose is a sugar that gives a negative result when tested with Benedict's solution.

A molecule of trehalose forms two α-glucose molecules when it is hydrolysed.

Which row is correct?

| | formula of trehalose | sugar that gives the same result with Benedict's as trehalose |
|---|---|---|
| **A** | $C_{12}H_{22}O_{11}$ | fructose |
| **B** | $C_{12}H_{22}O_{11}$ | sucrose |
| **C** | $C_{12}H_{24}O_{12}$ | fructose |
| **D** | $C_{12}H_{24}O_{12}$ | sucrose |

Ans: B

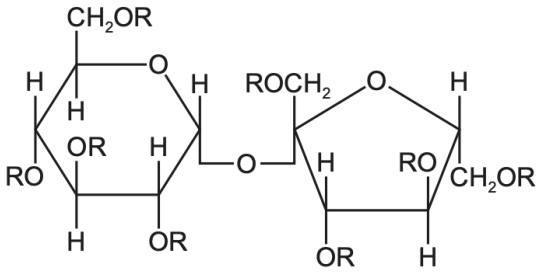
- Trehalose should be deficient of 1 water molecule, since a glycosidic bond is formed when it is synthesised from 2 glucose molecules
- Thus it should be either A or B

- Sucrose = non-reducing sugar which gives negative result with Benedict's

14.

Olestra is an artificial lipid. It is made by attaching fatty acids, by condensation, to a sucrose molecule.

A simplified diagram of olestra is shown. R represents the position where fatty acids would be attached.




Humans cannot hydrolyse olestra. However, other animals may be able to do so.

How many molecules of water would be needed to hydrolyse one molecule of olestra into fatty acids, fructose and glucose?

**A** 11 **B** 10 **C** 9 **D** 8

Ans: C

- To hydrolyse 1 glycosidic bond = 1 molecule of water
- To hydrolyse fatty acids = 1 molecule of water
- Thus number of water molecules required = 1 + 8 = 9

15.

Which statements are correct for amylose and also for amylopectin?

1 They are carbohydrate molecules.

2 They are formed by condensation reactions.

3 They are linear molecules.

4 They contain $\alpha$-1,4 glycosidic bonds.

**A** 1, 2 and 3 **B** 1, 2 and 4 **C** 1, 3 and 4 **D** 2, 3 and 4

Ans: B

NOTE:

- Amylose = linear
- Amylopectin = not linear, but branched

16.

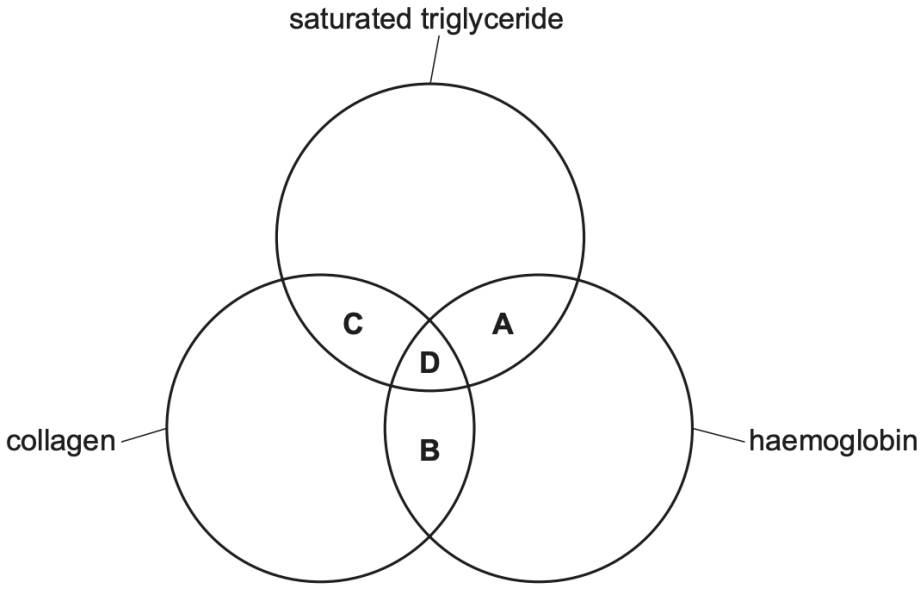
Which row correctly shows levels of protein structure that can be held together by each type of interaction?

| | hydrogen bonds | hydrophobic interactions | covalent bonds |
|---|---|---|---|
| **A** | primary, secondary and tertiary structure | tertiary structure | primary and tertiary structure |
| **B** | secondary structure | primary and tertiary structure | tertiary structure |
| **C** | secondary and tertiary structure | tertiary structure | primary and tertiary structure |
| **D** | secondary and tertiary structure | tertiary structure | primary and secondary structure |

Ans: C

17.

Which molecules contain at least three double bonds?




Ans: D

- Saturated triglyceride has 3 double bonds C=O.
- Collagen and haemoglobin are made of many amino acids. Each amino acid has 1 double bond (C=O) due to COOH group.

18.

Insulin is a globular protein involved in cell signalling. It is transported in the blood plasma from the cells that synthesise it to its target cells. A molecule of insulin contains six sulfur-containing amino acids and has two polypeptide chains.

Which statements about insulin are correct?

1 An insulin molecule has a quaternary structure.

2 Insulin polypeptides are held together by six disulfide bonds.

3 Amino acids with hydrophobic R groups would be found in the centre of an insulin molecule.

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

Ans: C

19.

Which statement correctly explains why blood plasma can be maintained at a stable temperature?

**A** It has a low specific heat capacity.

**B** It has a high specific heat capacity.

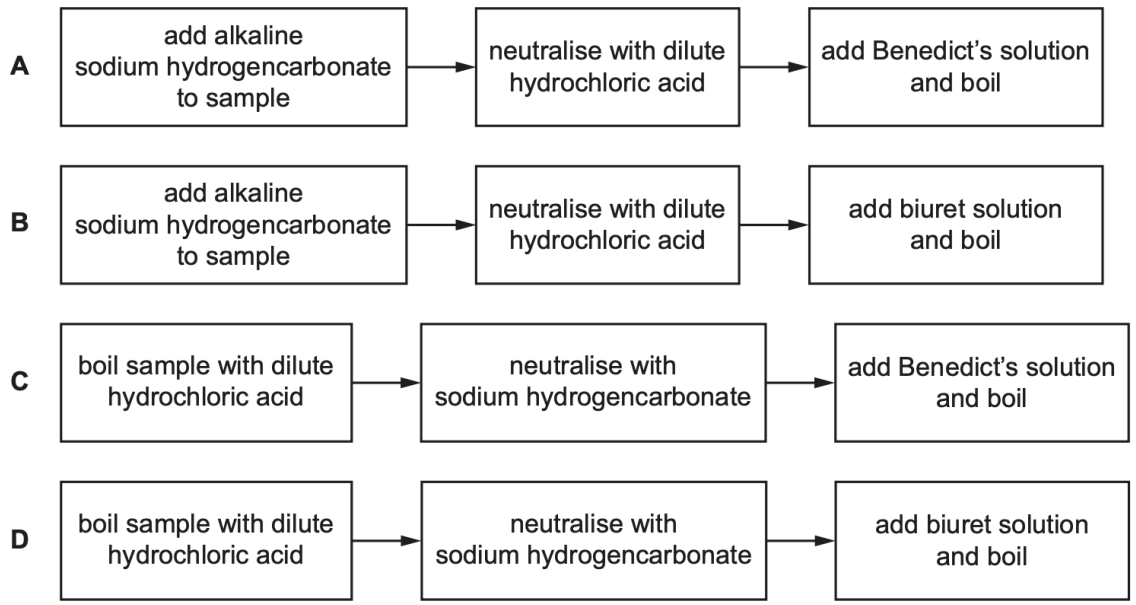
**C** It has a low latent heat of vaporisation.

**D** It has a high latent heat of vaporisation.

Ans: B

20.

Which flow chart outlining the test for non-reducing sugars is correct?

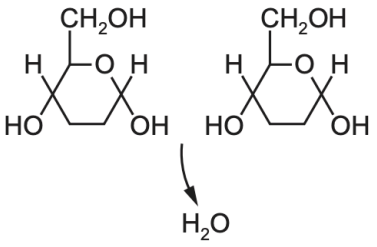


Ans: C

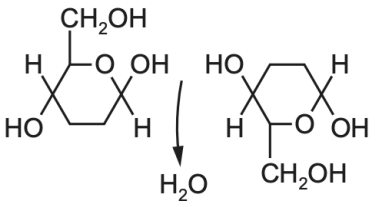
21.

Which diagrams show the release of a water molecule during the formation of a glycosidic bond?

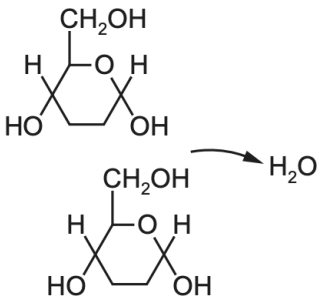
1




2




3




**A** 1, 2 and 3 **B** 1 only **C** 2 and 3 only **D** 3 only

Ans: A

22.

Tests for biological molecules were carried out on three solutions. Each solution contained only one type of biological molecule.

The observations were as follows.

| solution | test | observation |
|---|---|---|
| 1 | Benedict's test | blue to orange |
| 2 | Benedict's test after acid hydrolysis | blue to red |
| 3 | biuret test | blue to purple |

Which solutions would contain either sucrose or amylase?

**A** 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 2 only

Ans: C

- Sucrose = non-reducing sugar; after acid hydrolysis = reducing
- Amylase = enzyme = protein!!

23.

Which row correctly identifies the weak and strong bonds in the tertiary and quaternary structure of a typical protein?

| | type of bond | | | |
|---|---|---|---|---|
| | disulfide | hydrogen | hydrophobic | ionic |
| **A** | strong | strong | weak | weak |
| **B** | strong | weak | weak | weak |
| **C** | weak | weak | strong | strong |
| **D** | weak | weak | weak | strong |

Ans: B

NOTE: strength of bonds in tertiary structure of proteins (strongest to weakest)
Disulfide bond → ionic bond → hydrogen bond → hydrophobic interactions

24.

Which row correctly describes haemoglobin?

| | | | | |
|---|---|---|---|---|
| **A** | four polypeptide chains, each containing a haem group | iron ions can associate with oxygen, forming oxyhaemoglobin | in each chain, hydrophobic R-groups of amino acids point towards the centre of the molecule | at 50% saturation, two oxygen molecules are transported by the molecule |
| **B** | polypeptide chains interact to produce a globular chain | each chain contains a haem group of amino acids surrounding an iron ion | consists of two identical alpha chains and two identical beta chains | each chain can transport an oxygen molecule |
| **C** | polypeptide chains interact to produce an almost spherical molecule | an iron ion is present within each haem group | quaternary structure has two alpha chains and two beta chains | each molecule can transport a total of four oxygen atoms |
| **D** | polypeptide chains produce a loose helical shape, which folds to form a spherical molecule | iron ions in the molecule can bind reversibly with oxygen | in each chain, hydrophobic R-groups of amino acids surround the iron ion | each molecule can transport a total of eight oxygen atoms |

Ans: A

25.

What causes the phosphate heads of phospholipids to become polar?

**A** The phosphate heads are joined to water molecules by hydrogen bonds.

**B** The phosphate heads are insoluble in water.

**C** The phosphate heads become ionised in water.

**D** The phosphate heads are joined to water molecules by covalent bonds.

Ans: C

26.

Which statements describe features of cellulose that adapt it for its function in plant cells?

1 Three cellulose molecules coil around each other to form a triple helix structure.

2 Many hydrogen bonds form between adjacent cellulose molecules.

3 Covalent bonds form between adjacent cellulose molecules.

**A** 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 2 only

Ans: D

27.

Which properties of water are dependent on hydrogen bonding between water molecules?

| | cohesion | high latent heat of vaporisation | solvent action | high specific heat capacity |
|---|---|---|---|---|
| **A** | ✓ | ✓ | ✓ | ✗ |
| **B** | ✓ | ✓ | ✗ | ✓ |
| **C** | ✓ | ✗ | ✓ | ✓ |
| **D** | ✗ | ✓ | ✓ | ✓ |

key
✓ = dependent
✗ = not dependent

Ans: B
Question refers to hydrogen bonding <u>between</u> water molecules

28.

A naturally occurring polysaccharide synthesised in a plant is a branched chain of α-glucose.

The straight parts of the molecule are linked by α-1,6 glycosidic bonds with only a small number of branches which are linked by either an α-1,3 glycosidic bond or an α-1,4 glycosidic bond.

Which polysaccharide has a structure **most** similar to that described?

**A** amylopectin

**B** amylose

**C** cellulose

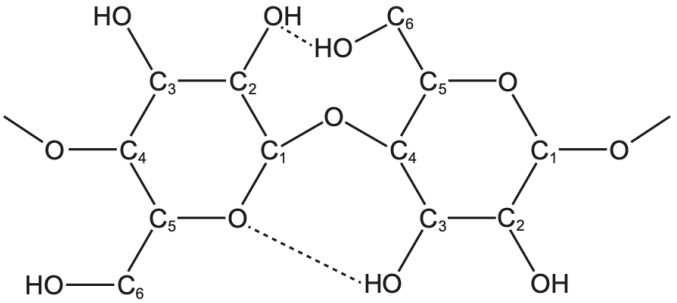
**D** glycogen

Ans: A

- Molecule has branches, but small number of branches = amylopectin

29.

The diagram shows how the alternating nature of β-glucose monomers along a chain allows hydrogen bonds to form between consecutive monomers.




Hydrogen bonds in cellulose affect the tensile strength (the ability to withstand pulling forces without breaking).

How do the hydrogen bonds shown in the diagram help cellulose function as a suitable material for a cell wall?

**A** The hydrogen bonds add additional tensile strength along individual cellulose molecules within the cell wall.

**B** The hydrogen bonds create stronger crosslinks between adjacent cellulose molecules, adding to the tensile strength of the cell wall.

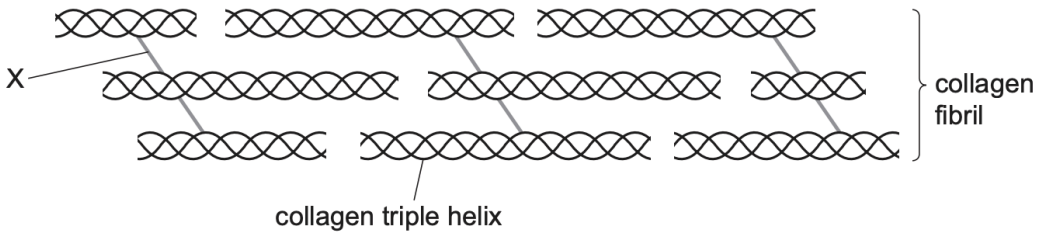
**C** Stronger hydrogen bonds form between adjacent cellulose molecules, adding to the tensile strength of the cell wall.

**D** Cellulose molecules within a cellulose microfibril have a stronger link between them, increasing the tensile strength of the cellulose microfibrils.

Ans: A

30.

The diagram shows part of a collagen fibril made of collagen triple helices. The collagen triple helices are linked to each other by one type of bond. This bond is labelled as X in the diagram.




What is bond X?

**A** covalent bond

**B** disulfide bond

**C** hydrogen bond

**D** peptide bond

Ans: A

NOTE:

- Multiple collagen triple helices are held together to form a collagen fibril
- The cross links between these triple helices are covalent bonds
- Disulfide bonds are mainly found in proteins with cysteine residues, such as keratin.
- Hydrogen bonds stabilize the triple helix within a single tropocollagen molecule, but they do not hold fibrils together.
- Also note, hydrogen bonds will always be shown by dotted lines!

31.

The table shows some information about the polypeptides that make up haemoglobin.

| | α-globin | β-globin |
|---|---|---|
| total number of amino acid residues in polypeptide chain | 141 | 146 |
| position of amino acid cysteine in polypeptide chain | 104 | 93 and 112 |

Scientists studied the region of the β-globin polypeptide chain containing the amino acid cysteine at position 93. They found that:

- this region faces outwards when **no** oxygen is attached to the haem group
- this region faces inwards when oxygen is attached to the haem group
- replacing cysteine with a different amino acid reduces the Bohr shift.

What can be concluded from the information about cysteine in haemoglobin?

**A** More than 1% of the amino acids in one haemoglobin protein are cysteine.

**B** In α-globin, there is a cysteine closer to the end of the polypeptide chain with an unreacted carboxyl group than in β-globin.

**C** The replacement of the cysteine at position 93 in β-globin decreases the affinity of haemoglobin for oxygen at low pH.

**D** The binding of oxygen to the haem group causes the region of β-globin containing cysteine at position 93 to become more hydrophilic.

Ans: A

32.

Which statements are correct reasons for how animals cool down in hot environments using latent heat of vaporisation of water?

1 Some animals lie down and roll in wet soil.

2 Fish move into deeper water.

3 Some animals lick their fur to make it wet.

4 Some animals breathe quickly with a wet tongue hanging out of their mouth.

**A** 1, 2 and 3 **B** 1, 2 and 4 **C** 1, 3 and 4 **D** 2, 3 and 4

Ans: C

33.

Which set of steps is the best method for conducting the emulsion test for lipids?

**A** Add 2 $cm^3$ of water to the sample.
Pour the water into a test-tube containing 2 $cm^3$ of ethanol.
Lipids are present if the mixture becomes cloudy.

**B** Add 2 $cm^3$ of ethanol to the sample and shake.
Pour the ethanol into a test-tube containing 2 $cm^3$ of water and boil.
Lipids are present if the mixture becomes clear.

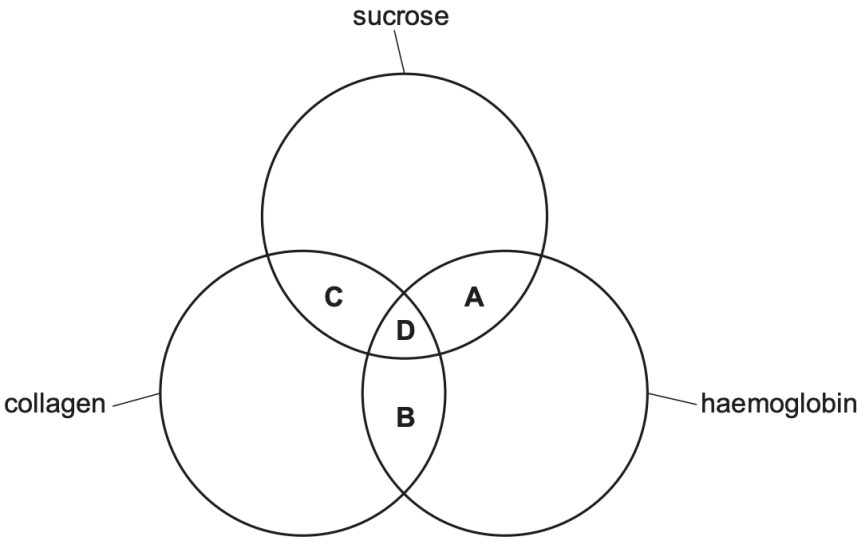
**C** Add 2 $cm^3$ of water to the sample and shake.
Pour the water into a test-tube containing 2 $cm^3$ of ethanol and boil.
Lipids are present if the mixture becomes cloudy.

**D** Add 2 $cm^3$ of ethanol to the sample and shake.
Pour the ethanol into a test-tube containing 2 $cm^3$ of water and shake again.
Lipids are present if the mixture becomes cloudy.

Ans: D

34.

Which molecules contain at least two double bonds?




Ans: B

35.

What is the maximum number of hydrogen bonds that can form between two single water molecules?

**A** 1 **B** 2 **C** 3 **D** 4

Ans: A