

Molecules (Unity and diversity) practice questions

15 questions • 47 marks • mark scheme at the back

For IB Diploma Biology, Standard Level and Higher Level (first assessment 2025). **HL only** is additional higher level content, for HL students only.

Name

Total / 47

Water **Spec A1.1**

1 PAPER 1A STYLE [1 mark]

What causes hydrogen bonds to form between water molecules?

- A. ☐ Unequal sharing of electrons in O-H covalent bonds makes the molecules polar
- B. ☐ Water molecules lose and gain electrons to form H^+ and OH^- ions
- C. ☐ Electrons are shared equally between the oxygen and hydrogen atoms
- D. ☐ Hydrogen atoms of neighbouring molecules form covalent bonds with each other

2 PAPER 1A STYLE [1 mark]

Which property of water is mainly responsible for water being drawn through the cellulose cell walls of leaf mesophyll cells?

- A. ☐ High specific heat capacity
- B. ☐ Adhesion to hydrophilic cellulose
- C. ☐ Buoyancy
- D. ☐ Low viscosity

3 PAPER 1A STYLE [1 mark]

Which substance is transported in blood plasma combined with proteins, because it does not dissolve well in water?

- A. ☐ Glucose
- B. ☐ Sodium ions
- C. ☐ Amino acids
- D. ☐ Cholesterol

4

[5 marks]

The table shows some physical properties of water and air at 20 °C. (a) Calculate how many times greater the thermal conductivity of water is than that of air. [1] (b) Using the data, explain why a ringed seal (*Pusa hispida*) swimming in cold Arctic water needs a thick layer of blubber. [2] (c) Suggest, using the data, why a black-throated loon (*Gavia arctica*) needs a streamlined body to catch fish underwater. [2]

Physical properties of water and air at 20 °C		
Property	Water	Air
Density / kg m ⁻³	998	1.2
Viscosity / mPa s	1.00	0.018
Thermal conductivity / W m ⁻¹ K ⁻¹	0.60	0.026
Specific heat capacity / J g ⁻¹ °C ⁻¹	4.18	1.01

Answer =

[illegible]

5

[3 marks]

Explain how cohesion allows water to be transported up the xylem of a tall tree.

6

[6 marks]

[illegible]

7

[3 marks]

HL only

```
=====
=====
=====
=====
=====
=====
=====
=====
```

Nucleic acids

Spec A1.2

8

[1 mark]

B. ☐ Ribose and thymine

C. ☐ Ribose and uracil

D. ☐ Deoxyribose and uracil

9

[1 mark]

HL only

B. ☐ Each base pair has one purine and one pyrimidine

C. ☐ Every base pair is held by the same number of hydrogen bonds

D. ☐ Histone proteins hold the strands a fixed distance apart

10 PAPER 1B STYLE

[5 marks]

The table shows the percentage of each base in the nucleic acid from four sources. Some values are missing. (a) Calculate the percentage of guanine in human DNA. [2] (b) Deduce the percentage of cytosine in wheat DNA, giving a reason. [1] (c) Identify which sample is RNA and explain one piece of evidence for your answer. [2]

Base composition of nucleic acids (percentage of bases, practice data)					
Source	Adenine	Thymine	Guanine	Cytosine	Uracil
Human DNA	30	30	?	?	0
Wheat DNA	27	27	23	?	0
Bacterial DNA	25	25	25	25	0
Sample X	29	0	22	18	31

Answer =

11 PAPER 2A STYLE

[2 marks]

Calculate the number of different base sequences possible for a DNA strand 8 nucleotides long, and state what this shows about the capacity of DNA for storing information.

Answer =

12 PAPER 2A STYLE

[4 marks]

Draw a labelled diagram of a section of RNA consisting of two nucleotides, and outline how they are joined.

13 PAPER 2B STYLE

[6 marks]

Explain the role of complementary base pairing in allowing genetic information to be replicated and expressed.

14

[4 marks]

HL only

In an experiment like that of Hershey and Chase, T2 bacteriophages labelled with either ^{35}S or ^{32}P were allowed to infect *E. coli*. After blending and centrifuging, the radioactivity in the pellet and supernatant was measured. (a) State which molecule each isotope labels. [1] (b) Analyse the results to deduce which molecule enters the bacteria. [2] (c) Suggest why the supernatant still contains some ^{32}P . [1]

Percentage of total radioactivity recovered (practice data)		
Isotope	Pellet (bacteria) / %	Supernatant / %
³⁵ S	20	80
³² P	85	15

[illegible]

15

[4 marks]

HL only

(a) Describe the structure of a nucleosome. [2] (b) Explain how Chargaff's data falsified the tetranucleotide hypothesis. [2]

[illegible]

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [1]

A A [1]

2. [1]

B B [1]

3. [1]

D D [1]

4. [5]

- (a) $0.60 \div 0.026 = 23$ (times) / accept 23.1 [1]
- (b) water conducts heat (about 23 times) faster than air / has a higher thermal conductivity [1]
- (b) so heat is lost from the seal's body much faster in water [1]
- (b) blubber is an insulator that reduces heat loss / helps maintain body temperature [1]
- (c) water is much more viscous than air / about 55 times more viscous [1]
- (c) so there is more drag / resistance to movement through water [1]
- (c) streamlining reduces drag so the loon can swim fast enough to catch fish / uses less energy [1]
- [max 5]: max 1 for (a), max 2 for (b), max 2 for (c)

5. [3]

- cohesion is attraction between water molecules due to hydrogen bonds [1]
- evaporation of water from leaves / transpiration pulls water up the xylem [1]
- water in the xylem is under tension / negative pressure [1]
- cohesion keeps the water column continuous / stops the column breaking under tension [1]
- adhesion of water to xylem walls helps support the column [1]
- [max 3]

6. [6]

- electrons are shared unequally in the O-H covalent bonds / oxygen is more electronegative [1]
- oxygen is δ^- and hydrogens are δ^+ , so water molecules are polar [1]
- hydrogen bonds form between water molecules / between water and other polar molecules [1]
- polar molecules and ions are hydrophilic / attracted to water molecules [1]
- water molecules surround ions / polar molecules so they dissolve OWTTE [1]
- named examples of hydrophilic solutes: glucose / amino acids / mineral ions [1]
- dissolved substances can move and collide, so reactions can happen [1]
- most enzymes catalyse reactions in aqueous solution / cytoplasm is mostly water [1]
- water is a reactant in hydrolysis / is used or released in metabolic reactions [1]
- blood plasma transports dissolved glucose / amino acids / urea / hormones [1]
- xylem transports dissolved mineral ions / phloem transports dissolved sucrose [1]
- first cells originated in water / water remains the medium for most life processes [1]
- [max 6]

7. [3] HL only

- water was delivered to Earth by asteroids / extraplanetary origin [1]
- Earth's gravity is strong enough to hold its atmosphere / water vapour [1]
- temperatures on Earth are low enough for water to condense into liquid [1]
- the Goldilocks zone is the distance from a star where liquid water can exist on a planet's surface [1]
- life as we know it requires liquid water as its medium [1]
- [max 3]

8. [1]

C C [1]

9. [1] HL only

B B [1]

10. [5]

- (a) $A + T = 60\%$, so $G + C = 100 - 60 = 40\%$ [1]
- (a) $G = C$, so guanine = 20% [1]
- (b) 23% because cytosine pairs with guanine / $G = C$ in double-stranded DNA [1]
- (c) sample X is RNA [1]
- (c) contains uracil and no thymine [1]
- (c) $A \neq U$ and $G \neq C$, so it is single-stranded / has no complementary base pairing between strands [1]
- [max 5]: ECF in (a) for $G =$ half of $(100 - A - T)$

11. [2]

- $4^8 = 65\,536$ [1]
- any length and any base sequence is possible so the capacity for storing information is (effectively) limitless / very large [1]

12. [4]

- each nucleotide drawn as circle (phosphate), pentagon (sugar) and rectangle (base) with base and phosphate on different corners of the sugar [1]
- labels: phosphate, ribose / pentose sugar, base [1]
- bases named as RNA bases (A, U, G or C), not T [1]
- phosphate of one nucleotide bonded to the sugar of the next, forming a sugar-phosphate backbone [1]
- joined by condensation / water released [1]
- the bond is covalent [1]
- [max 4]

13. [6]

- A pairs with T (or U in RNA) and G pairs with C [1]
- complementarity is based on hydrogen bonding between bases [1]
- in replication the two DNA strands separate and each acts as a template [1]
- free nucleotides pair with complementary bases on the template [1]
- producing two identical DNA molecules / the base sequence is copied accurately [1]
- in transcription mRNA is built with bases complementary to the template strand of DNA [1]
- uracil pairs with adenine in transcription [1]
- in translation tRNA anticodons pair with complementary mRNA codons [1]
- so amino acids are linked in the sequence coded by the gene [1]
- the genetic code is shared by (almost) all organisms, so base sequences are translated the same way [1]
- [max 6]

14. [4] HL only

- (a) ^{35}S labels protein and ^{32}P labels DNA [1]
- (b) most ^{32}P (85%) is in the pellet / with the bacteria [1]
- (b) most ^{35}S (80%) is in the supernatant / stays outside [1]
- (b) so DNA enters the bacteria (and protein does not), so DNA is the genetic material [1]
- (c) some viruses had not injected their DNA / not all viruses infected bacteria / some bacteria burst or stayed in the supernatant OWTTE [1]
- [max 4]: max 1 for (a), max 2 for (b), max 1 for (c)

15. [4] HL only

- (a) DNA wrapped around a core of eight histone proteins [1]
- (a) an additional histone protein attached to linker DNA holds the DNA in place [1]
- (a) positive histones attract negatively charged DNA phosphates [1]
- (b) tetranucleotide hypothesis: DNA is a repeating sequence of the four bases, so all four in equal amounts [1]
- (b) Chargaff found base proportions differ between species / $A + T$ is not equal to $G + C$ [1]
- (b) only $A = T$ and $G = C$, so the bases are not all equal and the hypothesis is false [1]
- [max 4]: max 2 for (a), max 2 for (b)