

Molecules (Interaction and interdependence) practice questions

24 questions • 75 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 / 75

Enzymes and metabolism **Spec C1.1**

1 PAPER 1A STYLE

[1 mark]

Which process is an example of catabolism?

- A. ☐ Formation of glycogen from glucose in liver cells
- B. ☐ Synthesis of a polypeptide at a ribosome
- C. ☐ Hydrolysis of starch to maltose in the small intestine
- D. ☐ Production of glucose in photosynthesis

2 PAPER 1A STYLE

[1 mark]

Which statement describes induced-fit binding?

- A. ☐ The active site is a rigid shape exactly complementary to the substrate before binding.
- B. ☐ Both the substrate and the active site change shape when binding occurs.
- C. ☐ The substrate changes shape but the enzyme does not.
- D. ☐ The enzyme denatures slightly each time a substrate binds.

3 PAPER 1A STYLE

[1 mark]

HL only

Statins lower blood cholesterol by inhibiting an enzyme in its synthesis pathway. As statins are competitive inhibitors, which change would reduce their effect?

- A. ☐ Increasing the concentration of the enzyme's substrate
- B. ☐ Lowering the temperature of the reaction
- C. ☐ Adding a substance that binds to the allosteric site
- D. ☐ Decreasing the concentration of the enzyme's substrate

4 PAPER 1B STYLE

[5 marks]

Students investigated the effect of temperature on the activity of catalase extracted from potato. They measured the volume of oxygen released from hydrogen peroxide in the first 60 seconds. The data are for practice and show the mean of three repeats. (a) Calculate the mean rate of oxygen production at 35 °C, in $\text{cm}^3 \text{s}^{-1}$. [1] (b) Describe the effect of temperature on the volume of oxygen released. [2] (c) Explain the result at 55 °C. [2]

Volume of oxygen released in 60 s at different temperatures

Temperature / °C	Mean volume of oxygen in 60 s / cm^3
15	6.0
25	11.4
35	19.8
45	15.6
55	2.4

Answer =

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5 PAPER 2A STYLE

[2 marks]

Outline how the structure of a globular protein allows it to act as an enzyme.

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6 PAPER 2A STYLE

[3 marks]

Explain how an enzyme increases the rate of a reaction, with reference to activation energy.

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7 PAPER 2A STYLE

[3 marks]

HL only

(a) Distinguish between intracellular and extracellular enzyme-catalysed reactions, giving one example of each. [2] (b) State why heat is always generated by metabolic reactions. [1]

[illegible]

8 PAPER 2B STYLE

[7 marks]

HL only

Explain how enzyme activity can be regulated or inhibited, using the isoleucine pathway and penicillin as examples.

[illegible]

Cell respiration Spec C1.2

9 PAPER 1A STYLE

[1 mark]

Which statement about ATP is correct?

- A. ☐ It is a nucleotide containing deoxyribose.
- B. ☐ Energy is required to hydrolyse it to ADP and phosphate.
- C. ☐ It is a nucleotide, and its hydrolysis to ADP and phosphate releases energy.
- D. ☐ It moves freely out of cells through the plasma membrane.

10 PAPER 1A STYLE

[1 mark]

Which feature is shared by aerobic and anaerobic cell respiration in humans?

- A. ☐ Both produce carbon dioxide.
- B. ☐ Both require mitochondria.
- C. ☐ Both can use glucose as the substrate.
- D. ☐ Both produce lactate.

11 PAPER 1A STYLE

[1 mark]

HL only

How many decarboxylations and oxidations occur in one turn of the Krebs cycle?

- A. ☐ One decarboxylation and two oxidations
- B. ☐ Two decarboxylations and four oxidations
- C. ☐ Two decarboxylations and three oxidations
- D. ☐ Four decarboxylations and two oxidations

12 PAPER 1B STYLE

[5 marks]

A respirometer containing 3.0 g of maggots and soda lime was kept at three temperatures. The distance moved by the liquid drop in 5 minutes was recorded. The capillary tube has a cross-sectional area of 0.80 mm². The data are for practice. (a) Calculate the rate of oxygen uptake per gram at 25 °C, in mm³ g⁻¹ min⁻¹. Show your working. [2] (b) Identify the independent and the dependent variable. [1] (c) Explain the trend shown in the data. [2]

Distance moved by the drop in 5 minutes	
Temperature / °C	Mean distance moved / mm
15	11
20	17
25	24

Answer =

[illegible]

13 PAPER 2A STYLE

[3 marks]

(a) State two processes in cells that use energy from ATP. [2] (b) Distinguish between cell respiration and gas exchange. [1]

[illegible]

HL only

(a) Outline the stages of glycolysis. [2] (b) Explain why yeast converts pyruvate to ethanol and carbon dioxide in anaerobic conditions. [2]

HL only

Explain why lipids yield more energy per gram than carbohydrates in cell respiration, and why fatty acids cannot be used in anaerobic respiration.

HL only

Explain how ATP is produced by the electron transport chain and chemiosmosis in the mitochondrion.

Photosynthesis

Spec C1.3

17 PAPER 1A STYLE [1 mark]

What is the source of the oxygen released in photosynthesis by plants, algae and cyanobacteria?

- A. ☐ Carbon dioxide
- B. ☐ Glucose
- C. ☐ Water
- D. ☐ Chlorophyll

18 PAPER 1A STYLE [1 mark]

Which statement explains why the action spectrum of photosynthesis is not zero in the green part of the spectrum?

- A. ☐ Chlorophyll absorbs green light more strongly than red light.
- B. ☐ Accessory pigments absorb some light in this region.
- C. ☐ Green light has the highest energy per photon.
- D. ☐ Green light is reflected and then used by the stroma.

19 PAPER 1A STYLE [1 mark]

HL only

In the Calvin cycle, how many molecules of triose phosphate are converted into three molecules of RuBP?

- A. ☐ Two
- B. ☐ Three
- C. ☐ Five
- D. ☐ Six

Pigments from a spinach leaf were separated by paper chromatography. The solvent front moved 9.0 cm from the origin. Reference R_f values for this method are: carotene 0.93, xanthophyll 0.70, chlorophyll a 0.50, chlorophyll b 0.40. The data are for practice. (a) Calculate the R_f value of spot 2. [1] (b) Using colour and R_f values, identify spots 1 and 3. [2] (c) Suggest why the pigments separate. [1]

Distances moved by pigment spots		
Spot	Colour	Distance from origin / cm
1	Orange-yellow	8.4
2	Yellow	6.3
3	Blue-green	4.5
4	Yellow-green	3.6

Answer =

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21 PAPER 1B STYLE

[5 marks]

An aquatic plant was placed 10 cm from a lamp behind filters that let through light of one colour. The volume of oxygen released in 10 minutes was measured. The data are for practice. (a) Calculate the rate of oxygen production in blue light, in $\text{cm}^3 \text{ min}^{-1}$. [1] (b) Compare the rates in the different colours of light. [2] (c) State two variables that should be controlled. [2]

Volume of oxygen released in 10 minutes		
Colour of light	Approximate wavelength / nm	Volume of oxygen / cm^3
Blue	450	1.8
Green	550	0.4
Red	680	1.5

Answer =

22 PAPER 2A STYLE

[3 marks]

Compare enclosed greenhouse experiments with free-air carbon dioxide enrichment (FACE) experiments as ways of predicting future rates of photosynthesis and plant growth.

HL only

(a) Explain why plants need high concentrations of Rubisco in the stroma. [2] (b) Predict, with a reason, what happens to the concentration of glycerate 3-phosphate when a plant is moved into darkness. [2]

HL only

Explain how the light-dependent reactions in the thylakoids produce ATP and reduced NADP.

Mark scheme

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

1. [1]

C C [1]

2. [1]

B B [1]

3. [1] **HL only**

A A [1]

4. [5]

- (a) $19.8 \div 60 = 0.33 \text{ cm}^3 \text{ s}^{-1}$ [1]
- (b) volume increases from 15 °C to 35 °C / up to an optimum of about 35 °C [1]
- (b) volume decreases above 35 °C, falling steeply to 2.4 cm³ at 55 °C [1]
- (c) (most) catalase molecules are denatured / bonds holding tertiary structure break [1]
- (c) active site changes shape so hydrogen peroxide cannot bind / fewer enzyme-substrate complexes form [1]
- (c) accept: some enzyme molecules still active so a little oxygen is produced [1]
- (c) [max 2]

5. [2]

- active site formed from only a few amino acids / R groups [1]
- interactions between amino acids elsewhere in the folded (tertiary) structure hold the active site in its shape [1]
- active site has shape/chemical properties that bind the substrate / allow catalysis OWTTE [1]
- globular protein is soluble so can move / collide with substrate [1]
- [max 2]

6. [3]

- activation energy is energy needed to break bonds in the substrate / to start the reaction [1]
- binding to active site stresses / weakens bonds in the substrate [1]
- enzyme lowers the activation energy [1]
- so more substrate molecules have enough energy to react (at a given temperature) [1]
- overall energy change of the reaction is not altered [1]
- [max 3]

7. [3] **HL only**

- (a) intracellular: occur inside the cell, e.g. glycolysis in cytoplasm / Krebs cycle in mitochondrial matrix [1]
- (a) extracellular: enzyme secreted and acts outside the cell, e.g. chemical digestion in the gut [1]
- (b) reactions are not 100% efficient in energy transfer / some energy is lost as heat [1]

8. [7] HL only

- non-competitive inhibitor binds to allosteric site (not the active site) [1]
- only specific substances bind to an allosteric site [1]
- binding causes conformational change that alters the active site so catalysis is prevented [1]
- binding is reversible [1]
- feedback inhibition: end product inhibits an enzyme early in the pathway [1]
- isoleucine inhibits threonine deaminase / first enzyme of the pathway from threonine [1]
- high isoleucine slows the pathway; low isoleucine allows it to resume, keeping concentration stable / avoids waste [1]
- mechanism-based inhibition: inhibitor binds irreversibly / covalently to the active site and changes it chemically [1]
- penicillin inhibits transpeptidases that cross-link peptidoglycan in bacterial cell walls [1]
- bacteria with altered transpeptidases (to which penicillin cannot bind) are resistant [1]
- [max 7]

9. [1]

C C [1]

10. [1]

C C [1]

11. [1] HL only

B B [1]

12. [5]

- (a) volume = $0.80 \times 24 = 19.2 \text{ mm}^3$ [1]
- (a) $19.2 \div 5 \div 3.0 = 1.28 \text{ mm}^3 \text{ g}^{-1} \text{ min}^{-1}$ / 1.3 [1]
- (b) independent: temperature; dependent: distance moved by drop / rate of oxygen uptake (both needed) [1]
- (c) rate of oxygen uptake / respiration increases with temperature [1]
- (c) respiration is catalysed by enzymes; more kinetic energy so more frequent substrate-active site collisions [1]
- (c) (temperatures are below the optimum so) no denaturation [1]
- (c) [max 2]

13. [3]

- (a) active transport across membranes [1]
- (a) synthesis of macromolecules / anabolism [1]
- (a) movement of the whole cell (e.g. muscle contraction, flagella) / movement of chromosomes [1]
- (a) [max 2]
- (b) cell respiration produces ATP from carbon compounds inside cells, whereas gas exchange is diffusion of O_2 and CO_2 between organism and environment OWTTE [1]

14. [4] HL only

- (a) phosphorylation of glucose using ATP [1]
- (a) lysis into two triose phosphates (3C) [1]
- (a) oxidation / removal of hydrogen, reducing NAD [1]
- (a) ATP formed; net yield 2 ATP (and 2 pyruvate) per glucose [1]
- (a) [max 2]
- (b) to regenerate NAD / reduced NAD is oxidised [1]
- (b) so glycolysis can continue producing (2) ATP [1]
- (b) no oxygen so reduced NAD cannot be oxidised by the electron transport chain [1]
- (b) [max 2]

15. [3] HL only

- lipids contain less oxygen / more oxidisable hydrogen and carbon (per gram) [1]
- so more reduced NAD (and ATP) produced per gram [1]
- fatty acids broken into acetyl groups that enter via acetyl CoA / bypass glycolysis [1]
- anaerobic respiration depends on glycolysis, which only uses carbohydrate / acetyl groups are oxidised only in the Krebs cycle, which needs oxygen (via the electron transport chain) to regenerate NAD [1]
- [max 3]

16. [7] HL only

- reduced NAD (from glycolysis, link reaction and Krebs cycle) passes a pair of electrons to the first carrier [1]
- NAD is regenerated [1]
- electron transport chain / carriers located in the inner mitochondrial membrane / cristae [1]
- electrons pass from carrier to carrier, releasing energy [1]
- energy used to pump protons from matrix into intermembrane space [1]
- proton gradient / high H^+ concentration in intermembrane space [1]
- protons diffuse back into matrix through ATP synthase (chemiosmosis) [1]
- ATP synthase couples energy from proton flow to phosphorylation of ADP [1]
- oxygen is the terminal electron acceptor [1]
- oxygen accepts electrons and protons forming (metabolic) water [1]
- allows continued flow of electrons along the chain [1]
- [max 7]

17. [1]

C C [1]

18. [1]

B B [1]

19. [1] HL only

C C [1]

20. [4]

- (a) $6.3 \div 9.0 = 0.70$ [1]
- (b) spot 1: R_f 0.93 / $8.4 \div 9.0$, orange-yellow, so carotene [1]
- (b) spot 3: R_f 0.50 / $4.5 \div 9.0$, blue-green, so chlorophyll a [1]
- (c) pigments differ in solubility in the solvent / attraction to the stationary phase, so travel different distances OWTTE [1]

21. [5]

- (a) $1.8 \div 10 = 0.18 \text{ cm}^3 \text{ min}^{-1}$ [1]
- (b) highest rate in blue light, then red [1]
- (b) lowest rate in green light, but not zero [1]
- (b) blue rate is 4.5 times green / use of values from the table [1]
- (b) [max 2]
- (c) light intensity / distance from lamp [1]
- (c) temperature [1]
- (c) CO_2 concentration / concentration of hydrogencarbonate [1]
- (c) same plant / mass of plant / time allowed to adjust [1]
- (c) [max 2]

22. [3]

- both: grow plants at raised CO_2 concentration to predict effects of future CO_2 levels [1]
- greenhouse: variables (temperature, water, light) easier to control [1]
- FACE: plants in field / natural ecosystem conditions so results more realistic [1]
- FACE: other variables (weather, soil, pests) harder to control / vary [1]
- [max 3]

23. [4] HL only

- (a) Rubisco works relatively slowly [1]
- (a) Rubisco is not effective at low CO_2 concentrations [1]
- (b) glycerate 3-phosphate concentration rises [1]
- (b) no ATP / reduced NADP from light-dependent reactions, so GP not converted to triose phosphate [1]
- (b) Rubisco still fixes CO_2 with the remaining RuBP, forming GP (until RuBP runs out) [1]
- (b) [max 2]

24. [8] HL only

- photosystems are arrays of chlorophyll and accessory pigments in the thylakoid membrane [1]
- light absorbed and energy passed to the reaction centre (special chlorophyll) [1]
- excited electrons emitted from photosystem II [1]
- photolysis of water in PSII replaces electrons, releasing protons (into lumen) and oxygen [1]
- electrons pass along a chain of carriers [1]
- energy used to pump protons from stroma into thylakoid lumen [1]
- proton gradient across the thylakoid membrane [1]
- protons diffuse through ATP synthase into the stroma: chemiosmosis [1]
- ATP synthase phosphorylates ADP to ATP [1]
- electrons reach photosystem I, are re-excited by light [1]
- NADP accepts two electrons from PSI and a hydrogen ion from the stroma, forming reduced NADP [1]
- cyclic photophosphorylation: electrons from PSI return to carriers to make ATP only [1]
- [max 8]