8.1 Metabolism

Question Paper

Course	DP IB Biology
Section	8. Metabolism, Cell Respiration & Photosynthesis (HL Only)
Topic	8.1 Metabolism
Difficulty	Hard

Time allowed: 70

Score: /52

Percentage: /100

Question 1a

a)

Many products of multi-step cellular reactions act as inhibitors of the enzymes that catalyse the preceding steps in a metabolic pathway.

For example, ATP acts as a non-competitive inhibitor of the enzyme pyruvate kinase, which catalyses the final step of glycolysis.
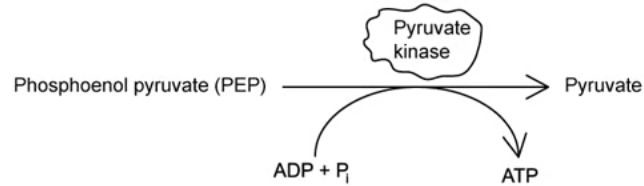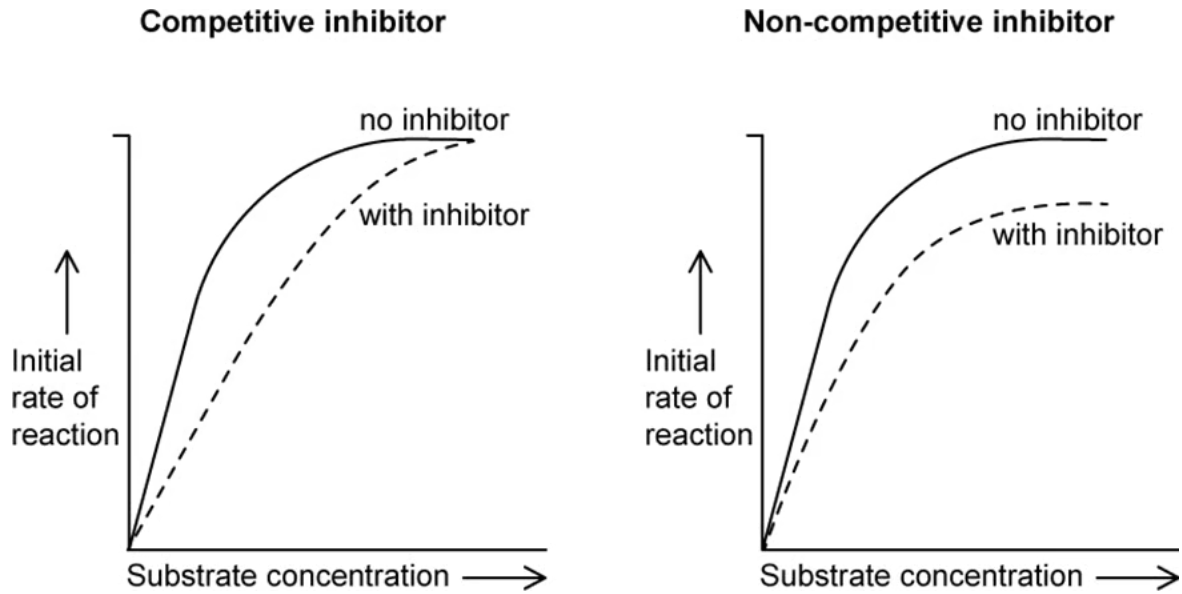

Suggest how the inhibition of pyruvate kinase by ATP allows cells to prevent overproduction and wasting of cellular energy.

[3 marks]

[3 marks]

Question 1b

b)
The graphs below shows the effects of increasing substrate concentration on enzyme activity in the presence and absence of a competitive and a non-competitive inhibitor.

Sketch a line on both graphs to indicate the effect of increasing inhibitor concentration in each case. Explain the position and shape of each line.

[4 marks]

[4 marks]

Question 1c

c)
Compare and contrast the features of a substrate and a competitive inhibitor.

[4 marks]

[4 marks]

Question 2a

a)
Copper (II) ions act as non-competitive inhibitors of the enzyme catalase.

Describe how copper (II) ions work to inhibit the activity of catalase.

[2 marks]

[2 marks]

Question 2b

b)
Catalase is found in all living things that are exposed to oxygen. It protects cells from damage by breaking down the toxic chemical hydrogen peroxide into water and oxygen.

Numbers of fish living in copper contaminated water have shown a decline in numbers. Scientists can study the action of catalase in fish in order to understand the full impact of copper contamination on the fish.

A group of students carried out an experiment to explore the effects of copper sulfate on the action of catalase. They measured the activity of catalase exposed to different concentrations of copper sulfate.

The results of their experiment are shown in the table below.

Concentration of copper sulfate (moles dm^{-3})	Volume of oxygen gas produced (cm^3)
0.00	15.70
0.05	11.32
0.10	8.12
0.15	6.25
0.20	4.98

In the space provided below, draw a graph of the results in the table.
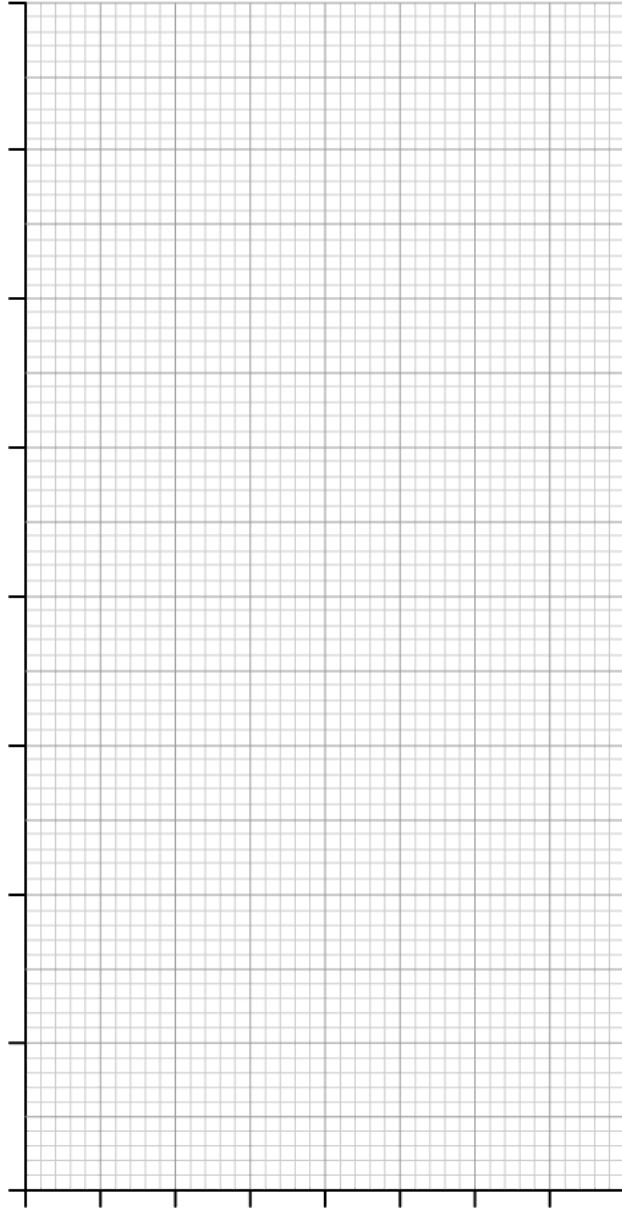
[4 marks]

[4 marks]

Question 2c

c)
What can the students conclude from their results?

[2 marks]

[2 marks]

Question 2d

d)
Three rivers in the Scottish Highlands were polluted with copper, which affected the aquatic wildlife. Scientists were provided with one dead brown trout, *Salmo trutta*, from each of the rivers.

Scientists were unable to take a direct measurement of the copper ion concentration in the river.

Using the information provided in part **(b)**, suggest the dependent, independent and control variables of an experiment using the fish tissue to compare the copper ion pollution in the three rivers.

[3 marks]

[3 marks]

Question 3a

a)

It is predicted that there could be as many as 80 000 plant species in the Amazon rainforest, however, many of these have never been studied or even formally identified.

Once a new plant species have been discovered, molecular analysis can be carried out on its chemical composition, including the identification of any chemicals unique to that species. The details of this analysis will be stored in a database.

What are some of the benefits of storing information about these chemicals in a database?

[2 marks]

[2 marks]

Question 3b

b)

When trying to conserve a forested area that has been earmarked for development or logging, scientists often need to put a monetary value on the area being conserved in order to compare this to the potential value of removing the forest.

Putting a value on the unique chemicals found in the plant species in the area can be hugely helpful in this process, but it is often a slow process to collect this information.

How can bioinformatics help to improve conservation in these areas?

[2 marks]

[2 marks]

Question 3c

c)
When studying plant species in areas of high biodiversity, or in any extreme environment, it is often useful to look at the metabolic pathways linked to the adaptations of the plants.

To investigate the metabolic pathways scientists can determine the proteome of the plant, or just focus on the proteome of specific specialised cells.

Suggest why just studying the proteome alone might not be enough to fully understand the metabolic pathways in the plant.

[2 marks]

[2 marks]

Question 4a

a)
Antifreeze is a chemical often used in vehicles, such as cars, to act as an engine coolant.

A small number of people have accidentally consumed antifreeze and become poisoned as a result. Once a person consumes antifreeze it is important that they receive treatment straight away, otherwise, there is a risk of death. This is because if the methanol goes to the liver it can be broken down by the enzyme alcohol dehydrogenase into toxic products such as methanoic acid and formaldehyde. If the methanol can't bind to the enzyme it will just be excreted via the kidneys and the person can be saved.

One method of treating methanol poisoning, in the rare instances where no other treatment is available, is to use large quantities of the alcohol ethanol.

Suggest how ethanol might be able to save someone from methanol poisoning.

[3 marks]

[3 marks]

Question 4b

b)
Although it may be an effective antidote, suggest why it is not recommended that people with methanol poisoning consume ethanol other than in extreme circumstances where no other treatment is available.

[1 mark]

[1 mark]

Question 4c

c)
One medicinal chemical that can be used to treat antifreeze poisoning is called fomepizole, which is a competitive inhibitor of the enzyme alcohol dehydrogenase.

Fomepizole is 160,000 times more likely to bind to alcohol dehydrogenase than methanol.

Using your knowledge of enzyme structure, suggest how this might be possible.
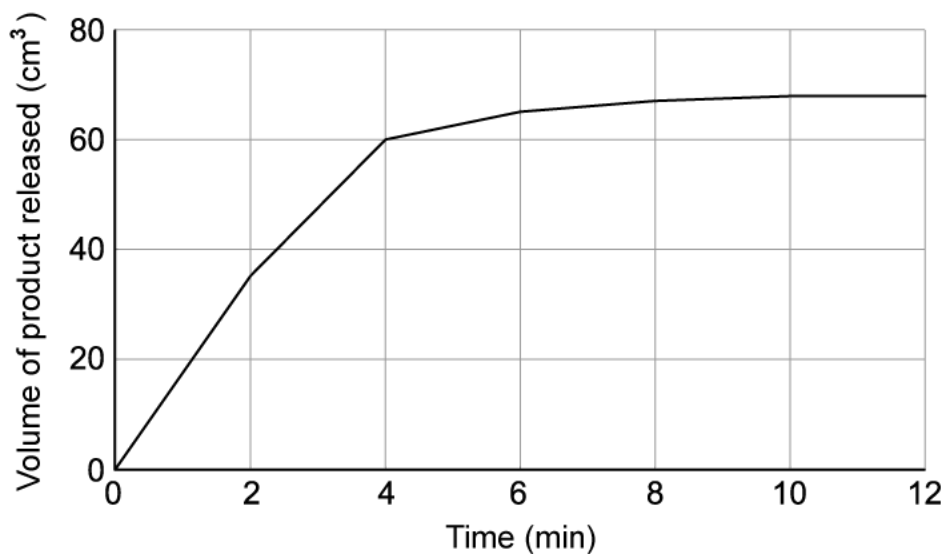
[2 marks]

[2 marks]

Question 4d

d)

Scientists were trying to investigate the rate of reaction of alcohol dehydrogenase by measuring the quantity of product, methanoic acid, produced over time, with a fixed quantity of methanol added at the start.

The graph below shows their results.

Use the graph below to calculate the rate of reaction of alcohol dehydrogenase after 3 minutes.

[3 marks]

[3 marks]

Question 5a

One mark is available for clarity of communication throughout this question.

a)
Phosphofructokinase (PFK) is an enzyme that catalyses an important step in the glycolysis process of respiration. PFK is inhibited by ATP.

PFK is known as the "pacemaker" enzyme for respiration.

Suggest what is meant by the term "pacemaker" in this context.

[3 marks]

[3 marks]

Question 5b

b)
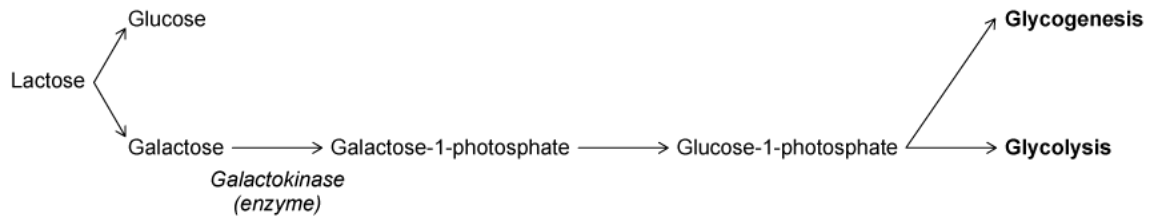Describe and explain the similarities and differences between competitive and non-competitive enzyme inhibition.

[5 marks]

[5 marks]

Question 5c

c)

The image below shows the pathway the human body uses to metabolise lactose.

There is a genetic condition that exists called galactosemia, which causes large quantities of galactose to build up in the body, particularly in the liver tissues.

If left untreated, it can be very harmful to sufferers, in the worst cases, it can lead to death.

Galactosemia is rare and only occurs in around 1 per 60,000 births for people of European ancestry, often skipping a generation before re-emerging.

Using the information from the question and your own knowledge, suggest the cause of galactosemia, some symptoms, a type of treatment for the condition.

[7 marks]

[7 marks]