3 The gene *LCT* codes for the enzyme lactase. In babies, lactase synthesis is necessary for digesting lactose, the sugar found in milk.

Another gene, *MCM6*, has introns that have a regulatory role in the expression of gene *LCT*. Gene *MCM6* codes for a protein that has **no** involvement in lactase synthesis.

As children get older, the *MCM6* introns are responsible for a decrease in lactase synthesis. This decrease in lactase synthesis is known as lactase non-persistence.

(a) *LCT* and *MCM6* are located on the same chromosome in humans.

Suggest differences between gene *LCT* and gene *MCM6*, **other than** their locations in different positions on the same chromosome.

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..... [3]

(b) With reference to the process of lactase synthesis, explain the relationship between:

- a transcribed strand and a primary transcript
- a primary transcript and messenger RNA (mRNA).

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..... [2]

(c) A mutation in a regulatory intron of *MCM6* allows lactase synthesis to continue. This is known as lactase persistence. In this mutation, the number of nucleotides in the intron remains the same, but one of the nucleotides is different to the original nucleotide.

State the type of mutation that is the cause of lactase persistence.

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..... [1]

(d) Fig. 3.1 summarises the reaction catalysed by lactase.

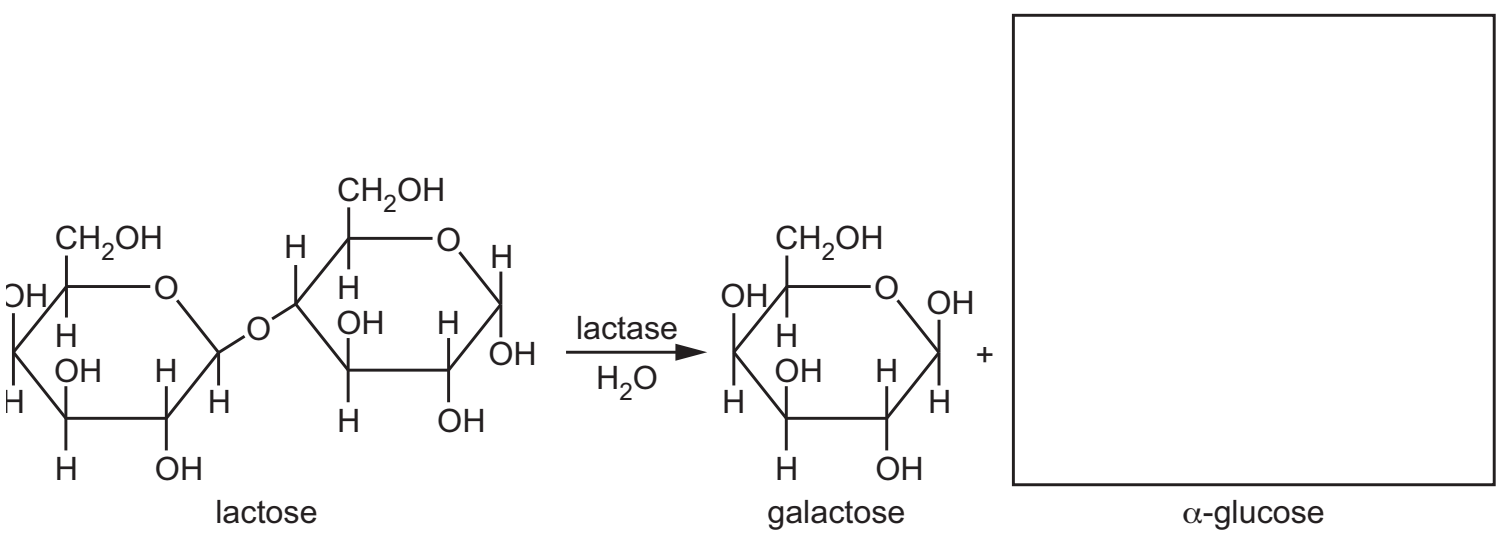

Fig. 3.1

Draw the ring structure of α-glucose in the box provided to complete Fig. 3.1. [1]

(e) Some people with lactase non-persistence may be lactose intolerant. They may have symptoms, such as abdominal pain, if their diet contains lactose.

(i) Lactase supplements (tablets) can be taken before milk or milk-based products are consumed to avoid symptoms of lactose intolerance.

A student compared the activity of two different concentrations of a lactase supplement using an artificial substrate, ONPG, instead of lactose.

A solution of ONPG is colourless, but the hydrolysis of ONPG by lactase releases a coloured product.

The student planned to follow the progress of the reaction for each concentration of lactase using a colorimeter.

Explain why the student chose to use a colorimeter to follow the progress of the reaction for each concentration of lactase.

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..... [2]

(ii) The lactose in milk can be hydrolysed using immobilised lactase or using lactase free in solution (free lactase). This results in milk and milk products that do not contain lactose and so are suitable for lactose-intolerant people.

Scientists carried out an investigation to compare the activity of lactase immobilised in very small magnetic beads (magnetic microspheres) with free lactase, at different temperatures and at different pH values.

Fig. 3.2 shows the activity of immobilised lactase and the activity of free lactase at 5 different temperatures.

Fig. 3.3 shows the activity of immobilised lactase and the activity of free lactase at 8 different pH values.

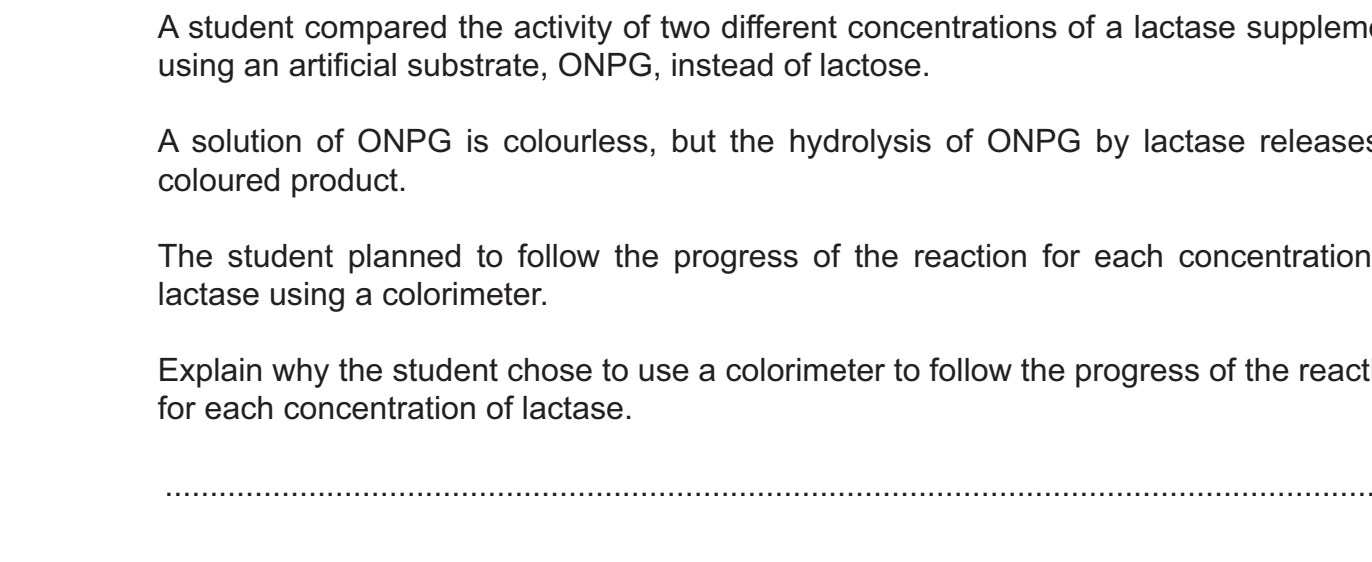

Fig. 3.2

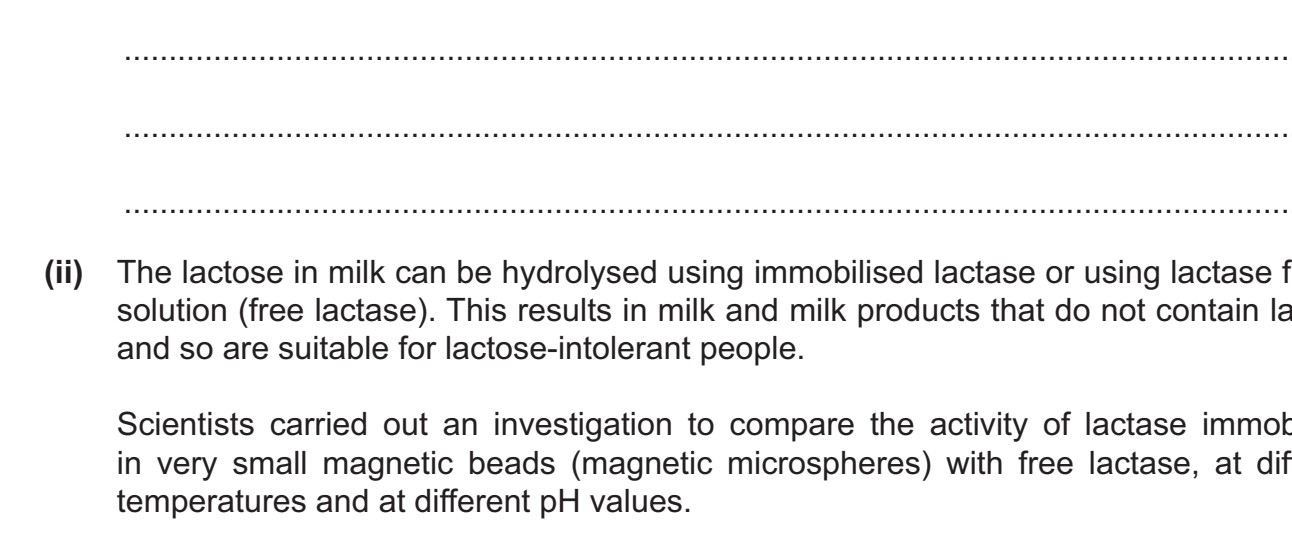

Fig. 3.3

One advantage of using magnetic microspheres with immobilised lactase is that they can be easily recovered using an electric field and reused.

With reference to Fig. 3.2 and Fig. 3.3, explain why the results indicate that there are **other** advantages in using immobilised lactase instead of free lactase to produce lactose-free products.

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..... [4]

[Total: 13]