Hydrogels and how they work

1. How much did the volume of the hydrogel in your experiments increase when it was put into water?

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2. What happened to the volume of the hydrogel when salt was added?

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3. Why is the hydrogel a 'smart material'?

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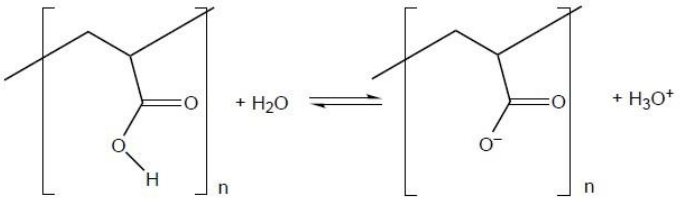
Understanding the structure and bonding of hydrogels helps to explain their properties. This in turn helps chemists to develop new hydrogels and find further uses for them.

Hydrogel structure

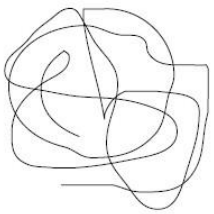
The hydrogel you have used is a polymer of a type of substance called a carboxylic acid. The acid groups stick off the main chain of the polymer, as shown in the diagram below.

When the hydrogel is put into water these acid groups react, the hydrogen atom comes off and the polymer chain is left with several negative charges along its length.

(Note: H_3O^+ is another way of writing H^+ in solution and shows that an acid is present.)



A polymer chain in solution tends to coil up so it looks like this:



However, the hydrogel polymer chain now has several negative charges along its length.

4. What will the negative charges do to each other?

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5. What effect will this have on the polymer chain?

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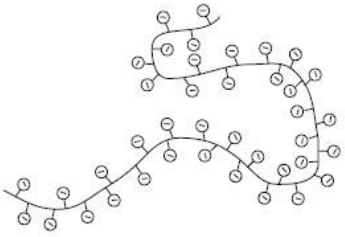
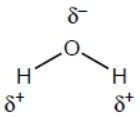
This diagram shows a section of the polymer chain.



Water is a polar molecule, which means that it has an uneven spread of charge over it, even though it is not charged overall. This is because oxygen is better at attracting electrons than hydrogen.



6. What will happen to the water molecules when they get near the polymer?

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Both of these effects mean that the molecules of the polymer get larger as they get wet. This makes the solution more viscous because the polymer resists the flow of the solvent molecules around it.

Quite why the polymer absorbs so much water is still not fully understood.

Hydrogels and salt

When salt (sodium chloride) dissolves in water it dissociates (splits up) into sodium ions and chloride ions.

7. Write an equation for this dissociation.

8. Which of the ions will interact with the negatively charged polymer chain? What will happen?

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9. What effect will this have on the charges on the chain?

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10. What effect will this have on the shape of the polymer molecule?

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The polymer changes shape in response to a change in the environment – in this case, a change in the concentration of ions. This is called smart behaviour.

Hydrogels and pH

Look back at the diagram showing the hydrogel polymer and how it reacts when it is put into water.

11. What does the symbol $\rightleftharpoons$ mean?

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12. What would happen in the reaction if you added:
    a. Acid?

    .....

    b. Alkali?

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13. Would you expect the hydrogel to show smart behaviour in response to changes in pH?

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Hydrogels and sugar

You have seen what happens to the hydrogel in the presence of water, distilled water and salt.

14. Predict what will happen when you add the hydrogel to sugar solution. Give a detailed explanation for your prediction.

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Use your remaining gel crystals to test your prediction by repeating the experiment that you carried out with salt solution, this time using sugar solution. If your results are unexpected, try to explain them.

Using hydrogels

15. What volume of distilled water did the hydrogel from the nappy absorb?

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16. How do you think this volume compares to the volume of urine it would absorb? Explain your answer.

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17. Why might manufacturers put hydrogels in hair gel?

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Fighting fires with Pampers?

Another use for hydrogels has recently been developed by a firefighter in the USA. John Bartlett was at a fire in which an entire house was destroyed – all except a used disposable nappy. He realised that a substance inside the nappy was responsible for preventing it from being burnt and discovered that the material was the hydrogel, which had absorbed liquid. BARRICADE® fire fighting gel was developed as a result. If the gel is sprayed with water onto a house which is in the path of a fire, the house will not burn. This is a major new tool for fire fighters to use when they are battling against the vast forest fires that can burn for days in the USA.

18. Explain how BARRICADE® gel might help prevent something from burning. (Hint: think about the fire triangle.)

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