Inside the Gel

How molecular structure helps a diaper absorb liquid

HS-PS2-6 "Communicate scientific and technical information about why the molecular-level structure is important in the functioning of materials."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the charged groups and cross-links named in the passage, then circle each effect they have on how the gel works.

The Chemistry Inside a Diaper

1 Inside a disposable diaper's absorbent layer are tiny grains of sodium polyacrylate, a polymer made of long, repeating molecular chains. Many units along each chain carry negatively charged carboxylate groups, with sodium ions nearby. Water molecules are polar: one end has a slight positive charge, and the other has a slight negative charge. The positive ends are attracted to the charged groups. As water enters a grain, the chains spread apart and the grain swells into a gel. The material's ability to take in water begins with charges arranged along its molecular chains.

2 If the chains separated completely, the polymer could dissolve instead of forming a useful gel. Links between neighboring chains, called cross-links, form a three-dimensional network. These links keep the chains connected as water enters. The swollen network holds water within the gel, so the material stays in place instead of flowing out like a solution. More cross-links usually make a firmer gel, but they also restrict how far its chains can spread. A tightly linked grain therefore generally absorbs less water than a loosely linked grain of the same polymer. Designers must balance holding a shape against absorbing a large amount of liquid.

3 Liquid composition matters, too. The gel swells less in salty liquid than in pure water. When dissolved ions are already present outside the gel, there is less difference between the ion concentrations inside and outside it. That difference helps draw water into the network, so reducing it limits swelling. This is one reason a diaper maker cannot judge performance using pure water alone. The charged groups, cross-links, and surrounding liquid all affect how much fluid the absorbent layer holds. Understanding these molecular details lets engineers test materials under conditions closer to actual use, rather than assuming every liquid behaves alike.

2 ANSWER WITH EVIDENCE

Use the passage

1. Explain how the charged groups along a polymer chain help a grain take in water.

2. Why does a network of cross-links make this polymer more useful in a diaper than separate, dissolved chains?

3. A designer adds more cross-links to make the gel firmer. What effect on absorption should the designer expect, and why?

4. Why would a test with only pure water give a diaper maker an incomplete picture of the gel's performance?

3 YOUR TURN

Your own words

Imagine using this polymer in a reusable plant-watering pad. Write 4 to 5 sentences to a product designer explaining why you would keep its charged groups, whether you would use more or fewer cross-links than a highly absorbent diaper gel, and the trade-off your choice creates.

ANSWER KEY

Inside the Gel

PART 1 · READ AND MARK

Underline the charged groups and cross-links named in the passage, then circle each effect they have on how the gel works. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Explain how the charged groups along a polymer chain help a grain take in water.	**The negatively charged groups attract the slightly positive ends of polar water molecules, helping water enter the grain.**
2	Why does a network of cross-links make this polymer more useful in a diaper than separate, dissolved chains?	**Cross-links keep the chains connected, allowing the swollen gel to hold water and stay in place rather than dissolve.**
3	A designer adds more cross-links to make the gel firmer. What effect on absorption should the designer expect, and why?	**The gel will generally absorb less water because the extra cross-links restrict how far its chains can spread.**
4	Why would a test with only pure water give a diaper maker an incomplete picture of the gel's performance?	**The gel swells less in salty liquid because outside ions reduce the ion-concentration difference that helps draw water into the network.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would keep the charged groups because they help attract water into the pad. I would use more cross-links than a highly absorbent diaper gel so the pad stays firmer when wet. The extra links would keep its polymer chains connected and restrict how far they spread. The trade-off is that the pad would hold less water, so the designer would need to decide how much firmness matters.

Accept explanations that connect a named molecular feature to an effect on the material's function. For the open task, students may choose fewer cross-links if they correctly explain the gain in absorption and loss of firmness.