Polymer Notes

Polymers are all around us! Materials like plastic and wood are made up of polymers.

**Kinds of Polymers**
Many polymers are found in nature (natural), and others are made by people (synthetic). Fill in the blanks with 3 items that contain natural or synthetic polymers:

<table>
<thead>
<tr>
<th>Natural:</th>
<th>Synthetic:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>1)</td>
</tr>
<tr>
<td>2)</td>
<td>2)</td>
</tr>
<tr>
<td>3)</td>
<td>3)</td>
</tr>
</tbody>
</table>

**What is a Polymer?**
A polymer is a large ______________ made up of repeating parts.

**An Example: Polyester**
Let’s take a closer look at what a polymer is. Maybe you have heard of a polymer called polyester. Polyester is a fabric used to make clothing like raincoats, pants, and shirts. This fabric is made of long chains of a compound called an ester. These ester compounds are made of ______________ on the ________________, mostly carbon, oxygen, and hydrogen.

Polyester fibers are used to make fabrics for clothing.
If we look closely at the polyester fibers, we would see chains of ester compounds tied together:

\[ \text{...—ester—ester—ester—ester—ester—ester—ester—...} \]

These repeating units are held together by ________________ bonds.
A covalent bond is formed when atoms in a compound __________ electrons.

Each chain is made of **thousands** of esters tied together like beads on a string:

![Ester compound](image)

**Naming Polymers**
Polymer names come from the **repeating** unit found in the polymer.
For example, raincoats are made from the polymer called poly**ester**. This polymer is made from thousands of **repeating ester** compounds.

As you can see, the name of the polymer is taken by combining “poly” with the name of the repeating unit, “ester”, to form “polyester”.

**Exercise**: Fill in the blanks by completing the polymer name or repeat unit.
I’ve done the first one for you:

<table>
<thead>
<tr>
<th>Repeating unit</th>
<th>Polymer name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ester</td>
<td>Polyester</td>
</tr>
<tr>
<td>ether</td>
<td>Poly____________</td>
</tr>
<tr>
<td>ethylene</td>
<td>___________________________</td>
</tr>
<tr>
<td>__________</td>
<td>Polystyrene (Styrofoam)</td>
</tr>
<tr>
<td>__________</td>
<td>Polyamine</td>
</tr>
</tbody>
</table>
**Polymer crosslinkers**

A *crosslinker* is a compound that is used to chemically bond polymer chains together. This gives the polymer stability and helps to determine the physical properties of the polymer.

The diagram below is a close-up of some polymer chains in a polymer fiber. Draw *crosslinkers* between the polymer chains:

Circle the correct terms to complete the sentence:
The (chemical | physical) make-up of polymers and their crosslinkers determine the (chemical | physical) properties of polymers.

List 2 physical properties of polymers:
1) __________________________
2) __________________________
Polymer Synthesis Lab

Polymers can be designed to have specific physical properties including density, transparency, and stiffness. These properties depend on the amount and type of repeat unit and crosslinker used to bond the polymer chains together.

The stiffness of a polymer is an important physical property. Polymers can be designed to create materials with a range of stiffness. A football helmet is much stiffer than Jell-O, even though they are both made of polymers!

Both of these items are made of polymers!

Objective
The purpose of this lab is to explore the relationship between the chemical and physical properties of polymers. We will synthesize polymers of varying stiffness by altering the ratio of a polymer with its crosslinker.

More info on polymers!
http://pslc.ws/macrog/kidsmac/kfloor2.htm

Materials
Plastic cups
A cup of “solution A”
A cup of “solution B”
Plastic teaspoons
Permanent marker
Food coloring
**Procedure**

By varying the ratio of mer repeat unit to crosslinker, a polymer can be made with different stiffness. To start, make a polymer with a 3 to 1 ratio of solution A to solution B:

1) Label a cup with “3:1.”
2) Add 3 teaspoons of solution A to the cup.
3) Add 1 teaspoon of solution B to the cup.
4) Stir the mixture until all of the liquid is gone.
5) Once you have a polymer gel, take it out of the cup and kneed it with your hands.

Questions:

1) Write down your observations of the polymer (color, shape, stiffness, etc.)

2) What happens when you pull the polymer apart quickly? Why do you think this happens?

3) What happens when you pull the polymer apart slowly? Why do you think this happens?
4) Roll the polymer into a ball and let it sit on the table for a few minutes. How does the polymer change? Why do you think this happens?

5) Would you characterize the polymer as a solid or a liquid? Why?
Design an Experiment

Experiment Objective: To determine how the amount of polymer crosslinker alters the stiffness of the polymer.

Goals
- Create 3 new polymers with different ratios of solution A to solution B.
- Compare the stiffness of all the polymers you made.
- Quantify and graph your results

1) State your hypothesis:

2) Record the ratios of solution A to solution B you used here:
   i) ___:___
   ii) ___:___
   iii) ___:___

3) Based on your observations, what happens to the stiffness of the polymer when you change the amount of crosslinker?
4) Describe the methods you used to measure polymer stiffness.

5) How will you communicate your findings to the rest of the class? Explain and show below: