You must show all work to receive full credit

1. (10 pts) On the line in front of each of the following statements, indicate if the statement is true or false.

   F  A polymer that is formed by the condensation process uses water to carry out the reaction.  
   No, water is formed.

   F  The main difference between soap and a detergent is in the chemical composition of the tail portion of the molecule.  
   Difference is the head.

   F  Hard water forms a scum or "curd" because hard water ions such as Ca^{2+} readily interact with the hydrophobic part of the soap molecule.  
   Interacts with hydrophilic part.

   F  Vulcanization is the high temperature process that is used to recycle the rubber from automobile tires.  
   It is used in the manufacturing of rubber.

   F  A homopolymer is one in which all the atoms in the polymer are the same.  
   atoms differing monomers are the same.

2. (8 pts) In the "paper clip polymer" demonstration:
   • What did the single paper clips represent in this model of a chemical reaction?
     Monomers

   • What happened to the paper clips after they were shaken up in the presence of the marbles?
     They were attached in a long chain.

   • What did the marbles represent in this model of a chemical reaction?
     Catalyst

   • What happened to the marbles after the "reaction" was complete?
     Initially, they were, catalyst does not change.

3. (5 pts) The ability to cross-link a polymer was first discovered by Charles Goodyear in 1839.
   • What is a cross-link at the molecular level?
     For rubber, it is a sulfur atom that connects two chains.

   • How did cross-linking change the properties of the polymer that Goodyear was working with?
     The rubber was flexible and not durable. The cross-link made the polymer so it was less flexible, more durable.
4. (5 pts) The structures of ethylene glycol and terephthalic acid are shown below. These monomers combine by the process of condensation to form the polymer known as Dacron, which is used in many different fabrics. Show a piece of the polymer that will result by combining two of each of the molecules. Your drawing should contain four of monomer units. Show all atoms.

[Diagram of ethylene glycol and terephthalic acid]

5. (5 pts) The way in which ethylene is polymerized can be controlled to produce two different forms of polyethylene, either high density polyethylene (HDPE) or low density polyethylene (LDPE).

- What is the difference between HDPE and LDPE at the molecular level?
  HDPE has few side branches, mostly long chains. These long chains can pack closely together in a crystalline manner. LDPE has many branches on the chain, so these molecules cannot pack closely together.

- What is the physical difference (besides density) between HDPE and LDPE, or what are the different uses for these different forms of polyethylene.
  HDPE = Rigid, used for containers.
  LDPE = Flexible, packaging films and bags.

6. (5 pts) The monomers of tetrafluorethylene and styrene are shown below. Show how at least four monomers can be combined to form either Teflon or Styrofoam. Recall that these polymers form by the process of addition. Show all atoms.

[Diagram of tetrafluorethylene and styrene]

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7. (5 pts) What was observed when a laser beam was passed through solution that contained some soap? The path of the light was observed.

What did this observation indicate about the behavior of soap molecules in water? What causes the observed effect at the molecular level? Soap molecules gather in structures called micelles that are large enough to scatter the light. Because the light is scattered, it was observed passing through the solution. The micelle solution is not homogeneous.

BONUS (2 pts): Who is the scientist that discovered this phenomena?

Tynan

8. (6 pts) What is the impact of a detergent on surface tension? What was an observation in class that illustrated this behavior? Detergent decreased surface tension. Demonstrated when the floating paper clip sank as soon as some soap was added to the water.

Draw a sketch that shows at the molecular level why surfactants have the impact that was described above. Be sure that the sketch is clearly labeled. Put the sketch in the space to the right.

The hydrophobic tails break through the water molecules at the surface, which causes the attractive forces to weaken the molecule.

9. (5 pts) Explain at the molecular level how a soap cleans grease from your clothes.

10. (4 pts) A water softener works by replacing or exchanging selected ions found in the incoming water for different ions that end up in the water used by the homeowner. Specifically describe what is exchanged in this process.

The resin exchange resin contains sodium ions, H2O.

Where calcium Ca^2+ my Ca. The hard water has become attracted to the resin and Na^+ and H^+ are released.

So not is exchanged for Na^+ in it.
11. (5 pts) The formation of nylon takes place by the combination of di-functional molecules (a diamine and a diacid). Why is it important that the monomers in this process (or any condensation process for that matter) are di-functional?

Because the polymer chain is formed by connecting monomers end-to-end, both ends of the monomer molecule must be able to react with other monomer to build the chain of molecules.

- What was the commercial nylon product that was "produced" when I rinsed off the nylon that was made during the demo in class?

12. (2 pts) When Dr. Williams introduced his presentation on nuclear chemistry, he mentioned a story from the morning newspaper about a town in South Carolina that wanted to be the home for a nuclear power plant. What is the name of the morning newspaper that had this story?

NEW YORK TIMES

BONUS (4 pts): Answer either question below.

Show how both of the monomers from problem 6 can be combined to form a copolymer that is a 1:1 ratio of the monomers. Include at least two of each monomer in the structure. Show all atoms.

Show how the amino acids shown below can react via a condensation reaction to form a tripeptide (you will need to include one more monomer). The \(-R\) represents the part of the molecule that is unique to each different amino acid and that it does not affect the way in which individual amino acids combine to form a peptide. Show all atoms.