Review Part 1: Reaction Rates Name ____________________

1. List **six** types of observations / measurements that can be taken to indicate that a reaction is happening and/or how fast the reaction is proceeding.

   Evidence of reaction: Fizzing sound, bubbles, formation of a new solid, temperature increase or decrease, color changes, corrosion or disintegration of a solid, appearance of a material with different properties than the reactants
   Indication of reaction speed: faster/slower time to complete, violence of bubbling, speed of corrosion, amount of heat produced

2. How are atom collisions important to chemical reaction rates?

   The more likely the collision of atoms, the faster a reaction can go. The higher the energy of the atoms, the more chance of an individual collision causing a reaction.

3. Explain how a different temperature can change the probability that two reactant molecules will collide.

   Particle are moving faster, so they have more chances to collide with other reactant molecules. They have higher energy, so the collisions have a better chance to cause a reaction.

4. Talk about how a different amount of total surface area can change the odds of two reactant molecules bumping into each other.

   More contact between different reactants provides more chances for molecules to collide and react. More surface area causes more contact between the reactants. More molecules are in contact with different types of molecules.

5. Describe the way a different solution concentration could affect the likelihood of two different molecules ending up in the same place at the same time.

   In a more concentrated solution, molecules are closer together, so they don't have to travel as far to collide with another molecule. This means they have more collisions. If a higher percentage of your solution is the reactant molecule, then a higher percentage of the collisions are the types of collisions that cause reactions; remember that only a certain type of collision will result in a reaction – it has to be between the exact correct two molecules, and it needs to have enough energy to trigger the reaction. Higher concentration can mean that any type of collision is more likely (more molecules in a smaller space) and also that each collision is more likely to be the right type of collision.

6. If you stir "Reaction ABC," but you don't stir "Reaction XYZ," and everything else was the same about the way you setup the two reactions, which one would react faster? Explain why?

   The stirred reaction will be faster. This encourages more contact between the reactants. Without stirring, the reactants can stay separated in clumps that don't touch the other reactant very often. Stirring breaks up those areas and makes them mix with areas that are concentrated in the other reactant. Also, stirring causes more movement of molecules which provides more chances for collisions.

7. Mr. Arrhenius is going to react some aluminum with some blue copper(II) chloride, $CuCl_2$, crystals to do the same reaction we did in one of the reaction labs. Mr. Arrhenius wants the reaction to finish as soon as possible. What are **four** ways that Mr. Arrhenius can setup and start the reaction to make it finish quickly?

   Use higher mass of crystals in a smaller amount of water to make a very concentrated solution. Stir the mixture very well before the reaction. Heat the liquid. Give the aluminum as much surface area as possible by cutting it up or turning it into a powder. Make sure the aluminum doesn't float and instead gets completely covered by the solution. Stir the solution quickly to make the solution contact the aluminum as much as possible as quickly as possible. You could even warm up the aluminum before adding it.

8. Baron Kelvin is also going to react some aluminum with some blue copper (II) chloride, $CuCl_2$, crystals. However, Baron Kelvin wants the reaction to last a long time. List **four** ways that Baron Kelvin should setup his reaction to make it take a long time?

   Cool the aluminum before adding it. Use cold water to mix the copper solution. Use lots of water to make a diluted solution. Only add a small amount of aluminum crystals. Don't stir the reaction at all.

9. Let's say you only have enough $CuCl_2$ crystals to do exactly **four trials** of the copper (II) chloride ($CuCl_2$) and aluminum reaction. Within just four trials, you need to study the effect of **temperature** and the effect of **concentration** of copper (II) chloride. You need to decide how to setup each trial so that you can study both variables before you run out of crystals.

   Fill in the table below to plan out the conditions for your four trials. Remember: your trials need to allow you to observe the effect of changing only **temperature** and the effect of changing only **copper (II) chloride concentration**.

Trial #	Amount of water (mL)	Amount of $CuCl_2$ (grams)	Amount of aluminum (grams)	Shape / Form of aluminum	Water Temperature (°C)
1		1.5			
2		1.5			
3		1.5			
4		1.5			

Values not filled in above because there are multiple ways to do it, but your answers should fit these rules:

1) All of the aluminum amounts (grams) should be the **same.**
2) All of the shapes / forms of aluminum should be the **same**.
3) Two of your trials (perhaps Trial 1 and Trial 2) should have the SAME amount of water, and DIFFERENT water temperature. These two trials will let you study the effect of water temperature on reaction rate.
4) Two of your trials (perhaps Trial 3 and Trial 4) should have DIFFERENT amount of water and SAME water temperature. These trials will let you study the effect of concentration on reaction rate.

10. Which trials could you use to study the effect of temperature?

    Whichever trials have different temperature and the same everything else.

11. What are the control variables in the temperature investigation?
    Solution concentration is ONE of the control variables in this investigation, but there are many others. That includes some factors not listed here. Aluminum mass, $CuCl_2$ crystal mass, aluminum shape, beaker size, type of solvent (water), amount of stirring, room temperature, brand of aluminum foil, etc. You want every single possible aspect of the experiment to be the same except the one thing you are changing.

12. In which of the temperature trials would you expect the fastest reaction rate?

    Whichever one has a higher water temperature.

13. Which trials would you use to study the effect of $CuCl_2$ concentration? (see notes below the table, previous page)

    Whichever trials have different water (concentration) and the same everything else.

14. In which of the concentration trials would you expect the fastest reaction rate?

    Whichever one has the least amount of water. Less water means higher concentration of $CuCl_2$.

15. What are the control variables in the concentration investigation?

    (see answer for #11). Temperature is one of the control variables, but many other things are also kept the same.

Part 2: Bond Energy

16a. Would you expect the following reaction to be endothermic or exothermic? $N + 2O \rightarrow NO_2$

Exothermic

16b. Why?

The atoms start as separate atoms of N and O, and then form bonds as a molecule of NO_2. The process of forming new bonds releases energy and is exothermic. Separate atoms have more energy than bonded atoms in molecules, which are stuck together. Separate atoms have the potential to attract other atoms like magnets going together. But when they are stuck together, they have lower potential energy and it takes energy to get them apart.

17a. A reaction has a net energy change of +150 kJ/mol. Is it exothermic or endothermic?

Endothermic. The positive number indicates that the **atoms** gain energy in the reaction. The product molecules have higher energy than the reactant molecules. This results in energy being absorbed from the surroundings, which cools the surroundings. The atoms themselves gain energy, while the surroundings lose that energy.

17b. Which is more stable for a reaction with an energy change of +150 kJ/mol: the products or the reactants?
The reactants are more stable, because they have less energy.

18. A chemical reaction cools its surroundings. Is this an endothermic or exothermic reaction?
Endothermic. The atoms gain energy, and that energy must come from the surroundings. This cools the surroundings.

19a. As H_2S begins to react, the H-S bonds are broken in the H_2S molecules. Are the atoms at a higher energy as H_2S molecules or as separate H and S atoms?

The separate atoms have a higher amount of potential energy.

19b. Why?

Separate atoms have the ability to attract other atoms and form new bonds. Forming new bonds releases energy. Bonded atoms are already at a lower potential energy, because they have already formed into a lower energy configuration that involves their charges moving closer to other opposite charges. After their charges get setup in this way, they lose some of their the ability to spontaneously move even closer to other opposite charges – less "potential" means less energy.

20.Which atoms are closer together: the nitrogen atoms in N-N (single bond) or the nitrogen atoms in N=N (double bond)? Explain how you know.

N=N double bonded nitrogen atoms are closer together, because a double bond has twice as many electrons (4) as a single bond (2). This means there is twice as much negative charge between the atoms to attract the nucleus protons closer together. The nucleus of each nitrogen repels the other nucleus, because they're both positive. The electrons in the middle, however, attracts both of those nuclei, and the more electrons are in the middle, the closer together these electrons can pull the nitrogen atoms. FYI: bond length questions will not be on the reactions quiz, but understanding a little bit about how a chemical bond works is a possible quiz topic.

21. A C-H bond has an average length of about 0.109 nm. If you pull the C and H atoms farther apart than that, would their potential energy increase or decrease? Why?

Energy increases. Pulling on a chemical bond is like pulling on a spring – you increase the energy if you stretch it, which causes it to spring back to its original length.

More advanced explanation: The C and H atoms are at their minimum energy at this bond length. At this length, there is a balance between positive charges (nucleus protons) repelling and attraction between electrons and protons. If you pull them farther apart, the electron attraction force (to each nucleus) gets stronger and pulls it back to the original length.

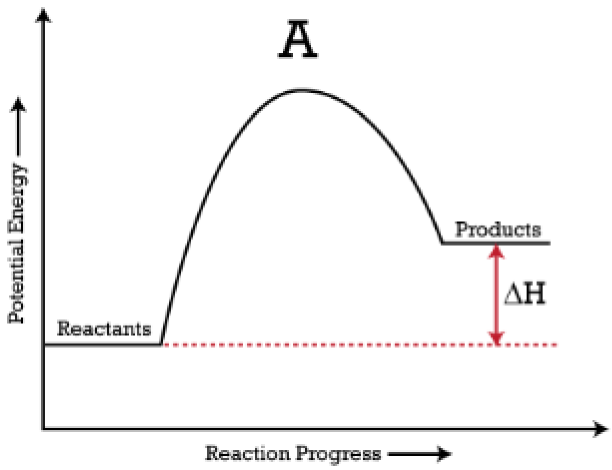
22. A C=O double bond has an average length of about 0.113 nm. What happens to the potential energy of the two atoms if you push them closer together? Why?

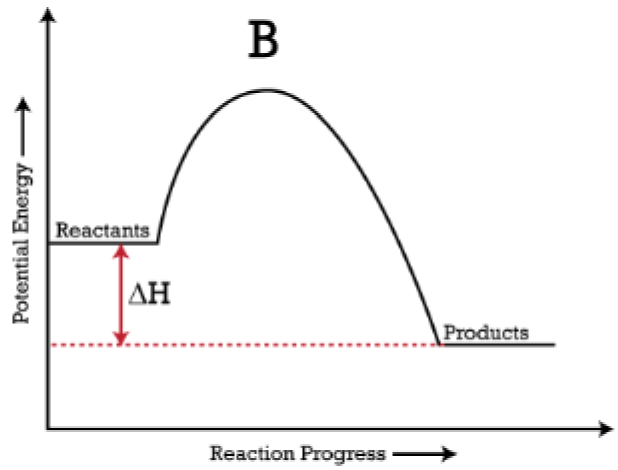
Energy increases. Once again, a bond is like a spring. If you **compress** a spring, it wants to extend back to its original length. The fact that it can expand all by itself tells you that it has more energy than when it was just sitting there doing nothing.

The reason energy is being stored is because the protons in each nucleus (two positive charges that repel each other) are being pushed closer together. Pushing two positive charges closer makes them want to repel, similar to when you push the north pole of two magnets together.

23. For each of the two reactions below, label each of the following:

a) Where are bonds formed? *It's the part of either graph where the line is dropping.*
b) Where are bonds broken? *The part of the graph where the graph line is increasing.*
c) Where are the atoms most stable? *The lowest point on the graph: it's reactants for Graph A, but it's the products for Graph B.*
d) Where are the atoms least stable? *The highest point on each graph: the middle where the atoms are separated, right after bonds are broken.*





24. One of the reactions above is exothermic and one is endothermic. Which is which, and how do you know?

Graph A: endothermic. The end products have more energy than the starting reactants. The atoms have gained energy, and ΔH is a positive amount of energy.

Graph B: exothermic. The end products have less energy than the starting reactants. The atoms lost energy, and this energy is released into the surroundings. ΔH is a negative amount of energy.