

Catalyst - Worksheet - ANSWERS

Part 1:

1. Identify five different factors that are likely to affect the rate of a reaction. Give a practical example of each.

Nature of Reactants, Concentration, Surface Area, Temperature, Catalyst - examples will vary so show me if you are concerned...

2. Which of the five factors that affect the rate of reactions applies only to heterogeneous systems? Give an example of such a system.

Surface Area is the only one that applies to heterogeneous systems. Ex. magnesium ribbon and acid would be slower than magnesium powder and acid.

3. What would happen to the rate of reaction if the temperature were raised from 20°C to 40°C? Explain qualitatively and make a quantitative prediction.

Qualitatively the rate would increase. Quantitatively the rate would increase by a factor of 4 because it would most likely double for every increase of 10°C.

4. A match can be applied to a lump of coal with little effect. However, the ignition of coal dust has caused many fatal mining explosions. Explain.

The coal dust has a much larger surface area for the oxygen to react with in this combustion reaction which leads to the explosion that can occur. The lump of coal has a lower surface area making it harder to react with the oxygen in the air and thus is much safer. **Think about the lycopodium powder demonstration that was done in class.**

5. Signs warn about the dangers of having sparks or open flames near oxygen tanks or near flammable fuels. Which of the five factors that affect reaction rate are involved in each of these warnings?

The factor involved in these warnings is concentration. The high concentration of oxygen leads to the combustion reaction occurring explosively fast.

Part 2:

1. Which of the five factors that affect rate of reaction do so by:

a. increasing the collision frequency?

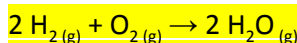
Temperature, Surface Area, Concentration

b. increasing the fraction of collisions that are effective?

Nature of Reactants, Temperature, Catalyst

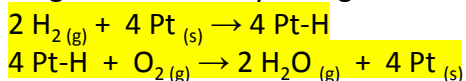
2. The reaction of hydrogen and oxygen is exothermic and self-sustaining.

a. Write the equation for this reaction, and provide a reason why it is not likely that the reaction occurs as a single step.



This reaction does not likely occur as a single step because the activation energy is very high. By the addition of a catalyst that causes the reaction to occur in multiple steps we can reduce the activation energy and cause this reaction to occur faster.

- b. This reaction is catalyzed by platinum metal, which provides a surface on which hydrogen gas splits to form Pt-H units that react readily with oxygen molecules. Suggest a possible mechanism for this process, given that a catalyst must be regenerated in any change.



3. Identify each of the following as examples of the action of homogeneous or heterogeneous catalysts:

- a. Rhodium and platinum metals are used in an automobile catalytic converter to convert exhaust gases into safer gases.

Heterogeneous catalyst

- b. Gaseous chlorofluorocarbons (CFCs) have been shown to catalyze the breakdown of ozone in the upper atmosphere.

Homogeneous catalyst

- c. Aqueous sulfuric acid catalyzes the decomposition of aqueous formic acid to carbon monoxide and water.

Homogeneous catalyst

- d. Powdered TiCl_4 is used in the formation of polyethylene polymer from gaseous ethylene.

Heterogeneous catalyst

4. Use collision theory to explain each of the following observations.

- a. Permanganate ion (MnO_4^-) react much more quickly with iron(II) ions (Fe^{2+}) than with oxalate ions ($\text{C}_2\text{O}_4^{2-}$).

The reaction with the Fe^{2+} ions is faster because it will always collide with the correct orientation thus there will be a higher number of effective collisions. The reaction involving oxalate ions will occasionally collide with the incorrect orientation thus the reaction will not occur.

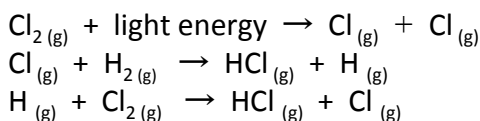
- b. When heated in a flame, steel wool burns but a steel nail just glows.

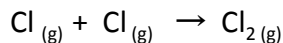
The steel wool has a higher surface area so according to collision theory this will increase the number of collisions which will cause the reaction to occur faster.

- c. Liquid nitroglycerin is a dangerous explosive, but people with heart conditions take nitroglycerin tablets.

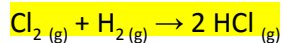
The solid pill that is taken will have particles with a lower amount of energy than the particles in the liquid state. Thus when they collide they will be less likely to react. So this reaction with the solid pill is safe because the fraction of effective collisions is lower.

5. The reaction of hydrogen with chlorine at room temperature is so slow as to be undetectable if the container is completely dark, but is explosively fast if sunlight is allowed to fall on the reactants. The following reaction mechanism has been suggested for this reaction:

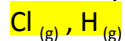




- a. Write the overall reaction equation.



- b. Identify the reaction intermediates.



- c. Compare the activation energy for the collision of molecular chlorine with molecular hydrogen to the activation energy for the collision of atomic chlorine with molecular hydrogen. Which reaction must have the greater activation energy, and what evidence can be used to support your argument?

The reaction involving the molecular form of both reactants is much slower (bonds have to be broken in both reactants) than the reaction involving the atomic chlorine with molecular hydrogen (bonds only have to be broken in one reactant). The reaction of molecular chlorine with molecular hydrogen will have a higher activation energy since it is seen to be a slower reaction.