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| Le Chatelier's Principle Explanation | |
| ***If a change is imposed on a chemical system at equilibrium, the system will react to re-establish equilibrium by partially undoing the change.***   * Le Chatelier's Principle is a useful tool to predict change in equilibrium position. However, it is important to understand how uneven forward and reverse reaction rates cause this shift in equilibrium. | |
| **Increasing the amount of a species**  N2(g) + 3H2(g) ⇋ 2NH3(g) ΔH = -92 kJ/mol  If H2 gas is added.   * Due to the increased number of particles on the left (reactants), the forward reaction rate increases / no initial change in the reverse rate. * The rate of the forward reaction is now greater than the rate of the reverse reaction. This causes a shift in equilibrium to the right 🡺 (products). * Notice how when equilibrium is established the rates of the backward and forward reactions, although equal, are higher than during the previous equilibrium. | http://www.dynamicscience.com.au/tester/solutions1/chemistry/equilibrium/rates14567.gif  **Notice:** Although the equilibrium shifts to the right at no point does rate of the reverse reaction decrease. The shift is caused by the initial sudden increase in the forward direction  The side with the species added shows a sudden increase in reaction rate |
| * Notice how the resulting changes in concentration are equal to the molar ratios given in the balanced equation. For example, [N2] decreases by a third that of the decrease in [H2]. The increase in [NH3] is 2/3 that of the decrease in [H2] * The value of K has remained constant | http://www.dynamicscience.com.au/tester/solutions1/chemistry/equilibrium/rates145678.gif |
| **Decreasing the amount of a species**  N2(g) + 3H2(g) ⇋ 2NH3(g) ΔH = -92 kJ/mol  If H2 gas is removed.   * Due to the decreased number of particles on the left (reactants), the forward reaction rate decreases / no initial change in the reverse rate. * The rate of the forward reaction is now slower than the rate of the reverse reaction. This causes a shift in equilibrium to the left 🡸 (reactants). * Notice how in the new equilibrium the rates of the backward and forward reactions, although equal, are lower than during the previous equilibrium. * The value of K has remained constant | http://www.dynamicscience.com.au/tester/solutions1/chemistry/equilibrium/rates1456789.gif  The side with the species lowered shows sudden decrease in rate  **Notice:** Although the equilibrium shifts to the left at no point does rate of the reverse reaction increase. The shift is due to the initial sudden decrease in the forward direction |
| **Change in volume**  N2(g) + 3H2(g) ⇋ 2NH3(g) ΔH = -92 kJ/mol  If volume is decreased (pressure increased):   * The system moves to reduce the total pressure. * This is done by reducing the total amount of particles in the system, thus shifting the equilibrium position towards the side with the least particles. * At equilibrium, the rates of the backward and forward reactions are equal, but greater than before. | http://www.dynamicscience.com.au/tester/solutions1/chemistry/equilibrium/rates14567811.gif  The side with the most particles increases the most |
| At equilibrium,   * At the new equilibrium the concentrations of all particles will increase overall as the change is partially opposed. * Value of K remains the same | http://www.dynamicscience.com.au/tester/solutions1/chemistry/equilibrium/rates14567812.gif |
| **Increase in volume**   * If the volume of the reaction vessel is increased, pressure decreases, and the system shifts in the direction of most particles thus increasing the total pressure. * At equilibrium, the concentration of all particles will be lower than before the change as change is partially opposed. | http://www.dynamicscience.com.au/tester/solutions1/chemistry/equilibrium/rates14567813.gif  The side with the most particles deceases the most |
| Note that the equilibrium position will not change if:   * A pressure change is due to the addition of an inert gas. It will only change if the pressure change is due to a change in volume.   OR   * The reaction has equal particles on both sides.  For example: The gaseous equilibrium H2(g) + Cl2(g) ⇋2HCl (g) has two particle on both the reactants and products side. It cannot respond to a change in pressure due to volume change. The reaction, 3H2(g) + N2(g) ⇋ 2NH3 (g), however, can respond as there are four particles on the reactants side and two particle on the products side. | |
| **Change in temperature**  The enthalpy change (∆H) must be known so that we can predict the response of the system to temperature change.  The diagrams shown demonstrate the effect of heating an endothermic reaction such as the thermal decomposition of a carbonate:  CaCO3(s) → CaO(s) + CO2(g)∆H = +178 kJ mol-1 | http://www.dynamicscience.com.au/tester/solutions1/chemistry/equilibrium/rates145678123.gif  The side with the largest activation energy increases the most |
| According to Le Chatelier’s principle   * If an equilibrium system is cooled, the system will adjust by creating heat by favouring the exothermic reaction * If an equilibrium system is heated the system will adjust by using heat and favouring the endothermic reaction * Since temperature has changed, so does the equilibrium constant.   Explanation   * The explanation for this is that when temperature is changed the direction with the largest activation energy increases or decreases the most this is due to a larger **proportional change** in the number of particles wit required activation energy. | http://dl.clackamas.edu/ch105/lesson%208%20images/lechat16.jpg |

<http://dl.clackamas.edu/ch105/lesson8lechateliers_principle.html>