

Unit X Answers

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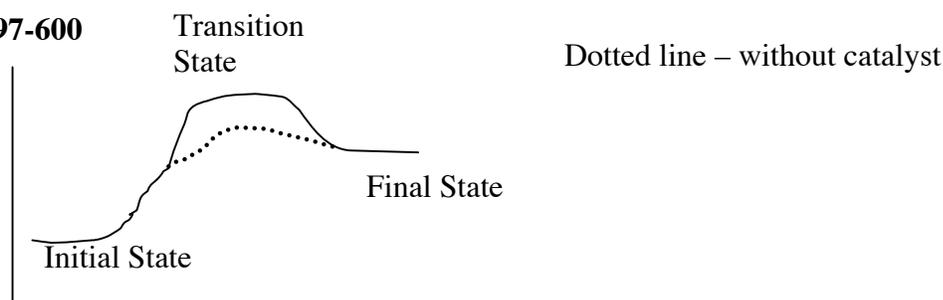
1. A rate is a change in some quantity divided by the length of time over which the change occurred. A reaction rate is the decrease in concentration of the reactant or the increase in the concentration of a product during a small time interval divided by that time.
3. Atoms must be in contact in the correct orientation for new bonds to form.
4. Reaction rates are measured by measuring the change in concentration of a reactant or product divided by the time that the change occurs.
5. The greater the concentration the more molecules of a reactant there are to react, the more probable it is that they will randomly run into each other in a way that allows new bonds to form.
6. One example – you find a different one – car batteries work better in the summer than in the winter.
13. The pressure affects the rates of reactions with gases because pressure affects the concentration of the gas molecules. Increasing the pressure increases the concentration of the gas.

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3. The molecules must hit each other in an orientation that allows new bonds to form and the collision must have enough energy to overcome the activation energy for the breaking and formation of the chemical bonds.
4. Catalysts are substances that do not change in the reaction (they are not reactants) but cause the rate of the reaction to increase. They work by providing an alternate pathway for the reaction that requires less activation energy.
5. your example
6. First order.
7. $8.1 \times 10^{-5} \text{ M/s}$
8. First order in B and second order in A
12. The enzymes often hold the molecules in the correct position so they can react. This is a structural fit – or a lock fitting into a key.

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22.



24. Rate = $4.5 \times 10^{-6} \text{ M/s}$

25. Rate = $1.4 \times 10^{-6} \text{ M/s}$

26. Rate = $1.4 \times 10^{-6} \text{ M/s}$

27. Rate = 1.8×10^{-6} M/s

28. Rate = 3×10^{-11} M/s

29. Rate = $k[\text{NO}]^2[\text{Br}_2]$

30. first order

31. an increase by a factor of two

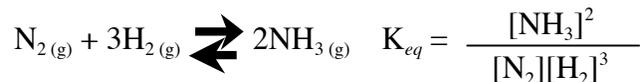
32. second order

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- c – the reaction only “goes” one way.
- At equilibrium the forward and reverse reaction rates are equal.
- A reversible reaction at equilibrium where the relative amounts are not known.
 - A reversible reaction at equilibrium where there are more products than reactants.
- During static equilibrium nothing changes. During dynamic equilibrium there is constant change of individual molecules but the overall amounts do not change.

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- The equilibrium constant expression is a ratio of the products over reactants each raised to the power of the coefficients in the balanced equation.



- solids, pure liquids and solvents are left out of the equilibrium expressions because the concentrations do not change during the reaction.
- K_{sp} can be assigned to salts (ionic compounds in general) that are slightly soluble in water and to hydroxides that are slightly soluble in water.
- K_{sp} does not apply to salts that are very soluble in water.
- $[\text{HI}] = 3.53 \times 10^{-3}$ M
- $[\text{Cu}^{+2}] = 1.1 \times 10^{-18}$ M
- $\text{C}_{(s)} + \text{CO}_{2(g)} \rightleftharpoons 2\text{CO}_{(g)} \quad K = 2.5 \times 10^{-2}$ M
- $K=1$
- $K_{sp} = [\text{Al}^{3=}][\text{OH}^-]^3$

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- LeChatelier’s Principle states that a system at equilibrium when subjected to a stress will change to relieve the stress.
- Stresses are changes in pressure (for gases), temperature or changes in concentration of reactants or products.

- The addition of reactant causes the equilibrium to produce more of the products by using some of the additional reactant. Adding product will cause the equilibrium to use up the additional product making more reactants.
- A change in temperature changes the value of the equilibrium constant.
- Reactions that have unequal moles of gases between products and reactants are affected by changes in pressure.
- The common ion effect is the reduction of the solubility of a compound (more precipitate is made) by adding another compound that contains an ion (common ion) of the first. Adding sodium chloride to a saturated solution of silver chloride will cause additional silver chloride to precipitate out of the solution.

$$\text{AgCl}_{(s)} \rightleftharpoons \text{Ag}^+_{(aq)} + \text{Cl}^-_{(aq)}$$
 Adding the chloride ion from sodium chloride will cause the equilibrium to “shift left”.

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- A balanced equation must be used because the coefficients of the balanced equation are used in the equilibrium expression.
- At the start A and B are at maximum concentration and there is no C or D. As A and B react their concentrations decrease and the concentrations of C and D increase. The rate at which A and B react slow down as their concentrations decrease. The rate at which C and D react to form A and B increase with increases in concentrations of C and D. When the rates of the two equations become equal the concentrations of A, B, C and D will remain constant – equilibrium is established.
- a) neither b) reverse c) forward
- a) $2\text{NO}_{(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{2(g)}$ b) $K_{eq} = \frac{[\text{NO}_2]^2}{[\text{NO}]^2[\text{O}_2]}$
- a) $K_{eq} = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2[\text{O}_2]}$ b) $K_{eq} = \frac{[\text{COCl}_2]}{[\text{CO}][\text{Cl}_2]}$
- c) $K_{sp} = [\text{Ag}^+][\text{Cl}^-]$ d) $K_{eq} = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$
- a) $K_{eq} = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = 1.8 \times 10^{-5}$ b) 5.6×10^4
- $K_{sp} = [\text{Ag}^+][\text{I}^-]$ $K_{sp} = [\text{Sr}^{2+}][\text{SO}_4^{2-}]$ $K_{sp} = [\text{Ag}^+]^2[\text{CO}_3^{2-}]$ $K_{sp} = [\text{Ag}^+]^2[\text{S}^{2-}]$
 $K_{sp} = [\text{Pb}^{2+}][\text{I}^-]^2$ $K_{sp} = [\text{Ag}^+][\text{IO}_3^-]$ $K_{sp} = [\text{Mg}^{2+}]^3[\text{PO}_4^{3-}]^2$ $K_{sp} = [\text{Hg}_2^{2+}][\text{Cl}^-]^2$
- Your words – economics principles, chemical reactions, social situations are some possibilities.
- a) forward (or make more products) b) reverse (or make more reactants)
- a) forward b) forward c) neither d) forward e) reverse f) neither

g) reverse h) neither

23. Higher pressure would produce more carbon dioxide because the equation has 3 moles of gases on the left and 2 on the right. Increasing the pressure would cause the equilibrium to shift to reduce the pressure which can be accomplished by making fewer moles of gases.

24. a) high reactant concentrations, high pressure, low temperature
b) high reactant concentrations, low temperature
c) high reactant concentrations, high temperature
d) high reactant concentrations, high pressure, low temperature

25. Greater concentrations of reactants will occur from increasing the sulfur trioxide concentration, decreasing the concentration of either reactant, decreasing the pressure or increasing the temperature.

26.
$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

27. More products will be made if the temperature is increased, the phosphorous pentachloride concentration is increased, or the concentration of either chlorine or phosphorous trichloride is decreased.

28.
$$K_{eq} = \frac{[Cl_2][PCl_3]}{[PCl_5]}$$

29. When a common ion is added to the solution it becomes more concentrated, placing a stress on the equilibrium that is relieved by reducing the ion concentration (and in the process reducing the concentration of the other ion and increasing the concentration or amount of salt precipitated.)

30. 1.74×10^{-5} 31. a) $K_{eq} = \frac{[Mn^{2+}][Cl_2]}{[H_3O^+]^4[Cl]^{-2}}$ b) $K_{eq} = [H_3AsO_4]^4$

32. 1.57 33. a) 0.67 b) 0.52 c) 311

34. 1.4×10^{10} 35. 0.048 M 36. 0.0106 M 37. 0.046 M

38. 110 M 39. 2.9×10^{-26} 40. 2.5×10^{-48} 41. 8.22×10^{-96}

42. 7.14×10^{-11} 43. 1.7×10^{-14} , 1.3×10^{-7} , 2.7×10^{-7} , 1.6×10^{-7}

44. For other charges cube, fourth or even fifth roots might need which may be difficult to calculate.

45. 4.0×10^{-5} 46. 7.3×10^{-7}

47. a) NaBr is completely soluble in water.
b) No. A very small amount dissolves or the equilibrium constant would be zero. Ba(OH)₂ is not completely insoluble either.

48. 0.44