Spring Training Review Session 2 — AP Chemistry

AP Topic 3.5: Kinetic Molecular Theory (28 questions/2.3%)

What's in this topic:

Enduring Understanding

Gas properties are explained macroscopically—using the relationships among pressure, volume, temperature, moles, gas constant—and molecularly by the motion of the gas.

Learning Objective

Explain the relationship between the motion of particles and the macroscopic properties of gases with: a. The kinetic molecular theory (KMT); b. A particulate model; c. A graphical representation.

Essential Knowledge

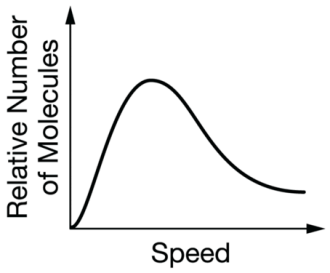
- The kinetic molecular theory (KMT) relates the macroscopic properties of gases to motions of the particles in the gas. The Maxwell-Boltzmann distribution describes the distribution of the kinetic energies of particles at a given temperature.
- All the particles in a sample of matter are in continuous, random motion. The average kinetic energy of a particle is related to its average velocity by the equation: $KE = \frac{1}{2} mv^2$
- The Kelvin temperature of a sample of matter is proportional to the average kinetic energy of the particles in the sample.
- The Maxwell-Boltzmann distribution provides a graphical representation of the energies/ velocities of particles at a given temperature.

Review Materials:

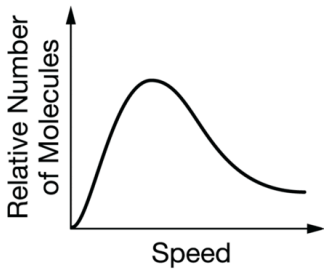
- Fuller's Review Video: Kinetic Molecular Theory (9:29)
- Fuller's PowerPoint Notes: None
- College Board Review Videos: 3.5 Daily Video 1 (5:36) and 3.5 Daily Video 2 (4:44)
- Bozeman Science Video: None
- Khan Academy Review Videos: Kinetic Molecular Theory of Gases (3 videos)
- Fiveable Review: Kinetic Molecular Theory (5 min read)
- "I Do, We Do, You Do" Practice: Kinetic Molecular Theory

"The Basics" Review Questions

1. What is kinetic energy?
2. What is potential energy?
3. A 5.00 L container of methane gas is full. All of the methane gas is moved to a 20.00 L container.
   a. Is the container 100% full or only 25% full of methane? Explain your reasoning.
   b. Did the mass of methane gas in the 20.00 L container increase, decrease, or remain the same as the mass in the 5.00 L container?
4. What does a Maxwell-Boltzmann distribution illustrate? Draw an example of one.
5. Does the velocity of a gas increase, decrease, or remain the same as …
   a. Temperature is increased.
   b. molar mass is increased.
6. Gas A (75 ℃, molar mass = 50 g/mol) and gas B (15 ℃, molar mass = 25 g/mol) are placed in the same container and are allowed to come to thermal equilibrium.
   a. What happens to the average kinetic energy of gas A as it approaches thermal equilibrium?
   b. What happens to the average kinetic energy of gas B as it approaches thermal equilibrium?
   c. Compare the temperature of gas A to the temperature of gas B at thermal equilibrium. Explain your reasoning.
   d. Compare the average kinetic energy of gas A to the average kinetic energy of gas B at thermal equilibrium. Explain your reasoning.
   e. Compare the average speed of gas A to the average speed of gas B at thermal equilibrium. Explain your reasoning.
7. Use the Maxwell-Boltzmann distributions shown below to answer the questions below each picture.

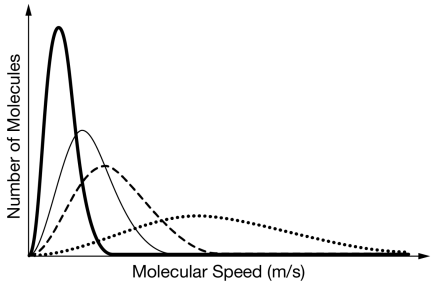


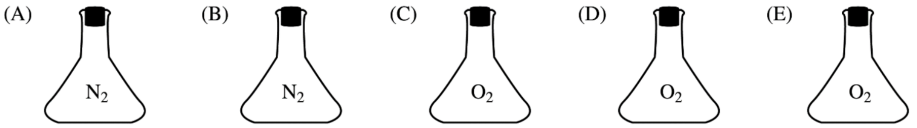
Shown above is the distribution for N_2 at 25 °C.
Draw and label the distribution for N_2 at 50 °C.



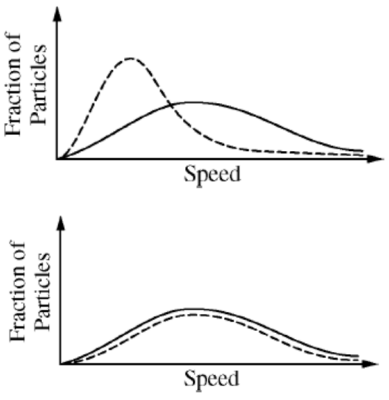
Shown above is the distribution for N_2 at 25 °C.
Draw and label the distribution for Xe at 25 °C

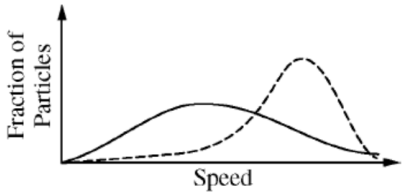
8. Describe the effect …
    a. of raising the temperature on the motion of gas particles. Explain your reasoning.
    b. on the pressure of a gas when the temperature is increased. Explain your reasoning.
9. The Maxwell-Boltzmann distrubition below was created using four different gases. What specific property of the gas can you determine from the graph alone?



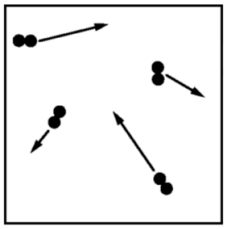


10. Use the five flasks above to answer the questions that follow.
    a. Which flask do the molecules have the greatest average speed of the particles? Explain your answer.
    b. Which nitrogen flask has the most number of particles? Explain your reasoning.
    c. Which oxygen flask has the most number of particles? Explain your reasoning.
    d. If flask C were placed into flask E, and there was no change in temperature, what would be the total pressure? Explain your reasoning.
    e. Which flasks have the same average kinetic energy? Explain your reasoning.
11. The Maxwell-Boltzmann distributions below show two different gases at the same temperature. Compare the molar mass of the gas depicted by the solid line (Gas X) to the molar mass of the gas depicted by the dashed line (Gas Y) by stating whether the molar mass of the Gas Y is greater than, less than, or equal to the molar mass of Gas X.

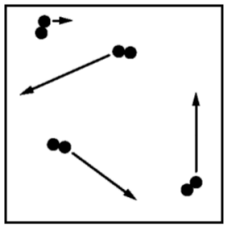




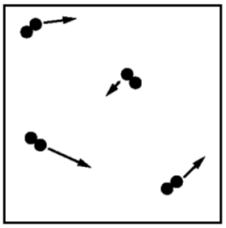
12. The particle picture below is a gas at a given temperature. Determine if the particle pictures are at a higher temperature or a lower temperature. Explain your reasoning.



Original temperature



Higher Temp or Lower Temp



Higher Temp or Lower Temp

Reasoning

AP Topic 3.4: Ideal Gas Law (48 questions/3.9%)

What's in this topic:

Enduring Understanding

Gas properties are explained macroscopically—using the relationships among pressure, volume, temperature, moles, gas constant—and molecularly by the motion of the gas.

Learning Objective

Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law.

Essential Knowledge

- The macroscopic properties of ideal gases are related through the ideal gas law: PV = nRT.
- In a sample containing a mixture of ideal gases, the pressure exerted by each component (the partial pressure) is independent of the other components. Therefore, the total pressure of the sample is the sum of the partial pressures.
- EQN: $P_A = P_{total} \times X_A$,
  where X_A = moles A/total moles;
- EQN: $P_{total} = P_A + P_B + P_C + \ldots$
- Graphical representations of the relationships between P, V, T, and n are useful to describe gas behavior.

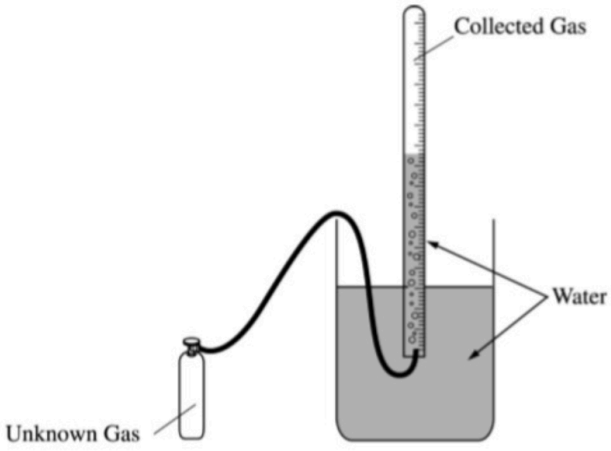
Review Materials:

- Fuller's Review Video: Ideal Gas Law (10:17)
- Fuller's PowerPoint Notes: Gases and the Ideal Gas Law
- College Board Review Videos: 3.4 Daily Video 1 (13:15), 3.4 Daily Video 2 (8:35), and 3.4 Daily Video 3 (9:21)
- Bozeman Science Video: Ideal Gas Law (9:57)
- Khan Academy Review Videos: Ideal Gas Law (5 videos)
- Fiveable Review: Ideal Gas Law (5 min read)
- "I Do, We Do, You Do" Practice: Ideal Gas Law

"The Basics" Review Questions

1. Perform the following conversions.
   a. A rigid container is 450 mL. Convert the volume to liters.
   b. How many mL is 2.00 L?
   c. Convert 125 mm Hg to atm.
   d. Determine the pressure in kPa if it is measured at 1.72 atm.
   e. A canister is measured to be at 0.892 kPa.
      i. Determine the pressure in mm Hg.
      ii. Determine the pressure in atm.
   f. An oven is ran at 200. °C. Determine the temperature in Kelvin.
   g. The flashpoint of carboard is 700. K. Determine the flashpoint in Celsius. (The flashpoint is the temperature at which the substance will auto-ignite.)
2. Give the following equations or definitions. Identify any variables in an equation.
   a. Ideal gas law
   b. Ideal gas law (solved for molar mass)
   c. Ideal gas law solved for density
   d. Mole fraction
   e. Partial pressure
   f. STP
   g. Molar volume of a gas
3. Determine the mass, in grams, of each gas under the conditions given.
   a. 22.4 L of $CH_4(g)$ at STP
   b. 2.2 L of $CO_2(g)$ at 1 atm and 0 °C
   c. 0.2 L of $SO_2(g)$ at STP
   d. 4 L of $N_2O(g)$ at 273 K and 1 atm
4. For the following changes to a gas, determine which will have a greater effect for the property specified without using a calculator.
   a. Would the pressure increase, decrease, or remain the same if the Celsius temperature is doubled from 10 °C to 20 °C while the volume the gas occupies is doubled from 2 L to 4 L? Explain your reasoning.
   b. Would the volume of a gas increase, decrease, or remain the same if the Kelvin temperature were doubled while the pressure is decreased by a factor of four? Explain your reasoning.
   c. Would the temperature of a gas have to increase, decrease, or remain the same if the volume of the container is reduced by half while the pressure was doubled? Explain your reasoning.

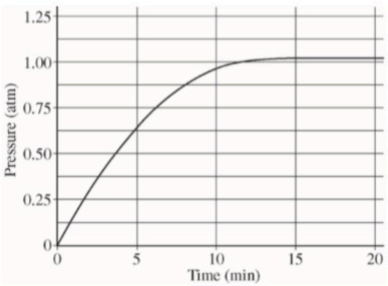
5. Perform the following calculations.
   a. Determine the partial pressure of each gas if the canister contains 0.5 moles of O_2, 1.0 moles of N_2, and 0.5 moles of Ar at a total pressure of 600 mm Hg.
   b. Determine the partial pressure of N_2 if the canister contains 0.5 moles of O_2, 0.5 moles of N_2, and 0.5 moles of Ar at a total pressure of 900 mm Hg.
6. A student collects a gas over water using the apparatus shown below. Answer the questions that follow about the lab experiment.



7. Explain why the water level on the inside of the collection tube and the outside of the collection tube needs to be at the same level.
   a. Explain why the pressure of the room is the same as the pressure of the gases (assuming a is true).
   b. Explain why the pressure of the room is NOT the pressure of the collected gas.
   c. How would you determine the mass of gas delivered?
   d. Use the data below to determine the molar mass of the unknown gas.

Room Pressure	750 mm Hg
P_{H2O} at 22 °C	19.8 mm Hg
Mass of Canister Before the lab	25.100 g
Mass of Canister After the lab	24.276 g
Temperature of Water (°C)	22.0 °C
Volume of Gas Collected (mL)	358 mL

8. A 5.00 milliliter vial contains 0.750 grams of CCl_4 at 0 °C. Calculate the pressure in the vial at 25 °C.
9. A gas has a vapor density of 7.50 g L^{-1} at 350 K. If a container of the gas has a pressure of 2.22 atm what would be the molar mass of the gas?
10. The pressure in a 1.00 L rigid flask at 1100 K was measured and recorded over time. Use the graph below to answer the questions that follow.



   a. Determine the moles of gas present in the flask at 5 minutes.

b. Determine the moles of gas present in the flask at 20 minutes.

c. Which reaction below could be occurring in the flask? Explain your reasoning. In your explanation you must discuss all three reactions.

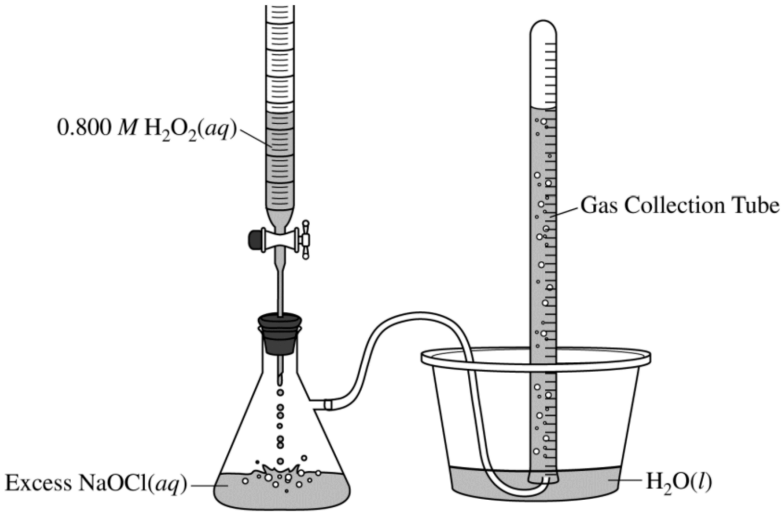
$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ Reaction A

$4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$ Reaction B

$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$ Reaction C

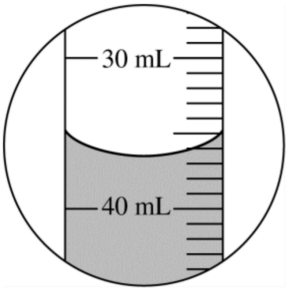
$$H_2O_2(aq) + OCl^-(aq) \rightarrow H_2O(l) + Cl^-(aq) + O_2(g)$$

11. A student investigates the reaction between $H_2O_2(aq)$ and NaOCl(aq), which is represented by the net-ionic equation shown above. The student decides to produce 40.0 mL of $O_2(g)$ at a pressure of 0.988 atm and a temperature of 298 K using the reaction represented above. The student uses the equipment shown below. The student sets up a 250 mL Erlenmeyer flask fitted with a one-hole stopper. The flask is connected to a 50 mL gas-collection tube that initially is completely filled with water.



a. Calculate the volume of 0.800 M $H_2O_2(aq)$ that the student should add to excess NaOCl(aq) to produce 40.0 mL of $O_2(g)$ at 0.988 atm and 298 K.

b. The student added the amount of $H_2O_2(aq)$ calculated in part (a) to excess NaOCl(aq). However, instead of producing 40.0 mL of $O_2(g)$, the volume indicated in the diagram below was produced.

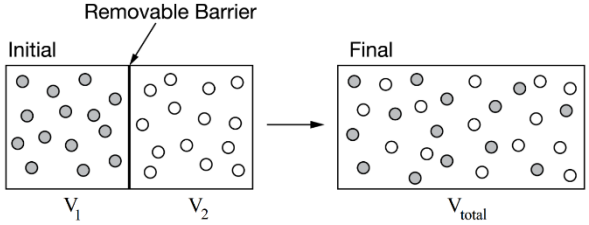


i. Based on the diagram above, what volume of gas was produced?

ii. Assuming that all the gas in the tube is $O_2(g)$, calculate the percent yield of $O_2(g)$.

iii. Is the assumption that all the gas in the tube is $O_2(g)$ correct? Explain.

12. In the apparatus shown below $V_1 = V_2$. Answer the questions that follow about the apparatus assuming that there is no change in temperature throughout the experiment.



a. How can you tell that in the Initial vessel there are equal number of moles in V_1 and V_2?

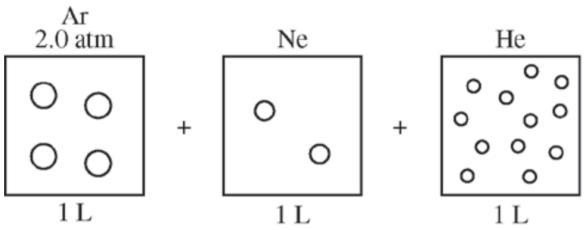
b. How would the initial pressure in V_1 compare to the initial pressure in V_2? Explain your reasoning.
c. How does the average KE of the particles in V_1 compare to the average KE of the particles in V_2?
d. What information would you need to know in order to compare the speed of the particles?
e. How does V_1 and V_2 compare to V_{total}?
f. What would happen to the pressure of the gas in V_1 once the barrier is removed, as shown in the Final container? Explain your reasoning.

13. Use the data below for the questions that follow. All three gases are in three identical, rigid containers.

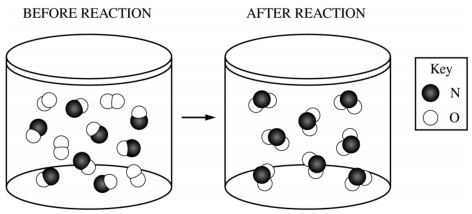
Container	A	B	C
Gas	Methane	Ethane	Butane
Formula	CH_4	C_2H_6	C_4H_{10}
Molar mass (g/mol)	16	30	58
Temperature (°C)	27	27	27
Pressure (atm)	2.0	4.0	2.0

a. Which container has the most number of particles? Explain your reasoning.
b. Which container do the particles have the lowest speed? Explain your reasoning.
c. Which container has the greatest density? Explain your reasoning.

14. Consider the boxes below all at the same temperature.



a. Determine the pressure in the Ne box. Explain your reasoning.
b. Determine the pressure in the He box. Explain your reasoning.
c. What would be the total pressure if all three gases were placed in the same 1 L container.
d. What would be the pressure of He if all three gases were placed into a 2 L container. Explain your reasoning.



15. A chemical reaction is carried out in a rigid container as illustrated above.
a. Write the balanced chemical equation.
b. How would the pressure of the container before the reaction compare to the pressure of the container after the reaction? Explain your reasoning.

16. Enough Ar(g) is pumped into a rigid container such that the pressure of Ar(g) is 0.45 atm.
a. What would be the pressure if the number of Ar(g) particles was doubled?
b. The container from (a) has additional CO_2(g) pumped in so that the partial pressure of CO_2(g) is 0.30 atm.
i. What is the partial pressure of Ar(g)?
ii. What is the total pressure?

AP Topic 3.7: Solutions and Mixtures (48 questions/3.9%)

What's in this topic:

Enduring Understanding

Interactions between intermolecular forces influence the solubility and separation of mixtures.

Learning Objective

Calculate the number of solute particles, volume, or molarity of solutions.

Essential Knowledge

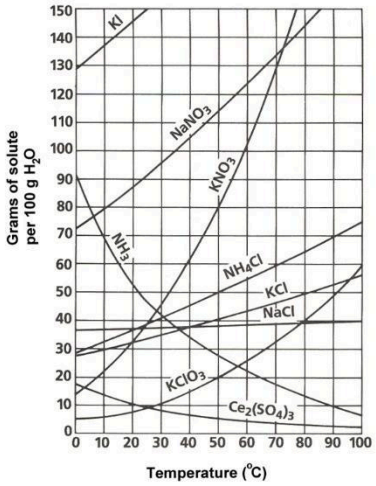
- Solutions, also sometimes called homogeneous mixtures, can be solids, liquids, or gases. In a solution, the macroscopic properties do not vary throughout the sample. In a heterogeneous mixture, the macroscopic properties depend on location in the mixture.
- Solution composition can be expressed in a variety of ways; molarity is the most common method used in the laboratory. EQN: $M = n_{solute} / L_{solution}$

Review Materials:

- Fuller's Review Video: Solutions and Mixtures (7:46)
- Fuller's PowerPoint Notes: Solutions and Solvation
- College Board Review Video: 3.7 Daily Video (6:15)
- Bozeman Science Video: Solutions (9:47)
- Khan Academy Review Videos: Solutions and Mixtures (3 videos)
- Fiveable Review: Solutions and Mixtures (6 min read)
- "I Do, We Do, You Do" Practice: Solutions and Mixtures

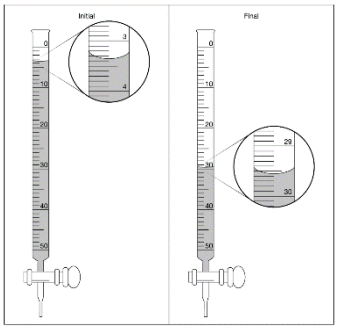
"The Basics" Review Questions

1. Use the chart to the right to answer the questions that follow.
   a. A saturated solution of KNO_3 is made in 100 g of water at 50 °C.
      i. Determine the molarity of the KNO_3(aq) at 50 °C. Assume the density of water is 1 g/mL.
      ii. The KNO_3 solution is cooled to 25 °C. Determine the new molarity of the solution at 25 °C. Assume the density of water is 1 g/mL.
   b. A saturated solution of NH_3 is made in 100 g of water at 20 °C.
      i. Determine the molarity of NH_3(aq) at 20 °C. Assume the density of water is 1 g/mL.
      ii. The solution made in 231.a above is heated to 90 °C. Determine the new molarity of NH_3(aq). Assume the density of water is 1 g/mL.



2. Describe the procedure a student should use to prepare 250. mL of 0.125 M $CuSO_4$(aq) using appropriate equipment selected from the list below. Assume that the student uses appropriate safety equipment.
   - 250 mL beaker
   - 250 mL graduated cylinder
   - 250 mL volumetric flask
   - Eye dropper
   - 500 mL wash bottle filled with distilled water
   - 3.000 M $CuSO_4$ in a 50 mL buret

3. Describe the procedure a student should use to prepare 100. mL of 0.250 M NaOH(aq) using appropriate equipment selected from the list below. Assume that the student uses appropriate safety equipment.
   - 100 mL beaker
   - 100 mL graduated cylinder
   - 100 mL volumetric flask
   - Eye dropper
   - 500 mL wash bottle filled with distilled water
   - Electronic balance
   - Weigh boat
   - NaOH(s)



4. A student used a 50.0 mL buret to add $KMnO_4$(aq) to $H_2C_2O_4$(aq) until a faint lavender color was ob indication that the end point of the titration had been reached.
   a. The initial and final volume readings of the solution in the buret are shown to the right. Write down the initial reading and the final reading and use them to determine the volume of $KMnO_4$(aq) that was added during the titration.
   b. Determine the moles of $KMnO_4$ delivered if the molarity of the $KMnO_4$(aq) is 0.320 M.
5. Perform the following calculations.
   a. A 100 mL sample of 0.500 M $NaNO_3$(aq) solution is mixed with 100 mL of 0.500 M $Ca(NO_3)_2$(aq) solution. What is the final concentration of the NO_3^- ion?

b. How many grams of $CaCO_3(s)$ (molar mass 100. g) are needed to make 10. mL of 0.50 M solution?

c. A 540 mg sample of glucose (molar mass 180 g) is dissolved in enough water to make 300. mL of solution. What would be the molarity of glucose in 100. mL of the solution?

d. A student dilutes 100. mL of 2.00 M $CaCl_2(aq)$ to a final volume of 400. mL with distilled water.

i. How many moles of chloride ion are in the 100. mL solution?

ii. How many moles of chloride ion are in the 400. mL solution?

iii. What is the molarity of chloride ion in the 100. mL solution?

iv. What is the molarity of chloride ion in the 400. mL solution?

AP Topic 4.2: Net Ionic Equations (38 questions/3.1%)

What's in this topic:

Enduring Understanding

A substance that changes its properties, or that changes into a different substance, can be represented by chemical equations.

Learning Objective

Represent changes in matter with a balanced chemical or net ionic equation: a) For physical changes. b) For given information about the identity of the reactants and/or product. c) For ions in a given chemical reaction.

Essential Knowledge

- All physical and chemical processes can be represented symbolically by balanced equations.
- Chemical equations represent chemical changes. These changes are the result of a rearrangement of atoms into new combinations; thus, any representation of a chemical change must contain equal numbers of atoms of every element before and after the change occurred. Equations thus demonstrate that mass is conserved in chemical reactions.
- Balanced molecular, complete ionic, and net ionic equations are differing symbolic forms used to represent a chemical reaction. The form used to represent the reaction depends on the context in which it is to be used.

Review Materials:

- Fuller's Review Video: Net Ionic Equations (8:15)
- Fuller's PowerPoint Notes: Ionic and Net Ionic Equations
- College Board Review Videos: 4.2 Daily Video 1 (6:06) and 4.2 Daily Video 2 (8:21)
- Bozeman Science Video: Molecular, Ionic, and Net Ionic Equations (9:39)
- Khan Academy Review Videos: Net Ionic Equations (1 video)
- Fiveable Review: Net Ionic Equations (6 min read)
- "I Do, We Do, You Do" Practice: Net Ionic Equations

"The Basics" Review Questions

First, a reminder of the basic solubility rules:

- All ionic compounds containing alkali ions (Li^+, Na^+, K^+, Rb^+, Cs^+) are soluble
- All ionic compounds containing the nitrate ion (NO_3^-), the ammonium ion (NH_4^+), and the acetate ion ($C_2H_3O_2^-$) are soluble
- Most chlorides (Cl^-), bromides (Br^-) or iodides (I^-) are **soluble**. Exceptions are those containing Ag^+, Hg^{+2}, Pb^{+2}, and Cu^{2+}.
- Most hydroxides (OH^-) are **insoluble**. Exceptions are the strong bases

1. Balance each of the following equations. Then write the net-ionic equation for each reaction.
   a. _____$Co(NO_3)_2(aq)$ + _____$NaOH(aq) \rightarrow$ _____$NaNO_3(aq)$ + _____$Co(OH)_2(s)$
   b. _____$H_2SO_4(aq)$ + _____$CaCO_3(aq) \rightarrow$ _____$CaSO_4(aq)$ + _____$H_2O(l)$ + _____$CO_2(g)$
   c. _____$HC_2H_3O_2(aq)$ + _____$NH_3(aq) \rightarrow$ _____$NH_4C_2H_3O_2(aq)$ [NOTE: $HC_2H_3O_2(aq)$ is a weak acid! Weak acids and base are written in their molecular form in net ionic equations]
2. Define the following:
   a. Non electrolyte
   b. Weak electrolyte
   c. Strong Electrolyte
3. What types of compounds are nonelectrolytes? Weak electrolytes? Strong electrolytes?
4. Complete the following equations for an ionic compound being placed in water.
   a. $Sr(NO_3)_2(s) \rightarrow$
   b. $LiCl(s) \rightarrow$
   c. $(NH_4)_2SO_4(s) \rightarrow$