

شرح قوانين الغازات والروابط الكيميائية



تم تحميل هذا الملف من موقع المناهج الإماراتية

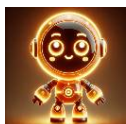
موقع المناهج ← المناهج الإماراتية ← الصف العاشر المتقدم ← كيمياء ← الفصل الثالث ← ملفات متنوعة ← الملف

تاريخ إضافة الملف على موقع المناهج: 2026-06-25 12:12:36

ملفات اكتب للمعلم اكتب للطالب ا اختبارات الكترونية ا اختبارات ا حلول ا عروض بوربوينت ا أوراق عمل
منهج انجليزي ا ملخصات وتقارير ا مذكرات وبنوك ا الامتحان النهائي ا للمدرس

المزيد من مادة
كيمياء:

التواصل الاجتماعي بحسب الصف العاشر المتقدم



صفحة المناهج
الإماراتية على
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

المزيد من الملفات بحسب الصف العاشر المتقدم والمادة كيمياء في الفصل الثالث

ورقة عمل على القوانين

1

شرح قوانين الغازات والروابط الكيميائية

2

هيكل الامتحان أسئلة وتدريبات

3

اختبار التقويم الثاني لمادة الكيمياء

4

ملزمة الهيكل للمراجعة النهائية

5

Question**	Learning Outcome***	Reference(s) in the Student Book	
		المرجع في كتاب الطالب	Page ****
السؤال**	ناتج التعلم***	Example/Exercise	****
		مثال/تمرين	الصفحة ****
1	CHM.5.2.01.001 Describe the kinetic molecular theory of particles, List the five assumptions of the Kinetic Molecular Theory يصف الحالات المختلفة للمادة وتحولاتها بالإعتماد على نظرية الحركة الجزيئية، ويذكر الفرضيات الخمسة لها	Textbook, standardized test Q.2 نص الكتاب وتدريب على الاختبار المعياري، Q2	270 -271

kinetic-molecular theory describes the behavior of matter in terms of particles in motion. The model makes several assumptions about the size, motion, and energy of gas particles.

2 List the five assumptions of the Kinetic Molecular Theory

The five assumptions are:

- 1) Gases consist of large numbers of tiny particles that are far apart relative to their size
- 2) Collisions between gas particles and between particles and container walls are elastic collisions
- 3) Gas particles are in continuous, rapid, random motion
- 4) There are no forces of attraction between gas particles
- 5) The temperature of a gas depends on the average kinetic energy of the particles of the gas

Q2 :

2. Which is NOT an assumption of the kinetic-molecular theory?

A. Collisions between gas particles are elastic.

B. All the gas particles in a sample have the same velocity.

C. A gas particle is not significantly attracted or repelled by other gas particles.

D. All gases at a given temperature have the same average kinetic energy.

 Select the statements that are TRUE about the assumptions made by the kinetic-molecular theory.

2 correct answers

☒ The average kinetic energy of gas particles depends on their temperature.

☐ Gas particles move in an intermittent, zigzag pattern.

☐ Gas particles never collide, but only slide past one another.

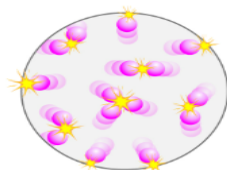
☐ Gas particles vibrate around a fixed position.

☐ Gas particles are closely packed together.

☒ The intermolecular forces between gas particles are negligible.

Select the correct answers.

Which terms BEST describes the motion of gas particles?



☒ straight line 

☒ random 

☐ weak

☐ zigzag pattern

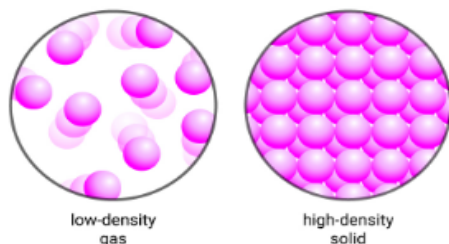
☐ interactive

☐ vibrating

Explaining the Behavior of Gases :

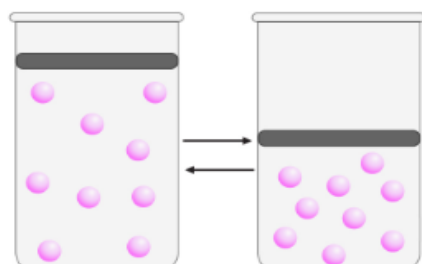
Low Density

At the same temperature and volume, the **density** of gases is very low compared to that of solids.



Compression

Gases can be compressed. This property is unique to all gases.



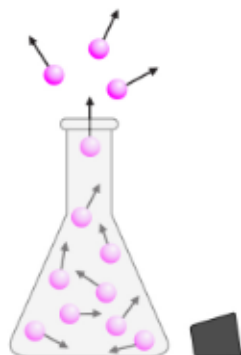
Expansion

Gases expand to fill the shape and volume of any container.



Diffusion

Gas particles spontaneously move from an area of high concentration to one of low concentration.



Effusion

Gas particles can move through a tiny hole into a vacuum.



Define

Graham's law of effusion states that the effusion rate of a gas is inversely proportional to the square root of its molar mass.

This inverse relationship can be expressed mathematically as:

$$\text{effusion rate} \propto \frac{1}{\sqrt{\text{molar mass}}}$$

Dalton's law of partial pressures states that the total pressure of a mixture of gases is equal to the sum of the pressures of all the gases in the mixture. The portion of the total pressure contributed by a single gas is

Dalton's Law of Partial Pressures

$$P_{\text{total}} = P_1 + P_2 + P_3 + \dots P_n$$

P_{total} represents total pressure. P_1 , P_2 , and P_3 represent the partial pressures of each gas up to the final gas, P_n .

To calculate the total pressure of a mixture of gases, add the partial pressures of each of the gases in the mixture.

EXAMPLE Problem 12.2

The Partial Pressure of a Gas A mixture of oxygen (O_2), carbon dioxide (CO_2), and nitrogen (N_2) has a total pressure of 0.97 atm. What is the partial pressure of O_2 if the partial pressure of CO_2 is 0.70 atm and the partial pressure of N_2 is 0.12 atm?

Math Handbook

Significant Figures
pages 949–951

1 Analyze the Problem

You are given the total pressure of a mixture and the partial pressure of two gases in the mixture. To find the partial pressure of the third gas, use the equation that relates partial pressures to total pressure.

Known

$$P_{\text{N}_2} = 0.12 \text{ atm}$$

$$P_{\text{CO}_2} = 0.70 \text{ atm}$$

$$P_{\text{total}} = 0.97 \text{ atm}$$

Unknown

$$P_{\text{O}_2} = ? \text{ atm}$$

2 Solve for the Unknown

$$P_{\text{total}} = P_{\text{N}_2} + P_{\text{CO}_2} + P_{\text{O}_2}$$

$$P_{\text{O}_2} = P_{\text{total}} - P_{\text{CO}_2} - P_{\text{N}_2}$$

$$P_{\text{O}_2} = 0.97 \text{ atm} - 0.70 \text{ atm} - 0.12 \text{ atm}$$

$$P_{\text{O}_2} = 0.15 \text{ atm}$$

State Dalton's law of partial pressures.

Solve for P_{O_2} .

Substitute $P_{\text{N}_2} = 0.12 \text{ atm}$, $P_{\text{CO}_2} = 0.70 \text{ atm}$, and $P_{\text{total}} = 0.97 \text{ atm}$.

3 Evaluate the Answer

Adding the calculated value for the partial pressure of oxygen to the known partial pressures gives the total pressure, 0.97 atm. The answer has two significant figures to match the data.

PRACTICE Problems

Extra Practice Page 984 and glencoe.com

- What is the partial pressure of hydrogen gas in a mixture of hydrogen and helium if the total pressure is 600 mm Hg and the partial pressure of helium is 439 mm Hg?
- Find the total pressure for a mixture that contains four gases with partial pressures of 5.00 kPa, 4.56 kPa, 3.02 kPa, and 1.20 kPa.
- Find the partial pressure of carbon dioxide in a gas mixture with a total pressure of 30.4 kPa if the partial pressures of the other two gases in the mixture are 16.5 kPa and 3.7 kPa.
- Challenge** Air is a mixture of gases. By percentage, it is roughly 78 percent nitrogen, 21 percent oxygen, and 1 percent argon. (There are trace amounts of many other gases in air.) If the atmospheric pressure is 760 mm Hg, what are the partial pressures of nitrogen, oxygen, and argon in the atmosphere?

Sol:- 4) $P_{tot} = P_H + P_{He}$

$$600 = P_H + 439 \Rightarrow P_H = 600 - 439 = 161 \text{ mm Hg}$$

$$5) P_{tot} = 5 + 4.56 + 3.02 + 1.2 = 13.78 \text{ kPa}$$

$$6) P_{CO_2} = P_{tot} - 16.5 - 3.7$$

$$= 30.4 - 16.5 - 3.7 = 10.2 \text{ kPa}$$

$$7) 760 \text{ mm Hg} \times 0.78 = N_2 = 590 \text{ mm Hg};$$

$$760 \text{ mm Hg} \times 0.21 = O_2 = 160 \text{ mm Hg};$$

$$760 \text{ mm Hg} \times 0.01 = Ar = 8 \text{ mm Hg}$$

4

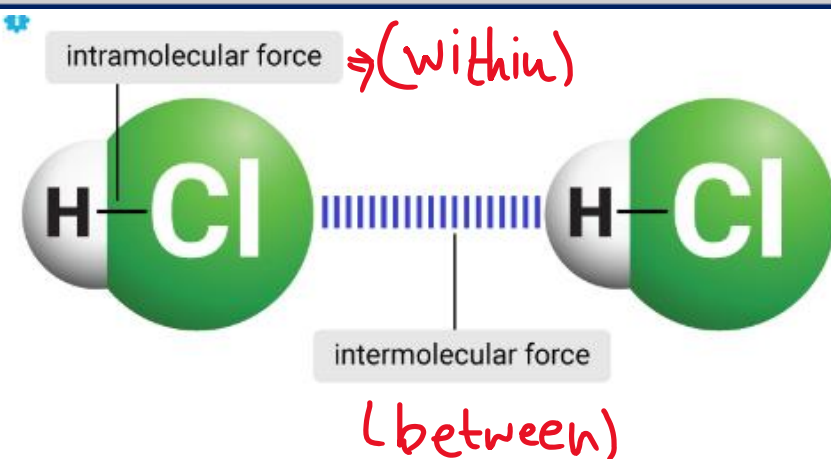
CHM.5.1.02.007 Compare between intramolecular and intermolecular forces

يقارن بين القوى البين جزيئية والقوى بين الجزيئات

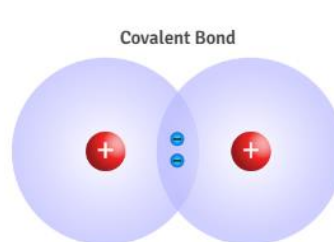
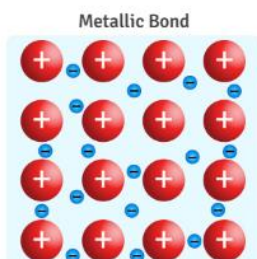
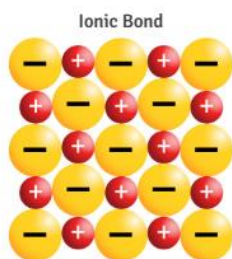
Textbook

نص الكتاب

279



Type of Intramolecular Forces



Types of Intermolecular Forces

You will recall that the three main intermolecular forces are:

- dispersion forces
- dipole-dipole forces
- hydrogen bonds

Q:

⚙️ Classify the examples into intramolecular forces and intermolecular forces.

Intramolecular Forces	Intermolecular Forces
covalent bond	dispersion force
ionic bond	dipole-dipole force
metallic bond	hydrogen bond

Q: Order forces from strong to weak force

Ionic bond > Metallic bond > Covalent bond > Hydrogen bond > dipole-dipole force > dispersion force

⚙️ Classify the features of ionic, metallic and covalent bonds.

Ionic Bonds	Metallic Bonds	Covalent Bonds
metal and nonmetal atoms involved	only metal atoms involved	mostly only nonmetal atoms involved
example: sodium chloride (NaCl)	example: sodium metal (Na)	example: chlorine gas (Cl ₂)
attraction between cations and anions	attraction between cations and delocalized electrons	attraction between positive nuclei and shared electrons
electrons transferred between atoms	electrons move freely in metallic lattice	electrons shared between atoms

5	CHM.5.2.01.001 Describe the different states of matter and its transformation according to the kinetic molecular theory while explaining the differences between them in terms of the forces between atoms, molecules, and ions	Textbook: reading check	280 – 281
	يصف الحالات المختلفة للمادة وتحولاتها بالإعتماد على نظرية الحركة الجزيئية، وموضحاً الفرق بينها من حيث القوى بين الذرات والجزيئات والأيونات	نص الكتاب: التحقق من فهم النص	

 **Reading Check** Explain why dispersion forces form.

Dispersion forces exist between all particles. Dispersion forces are weak for small particles, and these forces have an increasing effect as the number of electrons involved increases. Thus, dispersion forces tend to become stronger as the size of the particles increase. For example, fluorine, chlorine, bromine, and iodine exist as diatomic molecules. Recall that the number of nonvalence electrons increases from fluorine to chlorine to bromine to iodine. Because the larger halogen molecules have more electrons, there can be a greater difference between the positive and negative regions of their temporary dipoles and, thus, stronger dispersion forces. This difference in dispersion forces explains why fluorine and chlorine are gases, bromine is a liquid, and iodine is a solid at room temperature.

 **Reading Check** Infer the physical state of the element astatine at room temperature and explain your reasoning.

Dipole-dipole forces Polar molecules contain permanent dipoles; that is, some regions of a polar molecule are always partially negative and some regions of the molecule are always partially positive. These attractions between oppositely charged regions of polar molecules are called **dipole-dipole forces**. Neighboring polar molecules orient themselves so that oppositely charged regions align.

 **Reading Check** Compare dipole-dipole forces and dispersion forces.

Hydrogen bonds One special type of dipole-dipole attraction is called a hydrogen bond. A **hydrogen bond** is a dipole-dipole attraction that occurs between molecules containing a hydrogen atom bonded to a small, highly electronegative atom with at least one lone electron pair. Hydrogen bonds typically dominate both dispersion forces and dipole-dipole forces. For a hydrogen bond to form, hydrogen must be bonded to either a fluorine, oxygen, or nitrogen atom. These atoms are electronegative enough to cause a large partial positive charge on the hydrogen atom, yet small enough that their lone pairs of electrons can come close to hydrogen atoms. For example, in a water molecule, the hydrogen atoms have a large partial positive charge and the oxygen atom has a large partial negative charge. When water molecules approach, a hydrogen atom on one molecule is attracted to the lone pair of electrons on the oxygen atom on the other molecule, as shown in **Figure 12.11**.

Table 12.3	Properties of Three Molecular Compounds		
Compound	Molecular Structure	Molar Mass (g)	Boiling Point (°C)
Water (H ₂ O)		18.0	100
Methane (CH ₄)		16.0	-33.4
Ammonia (NH ₃)		17.0	-164

مطلوب في هذا الهدف
جميع ما طلبت في الهدف
رقم 5

Hydrogen bonds explain why water is a liquid at room temperature, while compounds of comparable mass are gases. Look at the data in **Table 12.3**. The difference between methane and water is easy to explain. Because methane molecules are nonpolar, the only forces holding the molecules together are relatively weak dispersion forces. The difference between ammonia and water is not as obvious. Molecules of both compounds can form hydrogen bonds. Yet, ammonia is a gas at room temperature, which indicates that the attractive forces between ammonia molecules are not as strong. Because oxygen atoms are more electronegative than nitrogen atoms, the O-H bonds in water are more polar than the N-H bonds in ammonia. As a result, the hydrogen bonds between water molecules are stronger than those between ammonia molecules.

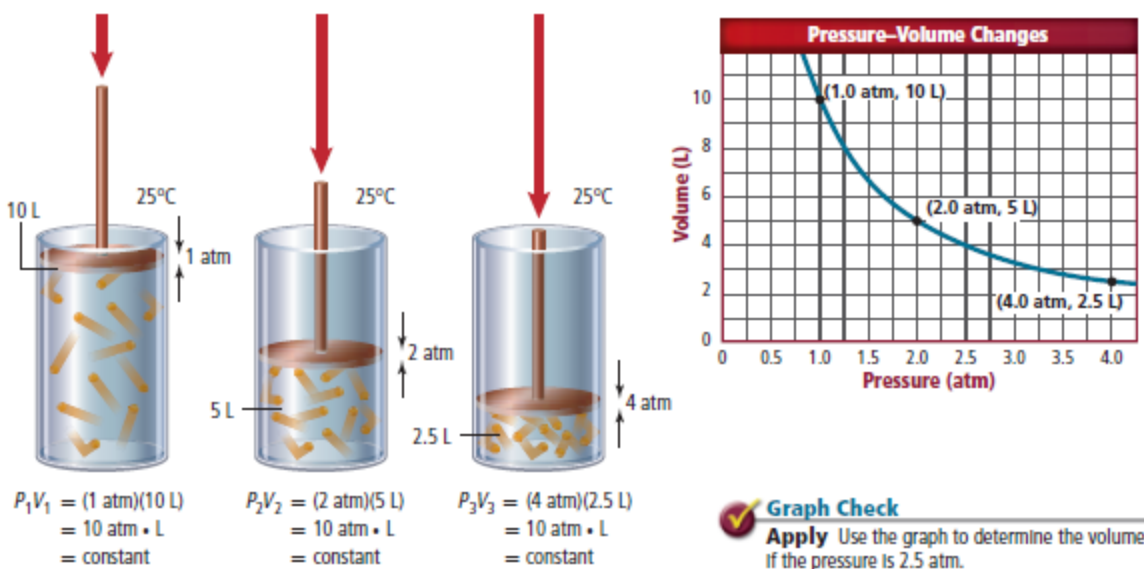
Boyle's law states that the volume of a fixed amount of gas held at a constant temperature varies inversely with the pressure.

Boyle's Law

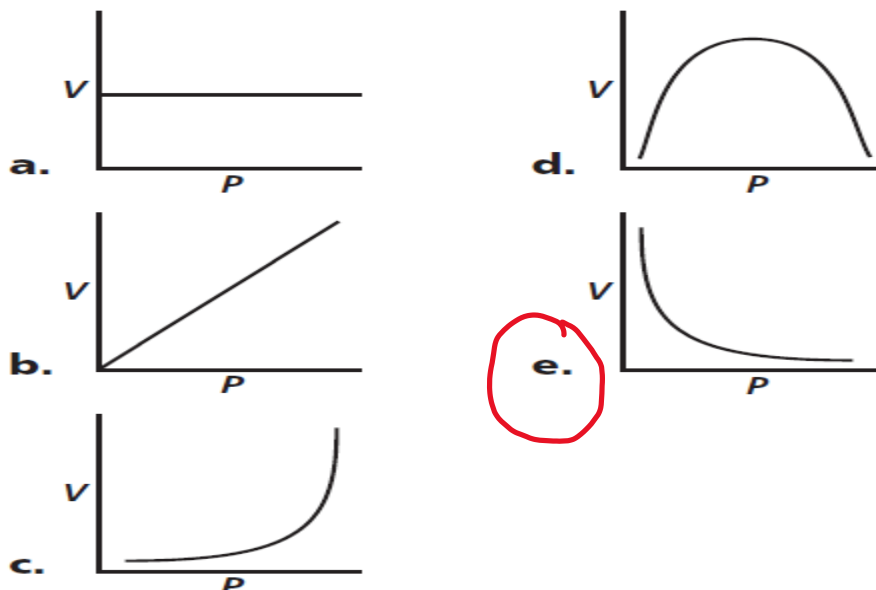
$$P_1 V_1 = P_2 V_2 \quad P \text{ represents pressure. } V \text{ represents volume.}$$

For a given amount of gas held at constant temperature, the product of pressure and volume is a constant.

Figure 13.1 As the external pressure on the cylinder's piston increases, the volume inside the cylinder decreases. The graph shows the inverse relationship between pressure and volume.



12. Which diagram shows the relationship between volume and pressure for a gas at constant temperature?



The Combined Gas Law

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

P represents pressure. V represents volume.
 T represents temperature.

For a given amount of gas, the product of pressure and volume, divided by the kelvin temperature, is a constant.

EXAMPLE Problem 13.4

The Combined Gas Law A gas at 110 kPa and 30.0°C fills a flexible container with an initial volume of 2.00 L. If the temperature is raised to 80.0°C and the pressure increases to 440 kPa, what is the new volume?

1 Analyze the Problem

Both pressure and temperature change, so you will need to use the combined gas law. The pressure quadruples, but the temperature does not increase by such a large factor. Therefore, the new volume will be smaller than the starting volume.

Known

$$\begin{aligned} P_1 &= 110 \text{ kPa} & P_2 &= 440 \text{ kPa} \\ T_1 &= 30.0^\circ\text{C} & T_2 &= 80.0^\circ\text{C} \\ V_1 &= 2.00 \text{ L} \end{aligned}$$

Unknown

$$V_2 = ? \text{ L}$$

2 Solve for the Unknown

Convert degrees Celsius to kelvins.

$$T_K = 273 + T_C$$

Apply the conversion factor.

$$T_1 = 273 + 30.0^\circ\text{C} = 303.0 \text{ K}$$

Substitute $T_1 = 30.0^\circ\text{C}$.

$$T_2 = 273 + 80.0^\circ\text{C} = 353.0 \text{ K}$$

Substitute $T_2 = 80.0^\circ\text{C}$.

Use the combined gas law. Solve for V_2 , and substitute the known values into the rearranged equation.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

State the combined gas law.

$$V_2 = V_1 \left(\frac{P_1}{P_2} \right) \left(\frac{T_2}{T_1} \right)$$

Solve for V_2 .

$$V_2 = 2.00 \text{ L} \left(\frac{110 \text{ kPa}}{440 \text{ kPa}} \right) \left(\frac{353.0 \text{ K}}{303.0 \text{ K}} \right)$$

Substitute $V_1 = 2.00 \text{ L}$, $P_1 = 110 \text{ kPa}$,
 $P_2 = 440 \text{ kPa}$, $T_2 = 353.0 \text{ K}$, and $T_1 = 303.0 \text{ K}$.

$$V_2 = 2.00 \text{ L} \left(\frac{110 \text{ kPa}}{440 \text{ kPa}} \right) \left(\frac{353.0 \text{ K}}{303.0 \text{ K}} \right) = 0.58 \text{ L}$$

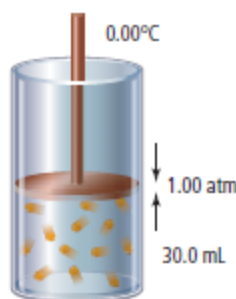
Multiply and divide numbers and units.

PRACTICE Problems

Extra Practice Page 984 and glencoe.com

Assume that the amount of gas is constant in the following problems.

11. A sample of air in a syringe exerts a pressure of 1.02 atm at 22.0°C. The syringe is placed in a boiling-water bath at 100.0°C. The pressure is increased to 1.23 atm by pushing the plunger in, which reduces the volume to 0.224 mL. What was the initial volume?
12. A balloon contains 146.0 mL of gas confined at a pressure of 1.30 atm and a temperature of 5.0°C. If the pressure doubles and the temperature decreases to 2.0°C, what will be the volume of gas in the balloon?
13. **Challenge** If the temperature in the gas cylinder at right increases to 30.0°C and the pressure increases to 1.20 atm, will the cylinder's piston move up or down?



Sol:-

$$T_1 = 22.0^\circ\text{C} + 273 = 295 \text{ K}$$

$$T_2 = 100.0^\circ\text{C} + 273 = 373 \text{ K}$$

11)

$$V_1 = \frac{V_2 T_1 P_2}{T_2 P_1} = \frac{(0.224 \text{ mL})(295 \text{ K})(1.23 \text{ atm})}{(373 \text{ K})(1.02 \text{ atm})}$$
$$= 0.214 \text{ mL}$$

12)

$$T_1 = 5.0^\circ\text{C} + 273 = 278 \text{ K}$$

$$T_2 = 2.0^\circ\text{C} + 273 = 275 \text{ K}$$

$$V_2 = \frac{P_1 T_2 V_1}{P_2 T_1} = \frac{(1.30 \text{ atm})(275 \text{ K})(146.0 \text{ mL})}{(2.60 \text{ atm})(278 \text{ K})}$$
$$= 72 \text{ mL}$$

13)

down

$$T_1 = 0.00^\circ\text{C} + 273 = 273 \text{ K}$$

$$T_2 = 30.0^\circ\text{C} + 273 = 303 \text{ K}$$

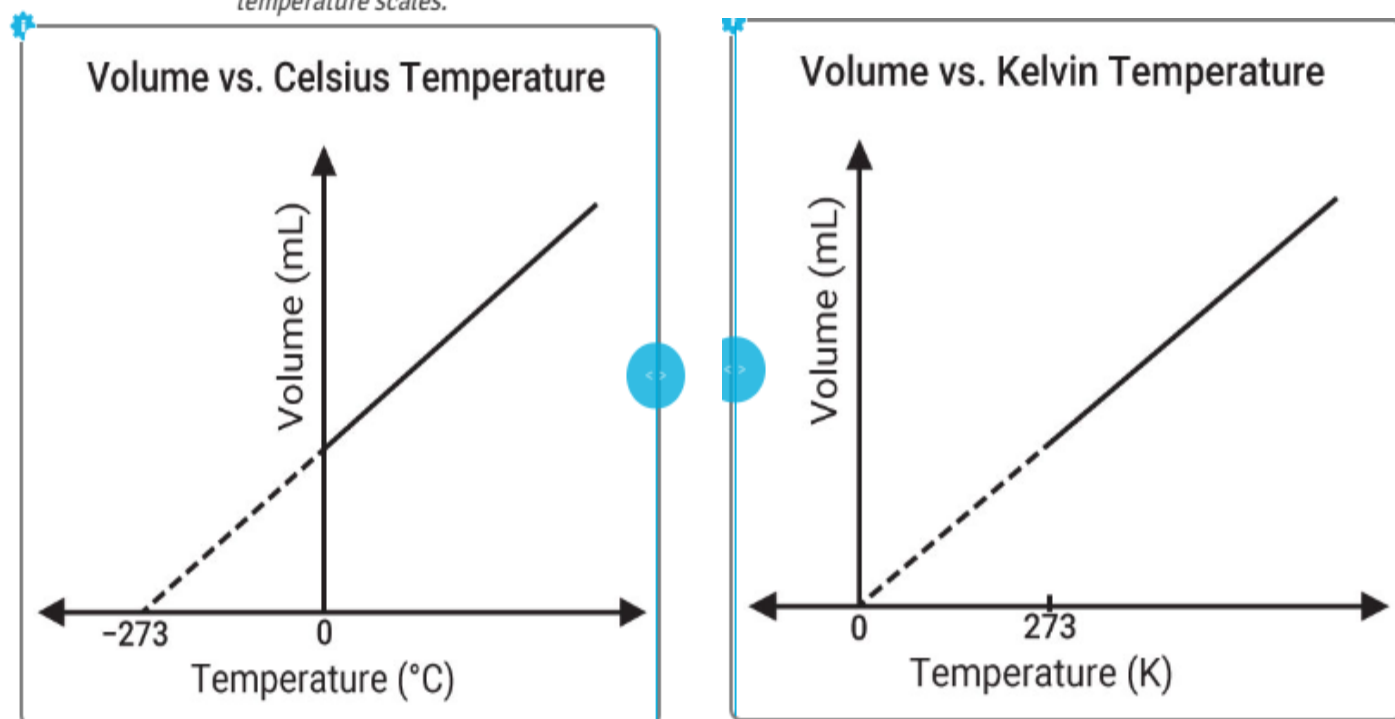
$$\frac{V_2}{V_1} = \frac{P_1 T_2}{P_2 T_1} = \frac{(1.00 \text{ atm})(303 \text{ K})}{(1.20 \text{ atm})(273 \text{ K})} = 0.92$$

This is a ratio, so there are no units. $0.92 < 1$, so V_2 must be less than V_1 . The final volume is less than the original volume, so the piston will move down.

9	CHM.5.2.01.004 Employ gas laws to describe the behaviour of gases and their practical applications, Define absolute zero	Textbook	312 - 313
	يوظف قوانين الغازات لفهم سلوك الغازات وتطبيقاتها العملية ويعرف الصفر المطلق	نص الكتاب	

volume. Zero on the Kelvin scale is also known as **absolute zero**. Absolute zero represents the lowest possible theoretical temperature. At absolute zero, the atoms are all in the lowest possible energy state.

Move the slider to compare volume-temperature graphs using the Celsius and Kelvin temperature scales.



10	CHM.5.2.01.004 Employ gas laws to describe the behaviour of gases and their practical applications, Use the mathematical formula of Gay-Lussac's law to calculate pressure-temperature changes at constant volume	textbook, example 3 & Applications	315 - 316
	يوظف قوانين الغازات لفهم سلوك الغازات وتطبيقاتها العملية، يوظف الصيغة الرياضية لقانون جاي لوساك لحساب تغيرات الضغط ودرجة الحرارة عند الحجم الثابت، يذكر قانون جاي لوساك ممثلاً بأنه من خلال رسم بياني ومن خلال معادلته الرياضية	نص الكتاب، مثال رقم 3 والتطبيقات	

Gay-Lussac's law states that the pressure of a fixed amount of gas varies directly with the kelvin temperature when the volume remains constant.

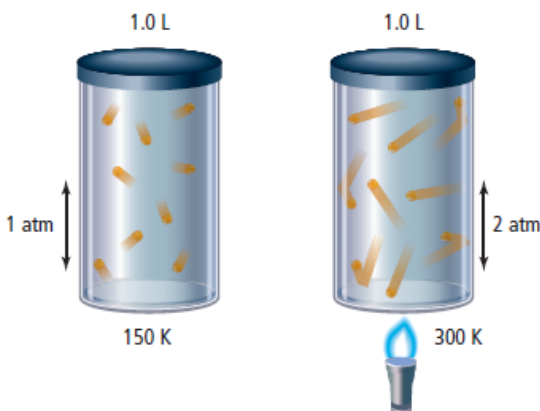
Gay-Lussac's Law

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

P represents pressure.
 T represents temperature.

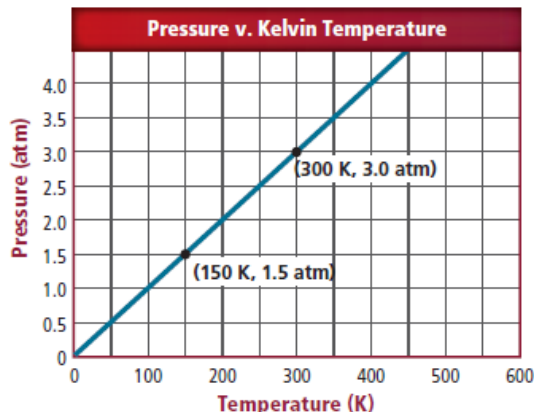
For a given amount of gas held at constant volume, the quotient of the pressure and the kelvin temperature is a constant.

Figure 13.3 When the cylinder is heated, the kinetic energy of the particles increases, increasing both the frequency and energy of the collisions with the container wall. The volume of the cylinder is fixed, so the pressure exerted by the gas increases.



$$\begin{aligned}\frac{P_1}{T_1} &= \frac{1.5 \text{ atm}}{150 \text{ K}} \\ &= 0.01 \text{ atm/K} \\ &= \text{constant}\end{aligned}$$

$$\begin{aligned}\frac{P_2}{T_2} &= \frac{3.0 \text{ atm}}{300 \text{ K}} \\ &= 0.01 \text{ atm/K} \\ &= \text{constant}\end{aligned}$$



Graph Check

Compare and contrast the graphs in Figures 13.2 and 13.3.

EXAMPLE Problem 13.3

Gay-Lussac's Law The pressure of the oxygen gas inside a canister is 5.00 atm at 25.0°C. The canister is located at a camp high on Mount Everest. If the temperature there falls to -10.0°C, what is the new pressure inside the canister?

1 Analyze the Problem

Gay-Lussac's law states that if the temperature of a gas decreases, so does its pressure when volume is constant. Therefore, the pressure in the oxygen canister will decrease. The initial pressure should be multiplied by a temperature ratio less than 1.

Known

$$\begin{aligned}P_1 &= 5.00 \text{ atm} \\ T_1 &= 25.0^\circ\text{C} \\ T_2 &= -10.0^\circ\text{C}\end{aligned}$$

Unknown

$$P_2 = ? \text{ atm}$$

2 Solve for the Unknown

Convert degrees Celsius to kelvins.

$$T_K = 273 + T_C$$

Apply the conversion factor.

$$T_1 = 273 + 25.0^\circ\text{C} = 298.0 \text{ K}$$

Substitute $T_1 = 25.0^\circ\text{C}$.

$$T_2 = 273 + (-10.0^\circ\text{C}) = 263.0 \text{ K}$$

Substitute $T_2 = -10.0^\circ\text{C}$.

Use Gay-Lussac's law. Solve for P_2 , and substitute the known values into the rearranged equation.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

State Gay-Lussac's law.

$$P_2 = P_1 \left(\frac{T_2}{T_1} \right)$$

Solve for P_2 .

$$P_2 = 5.00 \text{ atm} \left(\frac{263.0 \text{ K}}{298.0 \text{ K}} \right)$$

Substitute $P_1 = 5.00 \text{ atm}$, $T_1 = 298.0 \text{ K}$, and $T_2 = 263.0 \text{ K}$.

$$P_2 = 5.00 \text{ atm} \left(\frac{263.0 \text{ K}}{298.0 \text{ K}} \right) = 4.41 \text{ atm}$$

Multiply and divide numbers and units.

Assume that the volume and the amount of gas are constant in the following problems.

8. The pressure in an automobile tire is 1.88 atm at 25.0°C. What will be the pressure if the temperature increases to 37.0°C?
9. Helium gas in a 2.00-L cylinder is under 1.12 atm pressure. At 36.5°C, that same gas sample has a pressure of 2.56 atm. What was the initial temperature of the gas in the cylinder?
10. **Challenge** If a gas sample has a pressure of 30.7 kPa at 0.00°C, by how many degrees Celsius does the temperature have to increase to cause the pressure to double?

8)

$$T_1 = 25.0^\circ\text{C} + 273 = 298 \text{ K}$$

$$T_2 = 37.0^\circ\text{C} + 273 = 310 \text{ K}$$

$$P_2 = \frac{P_1 T_2}{T_1} = \frac{(1.88 \text{ atm})(310 \text{ K})}{298 \text{ K}} = 1.96 \text{ atm}$$

9)

$$T_2 = 36.5^\circ\text{C} + 273 = 309.5 \text{ K}$$

$$T_1 = \frac{T_2 P_1}{P_2} = \frac{(309.5 \text{ K})(1.12 \text{ atm})}{2.56 \text{ atm}} = 135 \text{ K}$$

$$135 \text{ K} - 273 = -138^\circ\text{C}$$

10)

$$T_1 = 0.00^\circ\text{C} + 273 = 273 \text{ K}$$

$$P_2 = (30.7 \text{ kPa})(2) = 61.4 \text{ kPa}$$

$$T_2 = \frac{T_1 P_2}{P_1} = \frac{(273 \text{ K})(61.4 \text{ kPa})}{30.7 \text{ kPa}} = 546 \text{ K}$$

$$546 \text{ K} - 273 = 273^\circ\text{C}$$

The temperature must increase by 273°C.

11	CHM.5.2.01.006 Explain Avogadro's hypothesis and its impact in understanding the chemical reactions of gases, State Avogadro's Law while representing its mathematical relation and graphical representation	Textbook	320
	يشرح فرضية أفوجادرو وأثرها في فهم التفاعلات الكيميائية للغازات ، يذكر قانون أفوجادرو ممثلاً اياه من خلال رسم بياني ومن خلال معادلته الرياضية	نص الكتاب	

posed this idea in 1811. **Avogadro's principle** states that equal volumes of gases at the same temperature and pressure contain equal numbers of particles. **Figure 13.5** shows equal volumes of carbon dioxide, helium, and oxygen.

Volume and moles Recall from Chapter 10 that 1 mol contains 6.02×10^{23} particles. The **molar volume** of a gas is the volume that 1 mol occupies at 0.00°C and 1.00 atm pressure. The conditions of 0.00°C and 1.00 atm are known as standard temperature and pressure (STP). Avogadro showed experimentally that 1 mol of any gas occupies a volume of 22.4 L at STP. Because the volume of 1 mol of a gas at STP is 22.4 L, you can use 22.4 L/mol as a conversion factor whenever a gas is at STP.

For example, suppose you want to find the number of moles in a sample of gas that has a volume of 3.72 L at STP. Use the molar volume to convert from volume to moles.

$$3.72 \text{ L} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.166 \text{ mol}$$

STP :-

$$P = 1 \text{ atm}$$

$$T = 0^\circ \text{C}$$

$$V = 22.4 \text{ L}$$

12	CHM.5.2.01.004.29 Use the ideal gas law to calculate pressure, volume, temperature, mass of a gas, when three quantities are given	example 5 & 6 and applications	321, 323
	يوظف قانون الغاز المثالي لحساب الضغط والحجم ودرجة الحرارة وكتلة الغاز عند إعطاء قيم ثلاث متغيرات	مثال 5 و 6 والتطبيقات	

EXAMPLE Problem 13.5

Molar Volume The main component of natural gas used for home heating and cooking is methane (CH_4). Calculate the volume that 2.00 kg of methane gas will occupy at STP.

1 Analyze the Problem

The number of moles can be calculated by dividing the mass of the sample, m , by its molar mass, M . The gas is at STP (0.00°C and 1.00 atm pressure), so you can use the molar volume to convert from the number of moles to the volume.

Known
 $m = 2.00 \text{ kg}$
 $T = 0.00^\circ \text{C}$
 $P = 1.00 \text{ atm}$

Unknown
 $V = ? \text{ L}$

2 Solve for the Unknown

Determine the molar mass for methane.

$$M = 1 \text{ C atom} \left(\frac{12.01 \text{ amu}}{1 \text{ C atom}} \right) + 4 \text{ H atoms} \left(\frac{1.01 \text{ amu}}{1 \text{ H atom}} \right)$$

$$= 12.01 \text{ amu} + 4.04 \text{ amu} = 16.05 \text{ amu}$$

$$= 16.05 \text{ g/mol}$$

Determine the molecular mass.

Express the molecular mass as g/mol to arrive at the molar mass.

Determine the number of moles of methane.

$$2.00 \text{ kg} \left(\frac{1000 \text{ g}}{1 \text{ kg}} \right) = 2.00 \times 10^3 \text{ g}$$

Convert the mass from kg to g.

$$\frac{m}{M} = \frac{2.00 \times 10^3 \text{ g}}{16.05 \text{ g/mol}} = 125 \text{ mol}$$

Divide mass by molar mass to determine the number of moles.

Use the molar volume to determine the volume of methane at STP.

$$V = 125 \text{ mol} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 2.80 \times 10^3 \text{ L}$$

Use the molar volume, 22.4 L/mol, to convert from moles to the volume.

حل آخر :-

$$n = \frac{m}{M}$$

$$= \frac{2 \times 10^3 \text{ g}}{16.05}$$

$$n = 125 \text{ mol}$$

② mol → Volume

$$125 \text{ mol} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 2.8 \times 10^3 \text{ L}$$

20. What size container do you need to hold 0.0459 mol of N_2 gas at STP?
21. How much carbon dioxide gas, in grams, is in a 1.0-L balloon at STP?
22. What volume in milliliters will 0.00922 g of H_2 gas occupy at STP?
23. What volume will 0.416 g of krypton gas occupy at STP?
24. Calculate the volume that 4.5 kg of ethylene gas (C_2H_4) will occupy at STP.
25. **Challenge** A flexible plastic container contains 0.860 g of helium gas in a volume of 19.2 L. If 0.205 g of helium is removed at constant pressure and temperature, what will be the new volume?

Sol:- 20)

20. What size container do you need to hold 0.0459 mol of N_2 gas at STP?

1.03 L

$$0.0459 \text{ mol} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 1.03 \text{ L}$$

21)

21. How much carbon dioxide gas, in grams, is in a 1.0-L balloon at STP?

2.0 g

$$1.0 \text{ L} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.045 \text{ mol}$$

$$0.045 \text{ mol} \times \frac{44.0 \text{ g}}{1 \text{ mol}} = 2.0 \text{ g}$$

22)

22. What volume in milliliters will 0.00922 g of H_2 gas occupy at STP?

102 mL

$$0.00922 \text{ g} \times \frac{1 \text{ mol}}{2.02 \text{ g}} = 0.00457 \text{ mol}$$

$$0.00457 \text{ mol} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 0.102 \text{ L or } 102 \text{ mL}$$

23. What volume will 0.416 g of krypton gas occupy at STP?

0.111 L

$$0.416 \text{ g} \times \frac{1 \text{ mol}}{83.80 \text{ g}} = 0.00496 \text{ mol}$$

$$0.00496 \text{ mol} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 0.111 \text{ L}$$

24. Calculate the volume that 4.5 kg of ethylene gas (C_2H_4) will occupy at STP.

$3.6 \times 10^3 \text{ L}$

$$4.5 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol}}{28.00 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 3.6 \times 10^3 \text{ L}$$

25. Challenge A flexible plastic container contains 0.860 g of helium gas in a volume of 19.2 L. If 0.205 g of helium is removed at constant pressure and temperature, what will be the new volume?

14.6 L

$$0.860 \text{ g} - 0.205 \text{ g} = 0.655 \text{ g He remaining}$$

Set up the problem as a ratio.

$$\frac{V}{0.655 \text{ g}} = \frac{19.2 \text{ L}}{0.860 \text{ g}}$$

Solve for V.

$$V = \frac{(19.2 \text{ L})(0.655 \text{ g})}{0.860 \text{ g}} = 14.6 \text{ L}$$

EXAMPLE Problem 13.6

The Ideal Gas Law Calculate the number of moles of ammonia gas (NH_3) contained in a 3.0-L vessel at $3.00 \times 10^2 \text{ K}$ with a pressure of 1.50 atm.

1 Analyze the Problem

You are given the volume, temperature, and pressure of a gas sample. Use the ideal gas law, and select the value of R that contains the pressure units given in the problem. Because the pressure and temperature are close to STP, but the volume is much smaller than 22.4 L, it would make sense if the calculated answer were much smaller than 1 mol.

Known

$$V = 3.0 \text{ L}$$

$$T = 3.00 \times 10^2 \text{ K}$$

$$P = 1.50 \text{ atm}$$

$$R = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

Unknown

$$n = ? \text{ mol}$$

Math Handbook

Significant Digits
page 949

2 Solve for the Unknown

Use the ideal gas law. Solve for n , and substitute the known values.

$$PV = nRT$$

$$n = \frac{PV}{RT}$$

$$n = \frac{(1.50 \text{ atm})(3.0 \text{ L})}{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(3.00 \times 10^2 \text{ K})}$$

$$n = \frac{(1.50 \text{ atm})(3.0 \text{ L})}{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(3.00 \times 10^2 \text{ K})} = 0.18 \text{ mol}$$

State the ideal gas law.

Solve for n .

Substitute $V = 3.0 \text{ L}$,
 $T = 3.00 \times 10^2 \text{ K}$,
 $P = 1.50 \text{ atm}$, and $R =$
 $0.0821 \text{ L} \cdot \text{atm} / \text{mol} \cdot \text{K}$.

Multiply and divide
numbers and units.

3 Evaluate the Answer

The answer agrees with the prediction that the number of moles present will be significantly less than 1 mol. The unit of the answer is the mole, and there are two significant figures.

PRACTICE Problems

Extra Practice Page 985 and glencoe.com

- Determine the Celsius temperature of 2.49 mol of a gas contained in a 1.00-L vessel at a pressure of 143 kPa.
- Calculate the volume of a 0.323-mol sample of a gas at 265 K and 0.900 atm.
- What is the pressure, in atmospheres, of a 0.108-mol sample of helium gas at a temperature of 20.0°C if its volume is 0.505 L?
- If the pressure exerted by a gas at 25°C in a volume of 0.044 L is 3.81 atm, how many moles of gas are present?
- Challenge** An ideal gas has a volume of 3.0 L. If the number of moles of gas and the temperature are doubled, while the pressure remains constant, what is the new volume?

- If the pressure exerted by a gas at 25°C in a volume of 0.044 L is 3.81 atm, how many moles of gas are present?

$$6.9 \times 10^{-3} \text{ mol}$$

$$n = \frac{PV}{RT} = \frac{(3.81 \text{ atm})(0.044 \text{ L})}{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(298 \text{ K})}$$

$$= 6.9 \times 10^{-3} \text{ mol}$$

- Determine the Celsius temperature of 2.49 mol of a gas contained in a 1.00-L vessel at a pressure of 143 kPa.

$$-266^\circ\text{C}$$

$$143 \text{ kPa} \times \frac{1.00 \text{ atm}}{101.3 \text{ kPa}} = 1.41 \text{ atm}$$

$$T = \frac{PV}{nR} = \frac{(1.41 \text{ atm})(1.00 \text{ L})}{(2.49 \text{ mol})(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})} = 6.90 \text{ K}$$

$$6.90 \text{ K} - 273 = -266^\circ\text{C}$$

- Calculate the volume of a 0.323-mol sample of a gas at 265 K and 0.900 atm.

$$7.81 \text{ L}$$

$$V = \frac{nRT}{P} = \frac{(0.323 \text{ mol})(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(265 \text{ K})}{0.900 \text{ atm}}$$

$$= 7.81 \text{ L}$$

- What is the pressure, in atmospheres, of a 0.108-mol sample of helium gas at a temperature of 20.0°C if its volume is 0.505 L?

$$5.14 \text{ atm}$$

$$T = 20.0^\circ\text{C} + 273 = 293 \text{ K}$$

$$P = \frac{nRT}{V} = \frac{(0.108 \text{ mol})(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(293 \text{ K})}{0.505 \text{ L}}$$

$$= 5.14 \text{ atm}$$

30. Challenge An ideal gas has a volume of 3.0 L. If the number of moles of gas and the temperature are doubled while the pressure remains constant, what is the new volume?

12 L

$$PV = nRT$$

$\frac{P}{R} = \frac{nT}{V}$ Because P and R are constants, they can be removed from the equation.

$$\frac{n_1T_1}{V_1} = \frac{n_2T_2}{V_2} \text{ where } n_2 = 2n_1 \text{ and } T_2 = 2T_1$$

$$\frac{n_1T_1}{V_1} = \frac{2n_12T_1}{V_2}$$

Multiply both sides by $\frac{1}{n_1}$ and $\frac{1}{T_1}$.

$$\frac{1}{V_1} = \frac{(2)(2)}{V_2}$$

$$V_2 = 4V_1$$

$$V_2 = 4(3.0 \text{ L}) = 12 \text{ L}$$

13	CHM.5.2.01.003 Define ideal gas , Describe the relationship between an ideal gas and the kinetic molecular theory (KMT), List the conditions for a gas to behave ideally, Describe a real gas	Textbook	325
	يعرّف الغاز المثالي، يصف العلاقة بين الغاز المثالي ونظرية الحركة الجزيئية (KMT)، يحدّد الشروط التي يجب توفّرها ليتصرّف الغاز بشكل مثالي، يصف الغاز الحقيقي	نص الكتاب	

Real Versus Ideal Gases

What does the term *ideal gas* mean? Ideal gases follow the assumptions of the kinetic-molecular theory, which you studied in Chapter 12. An ideal gas is one whose particles take up no space. Ideal gases experience no intermolecular attractive forces, nor are they attracted or repelled by the walls of their containers. The particles of an ideal gas are in constant, random motion, moving in straight lines until they collide with each other or with the walls of the container. Additionally, these collisions are perfectly elastic, which means that the kinetic energy of the system does not change. An ideal gas follows the gas laws under all conditions of temperature and pressure.

In reality, no gas is truly ideal. All gas particles have some volume, however small, and are subject to intermolecular interactions. Also, the collisions that particles make with each other and with the container are not perfectly elastic. Despite that, most gases will behave like ideal gases at a wide range of temperatures and pressures. Under the right conditions, calculations made using the ideal gas law closely approximate experimental measurements.

 **Reading Check** Explain the relationship between the kinetic-molecular theory and an ideal gas.

Click on the hotspots to distinguish between ideal and real gases

Ideal Gases	Real Gases
theoretical gases	real gases
obey all gas laws under all conditions	obey gas laws only at low pressure and high temperature
gas particles have negligible volume	gas particles have volume
no attractive intermolecular forces	weak attractive intermolecular forces
elastic collision between particles	non-elastic collisions between particles

1 Low Pressure

At relatively low pressures, the gas particles are so far apart that there is practically no attraction between the particles. They almost behave like the particles of an ideal gas.

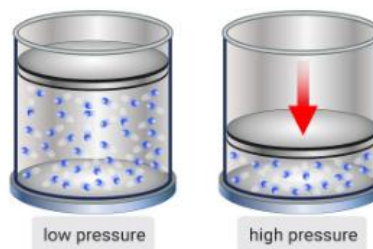
The gas particles move closer together at high pressures, which reduces the space between the particles.

The increase in the empty space at low pressure validates the assumption that the volume of the particles themselves is negligible.

2 High Temperature

3 Low Polarity

4 Small Particles



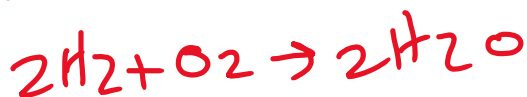
الشروط لسلوك الغاز مثالي
الغاز المثالي

14	CHM.5.2.01.006 Explain Avogadro's hypothesis and its impact in understanding the chemical reactions of gases, Identify what the coefficients in a balanced chemical equation specify	Textbook & (section main idea), section 3 study guide	328 & 335
	يشرح فرضية أفوجادرو وأثرها في فهم التفاعلات الكيميائية للغازات ، يشرح ماذا تمثل المعاملات في المعادلة الكيميائية الموزونة	نص الكتاب والفكرة الرئيسية للقسم و دليل الدراسة للقسم 3	

Gas Stoichiometry

MAIN Idea When gases react, the coefficients in the balanced chemical equation represent both molar amounts and relative volumes.

الفكرة ان المعاملات coefficients هي نفسها عدد المولات والحجم



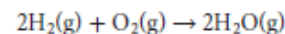
2 mol 1 mol 2 mol

2 Volume 1 volume 2 volume

Real-World Reading Link To make a cake, it is important to add the ingredients in the correct proportions. In a similar way, the correct proportions of reactants are needed in a chemical reaction to yield the desired products.

Stoichiometry of Reactions Involving Gases

The gas laws can be applied to calculate the stoichiometry of reactions in which gases are reactants or products. Recall that the coefficients in chemical equations represent molar amounts of substances taking part in the reaction. For example, hydrogen gas can react with oxygen gas to produce water vapor.



From the balanced chemical equation, you know that 2 mol of hydrogen gas reacts with 1 mol of oxygen gas, producing 2 mol of water vapor. This tells you the molar ratios of substances in this reaction. Avogadro's principle states that equal volumes of gases at the same temperature and pressure contain equal numbers of particles. Thus, for gases, the coefficients in a balanced chemical equation represent not only molar amounts but also relative volumes. Therefore, 2 L of hydrogen gas would react with 1 L of oxygen gas to produce 2 L of water vapor.

Stoichiometry and Volume-Volume Problems

To find the volume of a gaseous reactant or product in a reaction, you must know the balanced chemical equation for the reaction and the volume of at least one other gas involved in the reaction. Examine the reaction in **Figure 13.10**, which shows the combustion of methane. This reaction takes place every time you light a Bunsen burner.

Because the coefficients represent volume ratios for gases taking part in the reaction, you can determine that it takes 2 L of oxygen to react completely with 1 L of methane. The complete combustion of 1 L of methane will produce 1 L of carbon dioxide and 2 L of water vapor.



BIG Idea Gases respond in predictable ways to pressure, temperature, volume, and changes in number of particles.

Section 13.1 The Gas Laws

MAIN Idea For a fixed amount of gas, a change in one variable—pressure, temperature, or volume—affects the other two.

Vocabulary

- absolute zero (p. 445)
- Boyle's law (p. 442)
- Charles's law (p. 445)
- combined gas law (p. 449)
- Gay-Lussac's law (p. 447)

Key Concepts

- Boyle's law states that the volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.

$$P_1V_1 = P_2V_2$$

- Charles's law states that the volume of a fixed amount of gas is directly proportional to its kelvin temperature at constant pressure.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

- Gay-Lussac's law states that the pressure of a fixed amount of gas is directly proportional to its kelvin temperature at constant volume.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

- The combined gas law relates pressure, temperature, and volume in a single statement.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Section 13.2 The Ideal Gas Law

MAIN Idea The ideal gas law relates the number of particles to pressure, temperature, and volume.

Vocabulary

- Avogadro's principle (p. 452)
- Ideal gas constant (p. 454)
- Ideal gas law (R) (p. 454)
- molar volume (p. 452)

Key Concepts

- Avogadro's principle states that equal volumes of gases at the same pressure and temperature contain equal numbers of particles.
- The ideal gas law relates the amount of a gas present to its pressure, temperature, and volume.

$$PV = nRT$$

- The ideal gas law can be used to find molar mass if the mass of the gas is known, or the density of the gas if its molar mass is known.

$$M = \frac{mRT}{PV} \quad D = \frac{MP}{RT}$$

- At very high pressures and very low temperatures, real gases behave differently than ideal gases.

Section 13.3 Gas Stoichiometry

MAIN Idea When gases react, the coefficients in the balanced chemical equation represent both molar amounts and relative volumes.

Key Concepts

- The coefficients in a balanced chemical equation specify volume ratios for gaseous reactants and products.
- The gas laws can be used along with balanced chemical equations to calculate the amount of a gaseous reactant or product in a reaction.

Objectives

- **Determine** volume ratios for gaseous reactants and products by using coefficients from chemical equations.
- **Apply** gas laws to calculate amounts of gaseous reactants and products in a chemical reaction.

Review Vocabulary

coefficient: the number written in front of a reactant or product in a chemical equation, which tells the smallest number of particles of the substance involved in the reaction

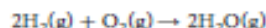
Gas Stoichiometry

MAIN Idea When gases react, the coefficients in the balanced chemical equation represent both molar amounts and relative volumes.

Real-World Reading Link To make a cake, it is important to add the ingredients in the correct proportions. In a similar way, the correct proportions of reactants are needed in a chemical reaction to yield the desired products.

Stoichiometry of Reactions Involving Gases

The gas laws can be applied to calculate the stoichiometry of reactions in which gases are reactants or products. Recall that the coefficients in chemical equations represent molar amounts of substances taking part in the reaction. For example, hydrogen gas can react with oxygen gas to produce water vapor.



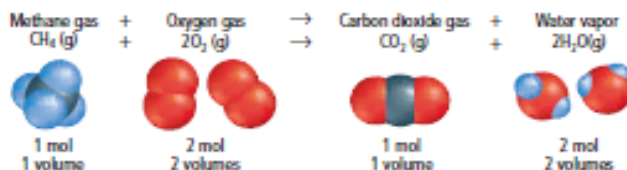
From the balanced chemical equation, you know that 2 mol of hydrogen gas reacts with 1 mol of oxygen gas, producing 2 mol of water vapor. This tells you the molar ratios of substances in this reaction. Avogadro's principle states that equal volumes of gases at the same temperature and pressure contain equal numbers of particles. Thus, for gases, the coefficients in a balanced chemical equation represent not only molar amounts but also relative volumes. Therefore, 2 L of hydrogen gas would react with 1 L of oxygen gas to produce 2 L of water vapor.

Stoichiometry and Volume-Volume Problems

To find the volume of a gaseous reactant or product in a reaction, you must know the balanced chemical equation for the reaction and the volume of at least one other gas involved in the reaction. Examine the reaction in **Figure 13.10**, which shows the combustion of methane. This reaction takes place every time you light a Bunsen burner.

Because the coefficients represent volume ratios for gases taking part in the reaction, you can determine that it takes 2 L of oxygen to react completely with 1 L of methane. The complete combustion of 1 L of methane will produce 1 L of carbon dioxide and 2 L of water vapor.

■ **Figure 13.10** The coefficients in a balanced equation show the relationships among numbers of moles of all reactants and products, and the relationships among volumes of any gaseous reactants or products. From these coefficients, volume ratios can be set up for any pair of gases in the reaction.



الفصل 13

EXAMPLE Problem 13.7

Volume-Volume Problems What volume of oxygen gas is needed for the complete combustion of 4.00 L of propane gas (C_3H_8)? Assume that pressure and temperature remain constant.

Math Handbook

Ratios
page 964

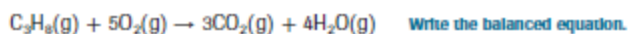
1 Analyze the Problem

You are given the volume of a gaseous reactant in a chemical reaction. Remember that the coefficients in a balanced chemical equation provide the volume relationships of gaseous reactants and products.

Known $V_{C_3H_8} = 4.00 \text{ L}$
Unknown $V_{O_2} = ? \text{ L}$

2 Solve for the Unknown

Use the balanced equation for the combustion of C_3H_8 . Find the volume ratio for O_2 and C_3H_8 , then solve for V_{O_2} .



$\frac{5 \text{ volumes } O_2}{1 \text{ volume } C_3H_8}$

Find the volume ratio for O_2 and C_3H_8 .

$$V_{O_2} = (4.00 \text{ L } C_3H_8) \times \frac{5 \text{ volumes } O_2}{1 \text{ volume } C_3H_8}$$

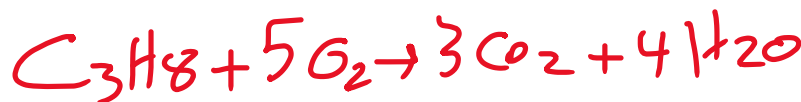
$$= 20.0 \text{ L } O_2$$

Multiply the known volume of C_3H_8 by the volume ratio to find the volume of O_2 .

3 Evaluate the Answer

The coefficients in the combustion equation show that a much larger volume of O_2 than C_3H_8 is used up in the reaction, which is in agreement with the calculated answer. The unit of the answer is liters, a unit of volume, and there are three significant figures.

حل آخر :-



1 L 5 L 3 L 4 L

4 L $\times \rightarrow V$

$$\frac{V \times 1}{4} = \frac{4 \times 5}{1} \Rightarrow V_{O_2} = 20 \text{ L}$$

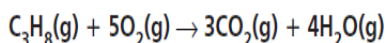
PRACTICE Problems

Extra Practice Page 985 and glencoe.com

38. How many liters of propane gas (C_3H_8) will undergo complete combustion with 34.0 L of oxygen gas?
39. Determine the volume of hydrogen gas needed to react completely with 5.00 L of oxygen gas to form water.
40. What volume of oxygen is needed to completely combust 2.36 L of methane gas (CH_4)?
41. **Challenge** Nitrogen and oxygen gases react to form dinitrogen oxide gas (N_2O). What volume of O_2 is needed to produce 34 L of N_2O ?

38. How many liters of propane gas (C_3H_8) will undergo complete combustion with 34.0 L of oxygen gas?

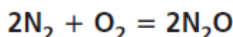
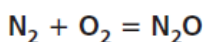
6.80 L C_3H_8



$$34.0 \text{ L } O_2 \times \frac{1 \text{ L } C_3H_8}{5 \text{ L } O_2} = 6.80 \text{ L } C_3H_8$$

41. **Challenge** Nitrogen and oxygen gases react to form dinitrogen monoxide gas (N_2O). What volume of O_2 is needed to produce 34 L of N_2O ?

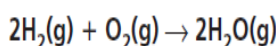
17 L O_2



$$34 \text{ L } N_2O \times \frac{1 \text{ L } O_2}{2 \text{ L } N_2O} = 17 \text{ L } O_2$$

39. Determine the volume of hydrogen gas needed to react completely with 5.00 L of oxygen gas to form water.

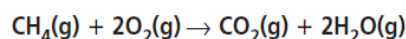
10.0 L H_2



$$5.00 \text{ L } O_2 \times \frac{2 \text{ L } H_2}{1 \text{ L } O_2} = 10.0 \text{ L } H_2$$

40. What volume of oxygen is needed to completely combust 2.36 L of methane gas (CH_4)?

4.72 L O_2



$$2.36 \text{ L } CH_4 \times \frac{2 \text{ L } O_2}{1 \text{ L } CH_4} = 4.72 \text{ L } O_2$$

Stoichiometry and Volume-Mass Problems

Connection to Biology What you have learned about stoichiometry can be applied to the production of ammonia (NH_3) from nitrogen gas (N_2). Fertilizer manufacturers use ammonia to make nitrogen-based fertilizers. Nitrogen is an essential element for plant growth. Natural sources of nitrogen in soil, such as nitrogen fixation by plants, the decomposition of organic matter, and animal wastes, do not always supply enough nitrogen for optimum crop yields. **Figure 13.11** shows a farmer applying fertilizer rich in nitrogen to the soil. This enables the farmer to produce a crop with a higher yield.

Example Problem 13.8 shows how to use a volume of nitrogen gas to produce a certain amount of ammonia. In doing this type of problem, remember that the balanced chemical equation allows you to find ratios for only moles and gas volumes, not for masses. All masses given must be converted to moles or volumes before being used as part of a ratio. Also, remember that the temperature units used must be kelvin.

EXAMPLE Problem 13.8

Volume-Mass Problems Ammonia is synthesized from hydrogen and nitrogen.

$$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$$

If 5.00 L of nitrogen reacts completely with hydrogen at a pressure of 3.00 atm and a temperature of 298 K, how much ammonia, in grams, is produced?

1 Analyze the Problem

You are given the volume, pressure, and temperature of a gas sample. The mole and volume ratios of gaseous reactants and products are given by the coefficients in the balanced chemical equation. Volume can be converted to moles and thus related to mass by using molar mass and the ideal gas law.

Known	Unknown
$V_{\text{N}_2} = 5.00 \text{ L}$	$m_{\text{NH}_3} = ? \text{ g}$
$P = 3.00 \text{ atm}$	
$T = 298 \text{ K}$	

2 Solve for the Unknown

Determine how many liters of gaseous ammonia will be made from 5.00 L of nitrogen gas.

$$\frac{1 \text{ volume N}_2}{2 \text{ volumes NH}_3}$$

Find the volume ratio for N_2 and NH_3 using the balanced equation.

$$5.00 \text{ L N}_2 \left(\frac{2 \text{ volumes NH}_3}{1 \text{ volume N}_2} \right) = 10.0 \text{ L NH}_3$$

Multiply the known volume of N_2 by the volume ratio to find the volume of NH_3 .

Use the ideal gas law. Solve for n , and calculate the number of moles of NH_3 .

$$PV = nRT$$

State the ideal gas law.

$$n = \frac{PV}{RT}$$

Solve for n .

$$n = \frac{(3.00 \text{ atm})(10.0 \text{ L})}{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(298 \text{ K})}$$

Substitute $V_{\text{N}_2} = 5.00 \text{ L}$, $P = 3.00 \text{ atm}$, and $T = 298 \text{ K}$.

$$n = \frac{(3.00 \text{ atm})(10.0 \text{ L})}{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(298 \text{ K})} = 1.23 \text{ mol NH}_3$$

Multiply and divide numbers and units.

$$M = \left(\frac{1 \text{ N atom} \times 14.01 \text{ amu}}{1 \text{ N atom}} \right) + \left(\frac{3 \text{ H atoms} \times 1.01 \text{ amu}}{1 \text{ H atom}} \right)$$

$$= 17.04 \text{ amu}$$

Find the molecular mass of NH_3 .

$$M = 17.04 \text{ g/mol}$$

Express molar mass in units of g/mol.

Convert moles of ammonia to grams of ammonia.

$$1.23 \text{ mol NH}_3 \times \frac{17.04 \text{ g NH}_3}{1 \text{ mol NH}_3} = 21.0 \text{ g NH}_3$$

Use the molar mass of ammonia as a conversion factor.

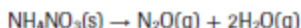
3 steps:-

① Volume $\rightarrow$ Volume
Known unknown

② $PV = nRT$

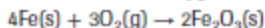
③ $n = \frac{m}{MM}$

42. Ammonium nitrate is a common ingredient in chemical fertilizers. Use the reaction shown to calculate the mass of solid ammonium nitrate that must be used to obtain 0.100 L of dinitrogen oxide gas at STP.



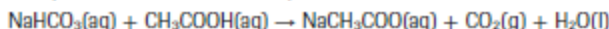
43. When solid calcium carbonate (CaCO_3) is heated, it decomposes to form solid calcium oxide (CaO) and carbon dioxide gas (CO_2). How many liters of carbon dioxide will be produced at STP if 2.38 kg of calcium carbonate reacts completely?

44. When iron rusts, it undergoes a reaction with oxygen to form iron(III) oxide.

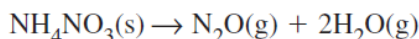


Calculate the volume of oxygen gas at STP that is required to completely react with 52.0 g of iron.

45. **Challenge** An excess of acetic acid is added to 28 g of sodium bicarbonate at 25°C and 1 atm pressure. During the reaction, the gas cools to 20°C. What volume of carbon dioxide will be produced? The balanced equation for the reaction is shown below.



42. Ammonium nitrate is a common ingredient in chemical fertilizers. Use the reaction shown to calculate the mass of solid ammonium nitrate that must be used to obtain 0.100 L of dinitrogen monoxide gas at STP.



$$0.357 \text{ g NH}_4\text{NO}_3$$

$$0.100 \text{ L N}_2\text{O} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.00446 \text{ mol N}_2\text{O}$$

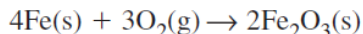
$$0.00446 \text{ mol N}_2\text{O} \times \frac{1 \text{ mol NH}_4\text{NO}_3}{1 \text{ mol N}_2\text{O}}$$

$$= 0.00446 \text{ mol NH}_4\text{NO}_3$$

$$0.00446 \text{ mol NH}_4\text{NO}_3 \times 80.03 \text{ g/mol}$$

$$= 0.357 \text{ g NH}_4\text{NO}_3$$

44. When iron rusts, it undergoes a reaction with oxygen to form iron(III) oxide.



Calculate the volume of oxygen gas at STP that is required to completely react with 52.0 g of iron.

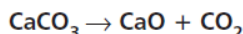
$$15.6 \text{ L O}_2$$

$$52.0 \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} \times \frac{3 \text{ mol O}_2}{4 \text{ mol Fe}} \times \frac{22.4 \text{ L}}{1 \text{ mol}}$$

$$= 15.6 \text{ L O}_2$$

43. When solid calcium carbonate (CaCO_3) is heated, it decomposes to form solid calcium oxide (CaO) and carbon dioxide gas (CO_2). How many liters of carbon dioxide will be produced at STP if 2.38 kg of calcium carbonate reacts completely?

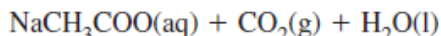
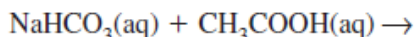
$$533 \text{ L CO}_2$$



$$2.38 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol CaCO}_3}{100.09 \text{ g}} \times$$

$$\frac{1 \text{ mol CO}_2}{1 \text{ mol CaCO}_3} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 533 \text{ L CO}_2$$

45. **Challenge** An excess of acetic acid is added to 28 g of sodium bicarbonate at 25°C and 1 atm pressure. During the reaction, the gas cools to 20°C. What volume of carbon dioxide will be produced? The balanced equation for the reaction is shown below.



$$7.9 \text{ L CO}_2$$

Molecular mass of sodium bicarbonate
= 83.9 g/mole

$$28 \text{ g NaHCO}_3 \times \frac{1 \text{ mol NaHCO}_3}{83.9 \text{ g}}$$

$$= 0.33 \text{ mol NaHCO}_3$$

For each mole of sodium bicarbonate, one mole of CO_2 is produced, so 0.33 mol NaHCO_3 will produce 0.33 mol CO_2 .

For an ideal gas, molar volume is 22.4 L at 273 K and 1 atm.

$$T = 20^\circ\text{C} + 273 = 293 \text{ K}$$

$$0.33 \text{ mol CO}_2 \times \frac{22.4 \text{ L}}{1 \text{ mol}} \times \frac{293 \text{ K}}{273 \text{ K}} = 7.9 \text{ L of CO}_2$$

17	CHM.5.2.02.007.05 Differentiate among different types of mixtures; solution, colloid and suspension in terms of type of mixture, separation upon standing, separation by filtration and Tyndall effect or scattering of light يُمَيِّزُ بَيْنَ الْأَنْوَاعِ الْمُخْتَلِفَةِ مِنَ الْمُخَالِيطِ: الْمُحَالِيلِ وَالْغُرُوبَاتِ وَالْمُعْلَقَاتِ مِنْ حَيْثُ نَوْعِ الْخَلِيطِ، وَالْفَصْلَ بِالتَّرْسِيبِ، وَالْفَصْلَ بِالتَّرْشِيعِ وَتَأْثِيرِ تَيَنْدَالٍ أَوْ نَشْتِ التَّضْوَاءِ	textbook & sec.1 review Q.5 - .8 نص الكتاب ومراجعة القسم 5 - 8	344 -347
----	--	---	----------

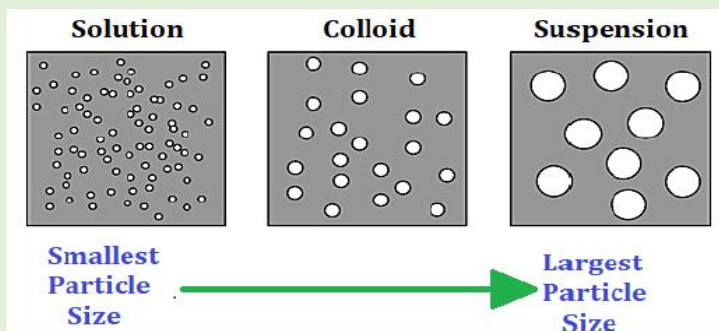
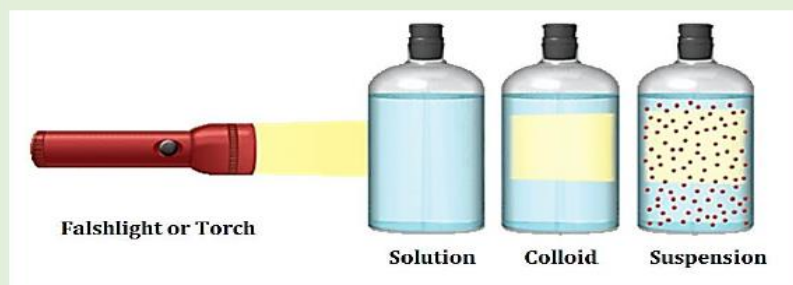
Inspire Chemistry – Module 13 – Lesson 1: Types of Mixtures (2 Periods)

3.3.1 Distinguish, using examples, between heterogeneous and homogenous mixtures

- Heterogeneous mixture: A mixture that does not have a uniform composition and in which the individual substances remain distinct
Examples: Milk, blood, smoke, and dust in air
- Homogenous mixture: A mixture that has a uniform composition throughout and always has a single phase.
Examples: Salt water, and sugar solution

3.3.5 Differentiate among different types of mixtures; solution, colloid, and suspension in terms of type of mixture, separation upon standing, separation by filtration and Tyndall effect or scattering of light

- Type of mixture:
Solution is homogenous, while colloid and suspension are heterogeneous
- Separation upon standing:
Solution and colloid do not separate upon standing while suspension does
- Separation by filtration:
Solution and colloid cannot be separated by filtration while suspension can
- Tyndall effect or scattering of light:
Solution does not scatter light, colloid scatters light while suspension may scatter light but is not transparent



Properties of Solutions, Colloids and Suspensions

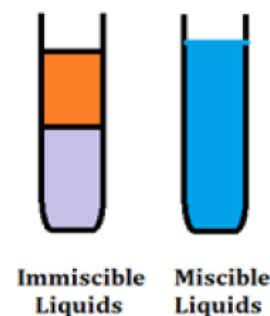
Property	System		
	Solution	Colloid	Suspension
Particle Type	Ions, atoms, and small molecules	Large molecules or particles	Large particles or aggregates
Particle Size	0.1 – 1 nm	1 – 1000 nm	1000 nm and larger
Effect of Light	No scattering	Exhibits Tyndall effect	Exhibits Tyndall effect
Effect of Gravity	Stable Does not separate	Stable Does not separate	Unstable Sediment forms
Filtration	Particles not retained on filter	Particles not retained on filter	Particles retained on filter
Uniformity	Homogenous	Heterogeneous	Heterogeneous

3.3.6 Distinguish, using examples, between miscible and immiscible liquids

- Miscible liquids: Two liquids that are soluble in each other in any proportion
- Immiscible liquids: Two liquids that can be mixed together but separate shortly after

Polar liquids include ethanol, water

Nonpolar liquids include gasoline, toluene, carbon tetrachloride

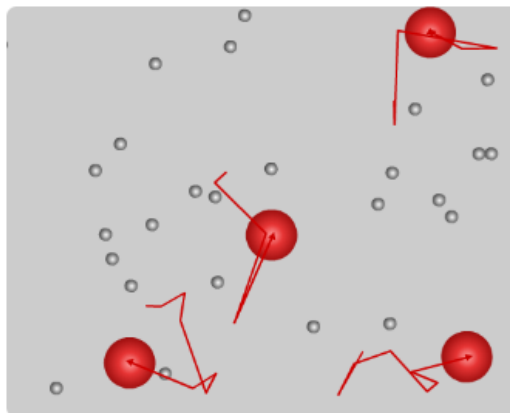


If you viewed the dispersed particles of a liquid colloid under a microscope, they would appear to move around in an irregular manner.

Define

Brownian motion is the erratic, random movement of solid dispersed particles caused by the collisions with particles of the **fluid** dispersion medium.

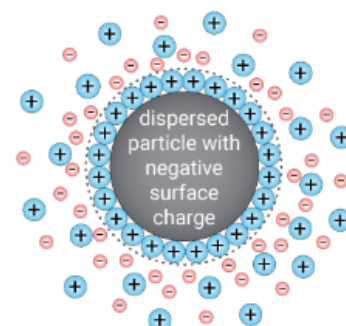
These collisions prevent the dispersed particles from settling out of the mixture.



Electrostatic Layering

The dispersed particles of a colloid usually have an electrical surface charge. These charged dispersed particles will attract oppositely-charged areas of the dispersion medium, forming charged layers around each particle. As dispersed particles move closer, the charged layers repel each other and prevent the dispersed particles from settling out.

When you stir in an electrolyte or heat the colloid, you interrupt this electrostatic layering and the forces between them, causing the dispersed particles to settle out of the mixture.



Suspension	Colloid
can be separated by filtration	cannot be separated by filtration
may scatter light	scatters light
particle sizes over 1,000 nm	particle sizes between 1–1,000 nm
separates out on standing	does not separate out on standing

3.3.2 Define solution

A solution is a homogenous mixture or a uniform mixture that contains solids, liquids, or gases

3.3.3 Define solute and solvent

Solute: One or more substances dissolved in a solution

Solvent: The substance that dissolves in a solute to form a solution, the most plentiful substance in the solution

Table 14.2

Types and Examples of Solutions

Interactive Table Explore the gas laws at glencoe.com.

Type of Solution	Example	Solvent	Solute
Gas	air	nitrogen (gas)	oxygen (gas)
Liquid	carbonated water	water (liquid)	carbon dioxide (gas)
	ocean water	water (liquid)	oxygen gas (gas)
	antifreeze	water (liquid)	ethylene glycol (liquid)
	vinegar	water (liquid)	acetic acid (liquid)
	ocean water	water (liquid)	sodium chloride (solid)
Solid	dental amalgam	silver (solid)	mercury (liquid)
	steel	Iron (solid)	carbon (solid)

The state of a solution depends on the state of the solvent.



Soluble

A substance (solute) is **soluble** when it readily dissolves in a solvent to form a solution.

Insoluble

A substance is **insoluble** when it does not dissolve in a solvent.

Section 14.1 Assessment

Section Summary

- The individual substances in a heterogeneous mixture remain distinct.
- Two types of heterogeneous mixtures are suspensions and colloids.
- Brownian motion is the erratic movement of colloid particles.
- Colloids exhibit the Tyndall effect.
- A solution can exist as a gas, a liquid, or a solid, depending on the solvent.
- Solutes in a solution can be gases, liquids, or solids.

- MAIN Idea Explain** Use the properties of seawater to describe the characteristics of mixtures.
- Distinguish** between suspensions and colloids.
- Identify** the various types of solutions. Describe the characteristics of each type of solution.
- Explain** Use the Tyndall effect to explain why it is more difficult to drive through fog using high beams than using low beams.
- Describe** different types of colloids.
- Explain** Why do dispersed colloid particles stay dispersed?
- Summarize** What causes Brownian motion?
- Compare and Contrast** Make a table that compares the properties of suspensions, colloids, and solutions.

م ص ح و ا
الامثلة

18

CHM.5.2.02.007.04 Identify, using examples, the various types of solutions (liquid, solid or gas) and the solute and solvent in its six types

table 2

347

يحدد، مستخدماً الأمثلة، الأنواع المختلفة من المحاليل (سائلة أو صلبة أو غازية) مبيّناً المذاب والمذيب في أنواعها الستة

جدول 2

Table 2 Types and Examples of Solutions

Type of Solution	Example	Solvent	Solute
Gas	air	nitrogen (gas)	oxygen (gas)
Liquid	carbonated water	water (liquid)	carbon dioxide (gas)
Liquid	ocean water	water (liquid)	oxygen gas (gas)
Liquid	antifreeze	water (liquid)	ethylene glycol (liquid)
Liquid	vinegar	water (liquid)	acetic acid (liquid)
Liquid	ocean water	water (liquid)	sodium chloride (solid)
Solid	dental amalgam	silver (solid)	mercury (liquid)
Solid	steel	iron (solid)	carbon (solid)

The state of a solution depends on the state of the solvent.

م ص ح و ا الجدول .
بم نوع المحلول يعتمد على نوع المذيب .

Just as solutions can exist in different forms, the solutes in the solutions can be gases, liquids, or solids, also shown in **Table 14.2**. Solutions, such as ocean water, can contain more than one solute.

Forming solutions Some combinations of substances readily form solutions, and others do not. A substance that dissolves in a solvent is said to be **soluble** in that solvent. For example, sugar is soluble in water—a fact you might have learned by dissolving sugar in flavored water to make a sweetened beverage, such as tea or lemonade. Two liquids that are soluble in each other in any proportion, such as those that form the antifreeze listed in **Table 14.2**, are said to be **miscible**. A substance that does not dissolve in a solvent is said to be **insoluble** in that solvent. Sand is insoluble in water. The liquids in a bottle of oil and vinegar separate shortly after they are mixed. Oil is insoluble in vinegar. Two liquids that can be mixed together but separate shortly after are said to be **immiscible**.

Miscible

قابلة للامتزاج ⇒

Two or more liquids are miscible if they are soluble in each other and mix together.

Example

Ethanol (colored red) and water are soluble in each other. The two liquids mix and will not separate on standing.



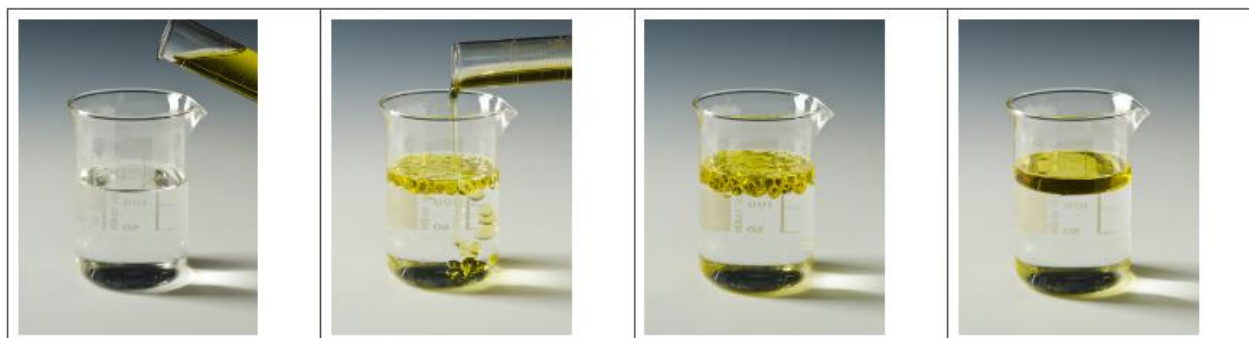
⇐ غير قابلة للامتزاج

Immiscible

Two or more liquids are immiscible if they are insoluble and do not mix. When mixed, the liquids will separate into layers on standing.

Example

Oil and water are insoluble in each other. If shaken up, the liquids mix temporarily but separate into two distinct layers on standing.





Sand is **insoluble** in water.

Oil and water are **immiscible**.

Salt is **soluble** in water. Salt is the **solute**, and water the **solvent**.

20	CHM.5.2.03.002 Define concentration, mass percent, percent by volume, molarity, dilution, concentration, molality and mole fraction. يحل المسائل المرتبطة بتركيز المحاليل من خلال إجراء الحسابات التي تتضمن المولات، ويعبر عن النتائج مستخدماً الوحدات المختلفة مثل مولالية ومولارية وجزءاً لكل مليون والتركيز المولي الكتلي والتركيز المولي الحجمي	Textbook	348
		نص الكتاب	

Expressing Concentration

The **concentration** of a solution is a measure of how much solute is dissolved in a specific amount of solvent or solution. Concentration can be described qualitatively using the words *concentrated* or *dilute*. Notice the pots of tea in **Figure 14.4**. One of the tea solutions is more concentrated than the other. In general, a concentrated solution contains a large amount of solute. The darker tea has more tea particles than the lighter tea. Conversely, a dilute solution contains a small amount of solute. The lighter tea in **Figure 14.4** is dilute and contains less tea particles than the darker tea.

Although qualitative descriptions of concentration can be useful, solutions are more often described quantitatively. Some commonly used quantitative descriptions are percent by mass, percent by volume, molarity, and molality. These descriptions express concentration as a ratio of measured amounts of solute and solvent or solution. **Table 14.3** lists each ratio's description.

Which qualitative description should be used? The description used depends on the type of solution analyzed and the reason for describing it. For example, a chemist working with a reaction in an aqueous solution most likely refers to the molarity of the solution, because he or she need to know the number of particles involved in the reaction.

Figure 14.4 The strength of the tea corresponds to its concentration. The darker pot of tea is more concentrated than the lighter pot.



Table 14.3 Concentration Ratios	
Concentration Description	Ratio
Percent by mass	$\frac{\text{mass of solute}}{\text{mass of solution}} \times 100$
Percent by volume	$\frac{\text{volume of solute}}{\text{volume of solution}} \times 100$
Molarity	$\frac{\text{moles of solute}}{\text{liter of solution}}$
Molality	$\frac{\text{moles of solute}}{\text{kilogram of solvent}}$
Mole fraction	$\frac{\text{moles of solute}}{\text{moles of solute} + \text{moles of solvent}}$

مع التعريف

العوائق والتبقيع
مع

EXAMPLE Problem 14.2

Calculating Molarity A 100.5-mL intravenous (IV) solution contains 5.10 g of glucose ($C_6H_{12}O_6$). What is the molarity of this solution? The molar mass of glucose is 180.16 g/mol.

1 Analyze the Problem

You are given the mass of glucose dissolved in a volume of water. The molarity of the solution is the ratio of moles of solute per liter of solution.

Known

mass of solute = 5.10 g $C_6H_{12}O_6$
molar mass of $C_6H_{12}O_6$ = 180.16 g/mol
volume of solution = 100.5 mL

Unknown

solution concentration = ? M

2 Solve for the Unknown

Calculate the number of moles of $C_6H_{12}O_6$.

$$(5.10 \text{ g } C_6H_{12}O_6) \left(\frac{1 \text{ mol } C_6H_{12}O_6}{180.16 \text{ g } C_6H_{12}O_6} \right) \\ = 0.0283 \text{ mol } C_6H_{12}O_6$$

Multiply grams of $C_6H_{12}O_6$ by the molar mass of $C_6H_{12}O_6$.

Convert the volume of H_2O to liters.

$$(100.5 \text{ mL solution}) \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) = 0.1005 \text{ L solution}$$

Use the conversion factor 1 L/1000 mL.

Solve for the molarity.

$$M = \frac{\text{moles of solute}}{\text{liters of solution}} \quad \text{State the molarity equation.}$$

$$M = \left(\frac{0.0283 \text{ mol } C_6H_{12}O_6}{0.1005 \text{ L solution}} \right) \quad \text{Substitute moles of } C_6H_{12}O_6 = 0.0283 \text{ and volume of solution = liters of solution = 0.1005 L.}$$

$$M = \left(\frac{0.0282 \text{ mol } C_6H_{12}O_6}{1 \text{ L solution}} \right) = 0.282M \quad \text{Divide numbers and units.}$$

Math Handbook

Solving Algebraic Equations
page 954

PRACTICE Problems

Extra Practice Pages 985–986 and glencoe.com

- What is the molarity of an aqueous solution containing 40.0 g of glucose ($C_6H_{12}O_6$) in 1.5 L of solution?
- Calculate the molarity of 1.60 L of a solution containing 1.55 g of dissolved KBr.
- What is the molarity of a bleach solution containing 9.5 g of NaOCl per liter of bleach?
- Challenge** How much calcium hydroxide ($Ca(OH)_2$), in grams, is needed to produce 1.5 L of a 0.25M solution?

- What is the molarity of an aqueous solution containing 40.0 g of glucose ($C_6H_{12}O_6$) in 1.5 L of solution?

$$\text{mol } C_6H_{12}O_6 = 40.0 \text{ g} \times \frac{1 \text{ mol}}{180.16 \text{ g}} = 0.222 \text{ mol}$$

$$\text{molarity} = \frac{\text{mol } C_6H_{12}O_6}{1.5 \text{ L solution}} = \frac{0.222 \text{ mol}}{1.5 \text{ L}} = 0.15M$$

- Calculate the molarity of 1.60 L of a solution containing 1.55 g of dissolved KBr.

$$\text{mol KBr} = 1.55 \text{ g} \times \frac{1 \text{ mol}}{119.0 \text{ g}} = 0.0130 \text{ mol KBr}$$

$$\text{molarity} = \frac{\text{mol KBr}}{1.60 \text{ L solution}} = \frac{0.0130 \text{ mol}}{1.60 \text{ L}} \\ = 8.13 \times 10^{-3}M$$

- What is the molarity of a bleach solution containing 9.5 g of NaOCl per liter of bleach?

$$\text{mol NaOCl} = 9.5 \text{ g} \times \frac{1 \text{ mol}}{74.44 \text{ g}} = 0.13 \text{ mol}$$

$$\text{molarity} = \frac{\text{mol NaOCl}}{1.00 \text{ L solution}} = \frac{0.128 \text{ mol}}{1.00 \text{ L}} \\ = 0.13M$$

- Challenge** How much calcium hydroxide ($Ca(OH)_2$), in grams, is needed to produce 1.5 L of a 0.25M solution?

$$0.25M = \frac{x \text{ mol } Ca(OH)_2}{1.5 \text{ L solution}}$$

$$x = 0.38 \text{ mol } Ca(OH)_2$$

$$0.38 \text{ mol } Ca(OH)_2 \times \frac{74.08 \text{ g}}{\text{mol}} = 28 \text{ g } Ca(OH)_2$$

20. How many grams of CaCl_2 would be dissolved in 1.0 L of a 0.10M solution of CaCl_2 ?
21. How many grams of CaCl_2 should be dissolved in 500.0 mL of water to make a 0.20M solution of CaCl_2 ?
22. How much NaOH are in 250 mL of a 3.0M NaOH solution?
23. **Challenge** What volume of ethanol ($\text{C}_2\text{H}_5\text{OH}$) is in 100.0 mL of 0.15M solution? The density of ethanol is 0.7893 g/mL.

$$\text{5d: } \textcircled{1} M = \frac{n}{V(L)}$$

$$\textcircled{2} n = \frac{m}{MM}$$

23. **Challenge** What volume of ethanol ($\text{C}_2\text{H}_5\text{OH}$) is in 100.0 mL of 0.15M solution? The density of ethanol is 0.7893 g/mL.

$$100. \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.15 \text{ mol-ethanol}}{1 \text{ L solution}} \times \frac{46 \text{ g ethanol}}{1 \text{ mol-ethanol}} \times \frac{1 \text{ mL ethanol}}{0.7893 \text{ g ethanol}} = 0.87 \text{ mL}$$

Dilution Equation

$$M_1 V_1 = M_2 V_2$$

M represents molarity.

V represents volume.

For a given amount of solute, the product of the molarity and volume of the stock solution equals the product of the molarity and the volume of the dilute solution.

20. How many grams of CaCl_2 would be dissolved in 1.0 L of a 0.10M solution of CaCl_2 ?

$$\text{mol CaCl}_2 = (0.10M)(1.0 \text{ L}) = (0.10 \text{ mol/L})(1.0 \text{ L}) = 0.10 \text{ mol CaCl}_2$$

$$\text{mass CaCl}_2 = 0.10 \text{ mol CaCl}_2 \times \frac{110.98 \text{ g}}{1 \text{ mol}}$$

$$\text{mass of CaCl}_2 = 11 \text{ g}$$

21. How many grams of CaCl_2 should be dissolved in 500.0 mL of water to make a 0.20M solution of CaCl_2 ?

$$\text{mol CaCl}_2 = 500.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times 0.20M = 0.10 \text{ mol}$$

$$\text{mass CaCl}_2 = 0.10 \text{ mol CaCl}_2 \times \frac{110.98 \text{ g}}{1 \text{ mol}}$$

$$\text{mass of CaCl}_2 = 11 \text{ g}$$

22. How many grams of NaOH are in 250 mL of a 3.0M NaOH solution?

$$\text{mol NaOH} = 250 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times 3.0M$$

$$= 250 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{3.0 \text{ mol}}{1 \text{ L}} = 0.75 \text{ mol}$$

$$\text{mass NaOH} = 0.75 \text{ mol NaOH} \times \frac{40.00 \text{ g}}{1 \text{ mol}}$$

$$\text{mass of NaOH} = 3.0 \times 10^1 \text{ g}$$

EXAMPLE Problem 14.3

Diluting Stock Solutions If you want to know the concentration and volume of the solution you want to prepare, you can calculate the volume of stock solution you will need. What volume, in milliliters, of 2.00M calcium chloride (CaCl_2) stock solution would you use to make 0.50 L of 0.300M calcium chloride solution?

1 Analyze the Problem

You are given the molarity of a stock solution of CaCl_2 and the volume and molarity of a dilute solution of CaCl_2 . Use the relationship between molarities and volumes to find the volume, in liters, of the stock solution required. Then, convert the volume to milliliters.

Known

$$M_1 = 2.00M \text{ CaCl}_2$$

$$M_2 = 0.300M$$

$$V_2 = 0.50 \text{ L}$$

Unknown

$$V_1 = ? \text{ mL } 2.00M \text{ CaCl}_2$$

Math Handbook

Solving Algebraic Equations
page 954

2 Solve for the Unknown

Solve the molarity-volume relationship for the volume of the stock solution V_1 .

$$M_1 V_1 = M_2 V_2$$

State the dilution equation.

$$V_1 = V_2 \left(\frac{M_2}{M_1} \right)$$

Solve for V_1 .

$$V_1 = (0.50 \text{ L}) \left(\frac{0.300M}{2.00M} \right)$$

Substitute $M_1 = 2.00M$, $M_2 = 0.300M$, and $V_2 = 0.50 \text{ L}$.

$$V_1 = (0.50 \text{ L}) \left(\frac{0.300M}{2.00M} \right) = 0.075 \text{ L}$$

Multiply and divide numbers and units.

$$V_1 = (0.075 \text{ L}) \left(\frac{1000 \text{ mL}}{1 \text{ L}} \right) = 75 \text{ mL}$$

Convert to milliliters using the conversion factor 1000 mL/1 L.

To make the dilution, measure out 75 mL of the stock solution and dilute it with enough water to make the final volume 0.50 L.

24. What volume of a $3.00M$ KI stock solution would you use to make 0.300 L of a $1.25M$ KI solution?
25. How many milliliters of a $5.0M$ H_2SO_4 stock solution would you need to prepare 100.0 mL of $0.25M$ H_2SO_4 ?
26. **Challenge** If 0.5 L of $5M$ stock solution of HCl is diluted to make 2 L of solution, how much HCl, in grams, was in the solution?

24. What volume of a $3.00M$ KI stock solution would you use to make 0.300 L of a $1.25M$ KI solution?

$$(3.00M)V_1 = (1.25M)(0.300\text{ L})$$

$$V_1 = \frac{(1.25M)(0.300\text{ L})}{3.00M} = 0.125\text{ L} = 125\text{ mL}$$

25. How many milliliters of a $5.0M$ H_2SO_4 stock solution would you need to prepare 100.0 mL of $0.25M$ H_2SO_4 ?

$$(5.0M)V_1 = (0.25M)(100.0\text{ mL})$$

$$V_1 = \frac{(0.25M)(100.0\text{ mL})}{5.0M} = 5.0\text{ mL}$$

26. **Challenge** If 0.5 L of $5M$ stock solution of HCl is diluted to make 2 L of solution, how much HCl, in grams, was in the solution?

$$\text{mol HCl} = 5M \times 0.5\text{ L} = 2.5\text{ mol HCl}$$

$$\text{mass of HCl} = \frac{36.45\text{ g HCl}}{1\text{ mol}} \times 2.5\text{ mol}$$

$$\text{mass of HCl} = 91.15\text{ g}$$

Molality

$$\text{molality } (m) = \frac{\text{moles of solute}}{\text{kg of solvent}}$$

The molality of a solution equals the number of moles of solute divided by kg of solvent.

EXAMPLE Problem 14.4

Calculating Molality In the lab, a student adds 4.5 g of sodium chloride (NaCl) to 100.0 g of water. Calculate the molality of the solution.

1 Analyze the Problem

You are given the mass of solute and solvent. Determine the number of moles of solute. Then, you can calculate the molality.

Known

mass of water (H_2O) = 100.0 g

mass of sodium chloride (NaCl) = 4.5 g

Unknown

$m = ?$ mol/kg

2 Solve for the Unknown

$$4.5\text{ g NaCl} \times \frac{1\text{ mol NaCl}}{58.44\text{ g NaCl}} = 0.077\text{ mol NaCl}$$

Calculate the number of moles of solute.

$$100.0\text{ g } H_2O \times \frac{1\text{ kg } H_2O}{1000\text{ g } H_2O} = 0.1000\text{ kg } H_2O$$

Convert the mass of H_2O from grams to kilograms using the factor $1\text{ kg}/1000\text{ g}$.

Substitute the known values into the expression for molality, and solve.

$$m = \frac{\text{moles of solute}}{\text{kilograms of solvent}}$$

Write the equation for molality.

$$m = \frac{0.077\text{ mol NaCl}}{0.1000\text{ kg } H_2O} = 0.77\text{ mol/kg}$$

Substitute moles of solute = 0.077 mol NaCl, kilograms of solvent = 0.1000 kg H_2O .

Math Handbook

Solving Algebraic
Equations
page 954

27. What is the molality of a solution containing 10.0 g of Na_2SO_4 dissolved in 1000.0 g of water?
28. **Challenge** How much $(\text{Ba}(\text{OH})_2)$, in grams, is needed to make a 1.00*m* aqueous solution?

27. What is the molality of a solution containing 10.0 g Na_2SO_4 dissolved in 1000.0 g of water?

$$\text{mol Na}_2\text{SO}_4 = 10.0 \text{ g Na}_2\text{SO}_4 \times \frac{1 \text{ mol}}{142.04 \text{ g}} \\ = 0.0704 \text{ mol Na}_2\text{SO}_4$$

$$\text{molality} = \frac{0.0704 \text{ mol Na}_2\text{SO}_4}{1.0000 \text{ kg H}_2\text{O}} = 0.0704 \text{ m}$$

28. **Challenge** How much $(\text{Ba}(\text{OH})_2)$, in grams, is needed to make a 1.00*m* aqueous solution?

$$\text{mol Ba}(\text{OH})_2 = \frac{1 \text{ mol}}{1 \text{ kg solvent}}$$

$$\text{molar mass of Ba}(\text{OH})_2 = \frac{171 \text{ g Ba}(\text{OH})_2}{1 \text{ mol}}$$

$$\text{mass of Ba}(\text{OH})_2 = 171 \text{ g}$$

22

CHM.5.2.03.002 Define concentration, mass percent, percent by volume, molarity, dilution, concentration, molality and mole fraction.

Textbook

355

يعرف التركيز، المولارية، المولالية، النسبة المئوية بالحجم، بالكتلة، التخفيف، الكسر المولي

نص الكتاب

Percent by mass The percent by mass is the ratio of the solute's mass to the solution's mass expressed as a percent. The mass of the solution equals the sum of the masses of the solute and the solvent.

Percent by Mass

$$\text{percent by mass} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$$

Percent by mass equals the mass of the solute divided by the mass of the whole solution, multiplied by 100.

Percent by volume Percent by volume usually describes solutions in which both solute and solvent are liquids. The percent by volume is the ratio of the volume of the solute to the volume of the solution, expressed as a percent. The volume of the solution is the sum of the volumes of the solute and the solvent. Calculations of percent by volume are similar to those involving percent by mass.

Percent by Volume

$$\text{percent by volume} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100$$

Percent by volume equals the volume of solute divided by the volume of the solution, multiplied by 100.

is molarity. **Molarity** (*M*) is the number of moles of solute dissolved per liter of solution. Molarity is also known as molar concentration, and the unit *M* is read as molar. A liter of solution containing 1 mol of solute is a 1*M* solution, which is read as a one-molar solution. A liter of solution containing 0.1 mol of solute is a 0.1*M* solution. To calculate a solution's molarity, you must know the volume of the solution in liters and the amount of dissolved solute in moles.

Molarity

$$\text{molarity (M)} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

The molarity of a solution equals the moles of solute divided by the liters of solution.

called **molality**—the ratio of the number of moles of solute dissolved in 1 kg of solvent. The unit *m* is read as molal. A solution containing 1 mol of solute per kilogram of solvent is a one-molal solution.

Molality

$$\text{molality (m)} = \frac{\text{moles of solute}}{\text{kg of solvent}}$$

The molality of a solution equals the number of moles of solute divided by kg of solvent.

a **mole fraction**—the ratio of the number of moles of solute in solution to the total number of moles of solute and solvent.

The symbol *X* is commonly used for mole fraction, with a subscript to indicate the solvent or solute. The mole fraction for the solvent (X_A) and the mole fraction for the solute (X_B) can be expressed as follows.

Mole Fraction

$$X_A = \frac{n_A}{n_A + n_B} \quad X_B = \frac{n_B}{n_A + n_B}$$

A mole fraction equals the number of moles of solute in a solution divided by the total number of moles of solute and solvent.

X_A and X_B represent the mole fractions of each substance.

n_A and n_B represent the number of moles of each substance.

التعريف والقانون
م

Factors That Affect Solvation

Solvation occurs only when the solute and solvent particles come in contact with each other. There are three common ways, shown in **Figure 14.13**, to increase the collisions between solute and solvent particles and thus increase the rate at which the solute dissolves: agitation, increasing the surface area of the solute, and increasing the temperature of the solvent.

① **Agitation** Stirring or shaking—agitation of the mixture—moves dissolved solute particles away from the contact surfaces more quickly and thereby allows new collisions between solute and solvent particles to occur. Without agitation, solvated particles move away from the contact areas slowly.

② **Surface area** Breaking the solute into small pieces increases its surface area. A greater surface area allows more collisions to occur. This is why a teaspoon of granulated sugar dissolves more quickly than an equal amount of sugar in cube form.

③ **Temperature** The rate of solvation is affected by temperature. For example, sugar dissolves more quickly in hot tea, shown in **Figure 14.13**, than it does in iced tea. Additionally, hotter solvents generally can dissolve more solid solute. Hot tea can hold more dissolved sugar than the iced tea. Most solids act in the same way as sugar—as temperature increases, the rate of solvation also increases. Solvation of other substances, such as gases, decreases at higher temperatures. For example, a carbonated soft drink will lose its fizz (carbon dioxide) faster at room temperature than when cold.

* خواص تؤثر على إذابة
المادة الصلبة

Solubility

Just as solvation can be understood at the particle level, so can solubility. The solubility of a solute also depends on the nature of the solute and solvent. When a solute is added to a solvent, solvent particles collide with the solute's surface particles; solute particles begin to mix randomly among the solvent particles. At first, the solute particles are carried away from the crystal. However, as the number of solvated particles increases, the same random mixing results in increasingly frequent collisions between solvated solute particles and the remaining crystal. Some colliding solute particles rejoin the crystal, or crystallize, as illustrated in **Figure 14.14**. As solvation continues, the crystallization rate increases, while the solvation rate remains constant. As long as the solvation rate is greater than the crystallization rate, the net effect is continuing solvation.

Depending on the amount of solute present, the rates of solvation and crystallization might eventually equalize. No more solute appears to dissolve and a state of dynamic equilibrium exists between crystallization and solvation (as long as the temperature remains constant).

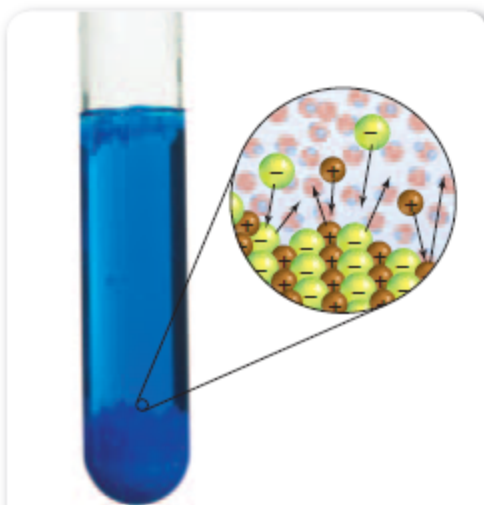


Figure 14.14 In a saturated solution, the rate of solvation equals the rate of crystallization. The amount of dissolved solute does not change.

Unsaturated solutions An **unsaturated solution** is one that contains less dissolved solute for a given temperature and pressure than a saturated solution. In other words, more solute can be dissolved in an unsaturated solution.

Saturated solutions Although solute particles continue to dissolve and crystallize in solutions that reach equilibrium, the overall amount of dissolved solute in the solution remains constant. Such a solution, illustrated in **Figure 14.14**, is said to be a **saturated solution**; it contains the maximum amount of dissolved solute for a given amount of solvent at a specific temperature and pressure.

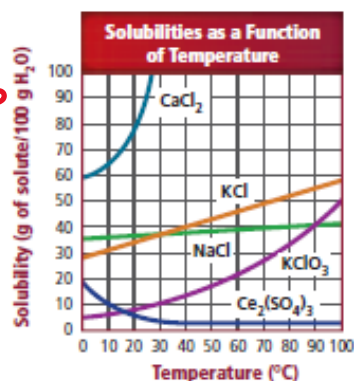
Temperature and supersaturated solutions Solubility is affected by raising the temperature of the solvent because the kinetic energy of its particles is increased, resulting in more-frequent collisions and collisions with greater energy than those that occur at lower temperatures. The fact that many substances are more soluble at high temperatures is demonstrated in **Figure 14.15**. For example, calcium chloride (CaCl_2) has a solubility of about 64 g CaCl_2 per 100 g H_2O at 10°C . Increasing the temperature to approximately 27°C increases the solubility by almost 50%, to 100 g CaCl_2 per 100 g H_2O . Other substances, such as cerium sulfate, have decreasing solubility as temperature increases, and then remains constant after a specific temperature is reached.

محلول
في مشبع

محلول
مشبع

محلول
فوق مشبع

Figure 14.15 The solubilities of several substances as a function of temperature are shown in graph.



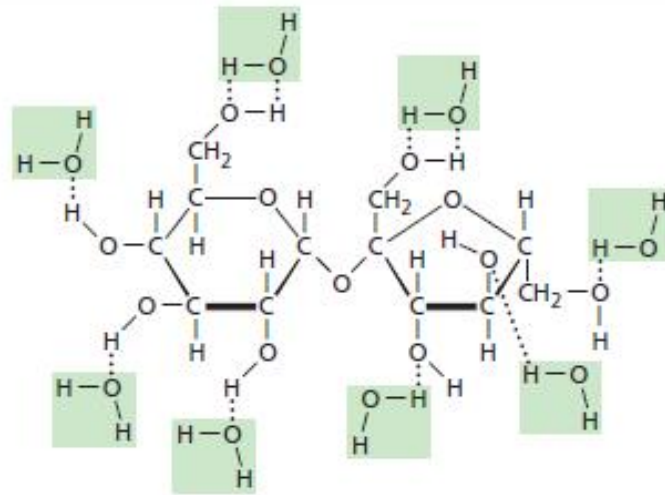
Graph Check

Interpret What is the solubility of NaCl at 80°C ?

لا يحصل التشكل

علاقة زائدية

المواد بدرجة الحرارة



Aqueous solutions of molecular compounds Water is also a good solvent for many molecular compounds. Table sugar is the molecular compound sucrose. As shown in **Figure 14.12**, sucrose molecules are polar and have several O-H bonds. As soon as the sugar crystals contact the water, water molecules collide with the outer surface of the crystal. Each O-H bond becomes a site for hydrogen bonding with water. The attractive forces among sucrose molecules are overcome by the attractive forces between polar water molecules and polar sucrose molecules. Sucrose molecules leave the crystal and become solvated by water molecules.

Oil is a substance made up primarily of carbon and hydrogen. It does not form a solution with water. There is little attraction between the polar water molecules and the nonpolar oil molecules. However, oil spills can be cleaned up with a nonpolar solvent because nonpolar solutes are more readily dissolved in nonpolar solvents.

Figure 14.12 Sucrose molecules contain eight O-H bonds and are polar. Polar water molecules form hydrogen bonds with the O-H bonds, which pulls the sucrose into solution.

القطبي يذوب في القطبي

(يجب ان يكون
المذاب والمذيب
متشابهان لتعملية
الذوبان)
⇒

Like dissolve Like
polar + polar
nonpolar + nonpolar

