

حل تجميعية مراجعة عامة وفق الهيكل الوزاري



تم تحميل هذا الملف من موقع المناهج الإماراتية

موقع المناهج ← المناهج الإماراتية ← الصف العاشر المتقدم ← كيمياء ← الفصل الثالث ← حلول ← الملف

تاريخ إضافة الملف على موقع المناهج: 2025-05-26 14:26:27

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

حل تجميعية مراجعة عامة وفق الهيكل الوزاري

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تجميعية تدريبات صفحات الكتاب وفق الهيكل الوزاري منهج بريدج

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Chemistry

Grade 10ADV EOT 3 coverage ppt

Particle Size

- Gases consist of small particles separated from one another by empty space.
- Because gas particles are far apart, they experience no significant attractive or repulsive forces.

Particle Motion

- Gas particles are in constant, random motion.
- Collisions between gas particles are elastic.
- An **elastic collision** is one in which no kinetic energy is lost.

Particle Energy

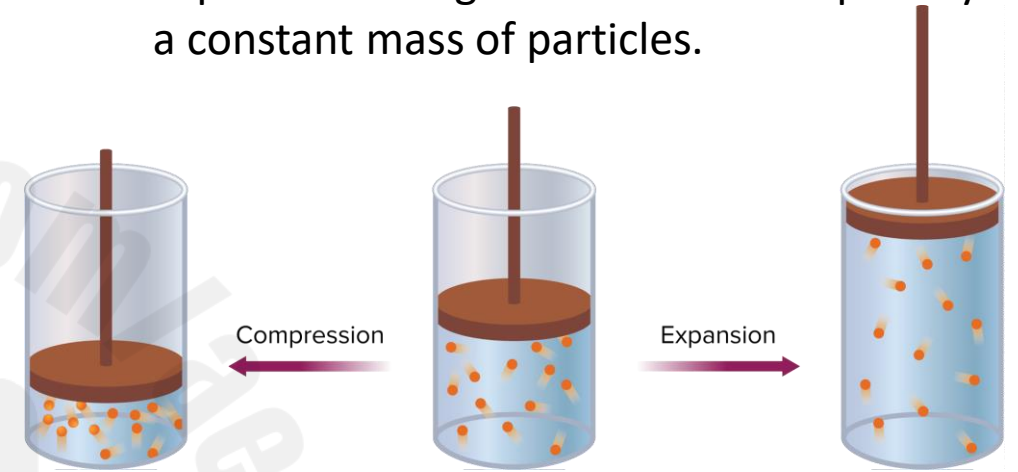
- Kinetic energy of a particle depends on mass and velocity.

$$KE = \frac{1}{2}mv^2$$

- KE is kinetic energy, m is the mass of the particle, and v is its velocity.
- **Temperature** is a measure of the average kinetic energy of the particles in a sample of matter.

Compression and Expansion

- In a closed container, compression and expansion change the volume occupied by a constant mass of particles.



1. The theory that describes the behavior of gases in terms of the motion of gas particles is _____.
 - A. the theory of intermolecular forces
 - B. Graham's law of effusion
 - C. Dalton's law of partial pressures
 - D. the kinetic-molecular theory

1. Describe the kinetic molecular theory of particles, List the five assumptions of the Kinetic Molecular Theory Page: 240-242

The measure of the average kinetic energy of the particles in a sample of matter is

Which of the following statements is true?

- ☐ particles of a gas collide with each other in elastic collisions
- ☐ particles of a gas collide with their container only
- ☐ particles of a gas collide with each other in inelastic collisions
- ☐ particles of a gas never collide

Correct Answer

particles of a gas collide with each other in elastic collisions

- ☐ speed.
- ☐ velocity.
- ☐ heat.
- ☐ temperature.

Correct Answer

temperature.

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

- ☐ Collisions between gas particles are elastic.
- ☐ All gases at a given temperature have the same average kinetic energy.
- ☐ All the gas particles in a sample have the same velocity.
- ☐ A gas particle is not significantly attracted or repelled by other gas particles.

Correct Answer

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

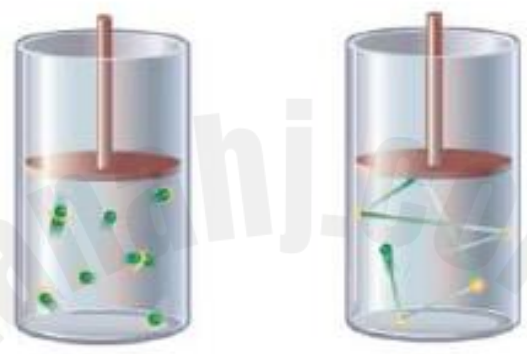
Which of the following assumptions is/are valid based on kinetic molecular theory?

I	Gas molecules have negligible volume compared to the volume of the container.
II	Gas molecules have strong attractive forces on each other.
III	The temperature of a gas is directly proportional to its kinetic energy.

1. Describe the kinetic molecular theory of particles, List the five assumptions of the Kinetic Molecular Theory Page: 240-242

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

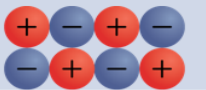
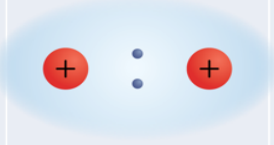
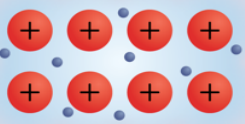
تالية ليست افتراضاً لنظرية الحركة الجزيئية؟



- a. Collisions between gas particles are elastic. الغاز أ.
- b. All the gas particles in a sample have the same velocity. ما تفه السرعة.
- c. A gas particle is not significantly attracted or repelled by other gas particles. ت الغاز ع بعض.
- d. All gases at a given temperature have the same average kinetic energy. معينة ن متوسط الطاقة الحركية.

Intermolecular Forces

- Intramolecular forces hold particles together in ionic, covalent, and metallic bonds.
- The prefix *intra-* means *within*.

Force	Model	Basis of Attraction	Example
Ionic		cations and anions	NaCl
Covalent		positive and nuclei and shared electrons	H ₂
Metallic		metal cations and mobile electrons	Fe

There are three types of intermolecular forces: **London dispersion forces (LDF)**, **dipole- dipole interactions**, and **hydrogen bonding**.

- Intramolecular forces do not account for all attractions between particles.
- There are forces of attraction called intermolecular forces.
- The prefix *inter-* means *between* or *among*.
- Intermolecular forces hold together identical particles or different types of particles.
- Some intermolecular forces are stronger than others, but all intermolecular forces are weaker than the intramolecular forces involved in bonding.

11. Compare the properties of real gases and ideal gases

- The **ideal gas law** describes the physical behavior of an ideal gas in terms of the pressure, volume, temperature, and number of moles of gas present.

$$PV = nRT$$

- Ideal gases follow the assumptions of the kinetic-molecular theory.
- Characteristics of ideal gases:
 - Their particles take up no space.
 - There are no intermolecular attractive or repulsive forces between particles or with their containers.
 - The particles are in constant random motion.
 - Collisions are perfectly elastic.

Most real gases behave like ideal gases under conditions of high temperature and low pressure.

- No gas is truly ideal, but most behave as ideal gases at a wide range of temperatures and pressures.
- All gas particles have some volume, however small, and are subject to intermolecular interactions.
- The collisions that particles make with each other and with the container are not perfectly elastic.
- Most gases behave like ideal gases at a wide range of temperatures and pressures.

- Real gases deviate most from ideal gas behavior at high pressures and low temperatures.**

Polarity and Size of Particles

- Polar molecules have larger attractive forces between particles.**
- Polar gases do not behave as ideal gases.**
- Large nonpolar gas particles occupy more space and deviate more from ideal gases.**

Why might you need to know the density of a gas? Consider fighting a fire. One way to put out a fire is to remove its oxygen source by covering it with another gas that will neither burn nor support combustion, as shown in **Figure 7**. This gas must have a greater density than oxygen so that it will displace the oxygen at the source of the fire.



Figure 7 To extinguish a fire, you need to take away fuel, oxygen, or heat. The fire extinguishers in the photo contain carbon dioxide, which displaces oxygen but does not burn. It also has a cooling effect due to the rapid expansion of the carbon dioxide as it is released from the nozzle.

Explain Why does carbon dioxide displace oxygen?

Deviations from the ideal gas law are greater at

- ☐ low temperatures and low pressures.
- ☐ low temperatures and high pressures.
- ☐ high temperatures and high pressures.
- ☐ high temperatures and low pressures.

Correct Answer

low temperatures and high pressures.

For a substance that remains a gas under the conditions listed, deviation from the ideal gas law would be most pronounced at

- ☐ 100°C and 2.0 atm.
- ☐ 0°C and 2.0 atm.
- ☐ -100°C and 2.0 atm.
- ☐ -100°C and 4.0 atm.
- ☐ 100°C and 4.0 atm.

Correct Answer

-100°C and 4.0 atm.

9. Methanol (CH_3OH) has a boiling point of 63.7°C. Under which of the following conditions would methanol vapor behave most ideally?

- (A) 1 atm pressure and 75°C
- (B) 1 atm pressure and 150°C
- (C) 3 atm pressure and 75°C
- (D) 3 atm pressure and 150°C

9(B)

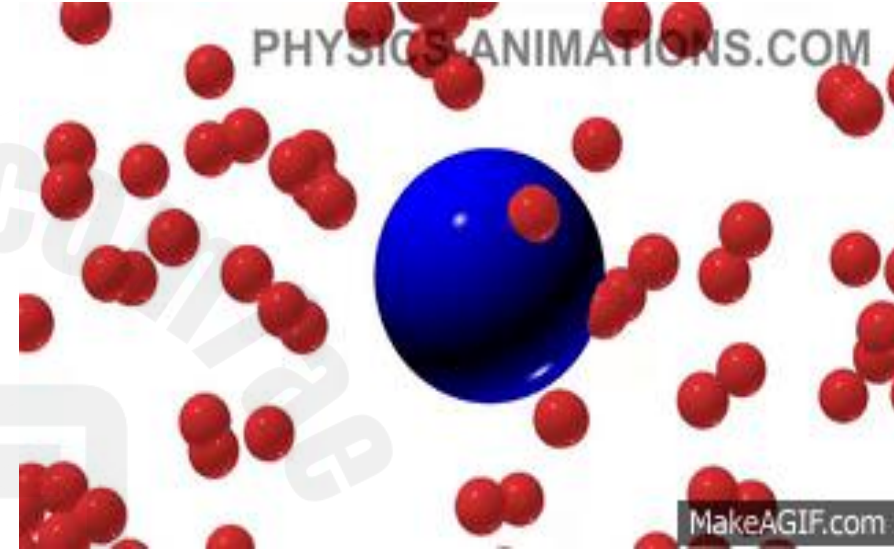
Colloids are heterogeneous mixtures

Comparing Solutions, Colloids, and Suspensions

Description	Solutions	Colloids	Suspensions
Settle upon standing?	no	no	yes
Separate using filter paper?	no	no	yes
Particle size	0.1–1 nm	1–100 nm	>100 nm
Scatter light?	no	yes	yes

CHARACTERISTICS OF SOLUTIONS, SUSPENSIONS, AND COLLOIDS			
PROPERTY	SOLUTIONS	COLLOIDS	SUSPENSIONS
Particle Size	Small (0.1 – 1 nm)	Medium (1-100 nm)	Large (100 nm or larger)
Tyndall Effect	No	Yes	No
Effect of Gravity	Do not settle out	Do not settle out	Settle out
Filtration	Cannot be separated	Cannot be separated	Can be separated
Uniformity	Homogeneous	Borderline	Heterogeneous

- **Brownian motion** is the jerky, random movements of particles in a liquid colloid, from the results of particle collisions.
- The **Tyndall effect** is the scattering of light by dispersed colloid particles.



How can colloids be distinguished from solutions? تميز الغرويات عن المحاليل؟

Learning Outcomes Covered

◦ CHM.5.2.02.007

- a.

Colloid particles are huge in size.

رويات : الحجم.
- b.

Colloid particles are much smaller than atoms.

رويات أء بكثير من الذرات.
- c.

Colloid particles can settle out or separate out through a filter.

وي يمكن فصلها عن طريق الترسيب أو الترشيح.
- d.

Colloids will scatter light beams that are shone through them.

ت أشعة ضوء التي تمر من خلالها.

Electrostatic layering The dispersed particles in a colloid often have polar or charged atomic groups on their surfaces. These groups are another factor that prevents particles from settling out of a colloid. The charged or polar areas on the surfaces of the particles attract the positively or negatively charged areas of the dispersing-medium particles. This results in the formation of electrostatic layers around the particles. The layers repel each other when the dispersed particles collide; thus, the particles remain suspended in the colloid.

If you interfere with the electrostatic layering, colloid particles will settle out of the mixture. For example, if you stir an electrolyte into a colloid, the dispersed particles clump together, destroying the colloid. Heating also destroys a colloid because it gives colliding particles enough kinetic energy to overcome the electrostatic forces and settle out. **Figure 2** shows how heating and adding acid, an electrolyte, to milk destroys the colloid.

Recipes for homemade cheese involve heating milk and adding lemon juice. Once the colloid separates, the mixture is passed through a cloth to remove the liquid, called the whey. The solids, the curds, can then be pressed to make cheese. This is a good example of how the structure and interactions of matter at a bulk scale are determined by electrical forces between atoms.



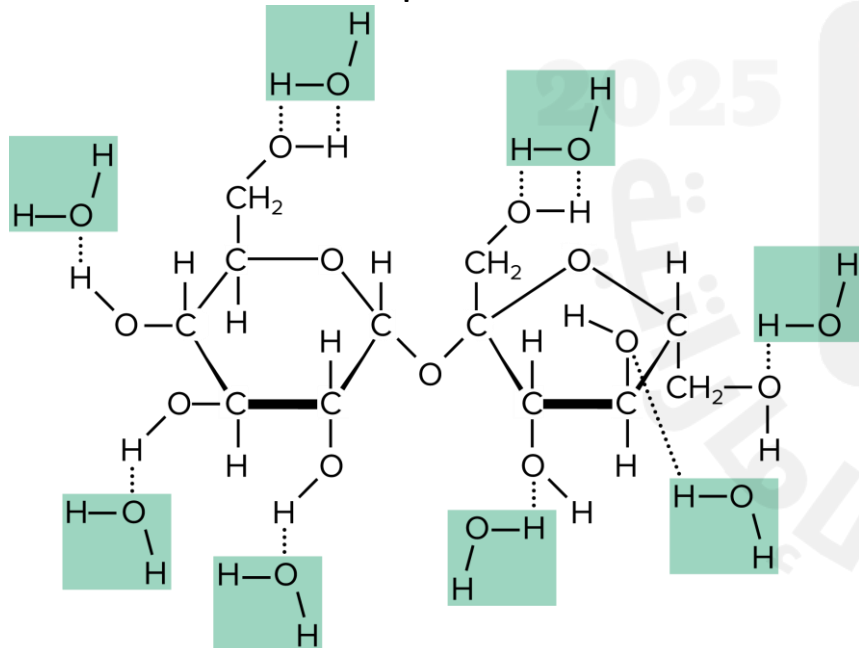
Figure 2 This milk has been heated and acid has been added to it. As a result, the colloid is destroyed and particles in the milk clump together, forming curds.

20. Explain the affect of the intermolecular forces on solvation

Page: 323-324

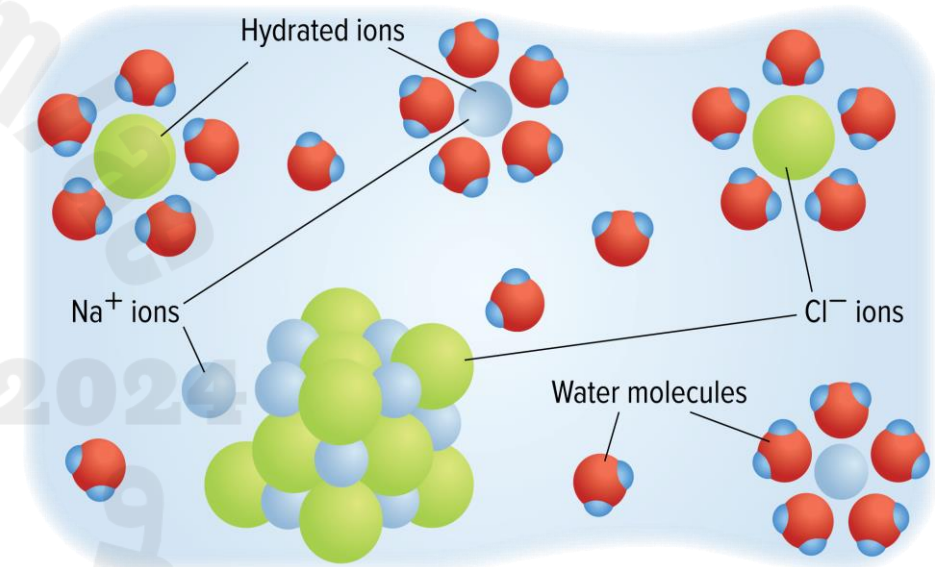
- **Solvation** is the process of surrounding solute particles with solvent particles to form a solution.
- Solvation in water is called hydration.
- Hydration occurs when the attraction between dipoles of a water molecule and the ions of a crystal are greater than the attraction among ions of a crystal.

Water is also a solvent for polar molecules, such as sucrose.



Sodium chloride dissolves in water as the water molecules surround the sodium and chloride ions. Note how the polar water molecules are oriented differently around the positive and negative ions.

Solvation Process of NaCl



1. **Polar solutes are soluble in polar solvents only.**
2. **Nonpolar solutes are soluble in Nonpolar solvents only.**

20. Explain the affect of the intermolecular forces on solvation

Page: 323-324

Why sucrose dissolves in water while oil does not form a solution with water?

ء بينما لا يكون الزيت محلولاً مع الماء؟

Learning Outcomes Covered

◦ CHM.5.2.03.001

a.

Because sucrose molecules are polar while oil molecules are nonpolar

بينما، يمتزج الزيت غير قطبي

b.

Because sucrose molecules are nonpolar while oil molecules are polar

قطبي، لا يمتزج الزيت قطبي

c.

Because oil molecules form hydrogen bonds with water molecules

رابط هـ، وجينية مع جسيمات الماء

d.

Because oil molecules form hydrogen bonds with water molecules

رابط هـ، وجينية مع جسيمات الماء

Diffusion and Effusion

- Gases easily flow past each other because there are no significant forces of attraction.
- **Diffusion** is the movement of one material through another.
- **Effusion** is a gas escaping through a tiny opening.

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

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

- Graham's law also applies to diffusion.

$$\frac{\text{Rate}_A}{\text{Rate}_B} = \sqrt{\frac{\text{molar mass}_B}{\text{molar mass}_A}}$$

1. Calculate the ratio of effusion rates for nitrogen (N₂) and neon (Ne).
2. Calculate the ratio of diffusion rates for carbon monoxide and carbon dioxide.
3. **CHALLENGE** What is the rate of effusion for a gas that has a molar mass twice that of a gas that effuses at a rate of 3.6 mol/min?

1. $R_{N_2}/R_{Ne} = 0.8488$
2. 1.253
3. 2.5 mol/min

different gases at the same temperature have the same average kinetic energy as described by the equation $KE = \frac{1}{2}mv^2$.

GRAHAM'S LAW

IN-CLASS EXAMPLE

Use with Example Problem 1.

Problem

Ammonia has a molar mass of 17.0 g/mol; hydrogen chloride has a molar mass of 36.5 g/mol. What is the ratio of their diffusion rates?

Response

ANALYZE THE PROBLEM

You are given the molar masses for ammonia and hydrogen chloride. To find the ratio of the diffusion rates for ammonia and hydrogen chloride, use the equation for Graham's law of effusion.

KNOWN

molar mass_{HCl} = 36.5 g/mol
molar mass_{NH₃} = 17.0 g/mol

UNKNOWN

ratio of diffusion rates = ?

SOLVE FOR THE UNKNOWN

- State the ratio derived from Graham's law.

$$\frac{\text{Rate}_{\text{NH}_3}}{\text{Rate}_{\text{HCl}}} = \sqrt{\frac{\text{molar mass}_{\text{HCl}}}{\text{molar mass}_{\text{NH}_3}}}$$

- Substitute molar mass_{HCl} = 36.5 g/mol and molar mass_{NH₃} = 17.0 g/mol.

$$\sqrt{\frac{36.5 \text{ g/mol}}{17.0 \text{ g/mol}}} = 1.47$$

The ratio of diffusion rates is 1.47.

EVALUATE THE ANSWER

A ratio of roughly 1.5 is logical because molecules of ammonia are about half as massive as molecules of hydrogen chloride. Because the molar masses have three significant figures, the answer also does. Note that the units cancel, and the answer is stated correctly without any units.

2. Show the effect of mass on the rates of diffusion and effusion

Which of these gas molecules has the *highest average kinetic energy* at 25°C?

- ☐ H₂
- ☐ O₂
- ☐ N₂
- ☐ Cl₂
- ☐ All the gases have the same average kinetic energy.

Correct Answer

All the gases have the same average kinetic energy.

Which of the following gases will diffuse the fastest at room temperature?

- ☐ CO₂
- ☐ N₂
- ☐ H₂
- ☐ Ne

Correct Answer

H₂

What is the ratio of diffusion rates for nitric oxide (NO) and nitrogen tetroxide (N₂O₄)?

- ☐ 0.571
- ☐ 1.751
- ☐ 3.066
- ☐ 0.306

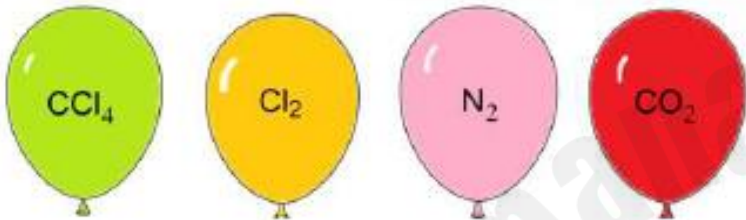
Correct Answer

1.751

2. Show the effect of mass on the rates of diffusion and effusion

Four identical balloons were filled with different gases to the same volume.
Which balloon does the gas effuse the fastest from it?

تم ملؤها بنفس الحجم من غازات مختلفة.
لغاز منه بشكل أسرع؟



Learning Outcomes Covered

◦ CHM.5.2.01.003

a.

CCl₄

b.

Cl₂

c.

N₂

d.

CO₂

3. Calculate the partial pressure of a gas by measuring the total pressure of gases mixture

Dalton's Law of Partial Pressures

- **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 of the mixture.
- The partial pressure of a gas depends on the number of moles, the size of the container, and temperature. The partial pressure of a gas is independent of the type of gas.
- At a given temperature and pressure, the partial pressure of 1 mol of any gas is the same.

Partial pressure can be used to calculate the amount of gas produced in a chemical reaction.

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

- 4. 161 mmHg
- 5. 13.78 kPa
- 6. 10.2 kPa
- 7. $\text{N}_2 = 590 \text{ mmHg}$; $\text{O}_2 = 160 \text{ mmHg}$; $\text{Ar} = 8 \text{ mmHg}$

4. What is the partial pressure of hydrogen gas in a mixture of hydrogen and helium if the total pressure is 600 mmHg and the partial pressure of helium is 439 mmHg?
5. 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.
6. 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.
7. **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 mmHg, what are the partial pressures of nitrogen, oxygen, and argon in the atmosphere?

Gas Pressure

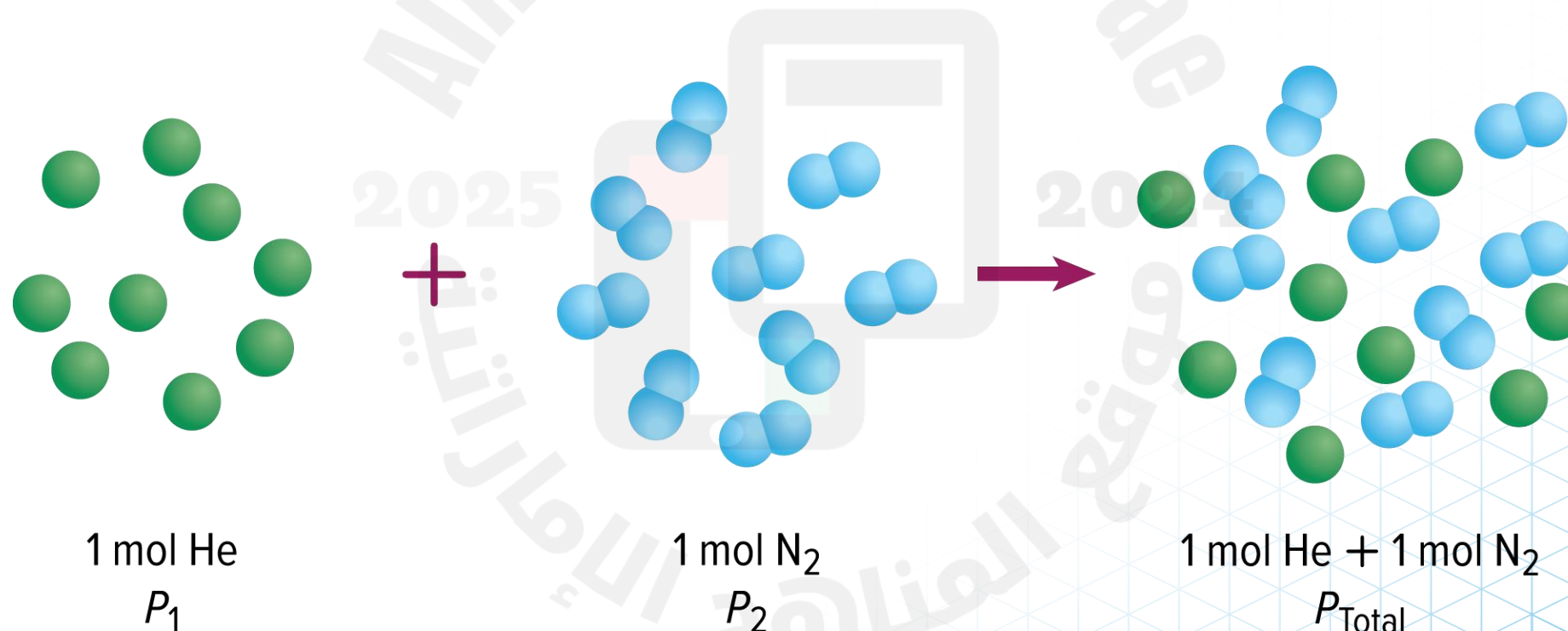
Dalton's Law of Partial Pressures

- **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 of the mixture.
- The partial pressure of a gas depends on the number of moles, the size of the container, and temperature. The partial pressure of a gas is independent of the type of gas.
- At a given temperature and pressure, the partial pressure of 1 mol of any gas is the same.

Gas Pressure

Partial pressure can be used to calculate the amount of gas produced in a chemical reaction.

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



THE PARTIAL PRESSURE OF A GAS

IN-CLASS EXAMPLE

Use with Example Problem 2.

Problem

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?

Response

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

$$P_{N_2} = 0.12 \text{ atm}$$

$$P_{CO_2} = 0.70 \text{ atm}$$

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

UNKNOWN

$$P_{O_2} = ? \text{ atm}$$

SOLVE FOR THE UNKNOWN

- State Dalton's law of partial pressures.

$$P_{\text{total}} = P_{N_2} + P_{CO_2} + P_{O_2}$$

- Solve for P_{O_2} .

$$P_{O_2} = P_{\text{total}} - P_{CO_2} - P_{N_2}$$

- Substitute $P_{N_2} = 0.12 \text{ atm}$, $P_{CO_2} = 0.70 \text{ atm}$, and $P_{\text{total}} = 0.97 \text{ atm}$.

$$P_{O_2} = 0.15 \text{ atm}$$

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.

Which of the following describes Dalton's Law?

- ☐ The pressure of a gas is proportional to its volume.
- ☐ The total pressure of a gas mixture is the sum of the partial pressures of each gas in the mixture.
- ☐ The temperature of a gas is proportional to its volume.
- ☐ Only one variable can be changed from an initial state to a final state for a gas.

Correct Answer

The total pressure of a gas mixture is the sum of the partial pressures of each gas in the mixture.

3. Calculate the partial pressure of a gas by measuring the total pressure of gases mixture

What is the total pressure for a mixture that contains three gases with partial pressures of 1.35 kPa, 3.81 kPa, and 5.22 kPa?

ما الضغط الكلي لخليط يحتوي على ثلاث غازات ضغوطها جزئية كالتالي 5.22 kPa ، 3.81 kPa ، 1.35 kPa ؟



- a. 6.57 kPa
- b. 10.38 kPa
- c. 7.68 kPa
- d. 12.76 kPa

5. Show the effect of intramolecular forces in the properties of matters

Hydrogen Bonds

- Hydrogen bonds are special dipole-dipole attractions that occur between molecules containing a hydrogen atom bonded to a small, highly electronegative atom with at least one lone electron pair.

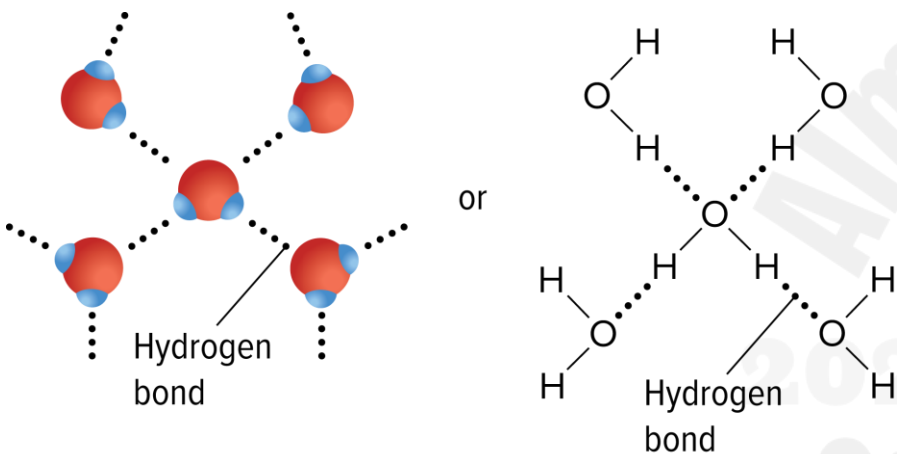


Figure 11 The hydrogen bonds between water molecules are stronger than typical dipole-dipole attractions because the bond between hydrogen and oxygen is highly polar.

- Hydrogen bonds explain why **water** is a liquid at room temperature while compounds of comparable mass are gases.
- Methane** is nonpolar, so relatively weak dispersion forces hold the molecule together.
- Ammonia** and water both form hydrogen bonds, but oxygen is more electronegative than nitrogen, making O-H bonds more polar and thus stronger.

Compound	Molar Mass (g)	Boiling (°C)
Water (H ₂ O)	18.0	100
Methane (CH ₄)	16.0	-161.5
Ammonia (NH ₃)	17.0	-33.5

5. Show the effect of intramolecular forces in the properties of matters

Why is the boiling point of ammonia much lower than the boiling point of water, as shown in the table below?
ونما أقل بكثير من درجة غليان الماء،
لماذا؟

- a.

Because N-H bonds in ammonia are less polar than O-H bonds in water

في الأمونيا أقل قطبية
في الماء
O-H
- b.

Because nitrogen atoms are more electronegative than oxygen atoms

تروجين أكثر سالبة كهربائية
أكسجين
- c.

Because ammonia is a liquid at room temperature

سائل، درجة حرارة الغرفة
- d.

Because the molar mass of ammonia is less than water

ولية لا، ونما أقل منها للماء

Compound	Molecular Structure	Molar Mass (g)	Boiling Point (°C)
Water (H ₂ O)		18.0	100
Methane (CH ₄)		16.0	161.5
Ammonia (NH ₃)		17.0	33.3

Which of the following is an intermolecular force?

من قوى الترابط بين الجزيئية؟

Learning Outcomes Covered

CHM.5.1.02.007

a.

Hydrogen bond

الرابطة الهيدروجينية

b.

Metallic bond

الرابطة الفلزية

c.

Ionic bond

الرابطة الأيونية

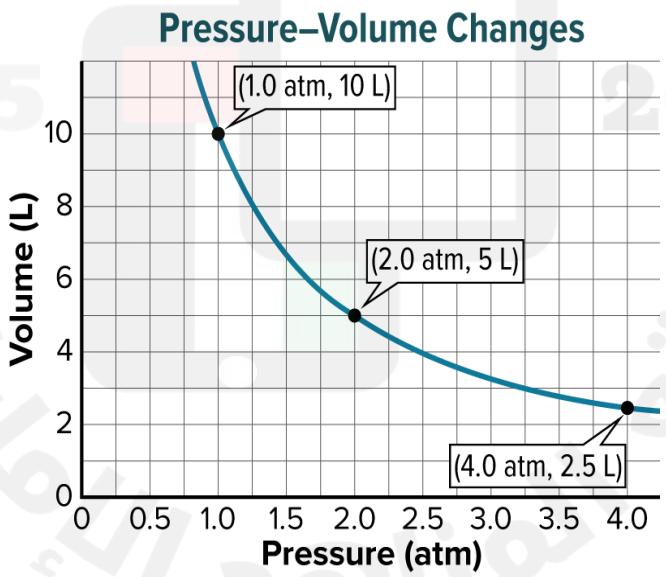
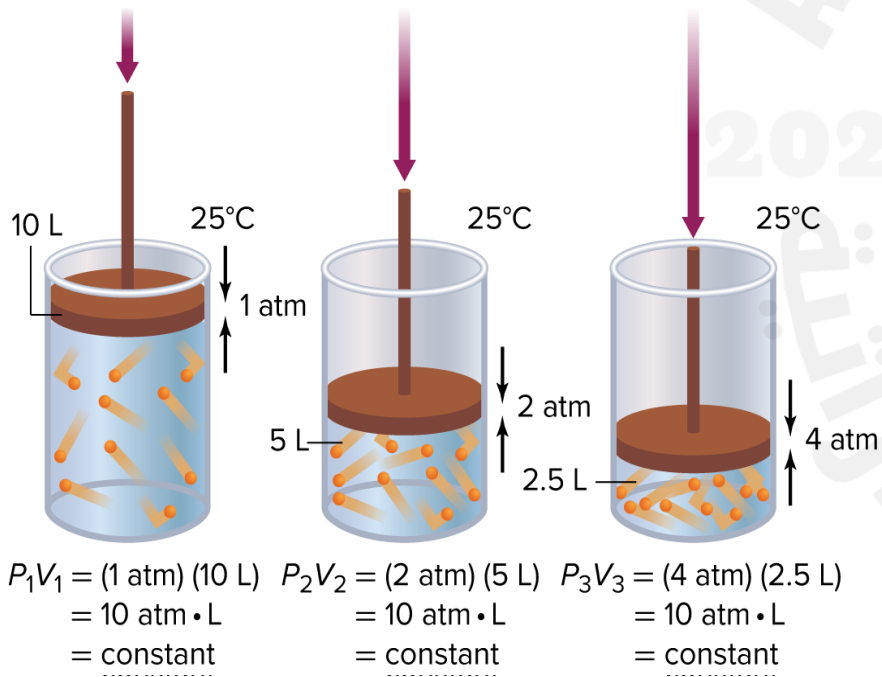
d.

Covalent bond

الرابطة التساهمية

How Pressure and Volume are Related

- **Boyle’s law** states that the volume of a fixed amount of gas held at a constant temperature varies inversely with the pressure.
- $P_1V_1 = P_2V_2$ where P = pressure and V = volume
- Look at the graph on the next slide in which volume versus pressure is plotted for a gas. The plot of an inversely proportional relationship results in a downward curve.



BOYLE’S LAW

IN-CLASS EXAMPLE

Use with Example Problem 1.

Problem

A diver blows a 0.75-L air bubble 10 m under water. As it rises to the surface, the pressure goes from 2.25 atm to 1.03 atm. What will be the volume of air in the bubble at the surface?

Response

ANALYZE THE PROBLEM

According to Boyle’s law, the decrease in pressure on the bubble will result in an increase in volume, so the initial volume should be multiplied by a pressure ratio greater than 1.

KNOWN

$$V_1 = 0.75 \text{ L}$$

$$P_1 = 2.25 \text{ atm}$$

$$P_2 = 1.03 \text{ atm}$$

UNKNOWN

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

SOLVE FOR THE UNKNOWN

Use Boyle’s law. Solve for V_2 , and calculate the new volume.

- State Boyle’s law.

$$P_1 V_1 = P_2 V_2$$

- Solve for V_2 .

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

- Substitute $V_1 = 0.75 \text{ L}$, $P_1 = 2.25 \text{ atm}$, and $P_2 = 1.03 \text{ atm}$.

$$V_2 = 0.75 \text{ L} \left(\frac{2.25 \text{ atm}}{1.03 \text{ atm}} \right)$$

- Multiply and divide numbers and units.

$$V_2 = 0.75 \text{ L} \left(\frac{2.25 \text{ atm}}{1.03 \text{ atm}} \right) = 1.6 \text{ L}$$

EVALUATE THE ANSWER

The pressure decreases by roughly half, so the volume should roughly double. The answer is expressed in liters, a unit of volume, and correctly contains two significant figures.

6. Use the gas laws to solve problems involving the pressure, temperature, and volume of a constant amount of gas

Practice questions – Page 280

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

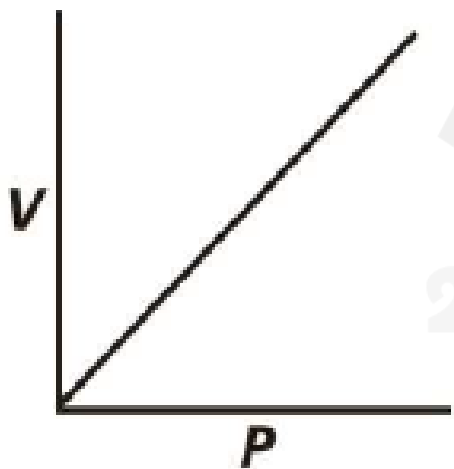
1. The volume of a gas at 99.0 kPa is 300.0 mL. If the pressure is increased to 188 kPa, what will be the new volume?
2. The pressure of a sample of helium in a 1.00-L container is 0.988 atm. What is the new pressure if the sample is placed in a 2.00-L container?
3. **CHALLENGE** Air trapped in a cylinder fitted with a piston occupies 145.7 mL at 1.08 atm pressure. What is the new volume when the piston is depressed, increasing the pressure by 25%?

1. 158 mL
2. 0.494 atm
3. 117 mL

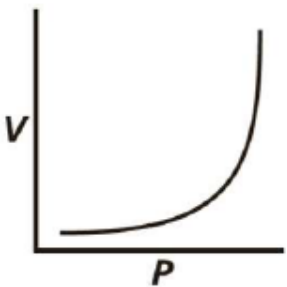
6. Use the gas laws to solve problems involving the pressure, temperature, and volume of a constant amount of gas

Which diagram shows the correct relationship between volume (V) and pressure (P) for a gas at constant temperature?

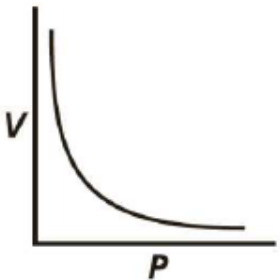
اللاقة الصحيحة بين حجم (V) وحرارة ثابتة؟



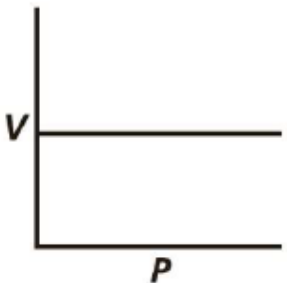
a.



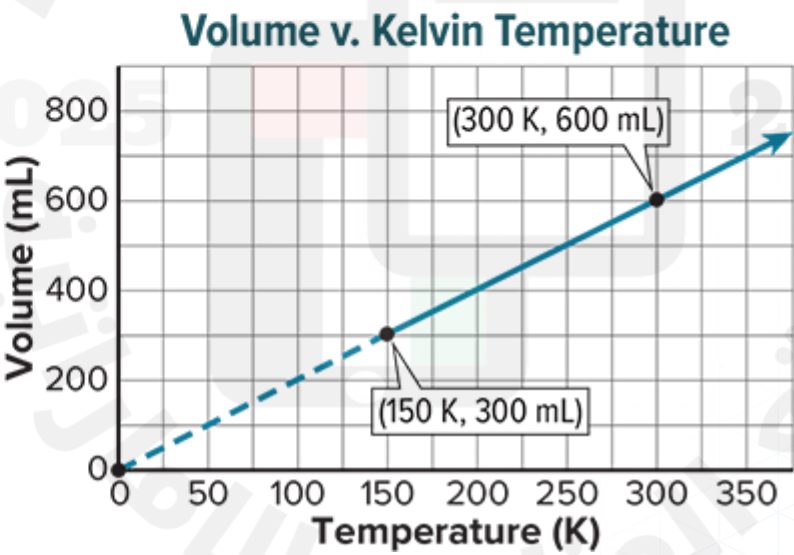
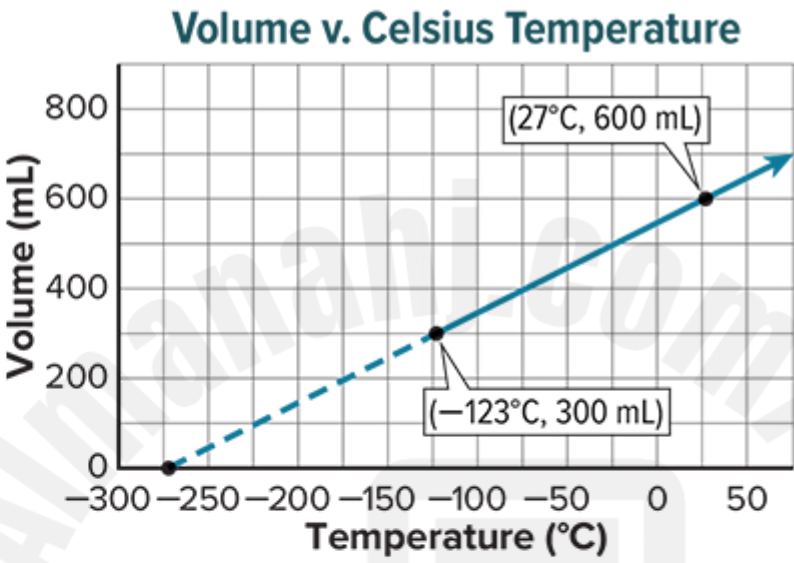
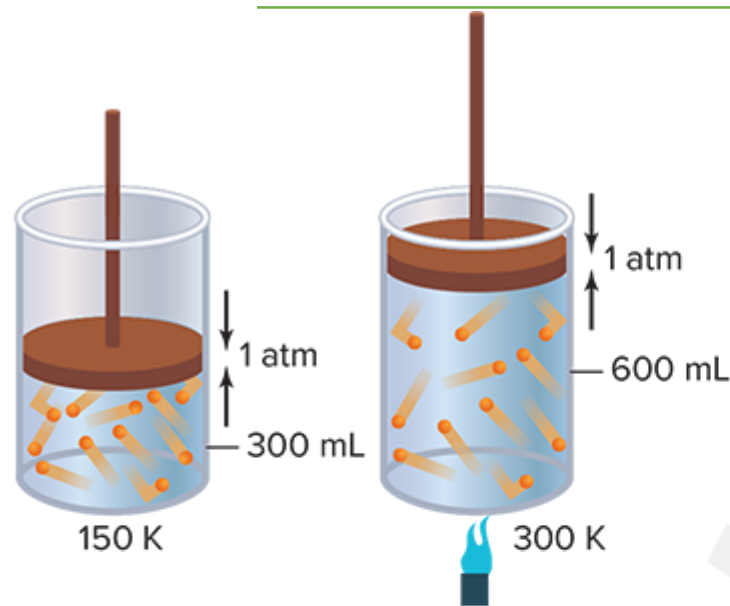
b.



c.



Charles's Law



How Temperature and Volume are Related

- As temperature increases, so does the volume of a gas sample when the amount of gas and pressure remain constant.

$$\begin{aligned} \frac{V_1}{T_1} &= \frac{300 \text{ mL}}{150 \text{ K}} \\ &= 2 \text{ mL/K} \\ &= \text{constant} \end{aligned}$$
$$\begin{aligned} \frac{V_2}{T_2} &= \frac{600 \text{ mL}}{300 \text{ K}} \\ &= 2 \text{ mL/K} \\ &= \text{constant} \end{aligned}$$

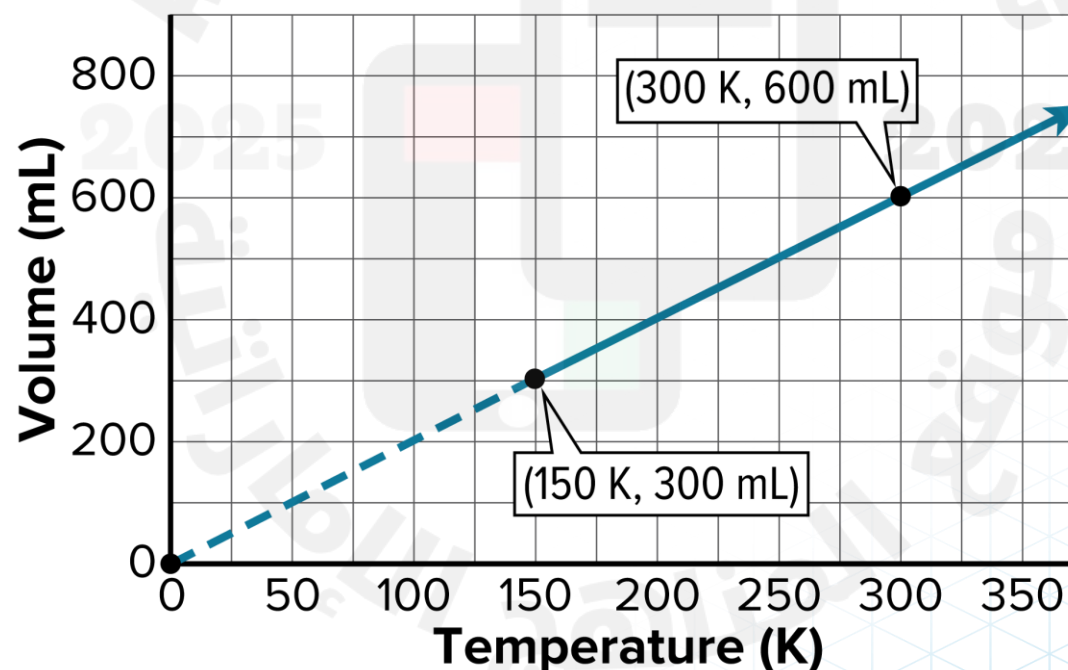
Figure 2 When the cylinder is heated, the kinetic energy of the gas particles increases, causing them to push the piston outward. The graphs show the relationship of volume to Celsius and Kelvin temperatures.

Charles's Law

Graphing Temperature and Volume

- A temperature of 0 K corresponds to 0 mL. Doubling temperature doubles volume.
- **Absolute zero** is zero on the Kelvin scale.

Volume v. Kelvin Temperature



Using Charles's law

Using Charles's Law

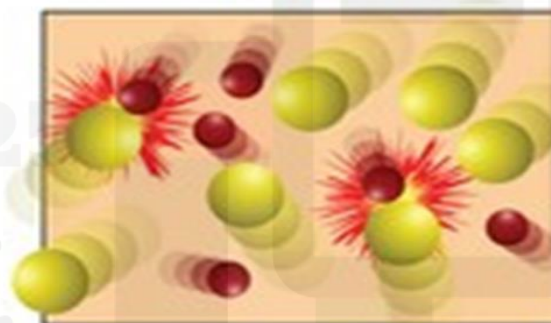
- **Charles's law** states that the volume of a given amount of gas is directly proportional to its Kelvin temperature at constant pressure.

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

Graphing Temperature and Volume

- A temperature of 0 K corresponds to 0 mL. Doubling temperature doubles volume.
- **Absolute zero** is zero on the Kelvin scale.
- Absolute zero represents lowest possible theoretical temperature.
- At absolute zero the atoms are all in the lowest possible energy state.

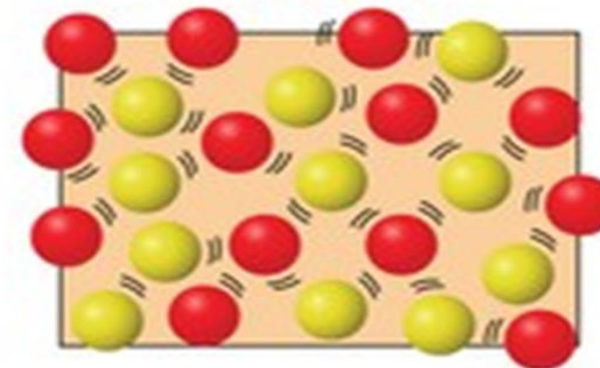
Temperature greater than -273.15 °C



Not absolute zero

Atoms move or vibrate all the time and have energy

Temperature -273.15 °C



Absolute zero

Absolute zero is the temperature at which the molecules of matter do not have kinetic energy
Absolute zero is the temperature at which all particles stop moving according to quantum mechanics

CHARLES’S LAW

IN-CLASS EXAMPLE

Use with Example Problem 2.

Problem

A helium balloon in a closed car occupies a volume of 2.32 L at 40.0°C. If the car is parked on a hot day and the temperature inside rises to 75.0°C, what is the new volume of the balloon, assuming the pressure remains constant?

Response

ANALYZE THE PROBLEM

Charles’s law states that as the temperature of a fixed amount of gas increases, so does its volume, assuming constant pressure. Therefore, the volume of the balloon will increase. The initial volume should be multiplied by a temperature ratio greater than 1.

KNOWN

$$T_2 = 40.0^{\circ}\text{C}$$

$$V_1 = 2.32 \text{ L}$$

$$T_2 = 75.0^{\circ}\text{C}$$

UNKNOWN

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

SOLVE FOR THE UNKNOWN

Convert degrees Celsius to kelvins.

- Apply the conversion factor.

$$T_K = 273 + T_C$$

- Substitute $T_1 = 40.0^{\circ}\text{C}$.

$$T_1 = 273 + 40.0^{\circ}\text{C} = 313.0 \text{ K}$$

- Substitute $T_2 = 75.0^{\circ}\text{C}$.

$$T_2 = 273 + 75.0^{\circ}\text{C} = 348.0 \text{ K}$$

CHARLES’S LAW

IN-CLASS EXAMPLE

Use with Example Problem 2.

SOLVE FOR THE UNKNOWN (continued)

Use Charles’s law. Solve for V_2 , and substitute the known values into the rearranged equation.

- State Charles’s law.

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

- Solve for V_2

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

- Substitute $V_1 = 2.32 \text{ L}$, $T_1 = 313.0 \text{ K}$, and $T_2 = 348.0 \text{ K}$.

$$V_2 = 2.32 \text{ L} \left(\frac{348.0 \text{ K}}{313.0 \text{ K}} \right)$$

- Multiply and divide numbers and units.

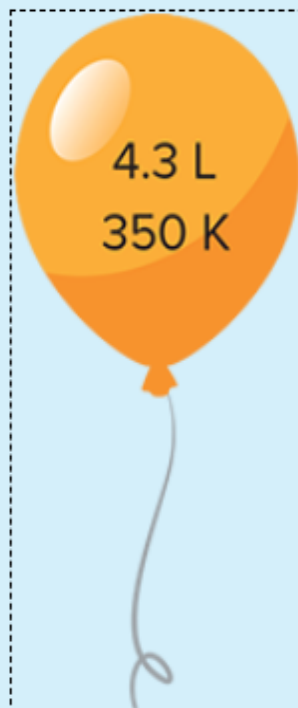
$$V_2 = 2.32 \text{ L} \left(\frac{348.0 \text{ K}}{313.0 \text{ K}} \right) = 2.58 \text{ L}$$

EVALUATE THE ANSWER

The increase in kelvins is relatively small, so the volume should show a small increase. The unit of the answer is liters, a volume unit, and there are three significant figures.

Practice questions – Page 282

4. What volume will the gas in the balloon occupy at 250 K?



4. 3.1 L

5. 330°C

6. 2.58 L

7. 190 K

5. A gas at 89°C occupies a volume of 0.67 L. At what Celsius temperature will the volume increase to 1.12 L?

6. The Celsius temperature of a 3.00-L sample of gas is lowered from 80.0°C to 30.0°C. What will be the resulting volume of this gas?

7. **CHALLENGE** A gas occupies 0.67 L at 350 K. What temperature is required to reduce the volume by 45%?

Which of the following statements is **correct** regarding the absolute zero?

حده فيما يتعلق بالصفر المطلق؟

Learning Outcomes Covered

CHM.5.2.01.004

a.

It is the zero on Celsius scale temperature

على ٠ من درجة الحرارة السيليزية

b.

There is a lower degree than the absolute zero in minus

الصفر - مطلق بالسالب

c.

All atoms are in the highest possible energy state

بأعلى حالة ممكنة من الطاقة

d.

It is the zero on the Kelvin scale and is equal to - 273 °C

أيسر كلفن يساوي -273° C

The Ideal Gas Law

- The **ideal gas constant** is represented by R and is 0.0821 L•atm/mol•K when pressure is in atmospheres.
- The **ideal gas law** describes the physical behavior of an ideal gas in terms of the pressure, volume, temperature, and number of moles of gas present.

$$PV = nRT$$
- For a given amount of gas held at constant temperature, the product of pressure and volume is a constant.

Table 2 Values of R

Value of R	Units of R
0.0821	$\frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$
8.314	$\frac{\text{L} \cdot \text{kPa}}{\text{mol} \cdot \text{K}}$
62.4	$\frac{\text{L} \cdot \text{mm Hg}}{\text{mol} \cdot \text{K}}$

THE IDEAL GAS LAW

IN-CLASS EXAMPLE

Use with Example Problem 6.

Problem

Calculate the number of moles of ammonia gas (NH₃) contained in a 3.0-L vessel at 3.00 × 10² K with a pressure of 1.50 atm.

Response

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 L
T = 3.00 × 10² K
P = 1.50 atm
R = 0.0821 $\frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$

UNKNOWN

n = ? mol

SOLVE FOR THE UNKNOWN (continued)

- Substitute V = 3.0 L, T = 3.00 × 10² K, P = 1.50 atm, and R = 0.0821 L • atm/mol • K.

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

- Multiply and divide numbers and units.

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

SOLVE FOR THE UNKNOWN

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

- State the ideal gas law.

$$PV = nRT$$

- Solve for n.

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

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 Questions

26. Determine the Celsius temperature of 2.49 mol of a gas contained in a 1.00-L vessel at a pressure of 143 kPa.
27. Calculate the volume of a 0.323-mol sample of a gas at 265 K and 0.900 atm.
28. 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?
29. 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?
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?

26. -266°C

27. 7.81 L

28. 5.14 atm

29. $6.9 \times 10^{-3}\text{mol}$

30. 12 L

What is the volume of a 0.323 mol sample
of a gas at 12°C and 0.900 atm?

حجم عينة من غاز عدد مولاتها 0.323 mol
: 12°C و 0.900 atm ؟

$R = 0.0821 \text{ L.atm/mol.K}$

Learning Outcomes Covered

◦ CHM.5.2.01.004

- a. 8.40 L
- b. 3.53 L
- c. 7.26 L
- d. 6.52 L

Which of the following is a characteristic of the ideal gas?

من الغاز المثالي؟

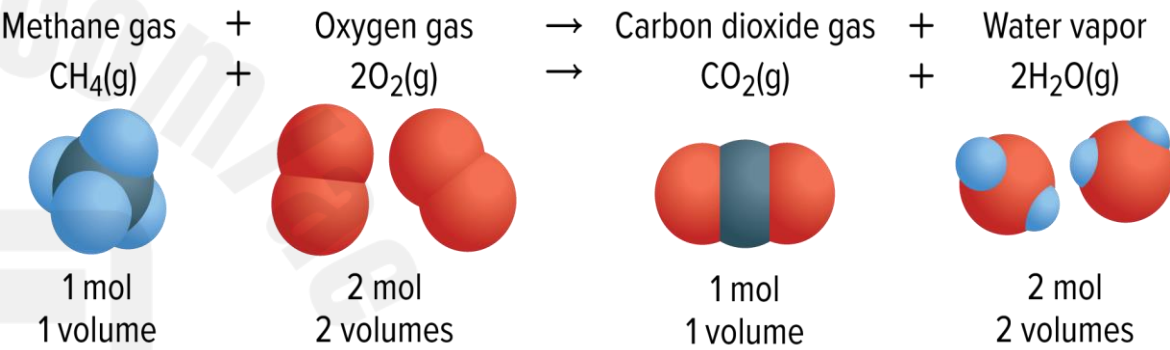
Learning Outcomes Covered

◦ CHM.5.2.01.003

- a. Its particles take up space and measured in volume units (L) فراغ و - عنها بوحدة الحجم (L)
- b. Its particles experience intermolecular attractive forces اذنب ب -
- c. Its particles move at variable velocities and on winding (zigzag) lines متغيرة ومسارات متعرجة
- d. Its particles collide with each other or with the wall surface in perfectly elastic way أو مع جدران الوعاء تصادمات

12. Calculate the amounts of gaseous reactants and products in a chemical reaction

- Gas laws can be applied to calculate gas stoichiometry.
- Coefficients in chemical equations represent molar amounts of substances in the reaction.
$$2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$$
- 2 mol of hydrogen gas reacts with 1 mol of oxygen gas, producing 2 mol of water vapor.
- For gases, coefficients represent both molar amounts and relative volumes.
- Therefore, 2 L of hydrogen gas reacts with 1 L of oxygen gas to produce 2 L of water vapor.



To find the volume of a gaseous reactant or product in a reaction, you must know the balanced equation for the reaction and the volume of at least one other gas involved in the reaction. The equation below shows the combustion of methane.

12. Calculate the amounts of gaseous reactants and products in a chemical reaction

Use with Example Problem 7.

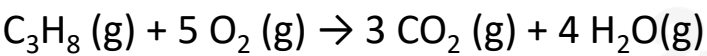
Problem

What volume of oxygen gas is needed for the complete combustion of 4.00 L of propane gas (C₃H₈)? Assume that pressure and temperature remain constant.

SOLVE FOR THE UNKNOWN

Use the balanced equation for the combustion of C₃H₈. Find the volume ratio for O₂ and C₃H₈, then solve for V_{O₂}.

- Write the balanced equation.



- Find the volume ratio for O₂ and C₃H₈

$$\frac{5 \text{ volumes O}_2}{1 \text{ volume C}_3\text{H}_8}$$

- Multiply the known volume of C₃H₈ by the volume ratio to find the volume of O₂.

$$\begin{aligned} V_{\text{O}_2} &= (4.00 \text{ L C}_3\text{H}_8) \times \frac{5 \text{ volumes O}_2}{1 \text{ volume C}_3\text{H}_8} \\ &= 20.0 \text{ L O}_2 \end{aligned}$$

38. How many liters of propane gas (C₃H₈) 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 (CH₄)?

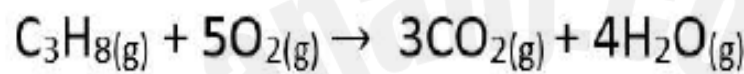
41. CHALLENGE Nitrogen and oxygen gases react to form dinitrogen monoxide gas (N₂O). What volume of O₂ is needed to produce 34 L of N₂O?

- 38. 6.80 L C₃H₈
- 39. 10.0 L H₂
- 40. 4.72 L O₂
- 41. 17 L O₂

12. Calculate the amounts of gaseous reactants and products in a chemical reaction

How many liters of propane gas (C₃H₈) will undergo complete combustion with 30.0 L of oxygen gas?
Assume that pressure and temperature remain constant

وبان (C₃H₈) التي سيتم احتراقها
من غاز الأكسجين؟
درجة الحرارة



a.

2 L

b.

1 L

c.

5 L

d.

6 L

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)
	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)

TABLE 1 TYPES OF COLLOIDS

Category	Example	Dispersed Particles	Dispersing Medium
Solid sol	colored gems	solid	solid
Sol	blood, gelatin	solid	liquid
Solid emulsion	butter, cheese	liquid	solid
Emulsion	milk, mayonnaise	liquid	liquid
Solid foam	marshmallow, soaps that float	gas	solid
Foam	whipped cream, beaten egg white	gas	liquid
Solid aerosol	smoke, dust in air	solid	gas
Liquid aerosol	spray deodorant, fog, clouds	liquid	gas

Which one of the following solutions has its solvent in the solid phase? التالية المذيب فيه بالحالة الصلبة؟

Learning Outcomes Covered

◦ CHM.5.2.02.007

a.

Dental amalgam

مملغم حشوة الأسنان

b.

Air

الهواء

c.

Ocean water

مياه المحيط

d.

Vinegar

الخل

Molarity

- **Molarity** is the number of moles of solute dissolved per liter of solution.

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

- Units of molarity are M , or mol/L.

17. Describe the concentration of solutions by using different units

CALCULATING MOLARITY

IN-CLASS EXAMPLE

Use with Example Problem 2.

Problem

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.

Response

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

SOLVE FOR THE UNKNOWN

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

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

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

Convert the volume of H_2O to liters.

- Use the conversion factor 1 L/1000 mL.

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

SOLVE FOR THE UNKNOWN (continued)

Solve for the molarity.

- State the molarity equation.

$$M = \left(\frac{\text{moles of solute}}{\text{liters of solutions}} \right)$$

- Substitute moles of $C_6H_{12}O_6$ = 0.0283 and volume of solution = liters of solution = 0.1005 L.

$$M = \left(\frac{0.0283 \text{ mol } C_6H_{12}O_6}{0.1005 \text{ L solution}} \right)$$

- Divide numbers and units.

$$M = \left(\frac{0.0283 \text{ mol } C_6H_{12}O_6}{0.1005 \text{ L solution}} \right) = 0.282 \text{ M}$$

EVALUATE THE ANSWER

The molarity value will be small because only a small mass of glucose was dissolved in the solution. The mass of glucose used in the problem has three significant figures; therefore, the value of the molarity also has three significant figures.

Practice questions – Molarity

Page: 315

16. What is the molarity of an aqueous solution containing 40.0 g of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) in 1.5 L of solution?
17. Calculate the molarity of 1.60 L of a solution containing 1.55 g of dissolved KBr.
18. What is the molarity of a bleach solution containing 9.5 g of NaOCl per liter of bleach?
19. **CHALLENGE** How much calcium hydroxide ($\text{Ca}(\text{OH})_2$), in grams, is needed to produce 1.5 L of a 0.25M solution?

16. 0.15M

17. $8.13 \times 10^{-3}\text{M}$

18. 0.13M

19. 28 g

A measure of a solution of how much solute is dissolved in specific amount of solvent or solution is _____.

ذاب الذائبة في كمية محدّدة من المذيب _____.

Learning Outcomes Covered

◦ CHM.5.2.03.002

a.

Mole ratio

النسبة المولية

b.

Concentration

التركيز

c.

Dilution

التخفيف

d.

Kelvin

الكلفن

Solubility of Gases

- Gases are less soluble in liquid solvents at higher temperatures than at lower temperatures.
- Solubility of gases increases as external pressure is increased.
- **Henry's law** states that at a given temperature, the solubility (S) of a gas in a liquid is directly proportional to the pressure (P).

$$\frac{S_1}{P_1} = \frac{S_2}{P_2}$$

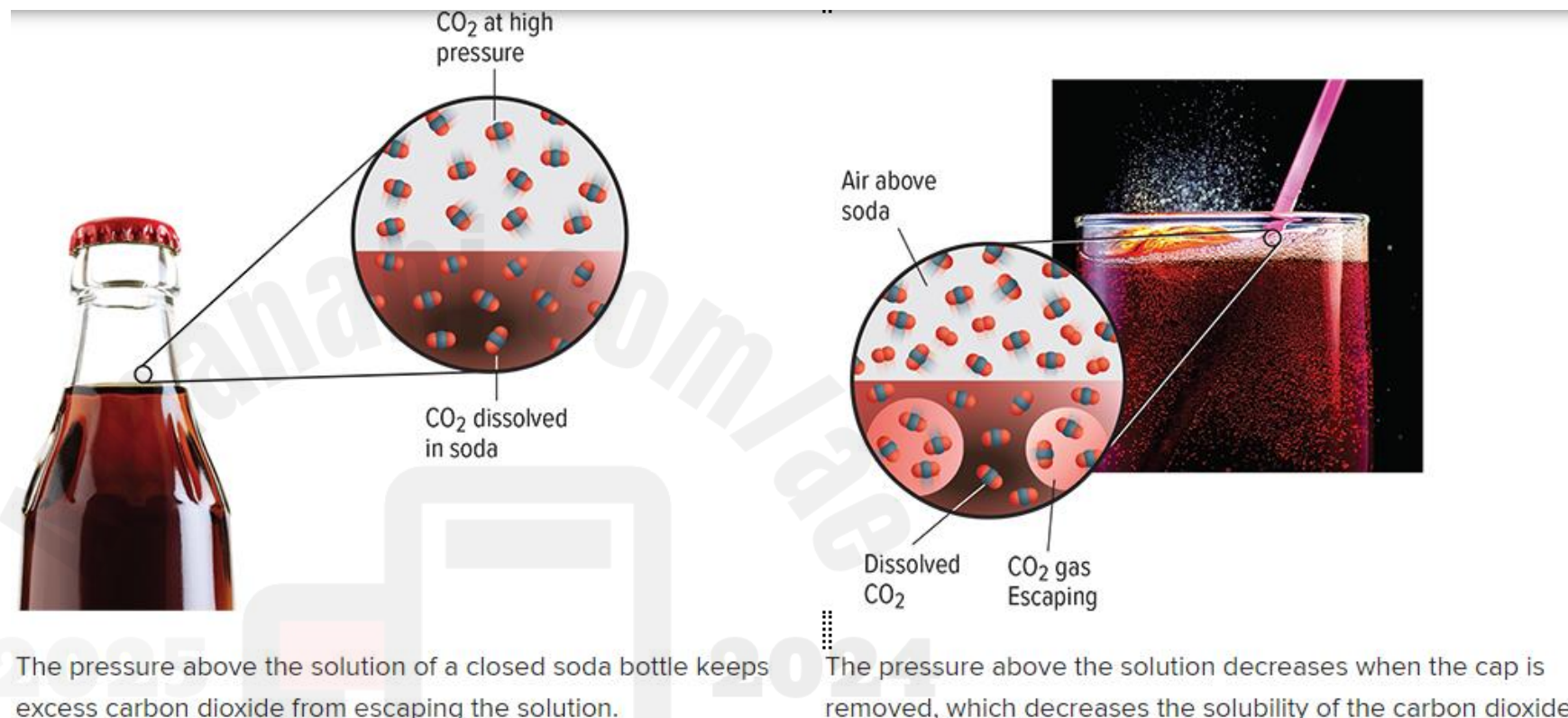


Figure 19 Carbon dioxide (CO₂) is dissolved in soda. Some CO₂ also is found in the gas above the liquid.

HENRY’S LAW

IN-CLASS EXAMPLE

Use with Example Problem 5.

Problem

If 0.85 g of a gas at 4.0 atm of pressure dissolves in 1.0 L of water at 25°C, how much will dissolve in 1.0 L of water at 1.0 atm of pressure and the same temperature?

Response

ANALYZE THE PROBLEM

You are given the solubility of a gas at an initial pressure. The temperature of the gas remains constant as the pressure changes. Because decreasing pressure reduces a gas’s solubility, less gas should dissolve at the lower pressure.

KNOWN

$S_1 = 0.85 \text{ g/L}$
 $P_1 = 4.0 \text{ atm}$
 $P_2 = 1.0 \text{ atm}$

UNKNOWN

$S_2 = ? \text{ g/L}$

SOLVE FOR THE UNKNOWN (continued)

- Substitute $S_1 = 0.85 \text{ g/L}$, $P_1 = 4.0 \text{ atm}$, and $P_2 = 1.0 \text{ atm}$. Multiply and divide numbers and units.

$$S_2 = \left(\frac{0.85 \text{ g}}{1.0 \text{ L}} \right) \left(\frac{1.0 \text{ atm}}{4.0 \text{ atm}} \right) = \mathbf{0.21 \text{ g/L}}$$

SOLVE FOR THE UNKNOWN

- State Henry’s law.
- Solve Henry’s law for S_2 .

$$\frac{S_1}{P_1} = \frac{S_2}{P_2}$$
$$S_2 = S_1 \left(\frac{P_2}{P_1} \right)$$

EVALUATE THE ANSWER

The solubility decreased as expected. The pressure on the solution was reduced from 4.0 atm to 1.0 atm, so the solubility should be reduced to one-fourth its original value, which it is. The unit g/L is a solubility unit, and there are two significant figures.

Practice questions

36. If 0.55 g of a gas dissolves in 1.0 L of water at 20.0 kPa of pressure, how much will dissolve at 110.0 kPa of pressure?
37. A gas has a solubility of 0.66 g/L at 10.0 atm of pressure. What is the pressure on a 1.0-L sample that contains 1.5 g of gas?
38. **CHALLENGE** The solubility of a gas at 7.0 atm of pressure is 0.52 g/L. How many grams of the gas would be dissolved per 1.0 L if the pressure increased 40.0 percent?

36. 3.0 g/L

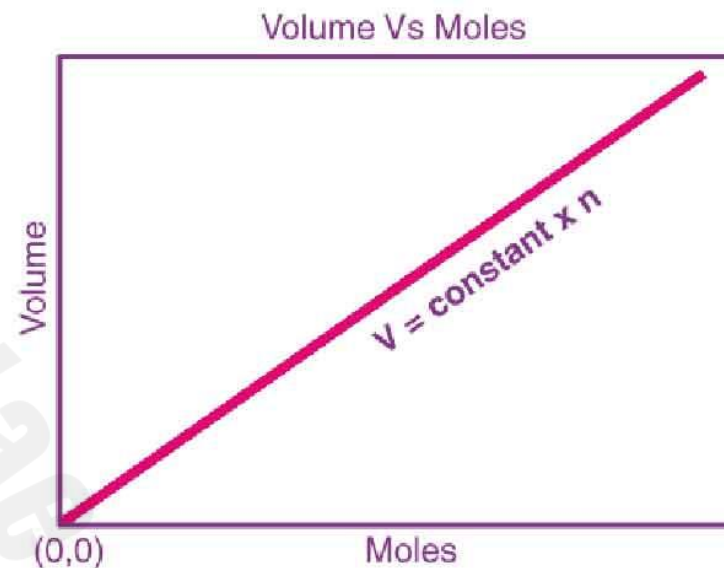
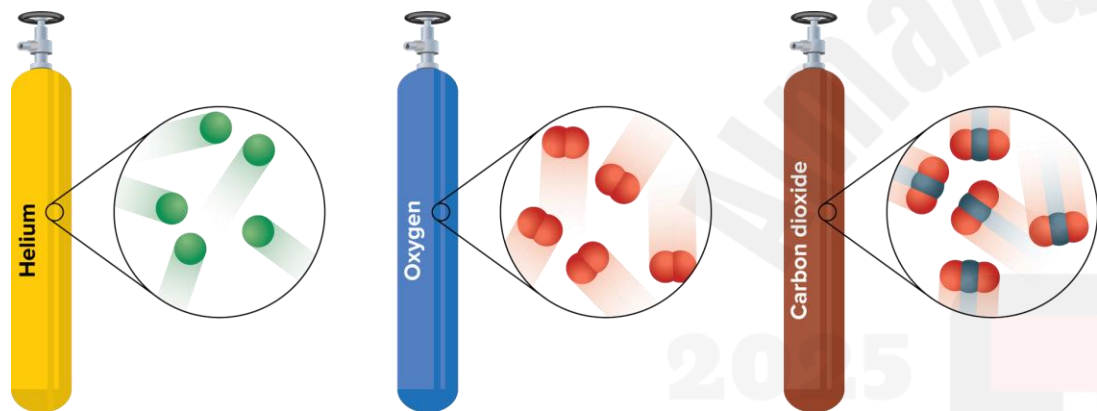
37. 23 atm

38. 0.73 g/L

8. Relate Avogadro's principle the number of particles of gas to the gas's volume

Avogadro's principle states that equal volumes of gases at the same temperature and pressure contain equal numbers of particles.

- The figure shows equal volumes of carbon dioxide, helium, and oxygen.



Volume and Moles

- The **molar volume** of a gas is the volume 1 mol occupies at 0.00°C and 1.00 atm of pressure.
- 0.00°C and 1.00 atm are called **standard temperature and pressure (STP)**.
- At STP, 1 mol of gas occupies 22.4 L.

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

8. Relate Avogadro's principle the number of particles of gas to the gas's volume

MOLAR VOLUME

IN-CLASS EXAMPLE

Use with Example Problem 5.

Problem

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.

Response

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

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

SOLVE FOR THE UNKNOWN

Determine the molar mass for methane.

- Determine the molecular mass.

$$M = 1\text{ C atom} \left(\frac{12.01\text{ amu}}{1\text{ C atom}} \right) + 4\text{ H atoms} \left(\frac{1.01\text{ amu}}{1\text{ H atom}} \right) = 12.01\text{ amu} + 4.04\text{ amu} = 16.05\text{ amu}$$

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

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

SOLVE FOR THE UNKNOWN (continued)

Determine the number of moles of methane.

- Convert the mass from kg to g.

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

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

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

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

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

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

EVALUATE THE ANSWER

The amount of methane present is much more than 1 mol, so you should expect a large volume, which is in agreement with the answer. The unit is liters, a volume unit, and there are three significant figures.

8. Relate Avogadro's principle the number of particles of gas to the gas's volume

Practice questions

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?

20. 1.03 L

21. 2.0 g

22. 102 mL

23. 0.111 L

24. 3.6×10^3 L

25. 14.6 L

8. Relate Avogadro’s principle the number of particles of gas to the gas’s volume

According to Avogadro’s principle, 1 mol of any gas
at STP occupies a volume of _____.

مول (mol) من أي غاز عند الضغط ودرجة الحرارة
جما قدره _____.

Learning Outcomes Covered

◦ CHM.5.2.01.006

a.

3.72 L

b.

22.4 L

c.

1.00 L

d.

6.02 L

Density and the ideal gas law

Recall that the density (D) of a substance is defined as mass (m) per unit volume (V). After rearranging the ideal gas equation to solve for molar mass, you can substitute D for m/V .

$$M = \frac{mRT}{pV}$$

substitute $\frac{m}{V} = D$

$$M = \frac{DRT}{P}$$

You can rearrange the new equation to solve for density.

$$D = \frac{MP}{RT}$$

Molar mass and the ideal gas law

To find the molar mass of a gas sample, the mass, temperature, pressure, and volume of the gas must be known. Recall that the number of moles of a gas (n) is equal to the mass (m) divided by the molar mass (M). Therefore, the n in the equation can be replaced by m/M .

$$PV = nRT$$

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

$$PV = \frac{mRT}{M}$$

You can rearrange the new equation to solve for the molar mass.

$$M = \frac{mRT}{PV}$$

Deriving Gas Laws

If you master the following strategy, you will need to remember only one gas law—the ideal gas law. Consider the example of a fixed amount of gas held at constant pressure. You need Charles’s law to solve problems involving volume and temperature.

1. Use the ideal gas law to write two equations that describe the gas sample at two different volumes and temperatures.
(Quantities that do not change are shown in red.)
2. Isolate volume and temperature—the two conditions that vary—on the same side of each equation.
3. Because n , R , and P are constant under these conditions, you can set the volume and temperature conditions equal, deriving Charles’s law.

$$PV_1 = nRT_1$$



$$\frac{V_1}{T_1} = \frac{nR}{P}$$



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

$$PV_2 = nRT_2$$



$$\frac{V_2}{T_2} = \frac{nR}{P}$$



2024

المناهج
موقع المناهج

10. Relate the amount of gas present to its pressure, temperature, and volume by the ideal gas law

Calculate the density of SO₂ gas, in grams per liter, at 55°C and 1.5 atm.

Calculate the density of CO₂(g) at 120°C and 790 mmHg pressure.

- ☐ 3.2 g/L
- ☐ 3.4g/L
- ☐ 3.6 g/L
- ☐ 3.8g/L
- ☐ None of the above

Correct Answer

3.6 g/L

- ☐ 0.032 g/L
- ☐ 1.4 g/L
- ☐ 1.8 g/L
- ☐ 3.4 g/L
- ☐ 8.0 g/L

Correct Answer

1.4 g/L

Calculate the molar mass of a gaseous substance if 0.125 g of the gas occupies 93.3 mL at STP.

- ☐ 30.0 g/mol
- ☐ 30.2 g/mol
- ☐ 30.4g/mol
- ☐ 30.6 g/mol
- ☐ None of the above

Correct Answer

30.0 g/mol

Use with Example Problem 8.

Problem

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?

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

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

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

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

SOLVE FOR THE UNKNOWN (continued)

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

- State the ideal gas law.

$$PV = nRT$$

- Solve for n .

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

- Substitute $P = 3.00 \text{ atm}$, $V_{\text{NH}_3} = 10.0 \text{ L}$, and $T = 298 \text{ K}$.

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

- Multiply and divide numbers and units.

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

- Find the molecular mass of NH_3 .

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

$$= 17.04 \text{ amu}$$

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

Convert moles of ammonia to grams of ammonia.

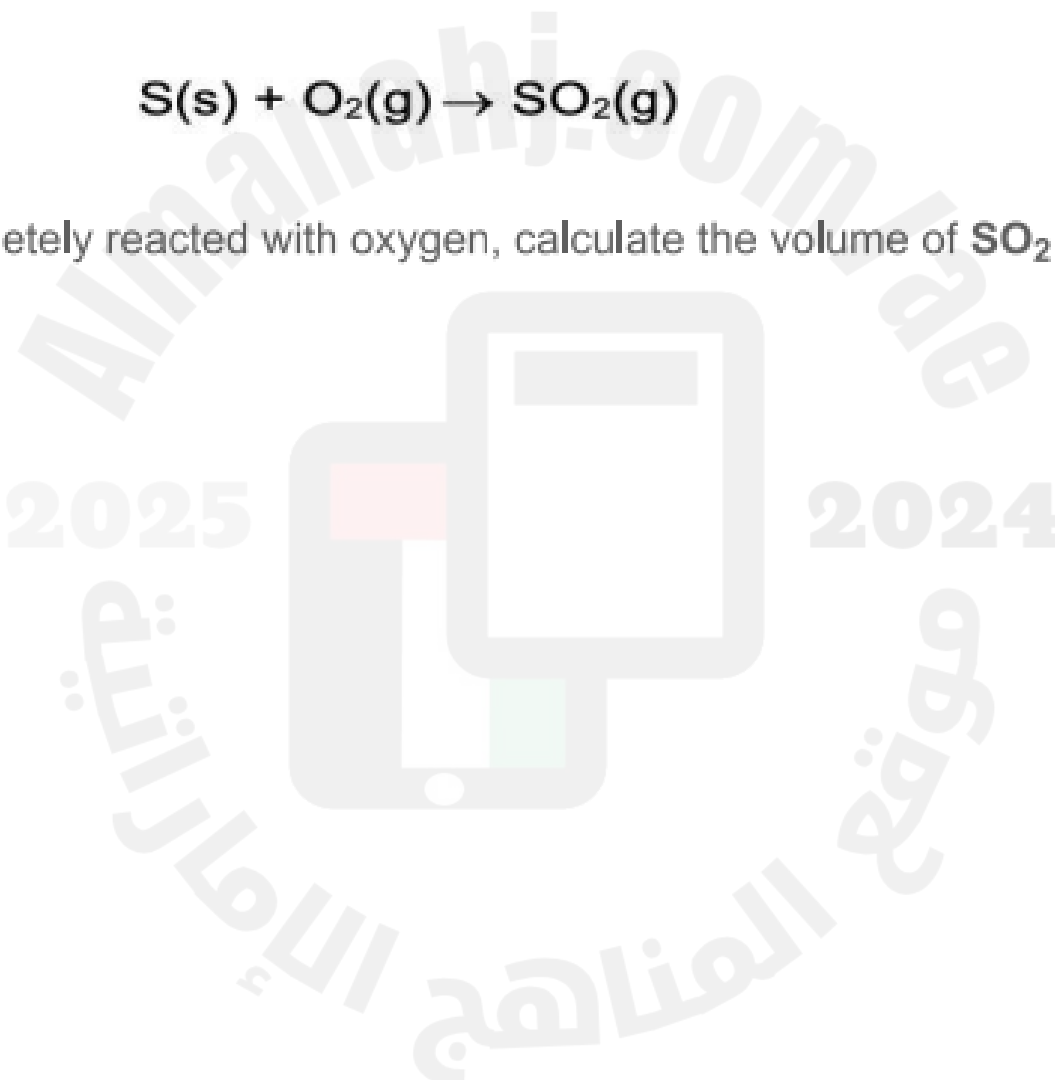
- Use the molar mass of ammonia as a conversion factor.

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

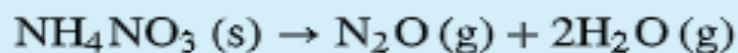
When coal is burned, the sulfur present in coal is converted to sulfur dioxide (SO₂), which is responsible for the acid rain phenomenon.



If 10 moles of sulfur (S) are completely reacted with oxygen, calculate the volume of SO₂ formed at 30.5 °C and 1.15 atm.



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.



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. 0.357 g NH_4NO_3

43. 533 L CO_2

44. 15.6 L O_2

45. 7.9 L CO_2

كربونات الكالسيوم

13. Calculate the amounts of gaseous reactants and products in a chemical reaction

What is the volume of carbon dioxide gas produced from the complete decomposition of 25 g from calcium carbonate by heating, according to the below equation, and at STP conditions? (if the molar mass of $\text{CaCO}_3 = 100 \text{ g/mol}$)
 $R = 0.0821 \text{ L.atm/mol.K}$



- a.

5.60 L
- b.

8.22 L
- c.

12.3 L
- d.

89.7 L

13. Calculate the amounts of gaseous reactants and products in a chemical reaction

In the chemical reactions' equations, which physical state/s of matter that can use their coefficients to represent both molar amounts and relative volumes?

الكيميائية، أي حالة/ حالات فيزيائية استخدام معاملاتها لتحديد كميات الحجمية لتلك المواد؟

i.	Gas	غاز	i.
ii.	Liquid	سائل	ii.
iii.	Solid	صلب	iii.

Learning Outcomes Covered

CHM.5.2.01.006

- a.

i and ii

أ و ب
- b.

i only

أ فقط
- c.

ii only

ب فقط
- d.

i, ii, and iii

أ ، ب ، و ج

$$M_1V_1 = M_2V_2$$



Step 1: The mass of the solute is measured.



Step 2: The solute is placed in a volumetric flask of the correct volume.



Step 3: Distilled water is added to the flask to bring the solution level up to the calibration mark.

Figure 8 Accurately preparing a solution of copper(II) sulfate involves several steps.

Explain why you cannot add 375 g of copper(II) sulfate directly to 1 L of water to make a 1.5M solution.

$$M_1V_1 = M_2V_2$$

Use with Example Problem 3.

Problem

If you 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?

SOLVE FOR THE UNKNOWN

Solve the molarity-volume relationship for the volume of the stock solution V_1 . Add direction bullet points as desired.

- State the dilution equation.

$$M_1V_1 = M_2V_2$$

- Solve for V_1 .

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

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

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

SOLVE FOR THE UNKNOWN (continued)

Solve the molarity-volume relationship for the volume of the stock solution V_1 . Add direction bullet points as desired.

- Multiply and divide numbers and units.

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

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

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

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 0.50 L of 5.00M stock solution of HCl is diluted to make 2.0 L of solution, how much HCl, in grams, is in the solution?

24. 125 mL

25. 5.0 mL

26. 91 g

How much 1M sodium hydroxide (NaOH), in milliliters, is needed to make 500 mL of 0.01M NaOH?

أصوديوم (NaOH) الذي تركيزه 1M بالمليتر
0.01M NaOH

Learning Outcomes Covered

- CHM.5.2.03.002
- CHM.5.2.03.003

a. 5 mL

b. 50 mL

c. 500 mL

d. 0.5 mL

Sample questions for Bonus

Which of the following factors generally increase the rate at which a **solid** dissolve in a liquid?

إمّل التالية تؤدي بشكل عام إلى زيادة معدل ذوبان
ما في مادة سائلة؟

i.	Increasing the pressure of the solution	زيادة في ضغط المحلول	i.
ii.	Shaking or stirring the solution	رّج أو تحريك المحلول	ii.
iii.	Increasing the surface area of the solute	زيادة في مساحة سطح المذاب	iii.
iv.	Increasing the temperature of the solvent	زيادة في درجة حرارة المذيب	iv.

- a. ☐ i and ii only ☐ i و ii فقط
- b. ☐ i, ii, and iii only ☐ i ، ii ، و iii فقط
- c. ☐ ii and iii only ☐ ii و iii فقط
- d. ☐ ii, iii and iv only ☐ ii ، iii و iv فقط

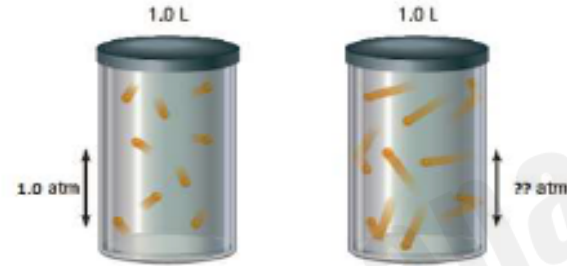
Sample questions for Bonus

The pressure for a gas in a cylinder is 1.00 atm at 300 K.

What will be the pressure if the temperature increases to 400 K?

في أسطوانة 1.00 atm عند 300 K.

لضغط إذا زادت درجة الحرارة إلى 400 K؟



Learning Outcomes Covered

◦ CHM.5.2.01.004

a.

0.75 atm

b.

1.30 atm

c.

2.44 atm

d.

2.67 atm

Sample questions for Bonus

What does “immiscible liquids” mean?

سائلان غير قابل للامتزاج؟

Learning Outcomes Covered

o CHM.5.2.03.001

a. They can be mixed together but separate shortly after

فصلان ، بعضهما البعض في فترة وجيزة

b. They are soluble in each other in any proportion

البعثر في نسبة كانت

c. They are insoluble in each other and would form a solid precipitate

ضوي أن راسب صلب

d. They have the maximum amount of dissolved solute

ن مذاب هم

Best of luck Boys

2025

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