

Gas laws and particle motion

AP Chemistry · Worksheet

Name: _____ Date: _____ Class: _____

These problems cover gas laws, the ideal gas equation, partial pressures, kinetic molecular theory and non-ideal behaviour. They are written for AP Chemistry unit 3 and match the data and graph skills used in the exam.

Early problems practise single steps and unit conversions. Later ones combine stoichiometry, mixtures and molecular speeds. In the last five, state your reasoning in sentences and show every substitution with units.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 3

Problem 1 Pressure units (easy)

Use $1 \text{ atm} = 101.3 \text{ kPa} = 760 \text{ mmHg}$.

1. Convert 0.750 atm to kPa and to mmHg .
2. Convert 95.0 kPa to atm .

Problem 2 Kelvin conversions (easy)

1. Convert 25°C , -40°C and 100°C to kelvin.
2. Convert 350 K to $^\circ\text{C}$.

Problem 3 Compressing a syringe (easy)

Wanjiru in Nairobi traps 6.0 L of air at 100 kPa in a bicycle pump and compresses it to 2.0 L at constant temperature.

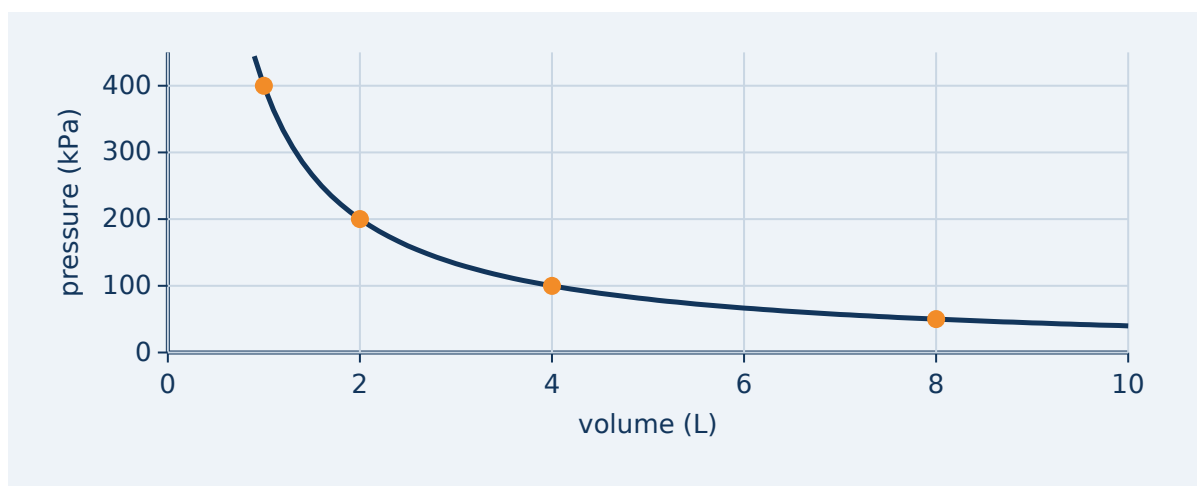
1. State the law that applies.
2. Calculate the new pressure.

Problem 4 Heating a balloon (easy)

A balloon holds 2.40 L of air at 27°C . It is warmed to 87°C at constant pressure.

1. Convert the temperatures to kelvin.
2. Calculate the new volume.

Problem 5 Reading a Boyle graph (easy)



Pressure against volume at constant temperature.

The graph shows one sample of gas at constant temperature.

1. Read the pressure at 2 L and at 8 L.
2. Calculate $P \times V$ for each point and state the pattern.
3. Predict the pressure at 10 L.

Problem 6 Kinetic theory statements (easy)

State whether each statement is true or false for an ideal gas, and correct the false ones.

1. Particles collide with the walls and lose energy.
2. Average kinetic energy depends only on temperature.
3. Particle volume is large compared with container volume.

Problem 7 Pressure from the ideal gas law (medium)

Emma in Leeds has 0.500 mol of gas in a 12.0 L tank at 20.0 °C. Calculate the pressure in kPa.

Problem 8 Identify a gas from its molar mass (medium)

A sample of unknown gas has mass 1.29 g, volume 0.500 L, pressure 100.0 kPa and temperature 27 °C (300.15 K).

1. Calculate the amount in mol.
2. Calculate the molar mass.
3. Choose from CH_3Cl (50.5 g/mol), $\text{C}_2\text{H}_5\text{Cl}$ (64.5 g/mol) and C_3H_8 (44.1 g/mol).

Problem 9 Density of carbon dioxide (medium)

Calculate the density of CO_2 (44.01 g/mol) at 25 °C and 101.3 kPa in g/L, and use it to explain why CO_2 collects in the bottom of a fermentation pit.

Problem 10 Partial pressures in a tank (medium)

A 20.0 L tank at 25 °C (298.15 K) contains 1.20 mol N₂ and 0.300 mol O₂.

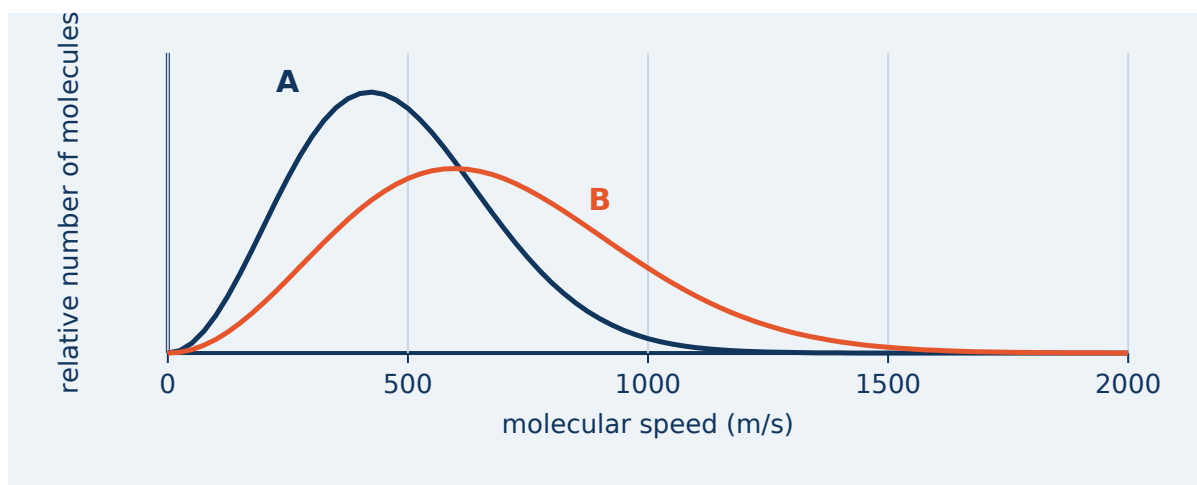
1. Calculate the total pressure.
2. Calculate the partial pressure of O₂.

Problem 11 Gas over water (medium)

Hydrogen is collected over water at 25 °C. The volume is 125 mL, the total pressure 101.3 kPa and the vapour pressure of water 3.17 kPa.

1. Calculate the partial pressure of hydrogen.
2. Calculate the amount of hydrogen in mol.

Problem 12 Two speed distributions (medium)



Speed distributions of the same gas at two temperatures.

Curves A and B show the speeds of N₂ molecules. A is at 300 K.

1. Identify the hotter sample and explain.
2. Estimate the temperature of B, using that the most probable speed is proportional to $\sqrt{T}$.
3. Compare the areas under the curves.

Problem 13 Pressure and temperature (medium)

A sealed 5.00 L can contains gas at 20.0 °C and 100.0 kPa. Use kinetic molecular theory to explain what happens to the pressure when the can is heated to 80.0 °C, then calculate the new pressure.

Problem 14 Effusion rates (medium)

Calculate how many times faster hydrogen (2.016 g/mol) effuses than oxygen (32.00 g/mol) under the same conditions. Use Graham's law, $\text{rate} \propto 1/\sqrt{M}$.

Problem 15 Gas from a reaction (medium)

Chiamaka in Lagos adds excess acid to 2.50 g of CaCO_3 (100.09 g/mol): $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$. Calculate the volume of CO_2 at 25 °C and 101.3 kPa.

Problem 16 Speeds of gas molecules (hard)

Calculate u_{rms} for N_2 (0.028014 kg/mol) and He (0.004003 kg/mol) at 300 K, using $u_{\text{rms}} = \sqrt{3RT/M}$, $R = 8.314 \text{ J/(mol}\cdot\text{K)}$.

Then explain why helium escapes from the atmosphere more easily than nitrogen.

Problem 17 A real gas calculation (hard)

One mole of CO_2 is held in 1.00 L at 300 K. For CO_2 , $a = 3.64 \text{ L}^2\cdot\text{bar/mol}^2$ and $b = 0.0427 \text{ L/mol}$; $R = 0.08314 \text{ L}\cdot\text{bar}/(\text{mol}\cdot\text{K})$.

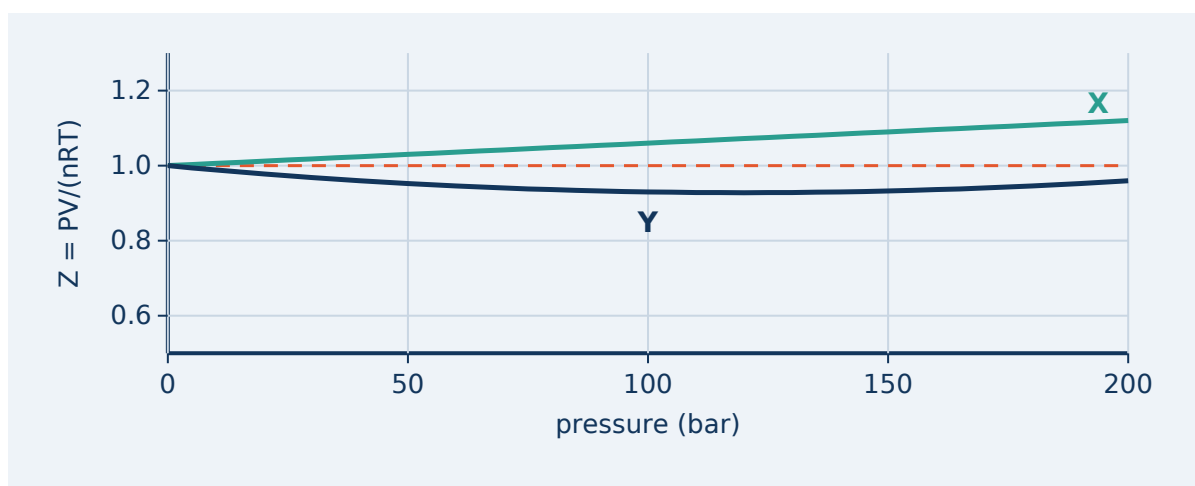
1. Calculate the pressure predicted by the ideal gas law.
2. Calculate the pressure using $(P + an^2/V^2)(V - nb) = nRT$.
3. Explain the difference.

Problem 18 Mixture from masses (hard)

Aarav in Pune has a 10.0 L vessel at 300 K with 8.00 g O_2 (32.00 g/mol) and 14.0 g N_2 (28.01 g/mol).

1. Calculate the amount of each gas.
2. Calculate the total pressure.
3. Calculate the mole fraction and the partial pressure of O_2 .

Problem 19 Interpreting compressibility (hard)



Compressibility factor Z of gases X and Y.

Gases X and Y are hydrogen and methane (not necessarily in that order). $Z = PV/(nRT)$.

1. State the value of Z for an ideal gas.
2. Identify X and Y and give your evidence.
3. Explain why Y dips below 1 at moderate pressure and rises above at high pressure.

Problem 20 Molar mass of a volatile liquid (hard)

Mei in Singapore vaporises a liquid in a 255 mL flask in boiling water (373.15 K) at 101.3 kPa. The vapour in the flask has mass 0.617 g.

1. Calculate the molar mass.
2. Explain why the flask must be at the same temperature as the boiling water.
3. Describe one source of error that would make the mass too low.