ANSWER KEY.

3.6 Deviation from Ideal Gas Law

AP Chemistry | ANSWER KEY

R = 0.08206 L·atm/(mol·K). Show work with units, and name the specific cause (attractions or particle volume) in every explanation.

1. Measured values of PV/nRT for three gas samples are 0.98, 0.72, and 1.15.

(a) Which sample behaves most like an ideal gas?

(b) For the sample at 0.72, is the measured pressure higher or lower than the ideal pressure? Which cause dominates?

(c) For the sample at 1.15, is the measured pressure higher or lower than the ideal pressure? Which cause dominates?

(a) 0.98, the closest to 1.

(b) Lower. Attractions dominate.

(c) Higher. Particle volume dominates.

2. A 1.00 mol sample of NH_3 is in a 1.00 L container at 300. K. Its measured pressure is 21.4 atm.

(a) Calculate the ideal gas pressure.

(b) Calculate PV/nRT.

(c) Explain the difference using the IMFs in NH_3.

(a) P = nRT/V = (1.00 mol)(0.08206 L·atm/(mol·K))(300. K) ÷ 1.00 L = 24.6 atm

(b) PV/nRT = 21.4 atm ÷ 24.6 atm = 0.870

(c) The ratio is less than 1, so attractions win. NH_3 has hydrogen bonding. Neighbors pull each molecule back as it nears the wall, so it hits with less force and the measured pressure is lower than ideal.

3. A sample of chlorine gas can be studied under any of these conditions.

Condition	A	B	C	D
Temperature	250 K	600 K	250 K	600 K
Pressure	10 atm	0.5 atm	0.5 atm	10 atm

(a) Under which condition is the gas most ideal? Justify your answer.

(b) Under which condition is the gas least ideal?

(a) B (600 K, 0.5 atm). At high T the molecules move fast, so attractions have little effect. At low P they are far apart, so attractions are weak and particle volume is tiny compared to the container.

(b) A (250 K, 10 atm), low T and high P.

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4. For each pair, under the same conditions, which gas deviates more from ideal behavior? Justify each answer by naming the IMFs.

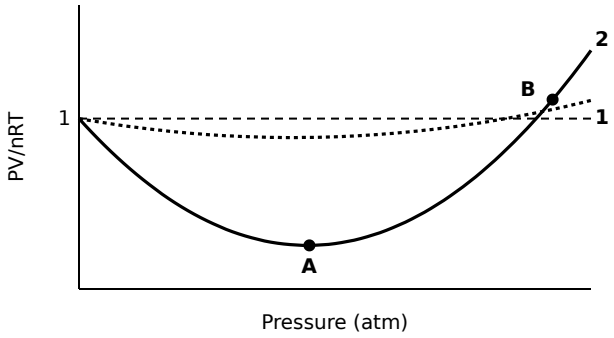
(a) F_2 or Cl_2

(b) methane or water vapor

(a) Cl_2. Both have only London dispersion forces, but Cl_2 has more electrons (34 vs. 18), so its dispersion forces are stronger. It is also a larger molecule.
(b) Water vapor (H_2O). The two have the same number of electrons (10), but H_2O has hydrogen bonding, while CH_4 is nonpolar with LDFs only. Stronger attractions mean more deviation.

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5. The graph shows *PV*/*nRT* vs. pressure for N_2 and CO_2 at the same temperature.



(a) Which curve, 1 or 2, is CO_2? Justify your answer.

(b) Explain why *PV*/*nRT* is less than 1 at point A but greater than 1 at point B.

(a) Curve 2. CO_2 has more electrons (22 vs. 14), so its London dispersion forces are stronger. Stronger attractions pull its ratio farther below 1.
(b) At A, the molecules are close enough for attractions to dominate, so they hit the walls with less force and P is lower than ideal. At B, the pressure is so high that particle volume is a large part of the container. With less free space, molecules hit the walls more often, so P is higher than ideal.

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6. A student says, "At extremely high pressure, *PV*/*nRT* is greater than 1 because the attractions between particles get stronger." Identify the error and correct it.

Attractions lower the pressure, so they make the ratio less than 1, not greater. The ratio rises above 1 because of particle volume: the particles fill so much of the container that there is less free space, so they hit the walls more often.

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