



AP[®] Chemistry (Operational) 2004 Sample Student Responses

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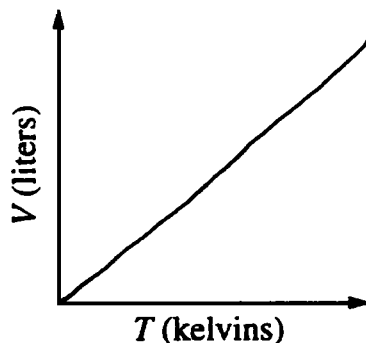
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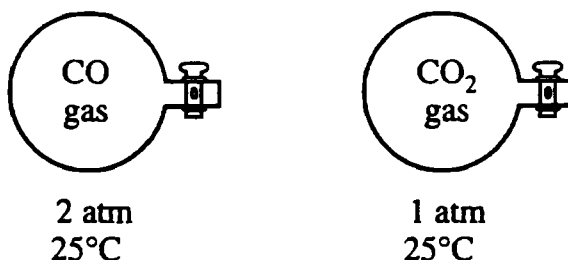
8. Answer the following questions about carbon monoxide, CO(g), and carbon dioxide, CO₂(g). Assume that both gases exhibit ideal behavior.

- (a) Draw the complete Lewis structure (electron-dot diagram) for the CO molecule and for the CO₂ molecule.
- (b) Identify the shape of the CO₂ molecule.
- (c) One of the two gases dissolves readily in water to form a solution with a pH below 7. Identify the gas and account for this observation by writing a chemical equation.
- (d) A 1.0 mole sample of CO(g) is heated at constant pressure. On the graph below, sketch the expected plot of volume versus temperature as the gas is heated.

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



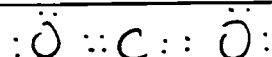
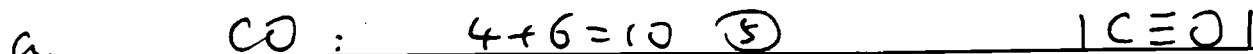
(e) Samples of CO(g) and CO₂(g) are placed in 1 L containers at the conditions indicated in the diagram below.



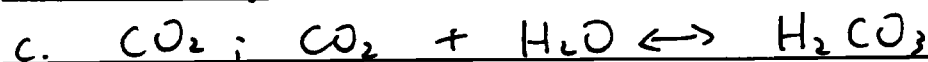
- (i) Indicate whether the average kinetic energy of the CO₂(g) molecules is greater than, equal to, or less than the average kinetic energy of the CO(g) molecules. Justify your answer.
- (ii) Indicate whether the root-mean-square speed of the CO₂(g) molecules is greater than, equal to, or less than the root-mean-square speed of the CO(g) molecules. Justify your answer.
- (iii) Indicate whether the number of CO₂(g) molecules is greater than, equal to, or less than the number of CO(g) molecules. Justify your answer.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 8.



b. linear



d.

e. i. Temperature is a measure of the average kinetic energy. Because the 2 gases are at the same temperature, their average ~~kin~~ molecular kinetic energies are equal.

ii. $v_{rms} = \sqrt{\frac{3RT}{M}}$

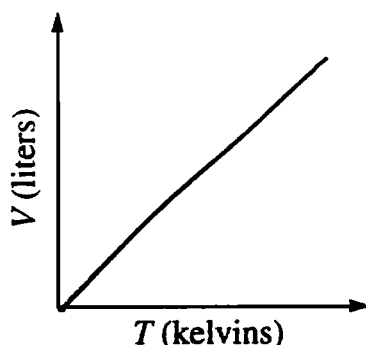
All other factors being equal, the molar mass of CO₂ is greater than that of CO, and therefore, according to above formula, the root-mean-square speed of the CO₂ molecules is less than that of CO molecules.

iii. $PV = nRT$
 $n = \frac{PV}{RT}$

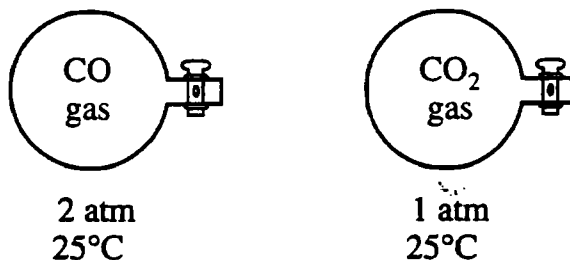
V, T, and R being equal, the pressure of CO is greater than that of CO₂, so there are more CO moles than CO₂ moles. The number of CO₂ molecules is less than the number of CO molecules.

8. Answer the following questions about carbon monoxide, $\text{CO}(g)$, and carbon dioxide, $\text{CO}_2(g)$. Assume that both gases exhibit ideal behavior.

- (a) Draw the complete Lewis structure (electron-dot diagram) for the CO molecule and for the CO_2 molecule.
- (b) Identify the shape of the CO_2 molecule.
- (c) One of the two gases dissolves readily in water to form a solution with a pH below 7. Identify the gas and account for this observation by writing a chemical equation.
- (d) A 1.0 mole sample of $\text{CO}(g)$ is heated at constant pressure. On the graph below, sketch the expected plot of volume versus temperature as the gas is heated.



(e) Samples of $\text{CO}(g)$ and $\text{CO}_2(g)$ are placed in 1 L containers at the conditions indicated in the diagram below.



- (i) Indicate whether the average kinetic energy of the $\text{CO}_2(g)$ molecules is greater than, equal to, or less than the average kinetic energy of the $\text{CO}(g)$ molecules. Justify your answer.
- (ii) Indicate whether the root-mean-square speed of the $\text{CO}_2(g)$ molecules is greater than, equal to, or less than the root-mean-square speed of the $\text{CO}(g)$ molecules. Justify your answer.
- (iii) Indicate whether the number of $\text{CO}_2(g)$ molecules is greater than, equal to, or less than the number of $\text{CO}(g)$ molecules. Justify your answer.

8. a) $:\text{C}::\text{O}:$ $:\ddot{\text{O}}::\text{C}::\ddot{\text{O}}:$
 b) linear
 c) (acid) $\text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3$
 d) on graph

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e)(i) The more pressure put on a molecule, the higher its kinetic energy will be. So CO gas has a higher kinetic energy because it has 2 atm of pressure.

(ii) Because CO₂ has a higher molar mass, its root-mean-square speed ~~is~~ is less. $v_{rms} = \sqrt{\frac{3kT}{m}}$
 \downarrow m ← the more you divide by the smaller your answer

(iii) Pressure + Volume is constant so more CO

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8. Answer the following questions about carbon monoxide, CO(g), and carbon dioxide, CO₂(g). Assume that both gases exhibit ideal behavior.

(a) Draw the complete Lewis structure (electron-dot diagram) for the CO molecule and for the CO₂ molecule.

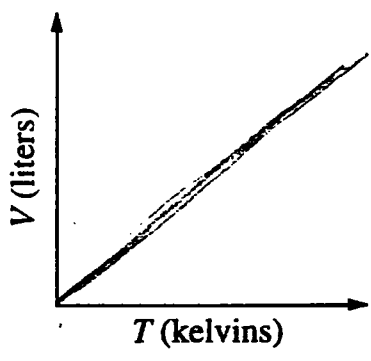
(b) Identify the shape of the CO₂ molecule.

10e⁻ 16e⁻

(c) One of the two gases dissolves readily in water to form a solution with a pH below 7. Identify the gas and account for this observation by writing a chemical equation.

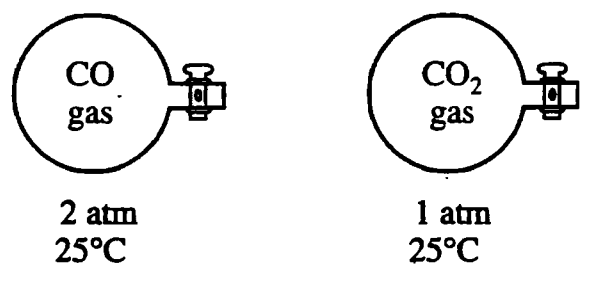


(d) A 1.0 mole sample of CO(g) is heated at constant pressure. On the graph below, sketch the expected plot of volume versus temperature as the gas is heated.



$\frac{PV}{T} = \frac{PV}{T}$
 $\frac{1}{T} = \frac{1}{T}$ $\frac{3}{1} = \frac{3}{1}$
 $\frac{4}{1} = \frac{2}{1}$

(e) Samples of CO(g) and CO₂(g) are placed in 1 L containers at the conditions indicated in the diagram below.



(i) Indicate whether the average kinetic energy of the CO₂(g) molecules is greater than, equal to, or less than the average kinetic energy of the CO(g) molecules. Justify your answer.

sqrt(3RT) M small - big gas

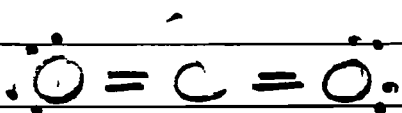
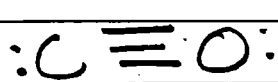
(ii) Indicate whether the root-mean-square speed of the CO₂(g) molecules is greater than, equal to, or less than the root-mean-square speed of the CO(g) molecules. Justify your answer.

(iii) Indicate whether the number of CO₂(g) molecules is greater than, equal to, or less than the number of CO(g) molecules. Justify your answer.

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a) CO CO₂



b) The CO₂ molecule is linear

c) CO dissolves in water



d) The relationship is $\frac{V_1}{T_1} = \frac{V_2}{T_2}$, thus they vary such that as temp increases, so does volume

e) i - $\frac{1}{2}mv^2$

The KE of the CO₂(g) would be greater than that of the CO as the mass is greater in CO₂. This increased collisions.

ii - The root mean square speed would be greater in the CO. This is because by increasing the molar mass, the speed is slowed as shown in the equation $u = \sqrt{\frac{3RT}{M}}$. By dividing by a small molar mass, the speed is increased assuming the conditions are the same.

iii - There would be more molecules of CO in order to have the same pressure within the two containers. As the individual molecules of CO are smaller, ~~the~~ more of them are required to attain ~~the~~ the same pressure.

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