AP® Chemistry (Operational)
2004 Sample Student Responses

 8A1

8. Answer the following questions about carbon monoxide, $CO(g)$, and carbon dioxide, $CO_2(g)$. Assume that both gases exhibit ideal behavior.

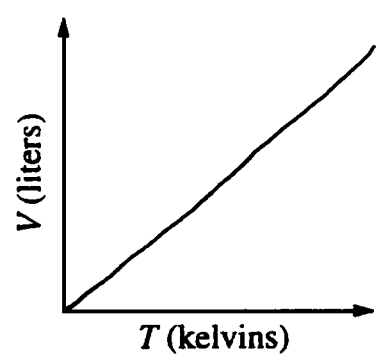
(a) Draw the complete Lewis structure (electron-dot diagram) for the CO molecule and for the CO_2 molecule.

(b) Identify the shape of the CO_2 molecule.

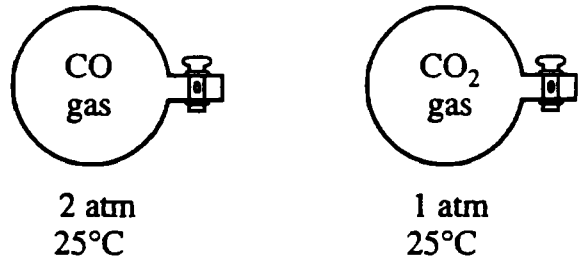
(c) One of the two gases dissolves readily in water to form a solution with a pH below 7. Identify the gas and account for this observation by writing a chemical equation.

(d) A 1.0 mole sample of $CO(g)$ 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 $CO_2(g)$ are placed in 1 L containers at the conditions indicated in the diagram below.



(i) Indicate whether the average kinetic energy of the $CO_2(g)$ 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 $CO_2(g)$ 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 $CO_2(g)$ molecules is greater than, equal to, or less than the number of $CO(g)$ molecules. Justify your answer.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

a. CO : $4+6=10$ (5) $|C\equiv O|$

$:C::O:$

CO_2 : $4+6\cdot2=16$ (8) $|\bar{O}=C=\bar{O}|$

$:\ddot{O}::C::\ddot{O}:$

b. linear

c. CO_2 ; $CO_2 + H_2O \leftrightarrow H_2CO_3$

d.

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

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

All other factors being equal, the molar mass of CO_2 is greater than that of CO, and therefore, according to above formula, the root-mean-square speed of the CO_2 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 CO_2, so there are more CO moles than CO_2 moles. The number of CO_2 molecules is less than the number of CO molecules.

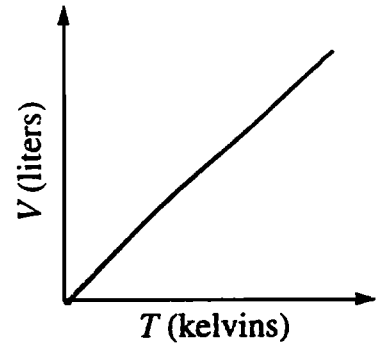
8. Answer the following questions about carbon monoxide, $CO(g)$, and carbon dioxide, $CO_2(g)$. Assume that both gases exhibit ideal behavior.

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



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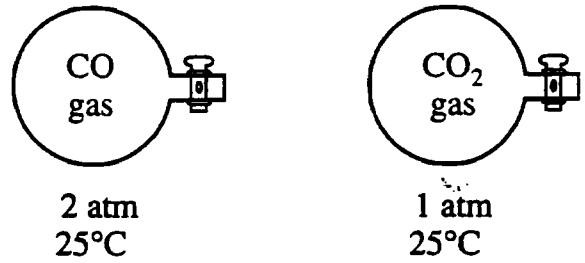

(i) Indicate whether the average kinetic energy of the $CO_2(g)$ molecules is greater than, equal to, or less than the average kinetic energy of the $CO(g)$ molecules. Justify your answer.

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(iii) Indicate whether the number of $CO_2(g)$ molecules is greater than, equal to, or less than the number of $CO(g)$ molecules. Justify your answer.

8. a) :C:::O: :Ö::C::Ö:

b) linear

c) (acid) $H_2O + CO_2 \rightarrow H_2CO_3$

d) on graph

ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

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 CO_2 has a higher molar mass, its root-mean-square speed is less. $u_{rms} = \sqrt{\frac{3kT}{m}}$ ← the more you divide by the smaller your answer

(iii) Pressure + Volume is constant so more CO

8C

8. Answer the following questions about carbon monoxide, $CO(g)$, and carbon dioxide, $CO_2(g)$. 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.

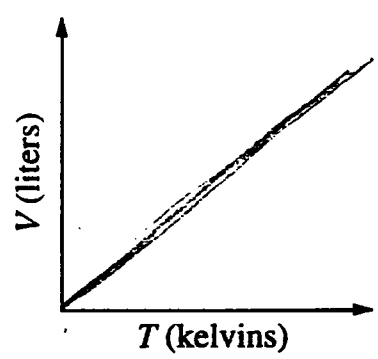
10e⁻ 16e⁻

(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.

$H_2O +$ 

(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.

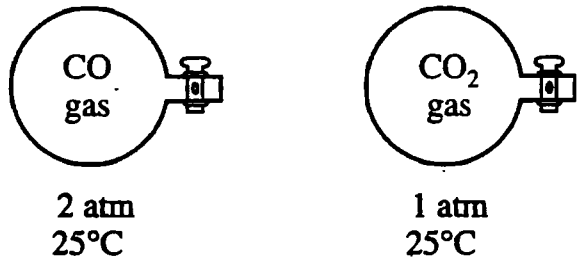


$\frac{PV}{T} = \frac{PV}{T}$

$\frac{V}{T} = \frac{V}{T}$ $\frac{3}{1} = \frac{9}{3}$

$\frac{4}{1} = \frac{8}{2}$

(e) Samples of $CO(g)$ and $CO_2(g)$ are placed in 1 L containers at the conditions indicated in the diagram below.



(i) Indicate whether the average kinetic energy of the $CO_2(g)$ molecules is greater than, equal to, or less than the average kinetic energy of the $CO(g)$ molecules. Justify your answer.

$\frac{3RT}{M}$ small-bigger

(ii) Indicate whether the root-mean-square speed of the $CO_2(g)$ 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 $CO_2(g)$ molecules is greater than, equal to, or less than the number of $CO(g)$ molecules. Justify your answer.

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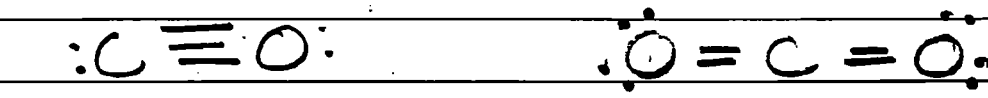
a) CO CO_2



b) The CO_2 molecule is linear

c) CO dissolves in water

$$2H_2O(l) + 2CO(g) \rightarrow CH_3COOH(aq) + O_2(g)$$

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 $CO_2(g)$ would be greater than that of the CO as the mass is greater in CO_2. This increases 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 ~~or~~ of CO are smaller, ~~the~~ more of them are required to attain ~~the~~ the same pressure.