



AP[®] Chemistry 2003 Sample Student Responses

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2A,

Answer EITHER Question 2 below OR Question 3 printed on page 14. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 20 percent.

2. A rigid 5.00 L cylinder contains 24.5 g of $N_2(g)$ and 28.0 g of $O_2(g)$.
- (a) Calculate the total pressure, in atm, of the gas mixture in the cylinder at 298 K.
- (b) The temperature of the gas mixture in the cylinder is decreased to 280 K. Calculate each of the following.
- (i) The mole fraction of $N_2(g)$ in the cylinder
- (ii) The partial pressure, in atm, of $N_2(g)$ in the cylinder
- (c) If the cylinder develops a pinhole-sized leak and some of the gaseous mixture escapes, would the ratio $\frac{\text{moles of } N_2(g)}{\text{moles of } O_2(g)}$ in the cylinder increase, decrease, or remain the same? Justify your answer.

A different rigid 5.00 L cylinder contains 0.176 mol of $NO(g)$ at 298 K. A 0.176 mol sample of $O_2(g)$ is added to the cylinder, where a reaction occurs to produce $NO_2(g)$.

- (d) Write the balanced equation for the reaction.
- (e) Calculate the total pressure, in atm, in the cylinder at 298 K after the reaction is complete.

$$(a) \quad 24.5 \text{ g } N_2 \times \frac{1 \text{ mol } N_2}{28.0 \text{ g } N_2} = .875 \text{ mol } N_2$$

$$28.0 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.0 \text{ g } O_2} = .875 \text{ mol } O_2$$

1.75 mol gas total

$$P(5.00 \text{ L}) = 1.75 \text{ mol} (.0821) 298 \text{ K}$$

$$P = 0.56 \text{ atm}$$

$PV = nRT$

$$(b) \quad (i) \quad X_{N_2} = \frac{.875 \text{ mol } N_2}{1.75 \text{ mol total}} = .500$$

$$(ii) \quad \frac{0.56 \text{ atm}}{298 \text{ K}} = \frac{X \text{ atm}}{280 \text{ K}}$$

$$\frac{P}{T} = \frac{P}{T}$$

$$X = 0.04 \text{ atm}$$

$$P_{N_2} = 0.04 \text{ atm} (.500)$$

$$P_A = P_{\text{total}} (X_A)$$

$$P_{N_2} = 4.02 \text{ atm}$$

GO ON TO THE NEXT PAGE.

2B,

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2. A rigid 5.00 L cylinder contains 24.5 g of $N_2(g)$ and 28.0 g of $O_2(g)$.
- (a) Calculate the total pressure, in atm, of the gas mixture in the cylinder at 298 K.
- (b) The temperature of the gas mixture in the cylinder is decreased to 280 K. Calculate each of the following.
- (i) The mole fraction of $N_2(g)$ in the cylinder
- (ii) The partial pressure, in atm, of $N_2(g)$ in the cylinder
- (c) If the cylinder develops a pinhole-sized leak and some of the gaseous mixture escapes, would the ratio $\frac{\text{moles of } N_2(g)}{\text{moles of } O_2(g)}$ in the cylinder increase, decrease, or remain the same? Justify your answer.

A different rigid 5.00 L cylinder contains 0.176 mol of $NO(g)$ at 298 K. A 0.176 mol sample of $O_2(g)$ is added to the cylinder, where a reaction occurs to produce $NO_2(g)$.

- (d) Write the balanced equation for the reaction.
- (e) Calculate the total pressure, in atm, in the cylinder at 298 K after the reaction is complete.

$$a) \quad PV = nRT$$

$$P = \frac{nRT}{V} \quad V = 5L \quad R = .0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K} \quad T = 298K$$

$$n = \text{total moles} = (24.5g N_2 / 28g/\text{mol} + 28.0g O_2 / 32g/\text{mol})$$

$$= .875 + .778 \text{ mol} = 1.65 \text{ mol}$$

$$P = \frac{(1.65 \text{ mol})(.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K})(298K)}{5L} = 8.09 \text{ atm}$$

$$P = 8.09 \text{ atm}$$

$$b) i) \quad \text{mol fraction} = \frac{\text{mol } N_2}{\text{total mol}} \quad \text{total mol} = 1.65$$

$$24.5g N_2 / 28g/\text{mol} = 0.875 \text{ mol}$$

$$\frac{0.875 \text{ mol}}{1.65 \text{ mol}} = 0.529 = \text{mol fraction } N_2$$

$$ii) \quad P = \frac{nRT}{V}, \quad n = .875 \text{ mol}, \quad R = .0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$$

$$T = 280K, \quad V = 5L$$

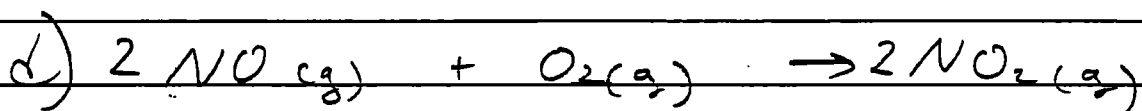
$$P_{N_2} = \frac{(.875 \text{ mol})(.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K})(280K)}{5L} = 4.02 \text{ atm} = P_{N_2}$$

GO ON TO THE NEXT PAGE.

2B2

ADDITIONAL PAGE FOR ANSWERING QUESTION 2.

c) The ratio of mols of $N_2(g)/O_2(g)$ would decrease since the rate of effusion is determined by $\frac{r_1}{r_2} = \frac{\sqrt{m_2}}{\sqrt{m_1}}$, meaning the smaller the molar mass, the faster the molecules will effuse, thus the N_2 w/ a MM of 28 g/mol will effuse faster than O_2 w/ a MM of 36 g/mol, resulting in a decrease in the mol $N_2(g)/O_2(g)$ ratio.



e) .176 mol $NO(g)$, .176 mol $O_2(g)$
 mol ratio of $NO:O_2 = 2:1$, ratio of $NO:NO_2 = 1:1$
 $.176 \text{ mol } NO + \frac{.176}{2} \text{ mol } O_2 \rightarrow .176 \text{ mol } NO_2$
 $.176/2 \text{ mol } O_2$ reacts, leaving $.176/2$ or $.088 \text{ mol } O_2$

$PV = nRT$

$n = \text{total mols} = .088 \text{ mol } O_2 + .176 \text{ mol } NO_2 = 0.264 \text{ mol}$

$R = .0821 \text{ c.atm/mol.k}$, $T = 298K$, $V = 5L$

$P = \frac{nRT}{V} = \frac{(0.264 \text{ mol})(.0821 \text{ c.atm/mol.k})(298K)}{5L} = 1.29 \text{ atm}$

$P = 1.29 \text{ atm}$

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2C1

Answer EITHER Question 2 below OR Question 3 printed on page 14. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 20 percent.

2. A rigid 5.00 L cylinder contains 24.5 g of $N_2(g)$ and 28.0 g of $O_2(g)$.
- (a) Calculate the total pressure, in atm, of the gas mixture in the cylinder at 298 K.
- (b) The temperature of the gas mixture in the cylinder is decreased to 280 K. Calculate each of the following.
- (i) The mole fraction of $N_2(g)$ in the cylinder
- (ii) The partial pressure, in atm, of $N_2(g)$ in the cylinder
- (c) If the cylinder develops a pinhole-sized leak and some of the gaseous mixture escapes, would the ratio $\frac{\text{moles of } N_2(g)}{\text{moles of } O_2(g)}$ in the cylinder increase, decrease, or remain the same? Justify your answer.

A different rigid 5.00 L cylinder contains 0.176 mol of $NO(g)$ at 298 K. A 0.176 mol sample of $O_2(g)$ is added to the cylinder, where a reaction occurs to produce $NO_2(g)$.

- (d) Write the balanced equation for the reaction.
- (e) Calculate the total pressure, in atm, in the cylinder at 298 K after the reaction is complete.

$$a) \quad 24.5 \text{ g } N_2 \times \frac{1 \text{ mol}}{28.0 \text{ g}} = .875 \text{ mol } N_2$$

$$28.0 \text{ g } O_2 \times \frac{1 \text{ mol}}{32.0 \text{ g}} = .875 \text{ mol } O_2$$

$$PV = nRT$$

$$P = \frac{nRT}{V}$$

$$= \frac{(2 \times .875 \text{ mol}) (.0821 \frac{\text{L atm}}{\text{mol K}}) (298 \text{ K})}{5.00 \text{ L}}$$

$$= \boxed{8.56 \text{ atm pressure in the cylinder}}$$

$$b) \quad i. \quad \text{mole fraction} = \frac{\text{mol } N_2}{\text{total mol}}$$

$$= \frac{.875 \text{ mol } N_2}{1.75 \text{ mol total}}$$

$$= \boxed{\frac{1}{2}} \quad \text{mole fraction of } N_2$$

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2.

ii.

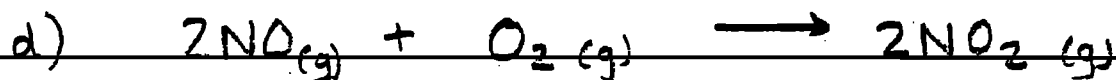
$$P_a = P_{\text{total}} \times \text{mole fraction}$$

$$= (8.56 \text{ atm}) \left(\frac{1}{2}\right)$$

$$= \boxed{4.28 \text{ atm}} \quad \leftarrow \text{part. pressure of } N_2 \text{ in cylinder}$$

c) No, the ratio $\frac{\text{mol } N_2}{\text{mol } O_2}$ would NOT remain the same. N_2 has

a smaller molecular weight than O_2 , therefore slightly more Nitrogen will escape from the hole compared to the O_2 . This changes the ratio of $\frac{\text{mol } N_2}{\text{mol } O_2}$.



$$e) \quad PV = nRT$$

$$P = \frac{nRT}{V}$$

$$= \frac{(0.176 \times 2 \text{ mol}) \left(0.0821 \frac{\text{L atm}}{\text{mol K}}\right) (298 \text{ K})}{(5.00 \text{ L})}$$

$$= \boxed{1.72 \text{ atm in the cylinder}}$$

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