1982 D

(a) From the standpoint of the kinetic-molecular theory, discuss briefly the properties of gas molecules that cause deviations from ideal behavior.

(b) At 25°C and 1 atmosphere pressure, which of the following gases shows the greatest deviation from ideal behavior? Give two reasons for your choice.

CH_4 SO_2 O_2 H_2

(c) Real gases approach ideality at low pressure, high temperature, or both. Explain these observations.

(a) The attractive forces between gas molecules will reduce the pressure compared to the ideal pressure. Gases have a volume and so larger gases increase the volume of the gas compared to the ideal volume.

(b) SO_2 would deviate most from ideal behavior. (1) SO_2 is a polar molecule (the only polar molecule in the list) and so they will experience strong attractive forces. (2) SO_2 has a larger molecular volume than the other molecules in the list.

(c) (1) At low pressure, there are relatively large distances between gas molecules so they experience few interactions where attractive forces would result.

(2) At high temperature, the high velocity of the particles allows them to break free of attractive forces, so the molecules travel in straighter lines and behave closer to ideal behavior.

1994 B

A student collected a sample of hydrogen gas by the displacement of water as shown by the diagram above. The relevant data are given in the following table.

GAS SAMPLE DATA	
Volume of sample	90.0 mL
Temperature	25°C
Atmospheric Pressure	745 mm Hg
Equilibrium Vapor Pressure of H_2O (25°C)	23.8 mm Hg

(a) Calculate the number of moles of hydrogen gas collected.

(b) Calculate the number of molecules of water vapor in the sample of gas.

(c) Calculate the ratio of the average speed of the hydrogen molecules to the average speed of the water vapor molecules in the sample.

(d) Which of the two gases, H_2 or H_2O, deviates more from ideal behavior? Explain your answer.

(a) $P_{H_2} = 745 - 23.8 = 721 \text{ mm Hg}$

$$\frac{721 \text{ mmHg}}{} \bigg| \frac{1 \text{ atm}}{760 \text{ mmHg}} = 0.949 \text{ atm}$$

$PV = nRT$

$$n = \frac{PV}{RT} = \frac{(0.949 \text{ atm})(0.090 \text{ L})}{(0.0821 \frac{\text{L·atm}}{\text{mol K}})(298 \text{ K})}$$

$n = 0.00349 \text{ moles } H_2$

(b) $P_{H_2O} = 23.8$ mmHg

$$\frac{23.8 \text{ mmHg}}{} \left| \frac{1 \text{ atm}}{760 \text{ mmHg}} \right. = 0.0313 \text{ atm}$$

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(0.0313 \text{ atm})(0.090 \text{ L})}{\left(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol K}}\right)(298 \text{K})}$$

$$n = 1.15 \times 10^{-4} \text{ moles } H_2O$$

$$\frac{1.15 \times 10^{-4} \text{ moles}}{} \left| \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol}} \right.$$

$$= 6.93 \times 10^{19} \text{ molecules } H_2O$$

(c) Both gases are at 25°C

$$\text{Ratio} = \frac{\text{velocity } H_2}{\text{velocity } H_2O}$$

$$= \frac{\sqrt{\frac{3(8.314)(298\text{K})}{0.00202}}}{\sqrt{\frac{3(8.314)(298\text{K})}{0.01801}}}$$

$$= 2.99$$

(d) H_2O deviates more from ideal behavior. It is more polar than H_2 causing significant attractions between molecules. It also has a larger molecular volume than H_2 and the kinetic molecular theory assumes the gas has no volume

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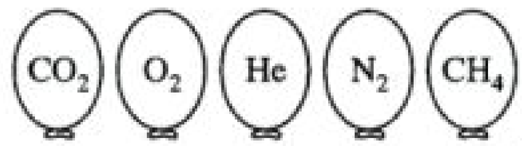
1996 D (Required)



Represented above are five identical balloons, each filled to the same volume at 25°C and 1.0 atmosphere pressure with the pure gases indicated.

(a) Which balloon contains the greatest mass of gas? Explain.

(b) Compare the average kinetic energies of the gas molecules in the balloons. Explain.

(c) Which balloon contains the gas that would be expected to deviate most from the behavior of an ideal gas? Explain.

(d) Twelve hours after being filled, all the balloons have decreased in size. Predict which balloon will be the smallest. Explain your reasoning.

2003 B

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.

6:55 PM

(a) Since all balloons have the same Volume, Temperatur, and pressure, they must contain the same number of moles.
To fing mass:
n x Molar mass
so CO_2 will have the highest mass since it has the highest molecular weight.

(b) All gases have the same K.E. because they are at the same temperature.

(c) CO_2 will deviate the most from ideal. All of the molecules listed are non-polar so molecular attractions will not play a role. KMT assumes that gases have no volume. CO_2 has the most volume so it will deviate from ideal more than the others.

(d) The He balloon will effuse faster than the others. He has the lowest molecular mass and according to Graham's Law, gases with lower molar mass effuse faster.

balloon will be the smallest. Explain your reasoning.

2003 B

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 $\frac{N_2(g)}{O_2(g)}$ 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.

1972

A 5.00 gram sample of a dry mixture of potassium hydroxide, potassium carbonate, and

6:55 PM

(a) $\frac{24.5\,g\,N_2 \mid 1\,mol}{\mid 28\,g} = 0.875\,mol\,N_2$

$\frac{28.0\,g\,O_2 \mid 1\,mol}{\mid 32\,g} = 0.875\,mol\,O_2$

$n_{Total} = 0.875 + 0.875 = 1.75\,mol$

$PV = nRT$

$P = \frac{nRT}{V} = \frac{(1.75\,mol)(0.0821)(298K)}{(5.00L)}$

$P = 8.56\,atm$ (3 sig figs)

(b) (i) $X_{N_2} = \frac{0.875\,mol}{1.75\,mol} = 0.500$

(ii) $P_{N_2} = 8.56 \cdot 0.500 = 4.28\,atm$

see next page

$P_{N_2} = 4.28$ before temp change

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\frac{4.28\,atm}{298K} = \frac{P_2}{280K}$

$P_2 = 4.02$ atm (This P_{N_2} after temp. change)

(c) The ratio of $\frac{N_2}{O_2}$ would decrease. N_2 has a lower molar mass than O_2 and therefore would effuse faster.

(d) $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

	$2NO(g)$	$O_2(g)$	$2NO_2(g)$
B	0.176 mol	0.176 mol	0 mol
$x = 0.088$ Δ	$-2x$	$-x$	$+2x$
A	0 mol	**0.088 mol**	**0.176 mol**

$n_{Total} = 0.088\,mol + 0.176\,mol = 0.264\,mol$

$PV = nRT$ $P = \frac{nRT}{V} = \frac{(0.264\,mol)(0.0821)(298K)}{(5.00L)}$

$P = 1.29$ atm 3 sig figs

1972

A 5.00 gram sample of a dry mixture of potassium hydroxide, potassium carbonate, and potassium chloride is reacted with 0.100 liter of 2.0 molar HCl solution.

(a) A 249 milliliter sample of dry CO_2 gas, measured at 22°C and 740 torr, is obtained from the reaction. What is the percentage of potassium carbonate in the mixture?

(b) The excess HCl is found by titration to be chemically equivalent to 86.6 milliliters of 1.50 molar NaOH. Calculate the percentages of potassium hydroxide and of potassium chloride in the original mixture.

(a) Find moles $CO_{2(g)}$ produced:

$T = 22°C + 273 = 295\,K$

$P = \dfrac{740\text{ torr} \mid 1\text{ atm}}{760\text{ torr}} = 0.97\text{ atm}$

$V = \dfrac{249\text{ mL} \mid 1\text{ L}}{1000\text{ mL}} = 0.249\text{ L}$

$PV = nRT \qquad n = \dfrac{PV}{RT}$

$n = 0.010$ moles (2 sig figs)

	K_2CO_3 +	$2HCl$ →	$2KCl + H_2O +$ CO_2
B	0.010 mol	0.020 mol	0 mol
Δ	−x	−2x	+x
A	0 mol	0 mol	0.010 mol

$\dfrac{0.010\text{ mol } K_2CO_3 \mid 138.2076\text{ g}}{1\text{ mol}} = 1.38\text{ g } K_2CO_3$

see next page

$\% K_2CO_3 = \left(\frac{\sout{1.38}\ 1.4\ g}{5.00}\right) \times 100 = 28\%$

(b)

- Amount of HCl that <u>did not</u> react:

  $1.50 M \cdot 0.0866 L = 0.1299 mol\ HCl$

- Amount of HCl in original solution:

  $2.0 M \cdot 0.100 L = 0.200 mol\ HCl$

- Amount of HCl reacted:

  $0.200 mol - 0.1299 mol = 0.0701 mol$

- Amount of HCl used by K_2CO_3:

  (see B & A table) 0.020 mol

- Amount of HCl that must have been used by KOH:

  $0.0701 - 0.020 mol = 0.0501 mol$

- Find amount of KOH reacted:

	KOH +	HCl →	KCl +	H_2O
B	0.0501	0.0501		
Δ	−x	−x		
A	0 mol	0 mol		

- $\frac{0.0501 mol\ KOH}{} \Big| \frac{56.0 g}{1 mol} = 2.8 g\ KOH$

see next page

$$\% \, KOH = \left(\frac{2.8 \, g}{5.00 \, g} \right) \times 100 = \boxed{56\%}$$

$$g \, KCl = 5.00 \, g \, (\text{total}) - 2.8 \, g \, (KOH) - 1.38 \, g \, (K_2CO_3)$$

$$= 0.82 \, g$$

$$\% \, KCl = \left(\frac{0.82 \, g}{5.00 \, g} \right) \times 100 = \boxed{16\%}$$