Recitation Worksheet (Optional Extra Practice)

Name: Key | UGA ID:

Textbook:
Chemistry & Chemical Reactivity
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Instructions:
- This recitation worksheet is optional extra practice for Ch. 10.3-10.6.
- You **do not** need to submit it to Gradescope.
- The answer key has been posted with this worksheet to eLC.
- A periodic table and formula sheet are attached to the end of this worksheet.

1. A sample of gas is held in a 7.50 L container at 1.66 atm. If the temperature of the gas is 43.0 °C, how many moles of the gas are in the container? Report your answer in **standard notation**.

$\boxed{0.480}$ mol

$PV = nRT$

$(1.66\ atm)(7.50\ L) = n\left(0.08206\ \frac{L\ atm}{mol\ K}\right)(43.0\ °C + 273.15)\ K$

2. A 6.50 L sample of gas is held at STP. How many moles of gas are in this sample? Report your answer in **standard notation**.

0 °C and 1 atm

$\boxed{0.290}$ mol

$PV = nRT$

$(1\ atm)(6.50\ L) = n\left(0.08206\ \frac{L\ atm}{mol\ K}\right)(273.15\ K)$

3. Consider a 15.0 L rigid container that holds nitrogen dioxide gas at 3.98 atm and 112.42 °C. How many *oxygen atoms* are in this container? Report your answer in **scientific notation**.

→ $38\underline{5}.57$ K

$\boxed{2.27} \times 10^{\boxed{24}}$ oxygen atoms

$PV = nRT$

$(3.98\ atm)(15.0\ L) = n\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(385.\underline{5}7\ K)$

$n = 1.8\underline{8}686\ mol\ NO_2$

$1.8\underline{8}686\ mol\ NO_2 \times \left(\frac{6.022e23\ molecules}{1\ mol}\right)\left(\frac{2\ O\ atoms}{1\ molecule}\right)$

$= \boxed{2.27e24\ O\ atoms}$

4. A scientist goes to the lab and finds that 2.10 g of an unknown gas exerts a pressure of 786.1 torr in a 500. mL container at 3.00 °C. Afterwards, they do elemental analysis on the gas and they determine the mass percentages in the table below.

Element	Mass Percentage
Nitrogen	30.45 %
Oxygen	69.55 %

Based on this information, what is the empirical formula of the gas? What is the molecular formula of the gas?

I. Empirical formula: NO_2

II. Molecular formula: N_2O_4

Assume 100 g :

$30.45 \text{ g } N \times \left(\frac{\text{mol}}{14.01 \text{ g}} N \right) = 2.17345 \text{ mol } N$

$69.55 \text{ g } O \times \left(\frac{\text{mol}}{16 \text{ g}} O \right) = 4.34688 \text{ mol } O$

$2.17345 \text{ mol } N / 2.17345 \text{ mol} = 1$

$4.34688 \text{ mol } O / 2.17345 \text{ mol} = 2$

$\boxed{NO_2}$

$$M = \frac{mRT}{PV} = \frac{(2.10 \text{ g})\left(0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}\right)(3.00 + 273.15 \text{ K})}{(786.1 \text{ torr} / 760) \text{ atm } (0.500 \text{ L})}$$

$= 92.01564 \text{ g/mol}$

NO_2 MM = 46.01 g/mol

Molecular : $92.01564 \text{ g/mol} / 46.01 \text{ g/mol} \rightarrow 2 \rightarrow \boxed{N_2O_4}$

$\rightarrow 293.15\ K$

5. A 96.0 g sample of a gas occupies 48.0 L at 0.921 atm and 20.0°C. What is the molecular weight of this gas?

$\boxed{C}$

$$M = \frac{mRT}{PV} = \frac{(96.0\ g)(0.08206\ \frac{L\ atm}{mol\ K})(293.15\ K)}{(0.921\ atm)(48.0\ L)}$$

A. 1.83 g/mol
B. 3.56 g/mol
C. 52.2 g/mol
D. 1390 g/mol
E. 5290 g/mol

6. A sample of gas is held in a rigid container. Which of the following statements are **false** about the density of the gases?

$\boxed{D}$

A. Decreasing the volume of the container while holding temperature constant would increase the density of the gas
B. Increasing the temperature of the gas, without changing the volume of the container, would not affect the density of the sample
C. Reacting the gas sample with chlorine to increase its molar mass, while keeping total moles the same, would also increase its density
D. None of the above are false
E. More than one of the above are false

$$d = \frac{m}{V} = \frac{MP}{RT}$$

7. A 249.9 mL sample of a diatomic gas has a mass of 1.782 g at STP. Calculate the molecular weight and determine the identity of the diatomic gas. Write the chemical formula of the gas in the answer box.

$$PV = nRT$$

Br_2

$$(1.0 \text{ atm})(249.9 \text{ mL}/1000 \text{ mL})\,L = n\left(0.08206 \frac{L \text{ atm}}{mol\ K}\right)(273.15\ K)$$

$$n = 0.011148539 \text{ mol}$$

$$\text{Molar mass} = \frac{1.782 \text{ g}}{0.011148539 \text{ mol}} = \frac{159.8358}{2} \rightarrow 79.9179 \text{ g/mol}$$

8. If a student needs to isolate 25.5 grams of Fe_2O_3 via the balanced reaction below, and the reaction has a 45.0% yield, what volume of O_2 (in L) will they need? The reaction will be conducted at 27.5 °C and 1.09 atm. You may assume FeS_2 will be in excess here. Report your answer in **standard notation**.

300.65 K

$$4\ FeS_2\ (s) + 11\ O_2\ (g) \rightarrow 2\ Fe_2O_3\ (s) + 8\ SO_2\ (g)$$

44.2

L

$$\%\ \text{yield} = \frac{\text{actual}}{\text{theor.}} \times 100 \rightarrow 45.0\% = \frac{25.5 \text{ g}}{\text{theor.}} \times 100$$

$$\text{theor.} = 56.66667 \text{ g } Fe_2O_3$$

$$56.66667 \text{ g } Fe_2O_3 \times \left(\frac{mol}{159.7\,g}\ Fe_2O_3\right) \times \left(\frac{11 \text{ mol } O_2}{2 \text{ mol } Fe_2O_3}\right) = 1.95158 \text{ mol } O_2$$

$$PV = nRT$$

$$(1.09 \text{ atm})(V) = (1.95158 \text{ mol } O_2)\left(0.08206 \frac{L \text{ atm}}{mol\ K}\right)(300.65\ K)$$

$$\boxed{V = 44.1725\ L}$$

9. A 45 g sample of methane reacts with an excess of oxygen at 245 °C to produce carbon dioxide gas and water vapor. The carbon dioxide was captured in a 30. L sealed container. What is the pressure (in atm) of the carbon dioxide within the container? Report your answer in **standard notation**.

$\boxed{4.0}$ atm

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 4H_2O_{(g)}$

$45 \text{ g } CH_4 \left(\frac{\text{mol}}{16.05 \text{ g } CH_4}\right)\left(\frac{1 \text{ mol } CO_2}{1 \text{ mol } CH_4}\right) = 2.8\underline{0}3738 \text{ mol } CO_2$

$PV = nRT$

$(P)(30.\text{ L}) = (2.8\underline{0}3738 \text{ mol } CO_2)\left(0.08206 \frac{\text{L atm}}{\text{mol K}}\right)(245 + 273.15)\text{K}$

10. A 1.10 g ribbon of magnesium reacted with 300.0 mL of 0.800 M HCl to produce magnesium chloride and hydrogen gas. If the reaction occurred at 25.0 °C at 1.00 atm, how much hydrogen gas (in liters) was generated? Begin the problem by writing a balanced chemical equation and determining the limiting reagent. Report your answer in **standard notation**.

$\boxed{1.11}$ L

$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$

$M = \frac{\text{mol}}{L} \rightarrow 0.800 \text{ M} = \frac{\text{mol}}{0.3000 \text{ L}} \rightarrow 0.240 \text{ mol}$

$1.10 \text{ g Mg} \left(\frac{\text{mol}}{24.31 \text{ g}}\right)\left(\frac{1 \text{ mol } H_2}{1 \text{ mol Mg}}\right) = 0.04\underline{5}2489 \text{ mol } H_2$

↳ limiting

$0.240 \text{ mol HCl} \left(\frac{1 \text{ mol } H_2}{2 \text{ mol HCl}}\right) = 0.120 \text{ mol } H_2$

$PV = nRT$

$(1.00 \text{ atm})(V) = (0.04\underline{5}2489 \text{ mol } H_2)\left(0.08206 \frac{\text{L atm}}{\text{mol K}}\right)(25.0 + 273.15)\text{K}$

11. A sample of 2.35 L of oxygen gas reacts with 3.72 L of hydrogen gas to form gaseous water, according to the equation below.

$$O_2 (g) + 2\ H_2 (g) \rightarrow 2\ H_2O (g)$$

If the system is held at constant pressure and temperature, how many liters of gaseous water will form?

Hint: try using the Law of Combining Volumes here.

$\boxed{B}$

$$2.35\ L\ O_2 \times \left(\frac{2\ L\ H_2O}{1\ L\ O_2}\right) = 4.70\ L\ H_2O$$

$$3.72\ L\ H_2 \times \left(\frac{2\ L\ H_2O}{2\ L\ H_2}\right) = 3.72\ L\ H_2O$$

↳ limiting

A. 0.152 L
B. 3.72 L
C. 4.70 L
D. 0.192 L
E. 6.07 L

12. A container is filled with various amounts of He, Ne, and Ar gas. It is determined that the partial pressure of He is 0.595 atm, and that the mole fraction of He is 0.425. Based on this information, what is the total pressure of the gaseous mixture?

$\boxed{B}$

$$X_{He} = \frac{n_{He}}{n_{total}} = \frac{P_{He}}{P_{total}}$$

$$0.425 = \frac{0.595\ atm}{P_{total}} \rightarrow P_{total} = \boxed{1.40\ atm}$$

A. 0.714 atm
B. 1.40 atm
C. 2.14 atm
D. There is not enough information to answer this question

13. Find the partial pressure of oxygen in dry air whose molar composition is O_2 (21.0%), N_2 (78.0%) and Ar (1.00%) and which has a total pressure of 5.00 atm.

$\boxed{D}$

$$5.00\ atm \times 0.210$$

A. 5.00 atm
B. 3.95 atm
C. 3.90 atm
D. 1.05 atm
E. 0.0500 atm

14. A scientist places two different gases into a closed, rigid container at 350 K. Which of the following statements below are true if the scientist adds a third gas to the container and keeps the temperature constant? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

DE

A. The partial pressure of the original two gases will decrease
B. The root mean square velocity of the original two gases will decrease
C. The molar mass of the original two gases will increase
D. The mole fraction of the original two gases will decrease
E. The total pressure of the container will increase

$\rightarrow 0.29165$ mol N_2

15. A 15.50 L gas bulb contains 8.17 g of N_2, 2.64 g of H_2, and 15.08 g of O_2. If the gas bulb is cooled to 15.0 °C, what is the partial pressure of nitrogen gas in atm? Report your answer in **standard notation**.

0.445 atm

$P_{N_2} V = nRT$

$P_{N_2}(15.50\ L) = (0.29165\ mol)(0.08206\ \frac{L\ atm}{mol\ K})(15.0 + 273.15\ K)$

16. A scientist goes to the lab to carefully collect hydrogen gas using both Mg metal and 2.00 M HCl according to the balanced equation given below. A table with the vapor pressure of water at various temperatures is also provided below for reference.

$$Mg\ (s) + 2\ HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2\ (g)$$

Temperature (°C)	Pressure (mm Hg)
20.0	17.55
25.0	23.78
30.0	31.86

→ 23.78 torr

→ P_{total}

I. If the atmospheric pressure at the time of the experiment was 752 torr, the temperature was 25.0 °C, and 279 mL of gas was collected, how many molecules of hydrogen were produced? Report your answer in **scientific notation**.

→ 298.15 K → 0.279 L

6.58 × 10^21 molecules hydrogen

$P_{total} = P_{H_2} + P_{H_2O}$

752 torr $= P_{H_2} + 23.78$ torr $\rightarrow P_{H_2} = 728.22$ torr $= 0.958184$ atm

$P_{H_2} V = nRT$

$(0.958184\ atm)(0.279\ L) = n\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(298.15\ K)$

$n = 0.0109266$ mol H_2

$0.0109266\ mol\ H_2 \times \left(\frac{6.022e23\ molecules}{1\ mol\ H_2}\right) = \boxed{6.58e21}$

II. Based on the information above, what volume of 2.00 M HCl did the scientist use (in mL) to complete this reaction? You may assume Mg metal was used in excess and that the percent yield was 100.0%. Report your answer in **standard notation**.

10.9 mL

$0.0109266\ mol\ H_2 \times \left(\frac{2\ mol\ HCl}{1\ mol\ H_2}\right) = 0.0218533$ mol HCl

$M = mol/L \rightarrow 2.00\ M = \frac{0.0218533\ mol\ HCl}{L} \rightarrow 0.0109266$ L HCl

$\rightarrow 10.9266$ mL

17. A student goes to the lab to collect O_2 gas over water by strongly heating (and thereby decomposing) a 0.500 g sample of *impure* Ag_2O according to the balanced reaction below:

$$2\ Ag_2O\ (s) \rightarrow 4\ Ag\ (s) + O_2\ (g)$$

↳ 296.15 K

If the student performs this experiment at 23.0 °C with a pressure of 1.010 atm, and they collect 15.9 mL of gas, what is the mass percentage of pure Ag_2O in the original sample? Note: the vapor pressure of water is 21.08 mm Hg at 23.0 °C. Report your answer in **standard notation**.

↳ 0.0277368 atm

59.6	%

$P_{total} = P_{O_2} + P_{H_2O}$

$1.010\ \text{atm} = P_{O_2} + 0.0277368\ \text{atm}$

$P_{O_2} = 0.9822632\ \text{atm}$

$P_{O_2} V = nRT$

$(0.9822632\ \text{atm})(0.0159\ L) = n\left(0.08206\ \frac{L\ \text{atm}}{\text{mol}\ K}\right)(296.15\ K)$

$n = 0.000642661\ \text{mol}\ O_2$

$0.000642661\ \text{mol}\ O_2 \times \left(\frac{2\ \text{mol}\ Ag_2O}{1\ \text{mol}\ O_2}\right) \times \left(\frac{231.74\ g}{\text{mol}}\ Ag_2O\right)$

$= 0.297861\ g\ Ag_2O$

$\%\ \text{pure}\ Ag_2O = \frac{0.297861\ g\ Ag_2O}{0.500\ g\ \text{sample}} \times 100 = \boxed{59.6\ \%}$

18. Identify the **incorrect** statement below:

$\boxed{D}$

A. The average kinetic energy of gas molecules is directly proportional to the temperature of the sample.
B. The average kinetic energy of molecules of different gases are equal at a given temperature.
C. The average speed of gas molecules is directly proportional to the square root of the temperature.
D. The average speed of molecules of different gases are ~~equal~~ at a given temperature.

19. At constant temperature, which gas has the **highest** average molecular speed?

$\boxed{B}$

A. Ne
B. CH_4 → smallest molar mass
C. H_2O
D. Ar
E. F_2

20. Calculate the root-mean-square speed (m/s) for nitrogen gas [N_2] at 35 °C [→ 308.15 K]. Report your answer in **standard notation**.

$\boxed{524}$ m/s

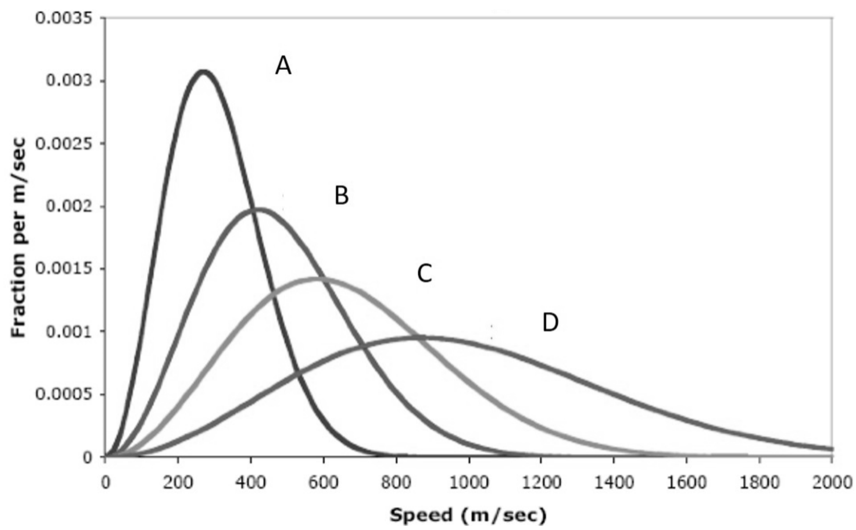
→ don't forget to change to kg!

N_2 $MM = 28.02\ g/mol = 0.02802\ kg/mol$

$$u_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314\ J/mol \cdot K \times 308.15\ K}{0.02802\ kg/mol}}$$

$$= \boxed{524\ m/s}$$

21. The velocity of different samples of gases are graphed below. Which of the following statements are **true** according to the graph? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).



BD

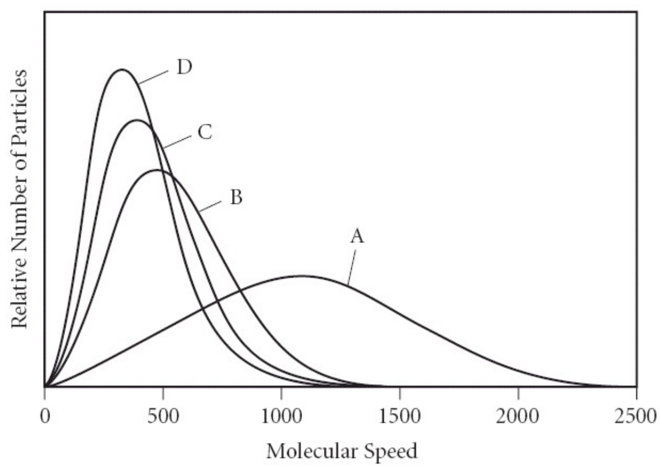
A. If all of the gases are at the same temperature, the gas with the lowest molar mass is graphed on line A
B. If all of the gases are at the same temperature, the gas with the lowest molar mass is graphed on line D
C. If all of the gases are the same molar mass, the gas with the highest temperature is graphed on line A
D. If all of the gases are the same molar mass, the gas with the lowest temperature is graphed on line A

22. Consider four hypothetical gases graphed below in the Maxwell—Boltzmann distribution (labeled A-D). The root mean square velocity (i.e. molecular speed) of all four gases were measured at different temperatures as shown in the table below. Based on this information, which of the following gases is correctly labeled “D” in the graph?

E

A. MX_2, because it was measured at the highest Kelvin temperature and because this molecule has the smallest number of atoms
B. MZ_4
C. MT_5
D. MQ_{12}, because it was measured at the lowest Kelvin temperature and because this molecule has the largest number of atoms
E. There is not enough information available to make a conclusion
(need molar masses)

Hypothetical Gases	Measured Temperature (K)
MX_2	855
MZ_4	453
MT_5	712
MQ_{12}	305



23. Which of the following would be **false** according to kinetic molecular theory?

$\boxed{D}$

A. All gases behave identically regardless of identity
B. Gases do not exchange energy when they collide with other gases or their container
C. The volume of a gas particle is negligible
D. Gases ~~exert small attractive forces on other gases~~, but no repulsive forces
E. The average kinetic energy of a gas rises with rising temperature

24. The average kinetic energies of CH_4 (g) and N_2 (g) molecules at 273 K and 546 K were measured. Which of the following are **true**? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

$\boxed{BEF}$

$KE = \frac{3}{2}RT$

A. The average kinetic energy is ~~not dependent on temperature.~~
B. The average kinetic energy is not dependent on the identity of the gas.
C. The average kinetic energy of CH_4 at 273 K is less than the average kinetic energy of N_2 at 273 K.
D. The average kinetic energy of CH_4 at 273 K is greater than the average kinetic energy of N_2 at 546 K.
E. The average kinetic energy of CH_4 at 273 K is less than the average kinetic energy of N_2 at 546 K.
F. Both CH_4 and N_2 will have the same average kinetic energy at a given temperature.

Additional Practice Questions:

$\rightarrow 200.15\ K$

1. How many molecules of an ideal gas are contained in 8.2 L at -73 °C and 0.50 atm?

$\boxed{B}$

$PV = nRT$

$(0.50\ atm)(8.2\ L) = n\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(200.15\ K)$

A. 0.25 molecules
B. 1.5 × 10^{23} molecules
C. -4.1 × 10^{23} molecules
D. 7.5 × 10^{23} molecules
E. 4.2 × 10^{-25} molecules

$n = 0.249630\ mol$

$0.249630\ mol \times \left(\frac{6.022e23\ molecules}{1\ mol}\right)$

2. Suppose 65.38 grams of Zn are added to a concentrated hydrochloric acid solution and hydrogen gas is liberated according to the following equation. How many liters of hydrogen gas would be generated, if it was collected *pure* at 25 °C and 1.00 atm pressure?

$\rightarrow 298.15\ K$

$$Zn + 2\ HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2\ (g)$$

$\boxed{A}$

$65.38\ g\ Zn \times \left(\frac{mol}{65.38\ g}\ Zn\right)\left(\frac{1\ mol\ H_2}{1\ mol\ Zn}\right) = 1.000\ mol\ H_2$

A. 24.5 L
B. 2.05 L
C. 134 L
D. 1.00 L

$PV = nRT$

$(1.00\ atm)(V) = (1.000\ mol\ H_2)\left(0.08206\ \frac{L\ atm}{mol\ K}\right)(298.15\ K)$

$V = 24.466\ L$

3. Determine the theoretical yield and the percent yield if 21.8 g of K_2CO_3 is produced from reacting 27.9 g KO_2 with 29.0 L of CO_2 (at STP). The molar mass of KO_2 = 71.10 g/mol and K_2CO_3 = 138.21 g/mol. ↳ 1 atm, 0 °C

$$4\ KO_2\ (s) + 2\ CO_2\ (g) \rightarrow 2\ K_2CO_3\ (s) + 3\ O_2\ (g)$$

$\boxed{A}$

A. 27.1 g, 80.4 % yield
B. 179 g, 12.2 % yield
C. 91.7 g, 23.8 % yield
D. 206 g, 10.6 % yield
E. 61.0 g, 35.7 % yield

$$27.9\ g\ KO_2 \times \left(\frac{mol}{71.1\ g}\ KO_2\right) = 0.392405\ mol\ KO_2$$

$$PV = nRT$$

$$(1\ atm)(29.0\ L) = n_{CO_2}\left(0.08206\ \frac{L\ atm}{mol\ K}\right)(273.15\ K)$$

$$n_{CO_2} = 1.293794\ mol\ CO_2$$

theor. yield ↓

$$0.392405\ mol\ KO_2 \times \left(\frac{2\ mol\ K_2CO_3}{4\ mol\ KO_2}\right) \times \left(\frac{138.21\ g}{mol}\ K_2CO_3\right) = \boxed{27.11715\ g}$$

$$1.293794\ mol\ CO_2 \times \left(\frac{2\ mol\ K_2CO_3}{2\ mol\ CO_2}\right) \times \left(\frac{138.21\ g}{mol}\ K_2CO_3\right) = 178.8153\ g$$

$$\%\ yield = \frac{21.8\ g}{27.11715\ g} \times 100 = \boxed{80.4\ \%}$$

4. Which of the following gases has the largest density at STP?

$\boxed{C}$

$d = \frac{MP}{RT}$

A. He
B. C_2H_2
C. F_2
D. N_2
E. H_2

$\uparrow M = \uparrow d$

5. A gas mixture consists of N_2, O_2, and Ne, where the mole fraction of N_2 is 0.55 and the mole fraction of Ne is 0.25. If the mixture is at STP in a 5.0 L container, how many molecules of O_2 are present? Report your answer in **scientific notation**.

$\hookrightarrow$ 1 atm, 0°C

$\boxed{2.7} \times 10^{\boxed{22}}$ molecules O_2

mole fraction O_2 = $1 - 0.55 - 0.25 = 0.20$

$PV = nRT$

$(1\ \text{atm})(5.0\ \text{L}) = n\left(0.08206\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}\right)(273.15\ \text{K}) \rightarrow n = 0.22\underline{3}068$ mol (total)

$0.20 = \frac{\text{mol } O_2}{0.22\underline{3}068 \text{ mol (total)}} \rightarrow 0.044\underline{6}136$ mol O_2

$0.044\underline{6}136$ mol $O_2 \times \left(\frac{6.022e23 \text{ molecules}}{1 \text{ mol } O_2}\right) = \boxed{2.\underline{6}8663e22 \text{ molecules}}$

6. Which of the following gas particles will travel the fastest at 525 K?

$\boxed{A}$

A. H_2 smallest molar mass
B. N_2
C. Ne
D. Cl_2
E. CO

7. A scientist measures the root mean square velocity of nitrogen dioxide gas molecules to be 684. m/s. What temperature is this experiment being performed at (in K)? Report your answer in **standard notation**.

863	K

$NO_2 \rightarrow 46.01\ g/mol \rightarrow 0.04601\ kg/mol$

$$684.\ m/s = \sqrt{\frac{3 \times (8.314\ J/mol\ K) \times (T)}{0.04601\ kg/mol}}$$

8. A sample of the gas occupying 2.24 L at 0 °C ($\rightarrow 273.15\ K$) and 1 atm is found to weigh 3.0 grams. Which one of the following substances could this gas be?

B

A. methane, CH_4
B. ethane, C_2H_6 $\rightarrow 30.08\ g/mol$
C. ethylene, C_2H_4
D. acetylene, C_2H_2

$$M = \frac{mRT}{PV} \rightarrow \frac{(3.0\ g)(0.08206\ \frac{L\ atm}{mol\ K})(273.15\ K)}{(1\ atm)(2.24\ L)}$$

9. What is the density of a hypothetical gas (molar mass = 150.0 g/mol) under STP conditions reported to three significant figures?

$\hookrightarrow 0\ °C$, 1 atm

C

A. 2.34 g/L
B. 73.1 g/L
C. 6.69 g/L
D. 25.6 g/L

$$d = \frac{MP}{RT}$$

$$= \frac{(150.0\ g/mol)(1\ atm)}{(0.08206\ \frac{L \cdot atm}{mol \cdot K})(273.15\ K)}$$

$$= \boxed{6.69\ g/L}$$

10. A 15.00 gram sample of potassium chlorate is decomposed according to the balanced equation below. What volume of oxygen gas (in L) was emitted if this reaction was performed under STP conditions? Report your answer in **standard notation**.

↳ 0°C, 1 atm

$$2\ KClO_3\ (s) \rightarrow 2\ KCl\ (s) + 3\ O_2\ (g)$$

4.115	L

$15.00\ g\ KClO_3 \times \left(\frac{mol\ KClO_3}{122.55\ g}\right)\left(\frac{3\ mol\ O_2}{2\ mol\ KClO_3}\right) = 0.18\underset{=}{3}5985\ mol\ O_2$

$PV = nRT$

$(1\ atm)(V) = (0.18\underset{=}{3}5985\ mol)\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(273.15\ K)$

$\boxed{V = 4.\underset{=}{1}1530\ L}$

11. A mixture of N_2 and O_2 has a total pressure of 1.45 atm. What is the partial pressure (in atm) of N_2 if there are 1.23 mol N_2 and 2.71 mol O_2 in the mixture?

0.453	atm

$\dfrac{1.23\ mol\ N_2}{(1.23\ mol + 2.71\ mol)\ total} \times 1.45\ atm$

12. A typical adult inhales 450 mL $\rightarrow 0.45\ L$ of air in any one breath. How many air particles are in a typical breath at 0.980 atm and 22°C $\rightarrow 295.15\ K$? Report your answer in **scientific notation**.

$\boxed{1.1} \times 10^{\boxed{22}}$ air particles

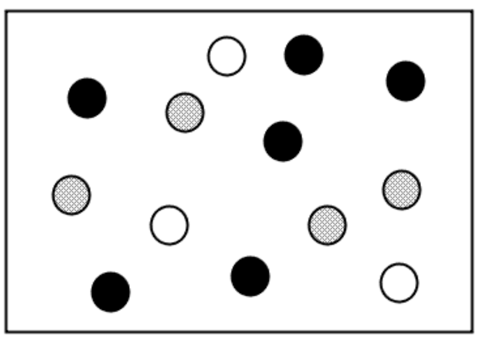
$PV = nRT$

$(0.980\ atm)(0.45\ L) = n\left(0.08206\ \frac{L\ atm}{mol\ K}\right)(295.15\ K)$

$n = 0.018208086\ mol$

$0.018208086\ mol \times \left(\frac{6.022 \times 10^{23}\ \text{air particles}}{1\ mol}\right)$

13. What is the partial pressure (in atm) of each component pictured below if the total pressure is 4.5 atm? Assume each circle is 1 mole.



$\rightarrow$ total = 13 moles

I. ● $\boxed{2.1}$ atm $\quad \frac{6\ mol}{13\ mol} \times 4.5\ atm$

II. ◍ $\boxed{1.4}$ atm $\quad \frac{4\ mol}{13\ mol} \times 4.5\ atm$

III. ○ $\boxed{1.0}$ atm $\quad \frac{3\ mol}{13\ mol} \times 4.5\ atm$

14. A small piece of zinc reacts with an excess of hydrochloric acid according to the balanced reaction below.

$$Zn\ (s) + 2\ HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2\ (g)$$

A total of 87.5 mL of gas was collected over water at 25.0 °C while monitoring the reaction. The gas pressure was recorded at 757 mm Hg. What was the initial mass of zinc metal (in grams) assuming all of the H_2 gas was captured? A table listing the vapor pressure of water at various temperatures is provided below. Report your answer in **standard notation**.

Temperature (°C)	Vapor Pressure (torr)
15.0	12.79
17.0	14.54
19.0	16.49
21.0	18.66
23.0	21.08
25.0	23.78
30.0	31.86

$\boxed{0.226}$ g

$P_{total} = P_{H_2} + P_{H_2O}$

$757\ mm\ Hg = P_{H_2} + 23.78\ mm\ Hg$

$P_{H_2} = 733.22\ mm\ Hg \rightarrow 0.9647632\ atm$

$PV = nRT$

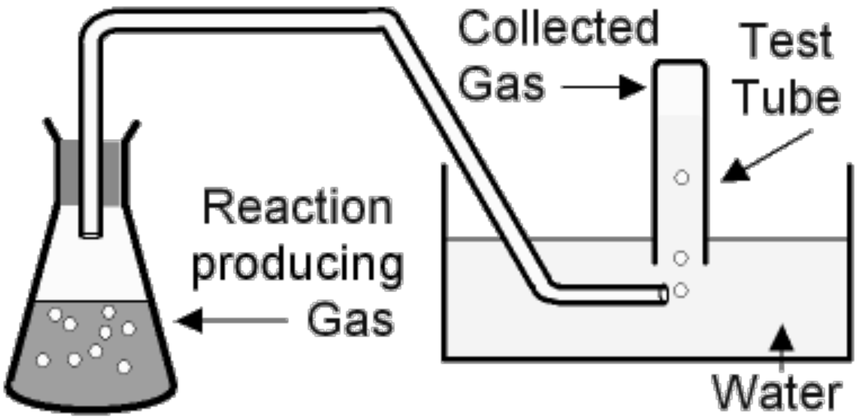
$(0.9647632\ atm)(87.5\ mL / 1000\ mL)L = n\left(0.08206\ \frac{L\ atm}{mol\ K}\right)(25.0 + 273.15)K$

$n = 0.0034503\ mol\ H_2$

$0.0034503\ mol\ H_2 \left(\frac{1\ mol\ Zn}{1\ mol\ H_2}\right)\left(\frac{65.38\ g}{mol}\ Zn\right)$

15. A 231.0 mL sample of hydrogen gas is collected over water at 22.50 °C in an apparatus similar to the one below.

→ 295.65 K



The total pressure of the system is 765.1 mmHg, and the vapor pressure of the water (22.50 °C) is 20.467 mmHg. How many moles of hydrogen gas formed? Report your answer in **scientific notation**.

$\boxed{9.329} \times 10^{\boxed{-3}}$ mol

$P_{total} = P_{H_2} + P_{H_2O}$

$765.1 \text{ mm Hg} = P_{H_2} + 20.467 \text{ mm Hg}$

$P_{H_2} = 744.633 \text{ mm Hg} \rightarrow 0.9797803 \text{ atm}$

$P_{H_2} V = nRT$

$(0.9797803 \text{ atm})(0.2310 \text{ L}) = n(0.08206 \frac{\text{L atm}}{\text{mol K}})(295.65 \text{ K})$

$n = 9.328918 \times 10^{-3} \text{ mol } H_2$

→ 304.65 K

16. What is the root mean square velocity (in m/s) of an argon atom at 31.5 °C? Report your answer in **standard notation**.

→ 39.95 g/mol = 3.995e-2 kg/mol

$\boxed{436.1}$ m/s

$$u_{rms} = \sqrt{\frac{3 \times (8.314 \text{ J/mol} \cdot \text{K}) \times (304.65 \text{ K})}{3.995\text{e-}2 \text{ kg/mol}}}$$

not needed 7.09e-2 kg/mol

17. A 20.00 g sample of Cl_2 gas (molar mass = 70.90 g/mol) is placed in a closed container at 26.0 °C. What is the root-mean-square velocity of this gas?

↳ 299.15 K

$\boxed{D}$

$$u_{rms} = \sqrt{\frac{3 \times (8.314\ J/mol\ K) \times (299.15\ K)}{7.09 \times 10^{-2}\ kg/mol}}$$

A. 3.024 m/s
B. 10.26 m/s
C. 14.51 m/s
D. 324.4 m/s
E. 458.8 m/s

18. Rank the molecular velocity of the following gases at 273 K from *slowest* to *fastest*.

$\boxed{B}$

A. H_2, NH_3, N_2
B. N_2, NH_3, H_2 — N_2 largest molar mass
C. NH_3, N_2, H_2 — H_2 smallest molar mass
D. NH_3, H_2, N_2
E. More information is needed to rank the velocity

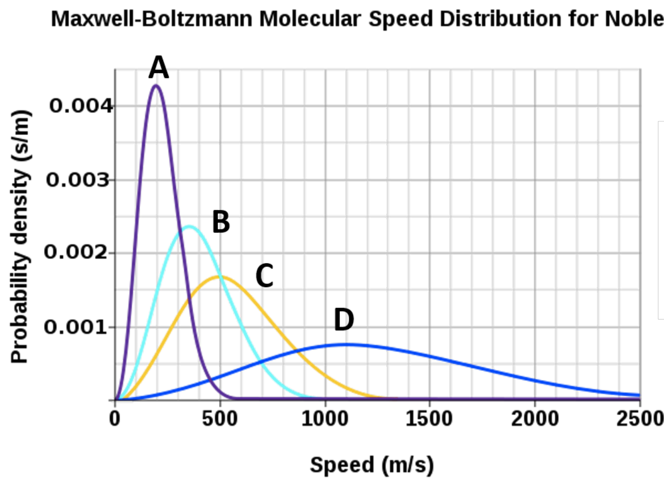
19. The temperature of a gas is doubled. By how much would the root-mean-square velocity change?

$\boxed{E}$

A. It would double
B. It would increase by a factor of √2
C. It would halve
D. It would decrease by a factor of √2
E. It would increase, but the units on the temperature must be known for an exact calculation

↳ Kelvin temp. only is proportional

20. Four noble gases – neon, argon, krypton, and xenon - are put into identical containers and held at the same temperature. Their speeds were measured and graphed below. Which of the lines represents neon? Write the corresponding letter in the box below.



D

Ne = smallest molar mass,
highest velocity

21. A student goes to lab and places 5.00 moles of Xe gas, 5.00 moles of Ar gas, and 5.00 moles of He gas in a rigid 25.00 L vessel at 24.1°C. Afterward, the student determines the total pressure exerted by the gas mixture. Which of the following is **true** regarding the partial pressures of these gases?

A

A. The partial pressure exerted by each gas is equal → equal moles
B. The partial pressure exerted by Ar gas is greatest
C. The partial pressure exerted by He gas is greatest because it has the smallest atomic mass
D. The partial pressure exerted by Xe gas is greatest because it has the largest atomic mass
E. The total pressure of the gas mixture is necessary to make a conclusion

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc [97]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
37 Cs 132.91	56 Ba 137.33		72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]		104 Rf [267]	105 Db [268]	106 Sg [269]	107 Bh [270]	108 Hs [269]	109 Mt [277]	110 Ds [281]	111 Rg [282]	112 Cn [285]	113 Nh [286]	114 Fl [290]	115 Mc [290]	116 Lv [293]	117 Ts [294]	118 Og [294]

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [262]

Formula Sheet

Length
1 kilometer = 0.62137 mile
1 inch = 2.54 centimeters (exactly)
1 Ångstrom = 1×10^{-10} meter

Energy
1 joule = 1 $kg \cdot m^2/s^2$
1 calorie = 4.184 joules
1 Calorie = 1 kilocalorie = 1000 calories
1 L·atm = 101.325 joules

Pressure
1 pascal = 1 N/m^3 = 1 $kg/m \cdot s^2$
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in^2
1 bar = 1×10^5 Pa (exactly)

Temperature
0 K = −273.15°C
K = °C + 273.15
°C = (5/9)(°F − 32)

Mass
1 kg = 2.205 lbs

Volume
1 mL = 1 cm^3 = 1 cc

Constants
$c = 2.998 \times 10^8$ m/sec
$h = 6.626 \times 10^{-34}$ J·sec
R = 0.08206 L·atm/mol·K = 8.314 J/mol·K
Specific heat of water = 4.184 J/g·K
Mass of an electron: 9.109×10^{-31} kg
Mass of a proton: 1.673×10^{-27} kg
RH = 2.18×10^{-18} J
Specific heat of water = 4.184 J/g·K
Avogadro's number: 6.022×10^{23}
F = 96485 J/(V·mol e^-)
$K_w = 1.0 \times 10^{-14}$ at 25 °C
$k_b = 1.381 \times 10^{-23}$ J/K

Equations
$(P + a(n^2/V^2)) \cdot (V - nb) = nRT$
molar mass (M) = mRT/PV
density (d) = MP/RT

$$KE = \frac{3}{2}RT$$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{Rate\ of\ effusion\ A}{Rate\ of\ effusion\ B} = \sqrt{\frac{MW_B}{MW_A}}$$

$$\Delta E = -2.18 \times 10^{-18} J(\frac{1}{n_f^2} - \frac{1}{n_i^2})$$

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$C_g = kP_g$
$P_{solution} = P_{solvent}\, X_{solvent}$
$P_{solution} = \sum P_j = \sum P_j X_j$
$\pi = MRTi$

Thermodynamic and Electrochemistry
$S = k_b \times \ln(W)$
$\Delta S = q_{rev}/T$
$\Delta G = \Delta G° + RT \cdot \ln Q$
R=8.314 J/mol.K
$\Delta G° = -RT \cdot \ln K$
$\Delta G = -nFE_{cell}$
$E°_{cell} = RT/nF \ln K$
$E°_{cell} = (0.0257/n) \ln K = (0.0592/n) \log K$
$E_{cell} = E°_{cell} - (RT/nF) \ln Q$
$E_{cell} = E°_{cell} - (0.0257/n) \ln Q$
Electrolysis: Q (total charge) = I × t = n × F

Integrated Rate Laws & half-life

$$\ln\frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$ln\frac{k_2}{k_1} = -\frac{E_a}{R}(\frac{1}{T_2} - \frac{1}{T_1})$$

Equilibrium and Acid / Base
$K_P = K_c \times (RT)^{\Delta n}$

$$ln\frac{K_2}{K_1} = \frac{\Delta H^{\circ}_{rxn}}{R}(\frac{1}{T_1} - \frac{1}{T_2})$$