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McCord CH301

unique: 49885

TTh 9:30 am - 11 am

Exam 1

Sep 17, 2018

Monday 7:30 - 9:00 PM

A - Mi in BUR 106

Mo - Z in JES A121A

Remember to refer to the Periodic Table handout that is separate from this exam copy.

NOTE: Please keep this exam copy intact (all pages still stapled - including this cover page). You must turn in ALL the materials that were distributed. This means that you turn in your exam copy (name and signature included), bubble sheet, periodic table handout, and all scratch paper. Please also have your UT ID card ready to show as well.

This print-out should have 20 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

Balance a Reaction
001 5.0 points

Consider the following unbalanced reaction:

$$Fe_2O_3 + CO \longrightarrow Fe + CO_2$$

What is the sum of the coefficients in the balanced chemical reaction? Remember to count the 1 if no coefficient is present.

1. 8

2. 9 **correct**

3. 6

4. 4

5. 12

6. 5

Explanation:

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$
$$\text{sum} = 9$$

Stoich Application Fuel w Phases
002 5.0 points

A fuel cell car is powered by electrons harvested from the flameless, low-temperature reaction

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

What volume of hydrogen is needed to fully react with 18.6 L of oxygen at STP?

1. 97.4 L

2. 38.2 L

3. 9.3 L

4. 2.02 L

5. 37.2 L **correct**

6. 18.6 L

Explanation:
At STP, the fuel cell reaction can be shown to relate volumes based on Avogadro's Law. It may be stated that 2 L hydrogen gas reacts with 1 L oxygen gas to form 2 L water. Therefore, 37.2 L of hydrogen is needed to react with 18.6 L oxygen.

Combustion Stoichiometry Calc
003 5.0 points

Use the following balanced chemical equation:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

6.45 moles of C_3H_8 and 9.56 moles of O_2 are combusted at 298.15 K and 1 atm. What is the volume of CO_2 formed after the reaction reaches 100% completion? Assume temperature and pressure remain constant.

1. 158 L

2. 234 L

3. 473 L

4. 140 L **correct**

5. 128 L

6. 46.8 L

Explanation:
Use limiting reagent stoichiometry to solve for the moles of CO_2 produced (n), then use the ideal gas law to solve for the volume.

Find the limiting reagent:

$$C_3H_8 : 6.45\,\text{mol} \times \frac{\text{rxn}}{1\,\text{mol}} = 6.45\,\text{rxn}$$
$$O_2 : 9.56\,\text{mol} \times \frac{\text{rxn}}{5\,\text{mol}} = 1.912\,\text{rxn}$$

We can see above that oxygen is the limiting reagent. Solve for the amount of CO_2 produced:

$$1.912\,\text{rxn} \times \frac{3\,\text{mol}}{\text{rxn}} = 5.736\,\text{mol} = n$$

We can use PV = nRT to finish this problem by solving for the volume:

$$V = \frac{nRT}{P} = \frac{5.736 \cdot 0.08206 \cdot 298.15}{1}$$

$$V = 140.33\,\mathrm{L}$$

Boyles Law Reasoning
004 5.0 points

From the microscopic perspective, Boyle's Law explains that for a closed gaseous system...

1. There can be no change in volume without a change in pressure

2. There is a linear relationship between volume and pressure

3. An increase in volume at constant temperature results in a higher pressure

4. All answer choices are true

5. An increase in volume at constant temperature results in fewer collisions between gas particles and the walls of the container **correct**

Explanation:
Boyle's Law demonstrates the inverse relationship between pressure and volume. From a microscopic perspective, an increase in volume results in fewer collisions between gas particles and the walls of the container (pressure).

Avogadros Law Concept
005 5.0 points

A balloon is inflated with 0.12 moles of helium to a volume equal to V_i. Which of the following represents the final volume (V_f) after 0.06 moles of helium are released from the inflated balloon at constant temperature and pressure?

1. None of these choices are true

2. $V_f = 3V_i$

3. $V_f = V_i$

4. $V_f = \frac{1}{3}V_i$

5. $V_f = \frac{1}{2}V_i$ **correct**

6. $V_f = 2V_i$

Explanation:
Avogadro's Law states that the volume and number of moles of gas are proportional. If you half the number of moles, you half the volume.

$$V_f = \frac{1}{2}V_i$$

In the equation above, you see that the final volume is equal to half the initial volume.

Charles Law Calc
006 5.0 points

A gas has a volume of 2.00 liters at a temperature of 127°C. What will be the volume of the gas if the temperature is increased to 254°C at constant pressure?

1. 3.03 L

2. 2.63 L **correct**

3. 1.52 L

4. 0.38 L

5. 4.00 L

6. 1.32 L

Explanation:
$T_1 = 127°\mathrm{C} + 273.15 = 400.15$ K $V_1 = 2.00$ L
$T_2 = 254°\mathrm{C} + 273 = 527.15$ K

Charles' Law relates the volume and absolute (Kelvin) temperature of a sample of gas:

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

$$V_2 = \frac{V_1\,T_2}{T_1} = \frac{(2.00\ \mathrm{L})\,(527.15\ \mathrm{K})}{400.15\ \mathrm{K}}$$

$$= 2.63\ \mathrm{L}$$

Combined Gas Law 1
007 5.0 points

A sample of helium (He) occupies 8.0 liters at 1 atm and 20.0°C. What pressure is necessary to change the volume to 1.0 liters at 10.0°C?

1. 7.7 atm **correct**

2. 4 atm

3. 0.13 atm

4. 8.3 atm

5. 16 atm

Explanation:

This question can be done without any calculations. The astute reader will appreciate that the change in volume predominated, and by itself would require a pressure of 8 atm, but the slight decrease in temperature would result in some pressure slightly less than 8 atm. Only one answer choice, 7.7 atm, satisfies this reasoning.

Alternatively, a calculation will yield 7.7 atm as well.

$V_1 = 8$ L $\quad T_1 = 20°\text{C} + 273.15 = 293.15$ K
$V_2 = 1$ L $\quad T_2 = 10°\text{C} + 273.15 = 283.15$ K
$P_1 = 1$ atm

We can use the combined gas law and solve for P_2:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$P_2 = \frac{P_1 V_1 T_2}{T_1 V_2} = \frac{(1\text{ atm})(8\text{ L})(283.15\text{ K})}{(293.15\text{ K})(1\text{ L})} = 7.7\text{ atm}$$

Gas bulb comparison
008 5.0 points

Equal masses of CO_2 and O_2 are placed in separate bulbs with equal volume and temperature. Assuming the gases behave ideally, which statement is true?

1. The bulb containing CO_2 has a greater mass density.

2. Both bulbs contain the same number of moles of gas.

3. The pressures in the two bulbs are the same.

4. The bulb containing CO_2 has a greater number density.

5. The pressure in the O_2 bulb is greater than the pressure in the CO_2 bulb. **correct**

Explanation:

The molecular weight of O_2 is less than that of CO_2, so in equal masses there are more moles of O_2 than of CO_2. At the same volume and temperature, the larger number of moles of O_2 would exert a higher pressure.

Gas Law Application
009 5.0 points

The vital capacity of the lungs is the maximum volume of air that can be exhaled after a full breath. The average human has a vital capacity of 238 in^3 with an internal lung pressure of 1.44 atm and a temperature of 37.0°C. How many moles of ideal gas are in a full exhalation?

1. 0.22 moles **correct**

2. 1.85 moles

3. 2.51 moles

4. 3.70 moles

5. 0.93 moles

Explanation:

$V = 238\text{ in}^3 = 3.90$ L

$T = 37°\text{C} + 273.15 = 310.15$ K

$P = 1$ atm

Use the ideal gas law:

$$PV = nRT$$

$$n = \frac{PV}{RT}$$

$$0.22 = \frac{(1.44)(3.90)}{(310.15)(0.08206)}$$

Ideal Gas Law Composition Stoich
010 5.0 points

How many nitrogen atoms are present in a nitrogen gas sample that occupies 54.6 L at STP?

1. 1.35×10^{25} N atoms

2. 3.29×10^{25} N atoms

3. 4.13×10^{-24} N atoms

4. 2.94×10^{24} N atoms **correct**

5. 1.47×10^{24} N atoms

6. 8.26×10^{-24} N atoms

Explanation:
Knowing that one mole occupies 22.4 L at STP and each nitrogen molecule has two nitrogen atoms:

$$54.6\,\text{L} \times \frac{\text{mol}}{22.4\,\text{L}} = 2.4375\,\text{mol}$$

$$2.4375\,\text{mol} \times \frac{2\,\text{mol N}}{\text{mol N}_2} = 4.975\,\text{mol N}$$

$$4.975\,\text{mol N} \times \text{N}_\text{A} = 2.94 \times 10^{24}\,\text{atoms}$$

Sparks Density Modified
011 5.0 points

What is the mass density of HBr gas at 30.5°C and 758 Torr?

1. Cannot be determined from this data.

2. 3.24 g/L **correct**

3. 0.309 g/L

4. 32.2 g/L

5. 2.46×10^{3} g/L

Explanation:
MW = 80.9 g/mol
$T = 30.4°\text{C} + 273.15 = 303.55$ K
$P = 758$ Torr

$$\begin{aligned} P\,V &= n\,R\,T \\ \frac{n}{V} &= \frac{P}{R\,T} \\ &= \frac{758\ \text{Torr}}{\left(62.36\ \frac{\text{L}\cdot\text{torr}}{\text{mol}\cdot\text{K}}\right)(303.55\ \text{K})} \cdot \frac{80.9\ \text{g}}{\text{mol}} \\ &= 3.23953\ \text{g/L} \end{aligned}$$

ChemPrin3e T04 25
012 5.0 points

If 250 mL of a gas at STP weighs 2 g, what is the molar mass of the gas?

1. $179\ \text{g} \cdot \text{mol}^{-1}$ **correct**

2. $28.0\ \text{g} \cdot \text{mol}^{-1}$

3. $44.8\ \text{g} \cdot \text{mol}^{-1}$

4. $8.00\ \text{g} \cdot \text{mol}^{-1}$

5. $56.0\ \text{g} \cdot \text{mol}^{-1}$

Explanation:
$V = 250$ mL $\quad P = 1$ atm
$T = 0°\text{C} = 273.15$ K $\quad m = 2$ g

The density of the sample is

$$\rho = \frac{m}{V} = \frac{2\ \text{g}}{0.25\ \text{L}} = 8\ \text{g/L}$$

The ideal gas law is

$$\begin{aligned} P\,V &= n\,R\,T \\ \frac{n}{V} &= \frac{P}{R\,T} \end{aligned}$$

with unit of measure mol/L on each side. Multiplying each by molar mass (MM) gives

$$\frac{n}{V} \cdot \text{MM} = \frac{P}{R\,T} \cdot \text{MM} = \rho\,,$$

with units of g/L.

$$\begin{aligned}\text{MM} &= \frac{\rho\, R\, T}{P}\\ &= \frac{(8\text{ g/L})(0.08206\text{ L}\cdot\text{atm/mol/K})}{1\text{ atm}}\\ &\quad\times(273.15\text{ K})\\ &= 179.318\text{ g/mol}\end{aligned}$$

Gas Mixture Percent by Mass
013 5.0 points

A mixture of oxygen and helium is 87.4% by mass oxygen with a total pressure of 675 Torr. What is the partial pressure of oxygen in this mixture?

1. 688 Torr

2. 590 Torr

3. 299 Torr

4. 314 Torr **correct**

5. 333 Torr

Explanation:

Assume you have 100 g of this mixture; calculate the number of moles:

$$\begin{aligned}n_{O_2} &= (87.4\text{ g }O_2)\,\frac{1\text{ mol }O_2}{31.9988\text{ g }O_2}\\ &= 2.73135\text{ mol }O_2\,.\end{aligned}$$

$$\begin{aligned}n_{\text{He}} &= (12.6\text{ g He})\frac{1\text{ mol He}}{4.0026\text{ g He}}\\ &= 3.14795\text{ mol He}\,.\end{aligned}$$

$$\begin{aligned}n_{\text{tot}} &= n_{O_2} + n_{\text{He}}\\ &= 2.73135\text{ mol }O_2 + 3.14795\text{ mol He}\\ &= 5.87931\text{ mol gas}\end{aligned}$$

Dalton's Law:

$$\begin{aligned}P_{O_2} &= P_{\text{tot}}\times\chi_{O_2}\\ &= P_{\text{tot}}\times\frac{n_{O_2}}{n_{\text{tot}}}\\ &= (687\text{ Torr})\frac{2.73135\text{ mol }O_2}{5.87931\text{ mol gas}}\\ &= 313.585\text{ Torr}\end{aligned}$$

Gas Law Stoich III
014 5.0 points

Consider the following balanced chemical reaction:

$$CH_3OCH_3(g) \rightarrow CH_4(g) + H_2(g) + CO(g)$$

118.9 g CH_3OCH_3 fully decomposes to give a pressure of 987 Torr. What is the partial pressure of hydrogen in the final reaction system?

1. 658 Torr

2. 388 Torr

3. 329 Torr **correct**

4. 493 Torr

5. 987 Torr

Explanation:

The decomposition reaction forms the products in a 1:1:1 ratio. Therefore, the mole fraction of hydrogen will be 1/3.

$$P_{H_2} = X_{H_2}P_{\text{tot}}$$
$$329 = (1/3)(987)$$

KMT Conceptual III
015 5.0 points

Which of the following is not an assumption made by kinetic molecular theory?

1. The kinetic energy of a gas is solely dependent on the temperature

2. Gas particles are constantly moving in random directions

3. The volume of the gas particles is negligible compared to the size of the container

4. An ideal gas steadily loses energy due to elastic collisions with the walls of the container **correct**

5. An ideal gas does not exhibit attractive or repulsive forces

Explanation:
The one pillar that is mischaracterized here is that ideal gases have elastic collisions. This is true, but it is actually the reason why ideal gases DO NOT steadily lose energy.

KMT Calculation Modified
016 5.0 points

If the average speed of a CO_2 molecule is $411\ \text{m} \cdot \text{s}^{-1}$ at 25°C, what is the average speed of a molecule of CH_4 at the same temperature?

1. $247\ \text{m} \cdot \text{s}^{-1}$

2. $410\ \text{m} \cdot \text{s}^{-1}$

3. $681\ \text{m} \cdot \text{s}^{-1}$ **correct**

4. $1130\ \text{m} \cdot \text{s}^{-1}$

5. $1000\ \text{m} \cdot \text{s}^{-1}$

Explanation:
From kinetic molecular theory, the temperature is *directly* proportional to mean KE.
$\text{KE}_{\text{mean}} = \frac{1}{2}(\text{MW})(\text{average molecular speed})^2$
and knowing T is constant,

$$\frac{v_{CH_4}}{v_{CO_2}} = \sqrt{\frac{MW_{CO_2}}{MW_{CH_4}}}$$

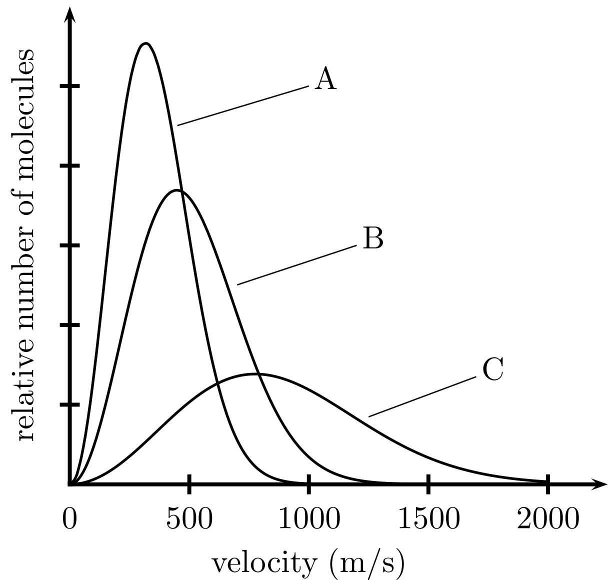
$$v_{CH_4} = v_{CO_2}\sqrt{\frac{MW_{CO_2}}{MW_{CH_4}}}$$

$$= (411\ \text{m/s})\sqrt{\frac{44.0098\ \text{g/mol}}{16.0426\ \text{g/mol}}}$$

$$= 680.737$$

Maxwell Distribution Graph
017 5.0 points

The graph shows the approximate Maxwell-Boltzmann distribution plots for three different gases at the same temperature.



Which of the following statements is true?

1. Gas C has the greatest kinetic energy

2. Gas A has the greatest kinetic energy

3. The v_{rms} for Gas C is 1500 m/s

4. Gas B is heavier than Gas A

5. Gas C has the lowest molar mass **correct**

Explanation:
All gases have the same temperature; therefore, gases A, B, and C have the same kinetic energy. Gas C is the fastest and the lightest.

Non Ideal Conditions Conceptual
018 5.0 points

A real gas is expected to behave most ideally at which of the following conditions?

1. 28 K, 1 atm

2. 580 K, 10 atm

3. 580 K, 0.1 atm **correct**

4. 28 K, 10 atm

5. 28 K, 0.1 atm

Explanation:
At high temperatures the gas molecules are moving more rapidly and the effects of the attractive forces are less significant. At low pressures the molecules are on average much further apart and the effects of the attractive forces are less significant because there are fewer 'close encounters'. The best choice here is the hottest temperature at the lowest pressure (580K, 0.1 atm).

Non Ideal Gases Conceptual 18
019 5.0 points

Consider the van der Waals equation for a non-ideal gas. Which of the following statements is true?

1. Attractive forces between particles cause the measured pressure to be lower than the ideal pressure **correct**

2. $(P + \frac{an^2}{V^2})$ is equal to the measured pressure

3. $(V - nb)$ is equal to the volume of the container holding the gas

4. This equation can only be used to model ideal gases

5. A large b value correlates with a low molecular weight

Explanation:
The van der Waals equation for non ideal gases is given below:

$(P + \frac{an^2}{V^2})(V - nb) = nRT$

In this equation, $(P + \frac{an^2}{V^2})$ represents the ideal pressure and $(V - nb)$ represents the available volume after making the corrections. The a term corrects for attractions and the b term corrects for the size of the particles (repulsions). Mathematically, the measured pressure is less than the ideal pressure. The available volume is less than the total volume.

Non Ideal Conceptual
020 5.0 points

A non-ideal gas is quantified at constant temperature and pressure. The compressibility factor (Z) is equal to 0.85. Which of the following statements best explains this gas?

1. The gas exhibits attractive forces, resulting in a measured pressure that is lower than the ideal pressure **correct**

2. The non-ideal gas has dominate repulsive forces, resulting in an ideal pressure that is lower than the measured pressure

3. The gas has a negligible a term in the van der Waal's equation

4. The gas exhibits attractive forces, resulting in an ideal pressure that is lower than the measured pressure

Explanation:
For an ideal gas:

$$PV = nRT$$

The question here is why does this particular gas deviate from the ideal gas law equation. For this gas:

$$\frac{PV}{nRT} = Z = 0.85$$

A Z value that is less than 1 occurs as a result of attractive forces. This is further explained by the fact that the attractive forces cause the measured pressure to be less than the ideal pressure.