

P J3 (pg 1 of 4) **Stoichiometry with Gases**

Name _____ Per _____

Write out your dimensional analysis work. If you need more room, work on another piece of paper. Circle your final answer. Put units, identifiers and descriptors on your answers. Concern yourself at least a little bit with significant figures.

1. Your little Honda Fit holds 10 gallons of gas, which is 37.85 L. On a cold day in December, 5°C and 0.985 atm pressure, you decide to go on trip and you use up an entire tank of gas. Write a balanced equation for the combustion of octane, C₈H₁₈ which is the major component of gasoline in the space below. The density of liquid octane is 0.703 g/ml.

- (a) Calculate the volume of oxygen gas that would be required to react with the full tank of gas.

Molar Mass g/mol	
C ₈ H ₁₈	114.26
O ₂	32.00
CO ₂	44.01
H ₂ O	18.02

Helpful Info	
R	0.0821 Latm/molK
R	62.4 LmmHg/molK
1atm = 760 mmHg	
K = °C + 273	

- (b) What volume of air is this?

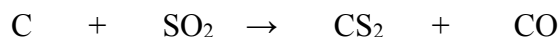
2. Excess nitrogen was reacted with 2.54 L of hydrogen gas. What volume of ammonia gas could be produced if the reaction is held at -75°C at 22.5 atm of pressure throughout the reaction.

P J3 (pg 2 of 4) **Stoichiometry with Gases**

3. Sodium carbonate will react with hydrochloric acid solution to produce sodium chloride, water, and carbon dioxide gas. Calculate the volume of carbon dioxide that would be collected when 45.0 ml of 2.5 M hydrochloric acid solution is poured over an excess of solid sodium carbonate. The carbon dioxide is collected at a pressure of 755 mm Hg at 15°C.

Helpful Info	
R	0.0821 Latm/molK
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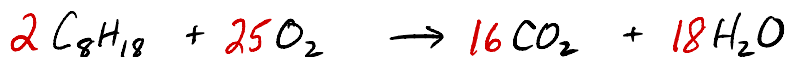
4. The reaction below represents the preparation of carbon disulfide by reacting coke (carbon) with sulfur dioxide.
- (a) Balance the equation below, and then calculate the volume of sulfur dioxide required to process 650. kg of carbon into carbon disulfide. The sulfur dioxide is stored in 40.0 L tanks at 250. atm of pressure at 20.0°C
- (b) How many tanks of sulfur dioxide should the foundry have on hand for every 650. kg of carbon?
- (c) The carbon monoxide is collected and stored in the same size 40.0 L tanks also at 250. atm of pressure. How many tanks of carbon monoxide can the foundry expect to produce for the 650. kg of carbon reacted?



Molar Mass	
g/mol	
C	12.01
SO ₂	64.07
CS ₂	76.15
CO	28.01

Write out your dimensional analysis work. If you need more room, work on another piece of paper. Circle your final answer. Put units, identifiers and descriptors on your answers. Concern yourself at least a little bit with significant figures.

1. Your little Honda Fit holds 10 gallons of gas, which is 37.85 L. On a cold day in December, 5°C and 0.985 atm pressure, you decide to go on trip and you use up an entire tank of gas. Write a balanced equation for the combustion of octane, C₈H₁₈ which is the major component of gasoline in the space below. The density of liquid octane is 0.703 g/ml.



- (a) Calculate the volume of oxygen gas that would be required to react with the full tank of gas.

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Convert the liquid octane to mass of octane using density

$$37.85 L C_8H_{18} \times \frac{1000 ml}{1 L} \times \frac{0.703 g}{1 ml} = 26,609 g C_8H_{18}$$

now you can start like any other typical stoichiometry prob.

$$26,609 g C_8H_{18} \times \frac{1 mol C_8H_{18}}{114.26 g C_8H_{18}} \times \frac{25 mol O_2}{2 mol C_8H_{18}} = 2,911 mol O_2$$

now we can use PV = nRT to calculate the volume of oxygen

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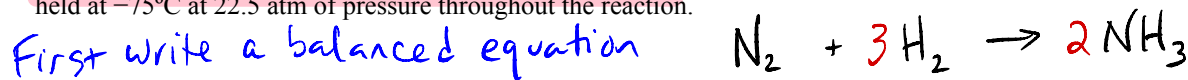
$$V_{O_2} = \frac{nRT}{P} = \frac{2,911 mol \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 278K}{0.985 atm} = 67,451 L O_2 \quad (67,500 L \text{ 3SF})$$

- (b) What volume of air is this? Perhaps you remember air is ~20% O₂ ~80% N₂

$$67,451 L O_2 \times \frac{5 parts Air}{1 part O_2} = 337,255 L of air \quad (337,000 L \text{ 3SF})$$

↪ 1/5th or 1 part O₂ / 5 parts air

2. Excess nitrogen was reacted with 2.54 L of hydrogen gas. What volume of ammonia gas could be produced if the reaction is held at -75°C at 22.5 atm of pressure throughout the reaction.



This problem is actually very simple because of Avogadro's Law. At constant temperature and pressure volume of gas is proportional to # of particles and in this problem, the temp and pressure are held constant this allows us to do stoichiometry with volumes.

$$2.54 L H_2 \times \frac{2 mol NH_3}{3 mol H_2} = 1.69 L of NH_3$$

Below this line is more explanation as to why you don't need to use the Ideal Gas Law

$$n = \frac{PV}{RT} = \frac{22.5 atm \cdot 2.54 L}{0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 198K} = 3.52 mol H_2 \times \frac{2 mol NH_3}{3 mol H_2} = 2.34 mol NH_3$$

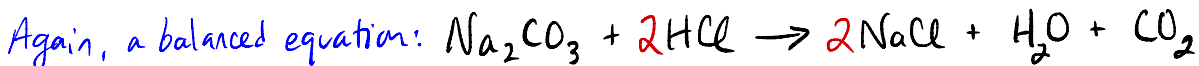
if you feel the need, you can check the calculation by using the ideal gas law to convert 2.54 L H₂ into 3.52 mol H₂, then use the LINK to get 2.34 mol NH₃, then use the ideal gas law to convert back into 1.69 L NH₃

$$V_{NH_3} = \frac{nRT}{P} = \frac{2.34 mol NH_3 \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 198K}{22.5 atm} = 1.69 L of NH_3$$

Same as above

you can see this is not necessary

3. Sodium carbonate will react with hydrochloric acid solution to produce sodium chloride, water, and carbon dioxide gas. Calculate the volume of carbon dioxide that would be collected when 45.0 ml of 2.5 M hydrochloric acid solution is poured over an excess of solid sodium carbonate. The carbon dioxide is collected at a pressure of 755 mm Hg at 15°C.



Don't forget molarity = $\frac{\text{moles}}{\text{Liter of solution}}$ and $M \times V = \text{moles}$

$$2.5 \text{ M} \times 0.045 \text{ L} = 0.1125 \text{ mol HCl}$$

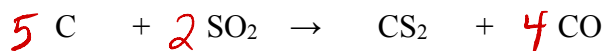
$$0.1125 \text{ mol HCl} \times \frac{1 \text{ mol CO}_2}{2 \text{ mol HCl}} = 0.05625 \text{ mol CO}_2$$

$$PV = nRT$$

$$V_{\text{CO}_2} = \frac{nRT}{P} = \frac{0.05625 \text{ mol} \cdot 62.4 \frac{\text{L} \cdot \text{mmHg}}{\text{mol} \cdot \text{K}} \cdot 288 \text{ K}}{755 \text{ mmHg}} = 1.33 \text{ L CO}_2$$

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4. The reaction below represents the preparation of carbon disulfide by reacting coke (carbon) with sulfur dioxide.
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 - How many tanks of sulfur dioxide should the foundry have on hand for every 650. kg of carbon?
 - The carbon monoxide is collected and stored in the same size 40.0 L tanks also at 250. atm of pressure. How many tanks of carbon monoxide can the foundry expect to produce for the 650. kg of carbon reacted?



$$650 \text{ kg C} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} \times \frac{2 \text{ mol SO}_2}{5 \text{ mol C}} = 21,649 \text{ mol SO}_2$$

$$PV = nRT$$

$$V_{\text{SO}_2} = \frac{nRT}{P} = \frac{21,649 \text{ mol} \cdot 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \cdot 293 \text{ K}}{250 \text{ atm}} = 2083 \text{ L of SO}_2 \text{ (2080 L 3SF)}$$

$$2083 \text{ L} \times \frac{1 \text{ tank}}{40 \text{ L}} = \sim 52 \text{ tanks SO}_2$$

Again like in problem # 2, since the tanks are at the same temp and pressure, equal volumes (tanks) will have equal numbers (moles) of molecules - Thus you can "do stoichiometry" with the tanks.

$$52 \text{ tanks SO}_2 \times \frac{4 \text{ mol CO}}{2 \text{ mol SO}_2} = 104 \text{ tanks CO}$$

Molar Mass g/mol	
C	12.01
SO ₂	64.07
CS ₂	76.15
CO	28.01