CHEMISTRY

GAS LAW STOICHIOMETRY

Recall: *Stoichiometry is the molar relationships between molecules in a balanced chemical equation.*

Formulae:

Now that we have access to the Ideal Gas Law, we can convert pressure, temperature, and volume data to moles for our stoichiometric calculations.

Steps:

1. Write a balanced chemical equation.
2. Write the given information under the appropriate columns and identify the unknown chemical to be solved.
3. Convert all amounts to moles.
4. Use the molar ratio defined by the chemical equation to determine the number of moles of the unknown.
5. Convert the new molar amount into the units required using $PV = nRT$.

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Ex: *Ammonia is produced by a reaction of nitrogen gas and hydrogen gas. Suppose that 12.0 L of nitrogen gas reacts with excess hydrogen gas at STP.*

a) *What volume of ammonia is produced?*
b) *What volume of hydrogen is consumed?*

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Ex: *When 300 mL of 1.5M sulfuric acid reacts 40 g of iron metal, a gas is produced as well as an iron(II) compound.*

a) *What volume of gas is produced if this reaction takes place in a lab where the temperature is 18°C and the pressure is 100.3 kPa?*

b) *If the percent yield for this experiment is 72%, what is the actual yield?*

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The Grand Finally - You're Welcome

An unknown gas consists of 80.0% carbon and 20.0% hydrogen. A 4.60 g sample of this gas occupies a 2.50 L volume at 25.00°C and 152 kPa.

a) If this sample was combusted with 20 g of oxygen gas, what is the volume of the unreacted excess reagent after combustion when the temp has climbed to 515°C ~ same pressure?

b) As the reaction cools below 100°C, the water vapour produced by the combustion reaction will start to react with the carbon dioxide to create carbonic acid. What is the pH of this acid?

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Pg. 560

Practice Problems

31. What volume of hydrogen gas will be produced at 93.0 kPa and 23°C from the reaction of 33 mg of magnesium with hydrochloric acid?

32. At STP, 0.72 g of hydrogen gas reacts with 8.0 L of chlorine gas. How many litres of hydrogen chloride gas are produced?

33. Determine the volume of nitrogen gas produced when 120 g of sodium azide, NaN(s), decomposes at 27°C and 100.5 kPa. Sodium metal is the other product.

34. When calcium carbonate, $CaCO_3(s)$, is heated, it decomposes to form calcium oxide, CaO(s), and carbon dioxide gas. How many liters of carbon dioxide will be produced at STP if 2.38 kg of calcium carbonate reacts completely?

35. When iron rusts, it undergoes a reaction with oxygen to form solid iron(III) oxide. Calculate the volume of oxygen gas at STP that is required to completely react with 52.0 g of iron.

36. Oxygen gas and magnesium react to form 2.43 g of magnesium oxide, MgO(s). What volume of oxygen gas at 94.9 kPa and 25.0°C would be consumed to produce this mass of magnesium oxide?

37. In the semiconductor industry, hexafluoroethane, $C_2F_6(g)$, is used to remove silicon dioxide, $SiO_2(s)$, according to the following chemical equation:

$$2SiO_2(s) + 2C_2F_6(g) + O_2(g) \rightarrow 2SiF_4(g) + 2COF_2(g) + 2CO_2(g)$$

What mass of silicon dioxide reacts with 1.270 L of hexafluoroethane at 0.200 kPa and 400.0°C?

38. What mass of oxygen gas reacts with hydrogen gas to produce 0.62 L of water vapour at 100.0°C and 101.3 KPa?

39. One method of producing ammonia gas involves the reaction of ammonium chloride, $NH_4Cl(aq)$, with sodium hydroxide, NaOH(aq); water and aqueous sodium chloride are also products of the reaction. During an experiment, 98 mL of ammonia gas was collected using water displacement. If the gas was collected at 20.0°C and 780 mmHg, determine the amount of sodium hydroxide that must have reacted.

40. A student reacts 0.15 g of magnesium metal with excess dilute hydrochloric acid to produce hydrogen gas, which she collects over water. What volume of dry hydrogen gas does she collect over water at 28°C and 101.8 kPa?

31. 36 mL
32. 16 L
33. 40 L
34. 5.40×10^2 L
35. 15.6 L
36. 0.787 L
37. 2.73×10^{-3} g
38. 0.32 g
39. 0.17 g
40. 0.16 L

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Gas Stoich - Practice

25. Use the following balanced equation to answer the questions below.

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$$

(a) What is the mole ratio of oxygen gas to water vapour?

(b) What is the volume ratio of oxygen gas to water vapour?

(c) What is the volume ratio of hydrogen gas to oxygen gas?

(d) What is the volume ratio of water vapour to hydrogen gas?

26. 1.5 L of propane gas are burned in a barbecue. The following equation shows the reaction. Assume all gases are at STP.

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

(a) What volume of carbon dioxide gas is produced?

(b) What volume of oxygen is consumed?

27. Use the following equation to answer the questions below.

$$SO_{2(g)} + O_{2(g)} \rightarrow SO_{3(g)}$$

(a) Balance the equation.

(b) 12.0 L of sulfur trioxide, $SO_{3(g)}$, are produced at 100°C. What volume of oxygen is consumed?

(c) What assumption must you make to answer part (b)?

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Gas Stoich - Practice

29. Engineers design automobile air bags that deploy almost instantly on impact. To do this, an air bag must provide a large amount of gas in a very short time. Many automobile manufacturers use solid sodium azide, NaN_3, along with suitable catalysts, to provide the gas that is needed to inflate the air bag. The balanced equation for this reaction is

$$2NaN_{3(s)} \rightarrow 2Na_{(s)} + 3N_{2(g)}$$

(a) What volume of nitrogen gas will be produced if 117.0 g of sodium azide are stored in the steering wheel at 20.2°C and 101.2 kPa?

(b) How many molecules of nitrogen are present in this volume?

(c) How many atoms are present in this volume?

30. 0.72 g of hydrogen gas, H_2, reacts with 8.0 L of chlorine gas, Cl_2, at STP. How many litres of hydrogen chloride gas, HCl, are produced?

31. How many grams of baking soda (sodium hydrogen carbonate, $NaHCO_3$), must be used to produce 45 mL of carbon dioxide gas at 190°C and 101.3 kPa in a pan of muffins? (The mole ratio of $NaHCO_3$ to CO_2 is 2:1.)

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Gas Stoich - Practice

32. How much zinc (in grams) must react with hydrochloric acid to produce 18 mL of gas at SATP? (**Hint:** Zinc chloride, $ZnC\ell_{2(s)}$ is a product.)

33. 35 g of propane gas burned in a barbecue, according to the following equation:

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

All the gases are measured at SATP.

(a) What volume of water vapour is produced?

(b) What volume of oxygen is consumed?

34. What mass of oxygen is reacted to produce 0.62 L of water vapour at 100°C and 101.3 KPa? Start by balancing the following equation:

$$H_{2(g)} + O_{2(g)} \rightarrow H_2O_{(g)}$$

Answers

25.(a) 1:2 **(b)** 1:2 **(c)** 2:1 **(d)** 1:1
26.(a) 4.5 L **(b)** 7.5 L **27.(b)** 6.00 L **28.(b)** a_4b_2 **29.(a)** 65.0 L
(b) 1.63×10^{24} molecules **(c)** 3.25×10^{24} atoms **30.** 16 L
31. 0.20 g **32.** 0.047 g **33.(a)** 79 L **(b)** 98 L **34.** 0.32 g