

## Ideal Gas Law

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- For every problem we have done, we also could have used the ideal gas law.
- On the test, you will have to do a couple of problems with the combined gas law, some with the ideal gas law and then you will be able to choose which law you want to use.

## Ideal gas law can be derived from the combined gas law

- $PV/T = PV/T$  (using kPa for pressure)
- $n$  (22.4) = Volume of any gas at STP ( $n$  is the number of moles)
- plug this into combined gas law for initial state.
- $PV/T = (101.2 \text{ kPa}) (n \cdot 22.414 \text{ L}) / 273 \text{ K}$
- $PV = n$  (8.31 kPa•L/K mol) T
- 8.31 kPa•L/K mol is the ideal gas constant for these units. It is abbreviated "R"

## The equation

- $PV = nRT$
- \*R can also be .0821 atm •L/K mol
- \*R can also be 62.4 torr •L/K mol
- The units of R must match the other units in the problem.
- If you are using **8.31 kPa•L/K mol**, your units are:
- kPa(L) = mol (8.31 kPa•L/K mol) K

## Converting pressures

- Use the standard pressures as a conversion factor
- 1.00 atm = 101 kPa = 760. torr
- convert 135 kPa to atm
- $135 \text{ kPa} \times 1 \text{ atm} / 101 \text{ kPa} = 1.34 \text{ atm}$
- convert 768 torr to kPa
- $768 \text{ torr} \times 101 \text{ kPa} / 760 \text{ torr} = 102 \text{ kPa}$

## Using the ideal gas law

- What volume will .76 mol of a gas occupy at .82 atm and 264 K?
- $PV = nRT$
- $0.82 \text{ atm} \times 101 \text{ kPa} / 1.00 \text{ atm} = 82.82 \text{ kPa}$
- $82.82 \text{ kPa} V = 0.76 \text{ mol} (8.31 \text{ kPa} \cdot \text{L/K mol}) 264 \text{ K}$
- $V = 20. \text{ L}$

## Ideal Gas Law Problem

- If a gas occupies 14 L at 135 kPa and 285 K, what volume will it occupy at STP?
- $PV = nRT$
- $135 \text{ kPa} (14 \text{ L}) = n$  8.31 kPa•L/K mol (285 K)
- $n = .798 \text{ mol}$
- $.798 \text{ mol} \times 22.4 \text{ L} / 1 \text{ mol}$
- = **18 L**

## or you can also

- take the .798 mol and plug it back into
- $PV = nRT$  (you would have to do this if you were not going to STP)
- $101 \text{ kPa} V = (.798 \text{ mol}) 8.31 (273 \text{ K})$
- $V = 18 \text{ L}$  (still)

## Ideal Gas Law Problems

### Number 1

- 1.54 mol of helium will occupy what volume at 92 kPa and 315 K?
- $PV = nRT$

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- 1.54 mol of helium will occupy what volume at 92 kPa and 315 K?
- $PV = nRT$
- $92 \text{ kPa } V = 1.54 \text{ mol } (8.31) 315 \text{ K}$
- $V = 44 \text{ L}$

### Number 2

- 126 mL of nitrogen at 113 kPa and 39° C will occupy what volume at STP?
- $PV = nRT$

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- 126 mL of nitrogen at 113 kPa and 39° C will occupy what volume at STP?
- $PV = nRT$
- $.126 \text{ L } (113 \text{ kPa}) = n(8.31)312 \text{ K}$
- $n = .00549 \text{ mol } \times 22.4 \text{ L/mol}$
- $V = .123 \text{ L } (123 \text{ mL})$

### Number 3

- 2.14 g of  $\text{NH}_3$ , ammonia, will occupy what volume at 795 torr and 315 K?

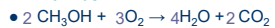
### Number 3

- 2.14 g of  $\text{NH}_3$ , ammonia, will occupy what volume at 795 torr and 315 K?
- $2.14 \text{ g} \times 1 \text{ mol} / 17.034 \text{ g} = .125 \text{ mol}$
- $795 \text{ torr} \times 101 \text{ kPa} / 760 \text{ torr} = 105.65 \text{ kPa}$
- $PV = nRT$
- $105.65 \text{ kPa } V = .125 \text{ mol } (8.31) 315 \text{ K}$
- $V = 3.10 \text{ L}$

### Number 4

- $\text{CH}_3\text{OH} + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{CO}_2$
- What volume of carbon dioxide will 5.2 g oxygen produce at 1.2 atm and 299 K?

### Number 4



- What volume of carbon dioxide will 5.2 g oxygen produce at 1.2 atm and 299 K?

5.2 g $\text{O}_2$	1 mol $\text{O}_2$	2 mol $\text{CO}_2$
	32.00 g $\text{O}_2$	3 mol $\text{O}_2$

- $= .108 \dots \text{ mol}$
- $1.2 \text{ atm} \times 101 \text{ kPa} / 1.00 \text{ atm} = 121.2 \text{ kPa}$
- $121.2 \text{ kPa } V = .108 (8.31) 299 \text{ K}$
- $V = 2.2 \text{ L}$

### Number 5

- $\text{HCl} + \text{Co} \rightarrow \text{CoCl}_2 + \text{H}_2$
- What volume of hydrogen gas will 5.2 g cobalt produce at 97 kPa and 285 K?

### Number 5

- $6\text{HCl} + 2\text{Co} \rightarrow 2\text{CoCl}_3 + 3\text{H}_2$
- What volume of hydrogen gas will 5.2 g cobalt produce at 97 kPa and 285 K?

5.2 g Co	1 mol Co	3 mol H <sub>2</sub>
	58.93 g Co	2 mol Co

- .132.. mol
- 97 V= .132mol(8.31)285K
- V = 3.2 L