Date: _____

11.4 - Combined Gas Law – Putting it all together!

Minds On! RECAP
Fill in the blanks:

STP: _____ **P =** _____ **T=** _____

SATP: _____ **P =** _____ **T=** _____

Boyle's Law: _____

Charles's Law: _____

Gay-Lusac's Law: _____

Do you think this is realistic? That only TWO variables change at a time → NO!

Combined Gas Law:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Practice Rearranging for:

V_2 =

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

Example 1:

Alex is having a birthday party on a mild winter's day. The weather changes and a higher-pressure (103.0 kPa) cold from (-25°C) rushes into town. The original air temperature was -2°C and the pressure was 100.8 kPa. What will happen to the volume of the 4.2 L balloons that were tied to the front of the house?

P_1 = 100.8 kPa P_2 = 103.0 kPa $V_2 = \frac{P_1 \cdot V_1 \cdot T_2}{T_1 \cdot P_2}$

V_1 = 4.2 L V_2 = ???

T_1 = 271K T_2 = 248K

$= \frac{100.8 \cdot 4.2 \cdot 248}{271 \cdot 103.0}$

$= 3.76\,L$

$= 3.8\,L$ ↓V as ↑P & ↓T

Example 2:

An automated instrument has been developed to help drug-research chemists determine the amount of nitrogen in a compound. Any compound containing carbon, nitrogen and hydrogen is reacted with copper (II) oxide to produce CO_2, H_2O and N_2 gases. The gases are collected separately and analyzed.

In an analysis of 39.8 mg of caffeine using this instrument, 10.1 mL of N2 gas was produced at 23°C and 746 torr. What must the new temperature of nitrogen be, in °C, if the volume is increased to 12.0 mL, and the pressure is increased to 780 torr?

P_1 = 746 P_2 = 780 torr $T_2 = \frac{P_2 \cdot V_2 \cdot T_1}{P_1 \cdot V_1}$

V_1 = 10.1mL V_2 = 12.0mL

T_1 = 296K T_2 = ??

$= \frac{780 \cdot 12.0 \cdot 296}{746 \cdot 10.1}$

$= 368K - 273K$

$= 94.7°C$

$= 95°C$

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$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Practice Problems

1. **A sample of gas has a volume of 150 mL at 260K and 92.3 kPa. What will the new volume be at 376K and 123 kPa?**

$P_1 = 92.3\ kPa$ $P_2 = 123\ kPa$

$V_1 = 150\ mL$ $V_2 = $ _____

$T_1 = 260\ K$ $T_2 = 376\ K$

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

$$= \frac{92.3 \cdot 150 \cdot 376}{260 \cdot 123}$$

$$= 163\ mL$$

2. **A cylinder at 48 atm pressure and 290 K releases 35 mL of carbon dioxide gas into a 4.0 L container at 297 K. What is the pressure inside the container?**

$P_1 = 48\ atm$ $P_2 = ?$

$V_1 = 35\ mL$ $V_2 = 4{,}000\ mL$

$T_1 = 290\ K$ $T_2 = 297\ K$

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

$$= \frac{48 \cdot 35 \cdot 297}{290 \cdot 4{,}000}$$

$$P_2 = 0.43\ atm$$

3. **In a large syringe, 48 mL of ammonia gas at STP is compressed to 24 mL and 110 kPa. What must the new temperature of the gas be?**

$P_1 = 101.325\ kPa$ $P_2 = 110\ kPa$

$V_1 = 48\ mL$ $V_2 = 24\ mL$

$T_1 = 273\ K$ $T_2 = ?$

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

$$= \frac{273 \cdot 110 \cdot 24}{101.325 \cdot 48} = 148\ K$$

4. **A 100 W light bulb has a volume of 180.0 cm³ at STP. The light bulb is turned on and the heated glass expands slightly, changing the volume of the bulb to 181.5 cm³ with an internal pressure of 214.5 kPa. What is the temperature of the light bulb (in °C)?**

$P_1 = 101.325\ kPa$ $P_2 = 214.5\ kPa$

$V_1 = 180.0\ cm^3$ $V_2 = 181.5\ cm^3$

$T_1 = 273\ K$ $T_2 = ?$

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

$$= \frac{273 \cdot 214.5 \cdot 181.5}{101.325 \cdot 180}$$

$$T_2 = 583\ K$$

5. **Sulphur hexafluoride, $SF_{6(g)}$, is used as a chemical insulator. A 5.0 L sample of this gas is collected at 205.0°C and 250 kPa. What pressure must be applied to this gas sample to reduce its volume to 1.7 L at 25°C?**

$P_1 = 250\ kPa$ $P_2 = ?$

$V_1 = 5.0\ L$ $V_2 = 1.7\ L$

$T_1 = 478\ K$ $T_2 = 298\ K$

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

$$= \frac{250 \cdot 5.0 \cdot 298}{478 \cdot 1.7}$$

$$= 458\ kPa$$