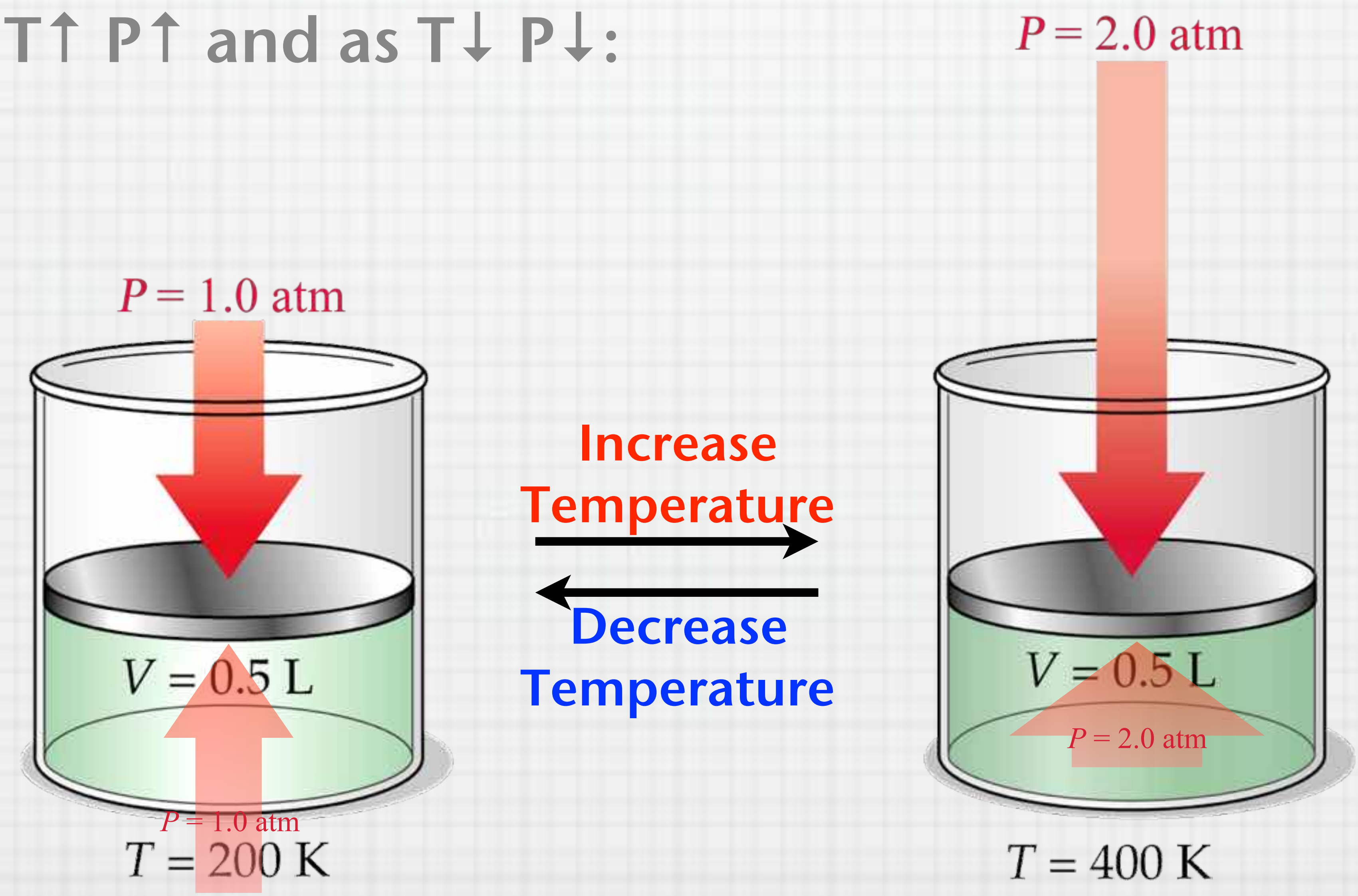
Gay-Lussac's Law & Combined Gas Law

Chemistry 1

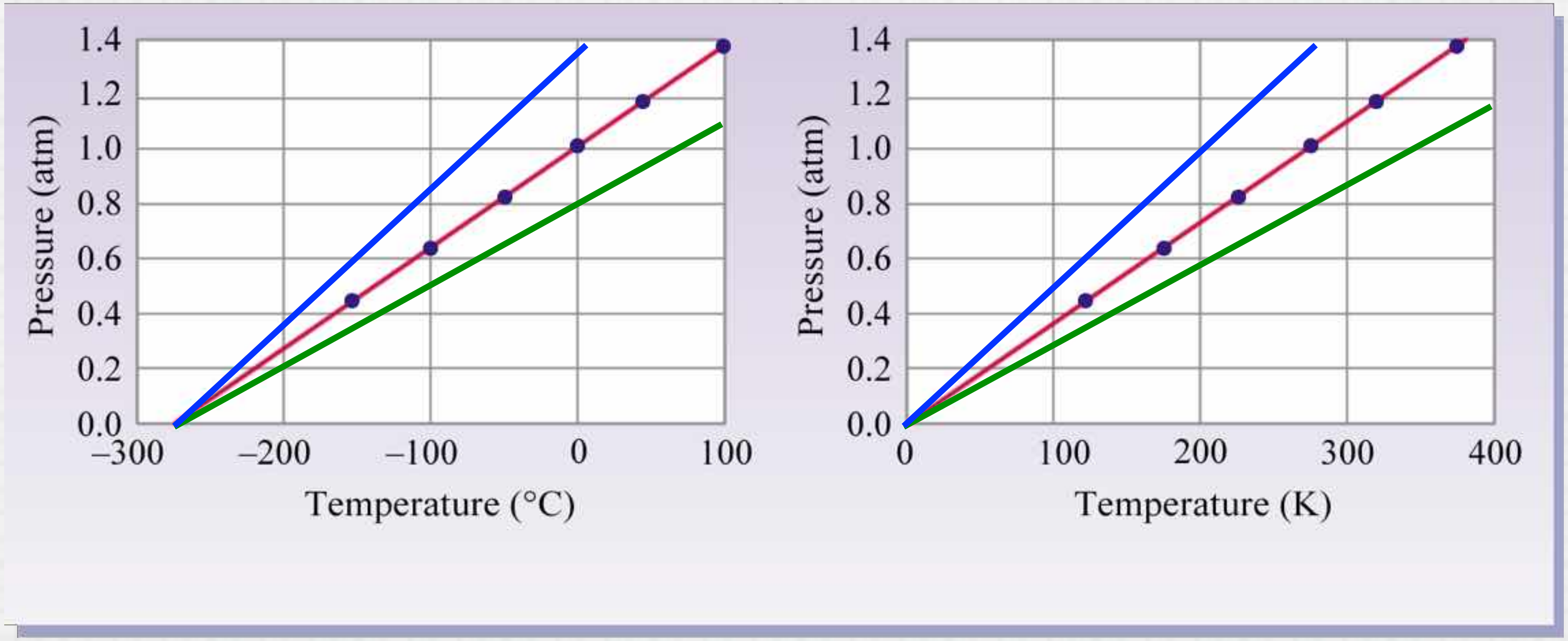
Gay-Lussac's Law

* Changes in P & T (V & n held constant)
  * From KMT: As T↑, speed of particles↑, so the the number of collisions↑ and force (energy) of each collision↑,
  * Since $P = \frac{\text{Force}}{\text{Area}}$, P↑ as V (area) remains constant
    * As T↑ P↑ and as T↓ P↓:



Graphing P vs. T

- Gay-Lussac realized that Pressure / Temperature = constant
  - Since P/T=constant, P & T are **directly related**: P = kT
  - Plot of P vs. T gives straight line



- As with Charles' Law, all gases extrapolate to P=0 at –273°C
  - At absolute 0, particles have no energy, all motion stops
  - Again, Kelvin (absolute temperature) used in gas problems

Gay-Lussac's Law Calculations

- If P or T change, still equal same constant, so $\boxed{\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}}$
- P-T problem: A gas sample initially has a pressure of 125.0 kPa at 25°C. At what Celsius temperature is the pressure 101.3 kPa?
  - Don't forget to convert T to Kelvin: T_1 = 25°C + 273 = 298 K

$$P_1 = 125.0\text{ kPa};\ P_2 = 101.3\text{ kPa};\ T_2 = ?$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \text{ so } \frac{125.0\text{ kPa}}{298\text{ K}} = \frac{101.3\text{ kPa}}{T_2}\text{; cross-multiply and divide:}$$

$$125.0\text{ kPa} \times T_2 = 101.3\text{ kPa} \times 298\text{ K}$$

$$T_2 = \frac{298\text{ K} \times 101.3\ \cancel{\text{kPa}}}{125.0\ \cancel{\text{kPa}}} = 241\text{ K}$$

$$\text{so } T_2 = 241\text{ K} - 273 = \boxed{-32°\text{C}}\text{; note that P}\downarrow\text{ when T}\downarrow$$

Combined Gas Law

* Combination of Boyle's, Charles', and Gay-Lussac's Laws
* $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$: Changes in P, V, T keeping n constant
  * Hold one variable constant to get the previous 3 laws

Combined Gas Law

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      Boyle's Law

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    Charles' Law

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  - Hold one variable constant to get the previous 3 laws

    Gay-Lussac’s Law

Combined Gas Law

- Combination of Boyle's, Charles', and Gay-Lussac's Laws
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  - Hold one variable constant to get the previous 3 laws
  - Given P, V, T, change any two & can find the third
  - Given a gas with P_1=0.75 atm, V_1=0.30 L, T_1=150 K; P_2=0.95 atm, T_2=300 K, what is V_2?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow \frac{(0.75\text{ atm})(0.30\text{ L})}{150\text{ K}} = \frac{(0.95\text{ atm})V_2}{300\text{ K}}$$

- Cross multiply and divide:

$$V_2 = \frac{(0.75\text{ atm})(0.30\text{ L})(300\text{ K})}{(0.95\text{ atm})(150\text{ K})} = \boxed{0.47\text{ L}}$$