Derivation:

$$P_1V_1 = nRT_1$$

$$P_2V_2 = nRT_2$$

Combined Gas Law: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Assumption: fixed amount (n is constant)

3. What is the volume occupied by 32 $\underset{n=2}{\text{g}}$ of oxygen (mass number = 16) at $\underbrace{\text{room temperature}}_{20°C \rightarrow 293K}$ and $\underbrace{\text{atmospheric pressure}}_{1.01\times10^5 Pa}$?

$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{2\,\cancel{mol}\; 8.31\, J\, \cancel{mol^{-1}}\, \cancel{K^{-1}}\; 293\,\cancel{K}}{1.01\times10^5\, \frac{\cancel{N}}{m^2}}$$

N·m

$= .048\, m^3$

4. A gas in a closed container is under a pressure of 1 atm and a temperature of -173 °C. The gas is then heated to 27 °C. What is the new pressure of the gas?

100K

300K

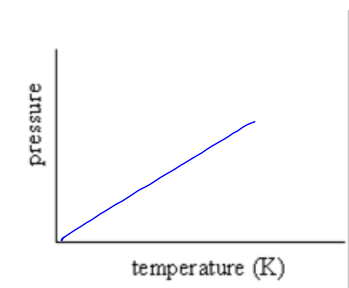
$$\frac{P_1 \cancel{V_1}}{T_1} = \frac{P_2 \cancel{V_2}}{T_2}$$

$$P_1 = P_2\left(\frac{T_1}{T_2}\right)$$

$$1\,atm\left(\frac{300K}{100K}\right)$$

$$= 3\,atm$$

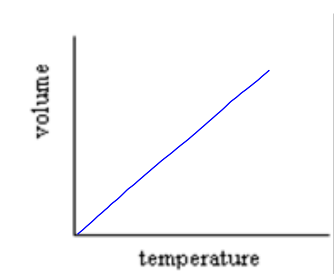
5. Sketch the graph of each relationship shown below for an ideal gas, state the control variable and the type of process.



Control = volume

Type of process:

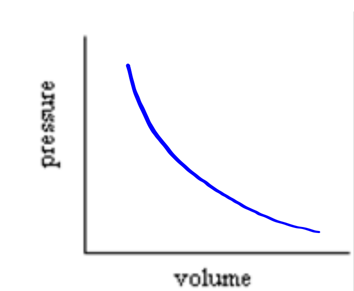
Isochoric



Control = pressure

Type of process:

isobaric

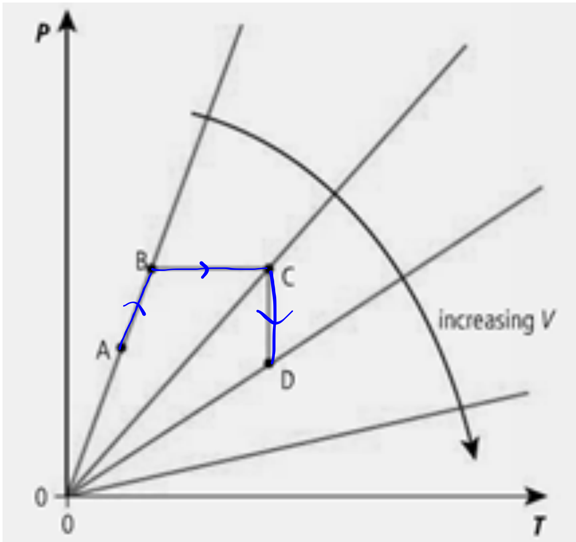


Control = temp

Type of process:

isothermal

6. For each graph below, identify each of the indicated processes.



Process AB:

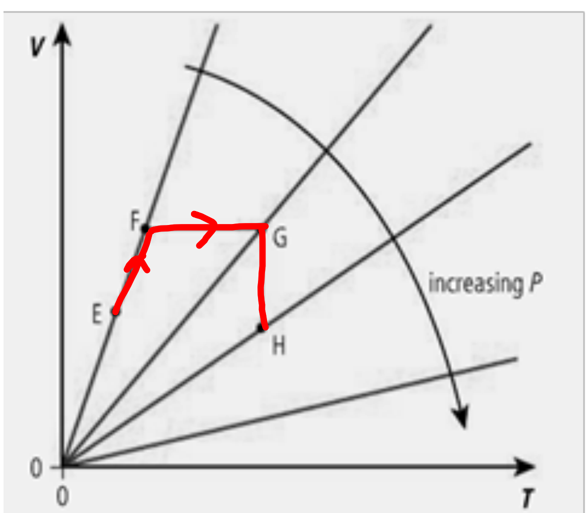
isochoric

Process BC:

isobaric

Process CD:

isothermal



Process EF:

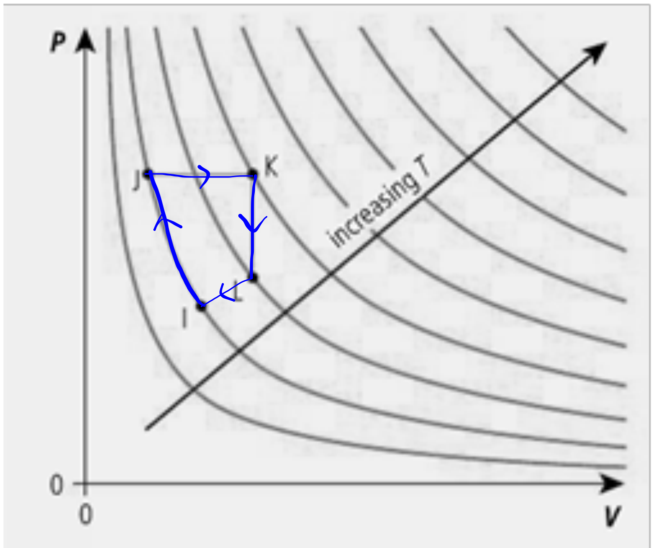
isobaric

Process FG:

isochoric

Process GH:

isothermal



Process IJ:

isothermal

Process JK:

isobaric

Process KL:

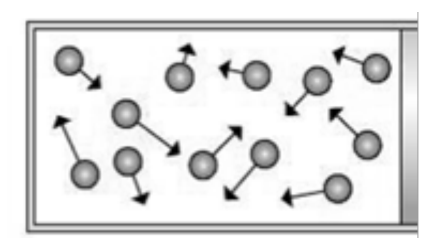
isochoric

Internal Energy of a Monatomic Ideal Gas

Monatomic gas: gas consisting of single atoms

According to the assumptions of the kinetic model of an ideal gas, there are no bonds or interatomic forces between any of the particles in the gas.

Therefore,



a) no internal potential energy

$U = \text{total } E_K + \text{total } E_P$

b) all of the internal energy is kinetic energy only

$U = \text{total } E_K$

c) internal energy is proportional to the temperature of the gas

$\bar{E}_k \propto T$

$U = N\bar{E}_k$

$U \propto T$

$PV = n\underline{\underline{R}}T$

$PV = N \cdot \underline{\underline{K}}\ T$

$\left(k = \frac{R}{N_A}\right)$

Formulas: $\frac{1}{2}mV_{Rms}^2 = \bar{E}_k = \frac{3}{2}K_B T$

$= \frac{3}{2}\frac{R}{N_A} \cdot T$

Where $k_B = 1.38 \times 10^{-23}\ J/K$

Derivation: $U = N\bar{E}_k = N \cdot \frac{3}{2}\frac{R}{N_A} \cdot T$

$= \frac{3}{2}nRT = \frac{3}{2}PV$

1. A container holds 8.0 grams of helium gas (He-4) at 20° C.

a) Calculate the average kinetic energy of the atoms.

$\bar{E}_k = \frac{3}{2}kT$

$= \frac{3}{2}\ 1.38 \times 10^{-23}\frac{J}{K} \cdot 293K$

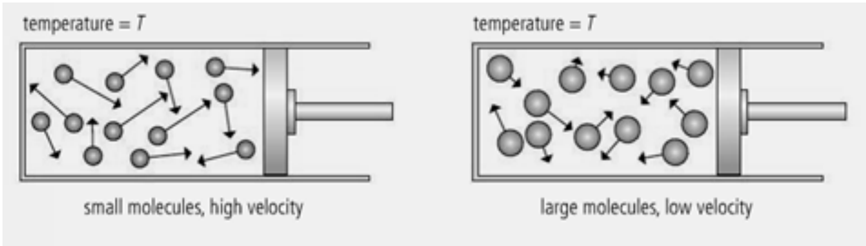
$= 6.07 \times 10^{-21}J = \frac{1}{2}mv^2$

4 Amu

$N\bar{E}_k \rightarrow 2 \times N_A \times 6.07 \times 10^{-21}J$

b) Calculate the total internal energy of the gas.

2. A sample of helium gas (He-4) and a sample of argon gas (Ar-40) are held at the same temperature in separate containers, as shown below. Compare the average speeds of the atoms.



$\bar{E}_K = \bar{E}_K$

$\frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_2 v_2^2$

$v_2 = \sqrt{\frac{m_1}{m_2}}\, v_1$

$V_H = \sqrt{10}\, V_A$