

Gas Laws

Ideal Gas Law Equation of State

Relationship between the variables that describe a gas, could be a parcel of air, or the entire atmosphere

Gas Variables

- **Pressure** – intensity of force applied to the parcel of gas (force/area)
- **Volume** – 3D space occupied by the parcel of gas
- **Mass** – quantity of gas in the parcel, measured in mass units
- **Density** – mass/volume
- **Temperature** – measure of average kinetic energy of the gas

Different Views of Pressure in the Atmosphere

1. At the surface of the earth or a given height above sea level

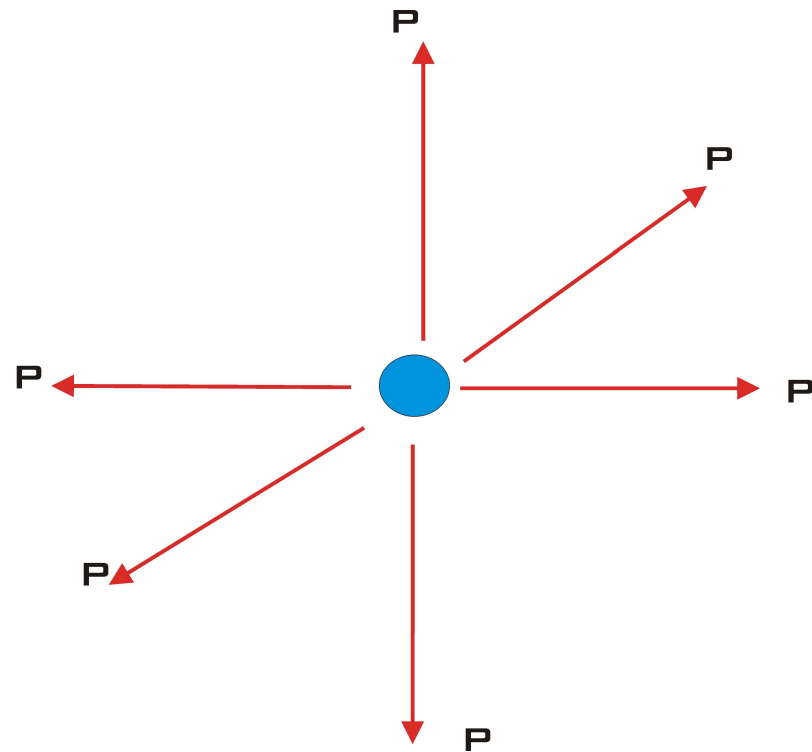
Pressure is the weight of the atmosphere per unit area (lbs/sq.in.)

2. For a parcel of air

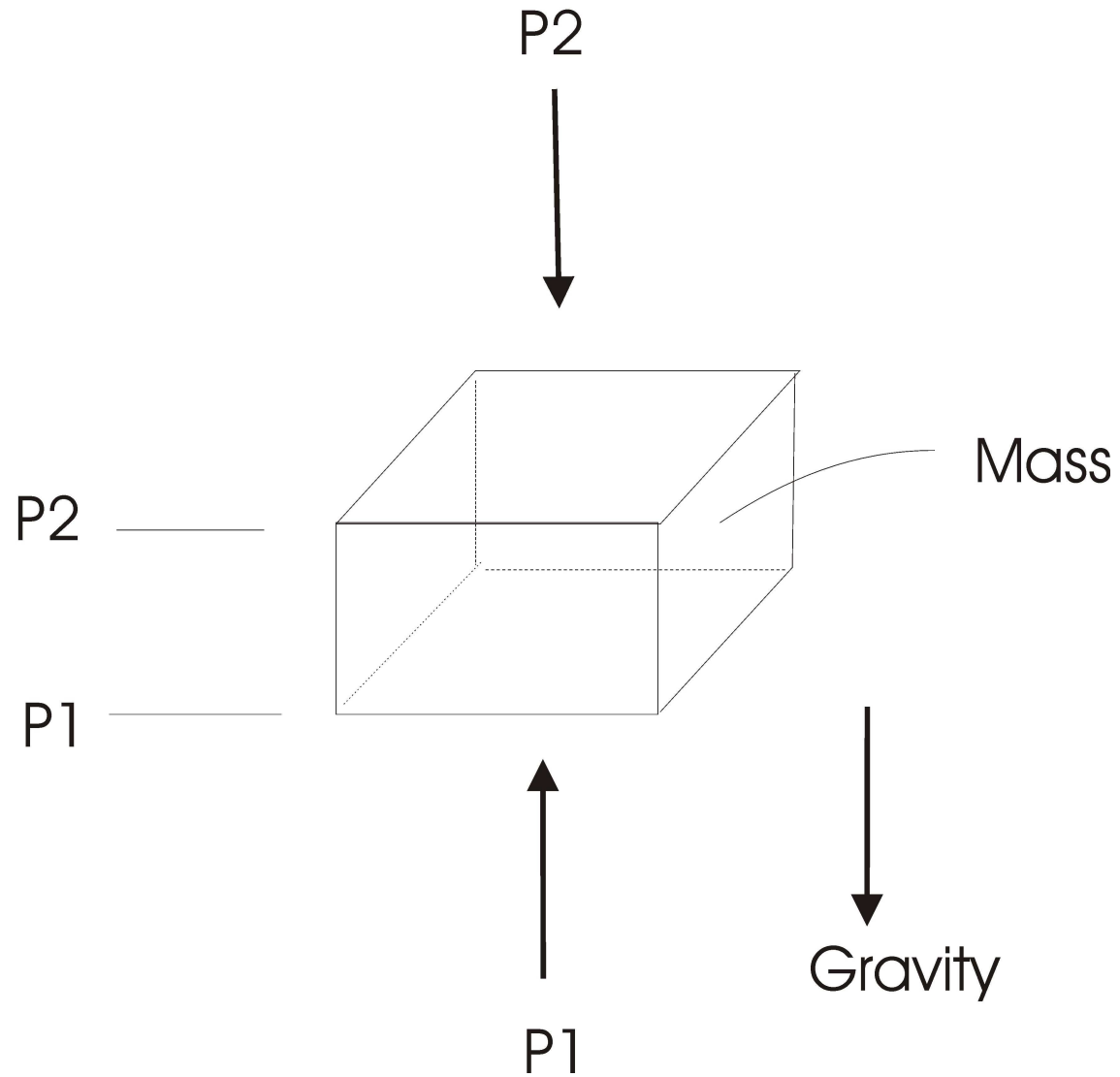
Pressure is the intensity of force applied either externally or internally (lbs/sq.in.)

Pressure is Isotropic

- **Isotropic** – equal in all directions
- Gas must be in **equilibrium** – not moving



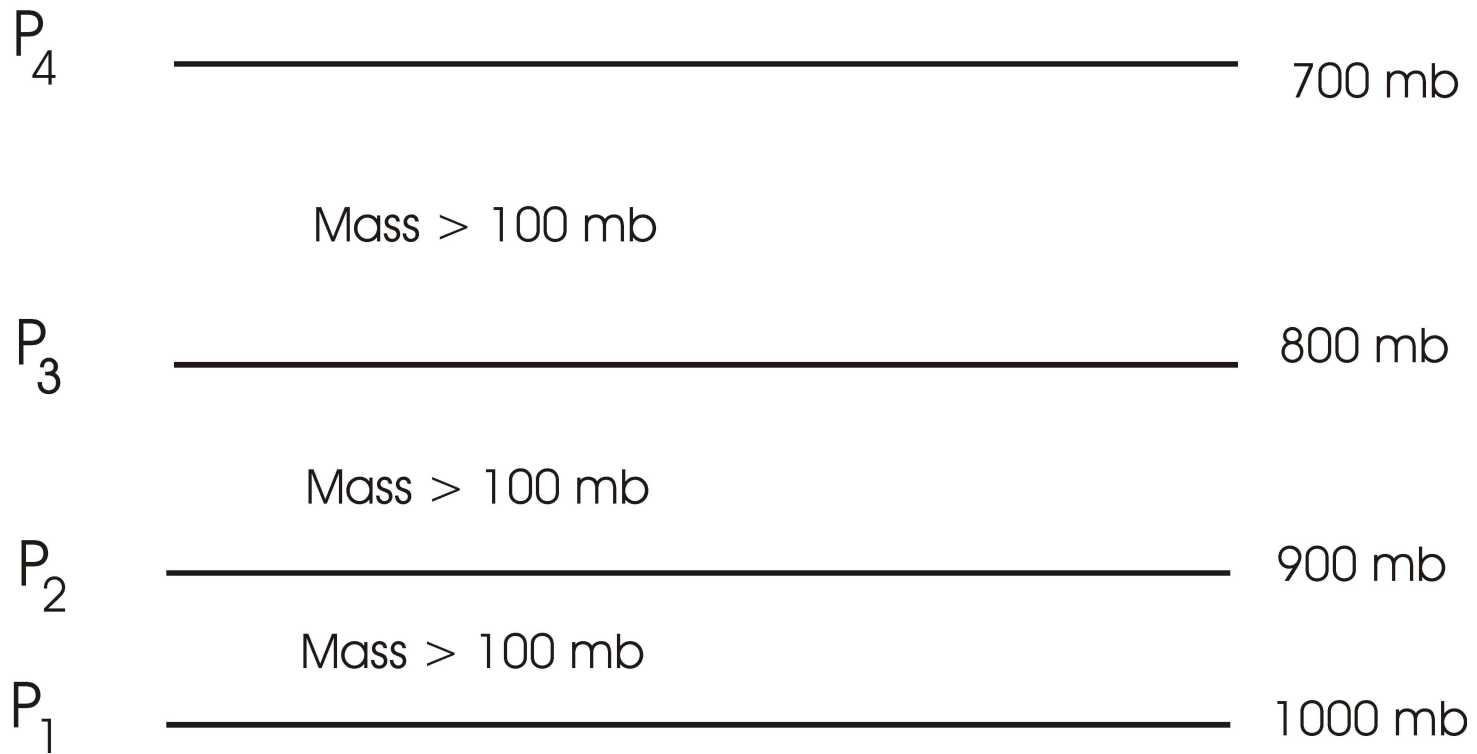
Hydrostatic Equilibrium



Hydrostatic Equilibrium

- Pressure decreases with height
- Net Force is upward due to difference in pressure on bottom and top of parcel
- Force of gravity depends on mass in parcel
- Force of gravity balances force due to pressure differences

Pressure Layers

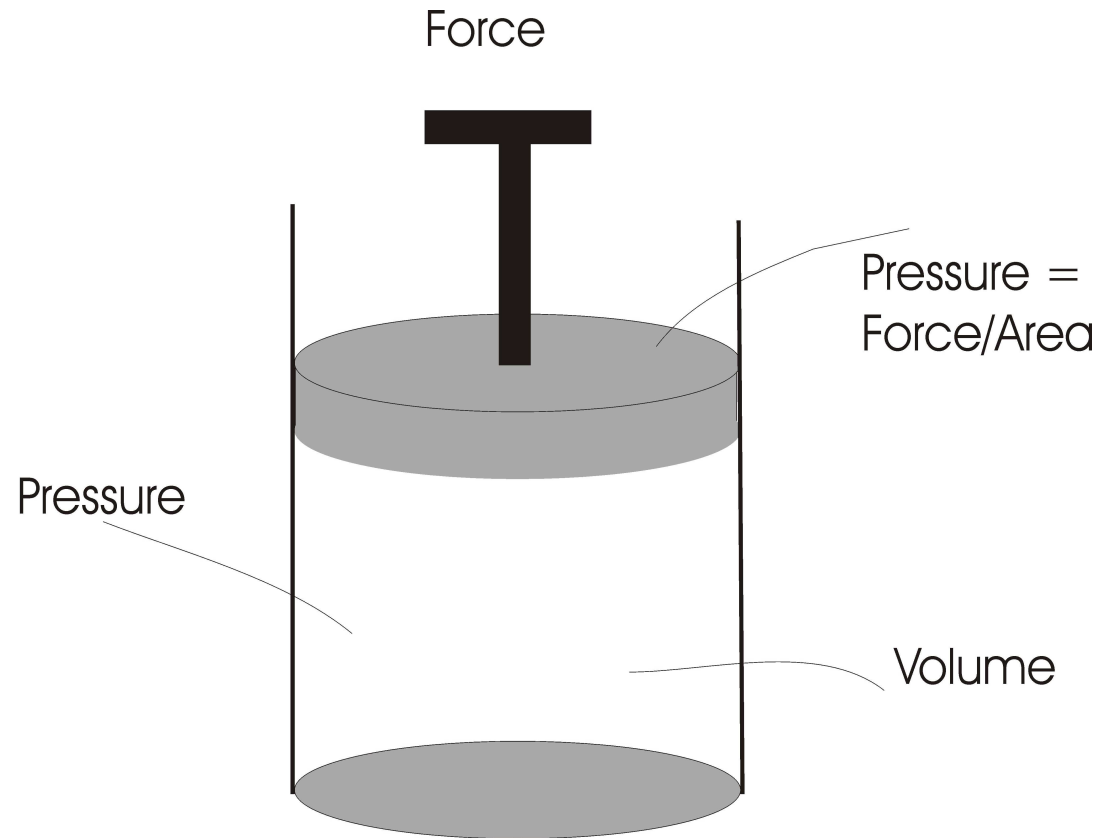


Gas Laws

Boyle's Law 1660

Relationship of
Pressure and
Volume

Temperature is
constant



Boyle's Law - Data

P	V	P x V
1	1	1
2	$\frac{1}{2}$	1
3	$\frac{1}{3}$	1
4	$\frac{1}{4}$	1

Boyle's Law Summary

Pressure and *Volume* of a gas are *Inversely* proportional (if the temperature is constant)

$$(\text{Pressure}) \times (\text{Volume}) = \text{Constant Value}$$

Boyle's Law Example

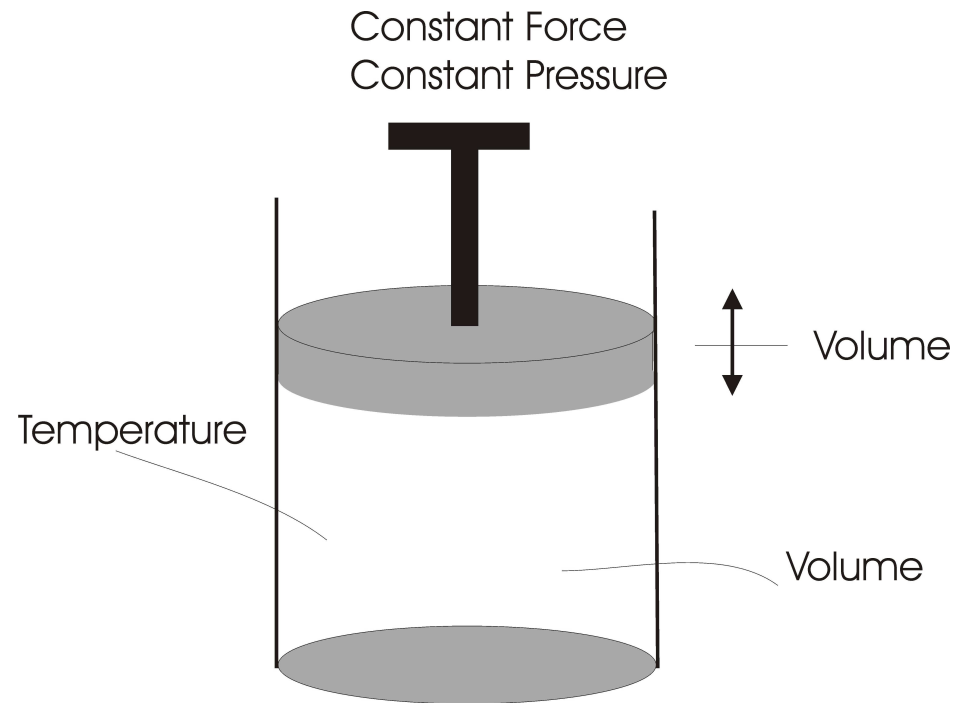
1. Start: $P = 1000 \text{ mb}$
 $V = 3 \text{ m}^3$
2. $P \times V = 1000 \times 3 = 3000$ (constant value)
3. Finish $P = 700 \text{ mb}$, ? What is V
4. $P \times V = 3000$
 $700 \times (V) = 3000$
 $V = 3000/700 = 4.3 \text{ m}^3$

Gas Laws

Charles Law

**Temperature and
Volume**

Pressure is
Constant



Charles' Law - Data

T	V	T x V	V/T
1	1	1	1
2	2	4	1
3	3	9	1
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	1

Charles' Law Summary

Temperature and *Volume* are *Directly* proportional (if pressure is constant)

$$(\text{Volume})/(\text{Temperature}) = \text{Constant Value}$$

Charles' Law Example

1. Start: $V=5 \text{ m}^3$, $T = 200 \text{ K}$
2. $V/T = 5/200 = 0.025$ (constant value)
3. Finish: $T=350 \text{ K}$, ? What is V
4. $V/T = 0.025$
 $V/350 = 0.025$
 $v = (0.025) \times (350) = 8.75 \text{ m}^3$

Ideal Gas Law

Relationship when P, V, and T may all be changing

Combination of Boyle's Law and Charles' Law

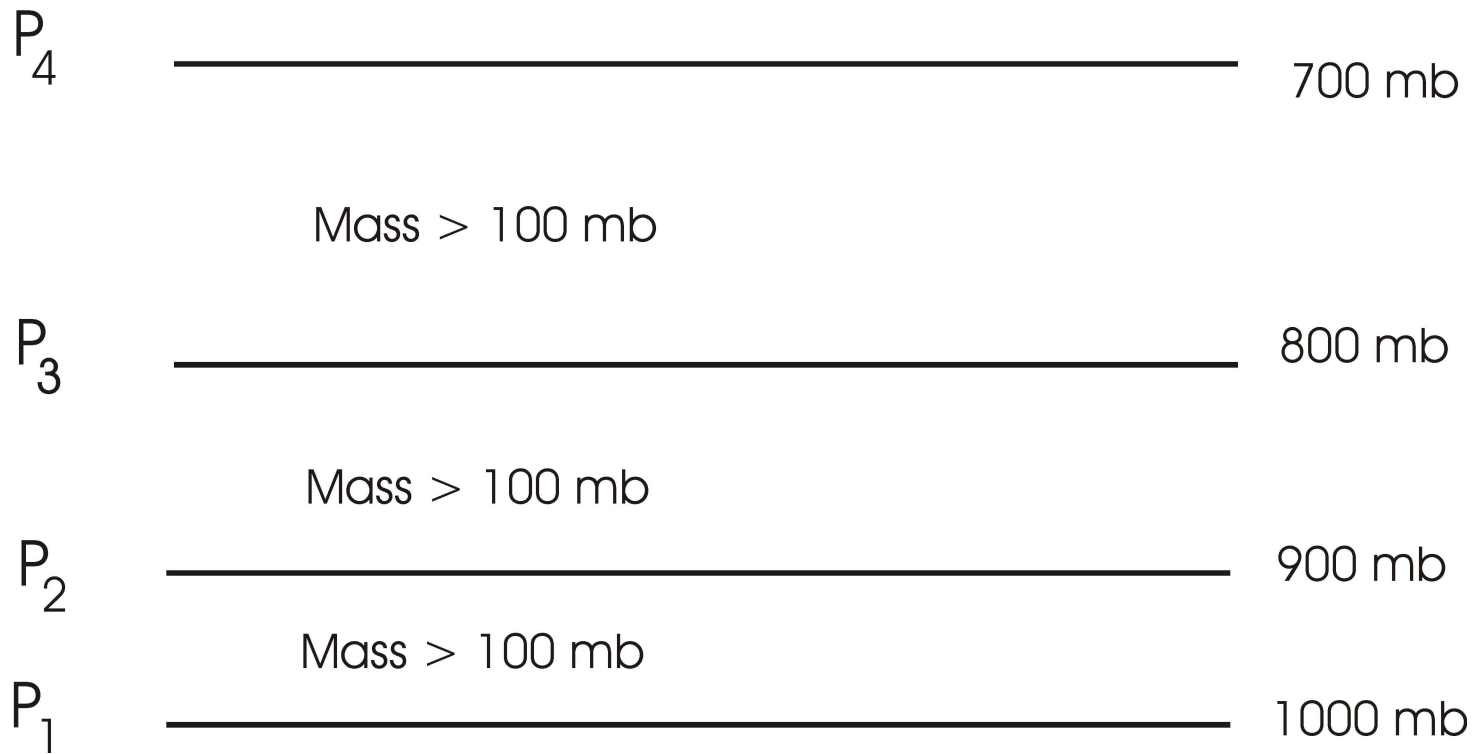
Ideal Gas Law

$$(P \times V)/T = \text{Constant Value}$$

Ideal Gas Law - Example

1. Start: $P=1000 \text{ mb}$, $V= 12 \text{ m}^3$, $T=280 \text{ K}$
2. $(P \times V)/T = (1000 \times 12)/280 = 42.85$
3. Finish: $P=600 \text{ mb}$, $T=240 \text{ K}$, What is V
4. $(P \times V)/T = 42.85$
 $(600 \times V)/240 = 42.85$
 $2.5 \times V = 42.85$
 $v = 42.85/2.5 = 17.1 \text{ m}^3$

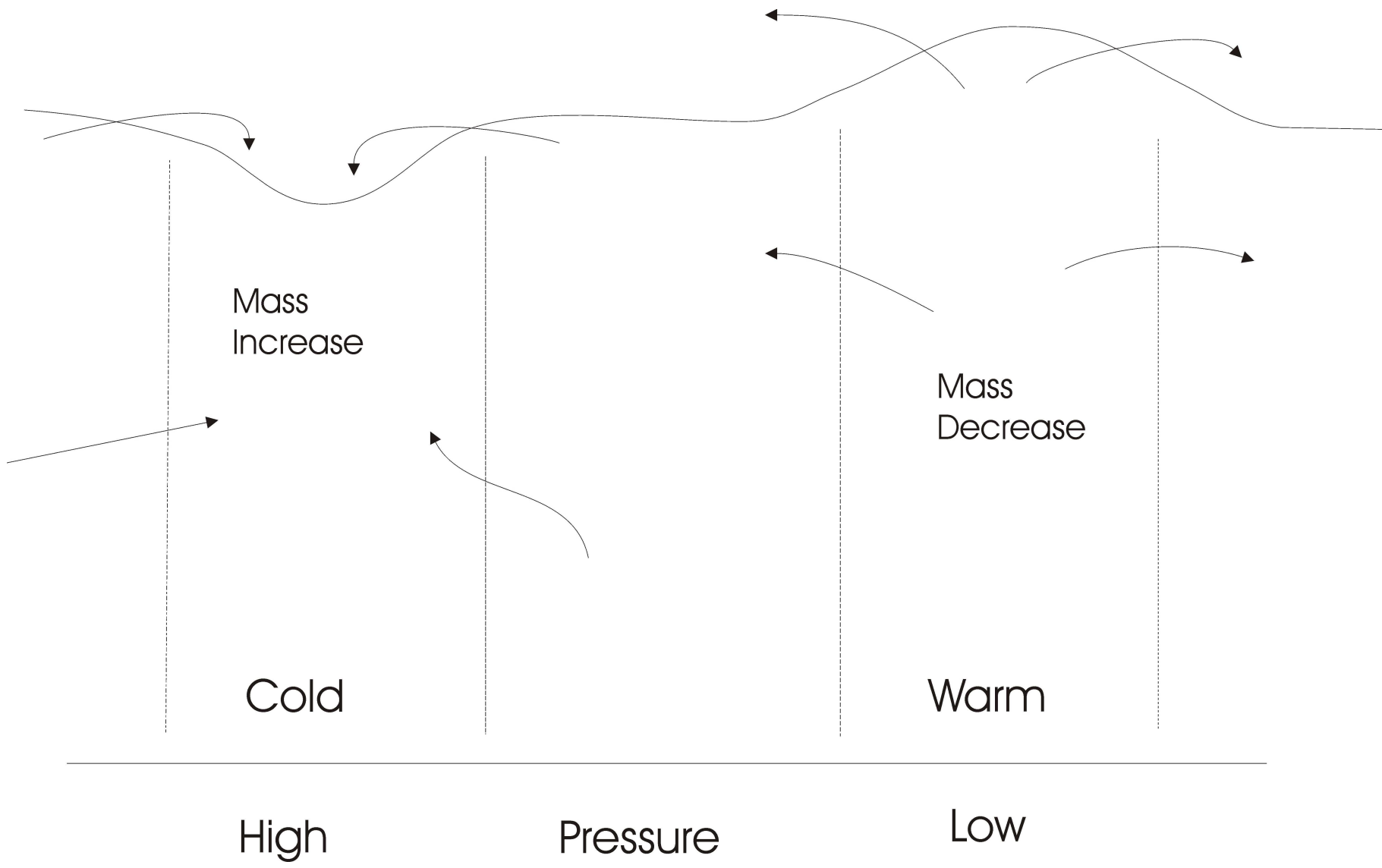
Pressure Layers

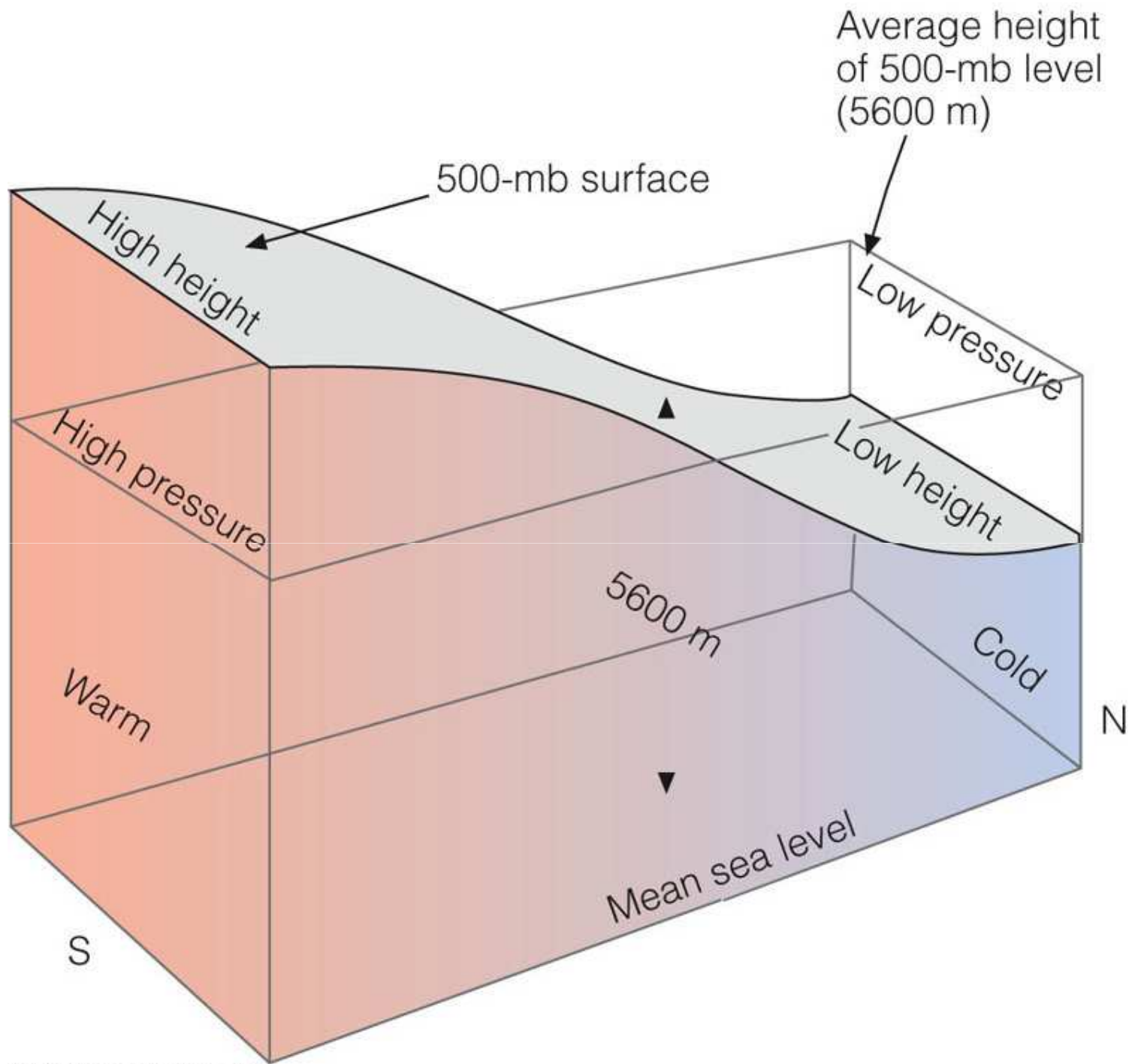


● **TABLE 8.1**

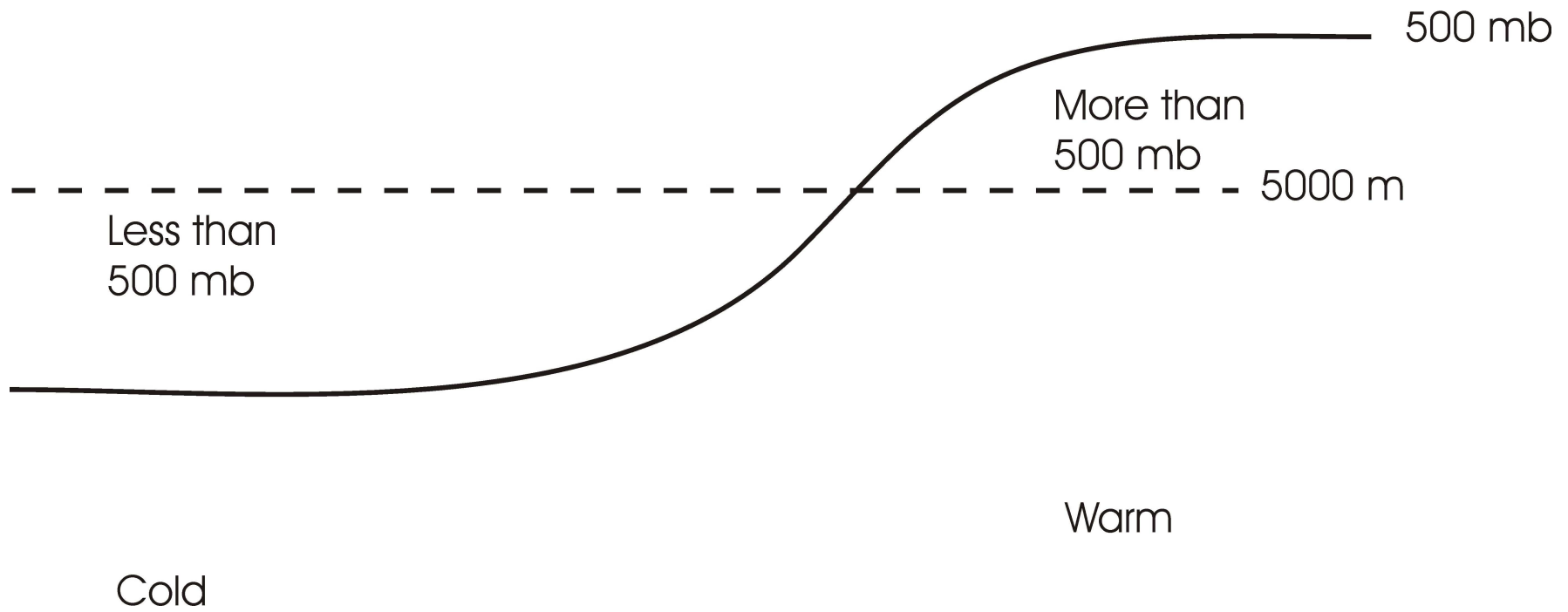
Common Isobaric Charts and Their Approximate Elevation above Sea Level

ISOBARIC SURFACE (MB) CHARTS	APPROXIMATE ELEVATION	
	(m)	(ft)
1000	120	400
850	1,460	4,800
700	3,000	9,800
500	5,600	18,400
300	9,180	30,100
200	11,800	38,700
100	16,200	53,200





Cross Section of an Isobaric Surface

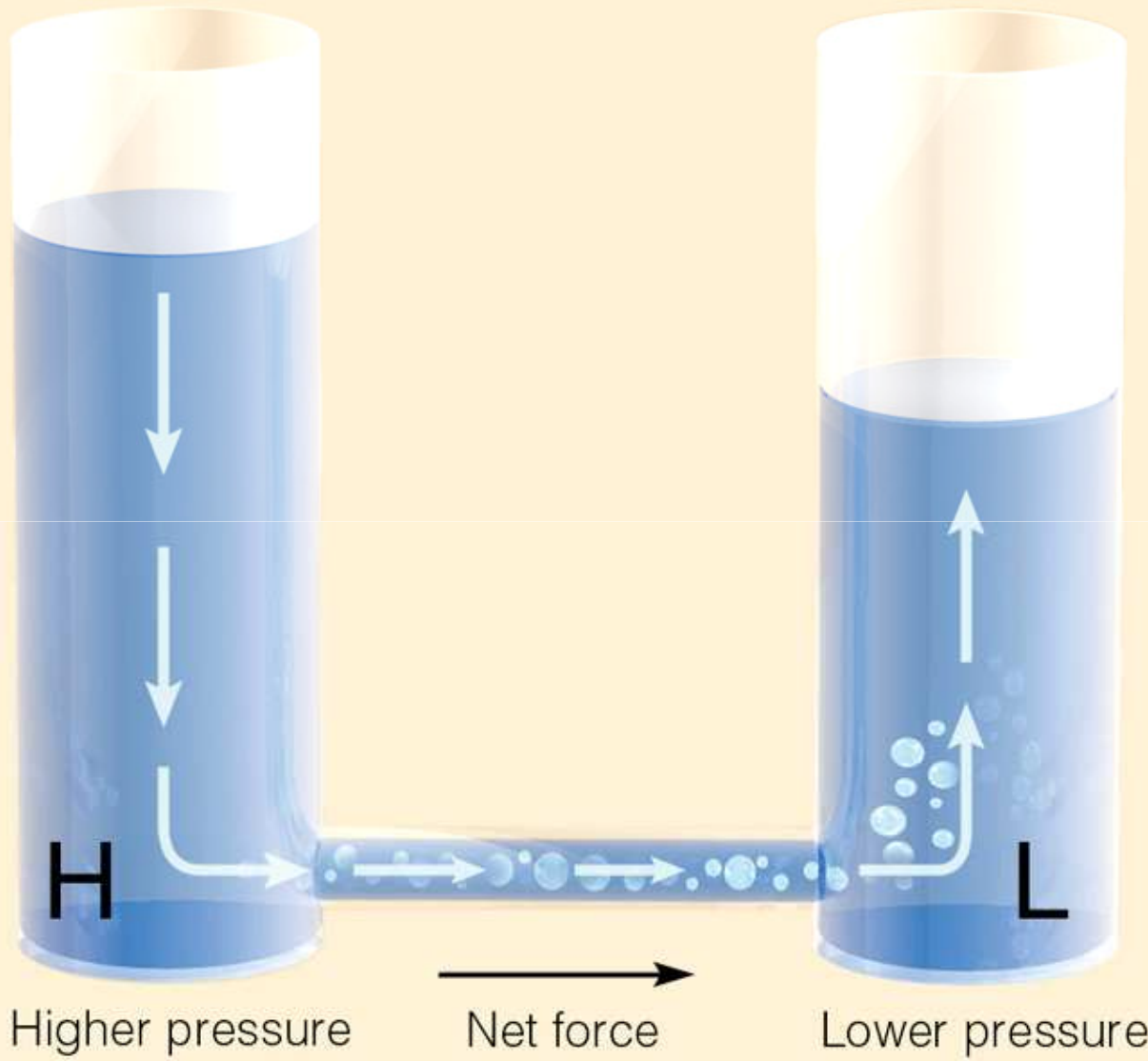


Pressure – Height - Temperature

	WARM	COLD
SURFACE	LOW Pressure	High Pressure
UPPER LEVELS	HIGH Pressure (Ridge)	LOW Pressure (Trough)

TANK A

TANK B



Higher pressure



Net force

Lower pressure

Dalton's Law of Partial Pressures

- Suppose you have a gas that is a mixture of gases A, B, and C (nitrogen, oxygen, and water vapor)
- The gas has a pressure of P_t
- The pressures of gases A, B, and C by themselves are P_A , P_B , and P_C
- $$P_t = P_A + P_B + P_C$$