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

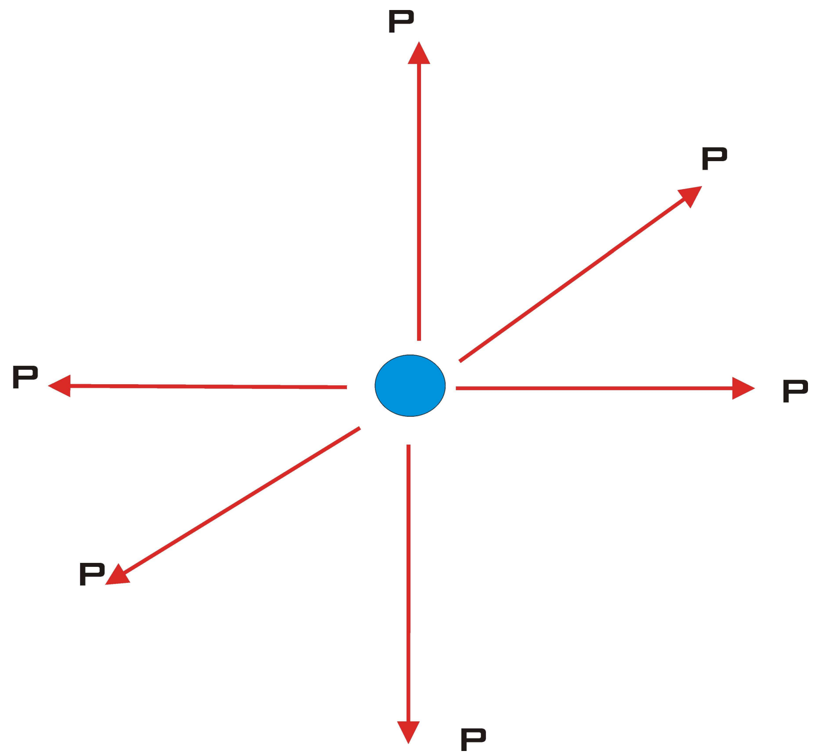
   Pressure is the weight of the atmosphere per unit area (lbs/sq.in.)

2. For a parcel of air

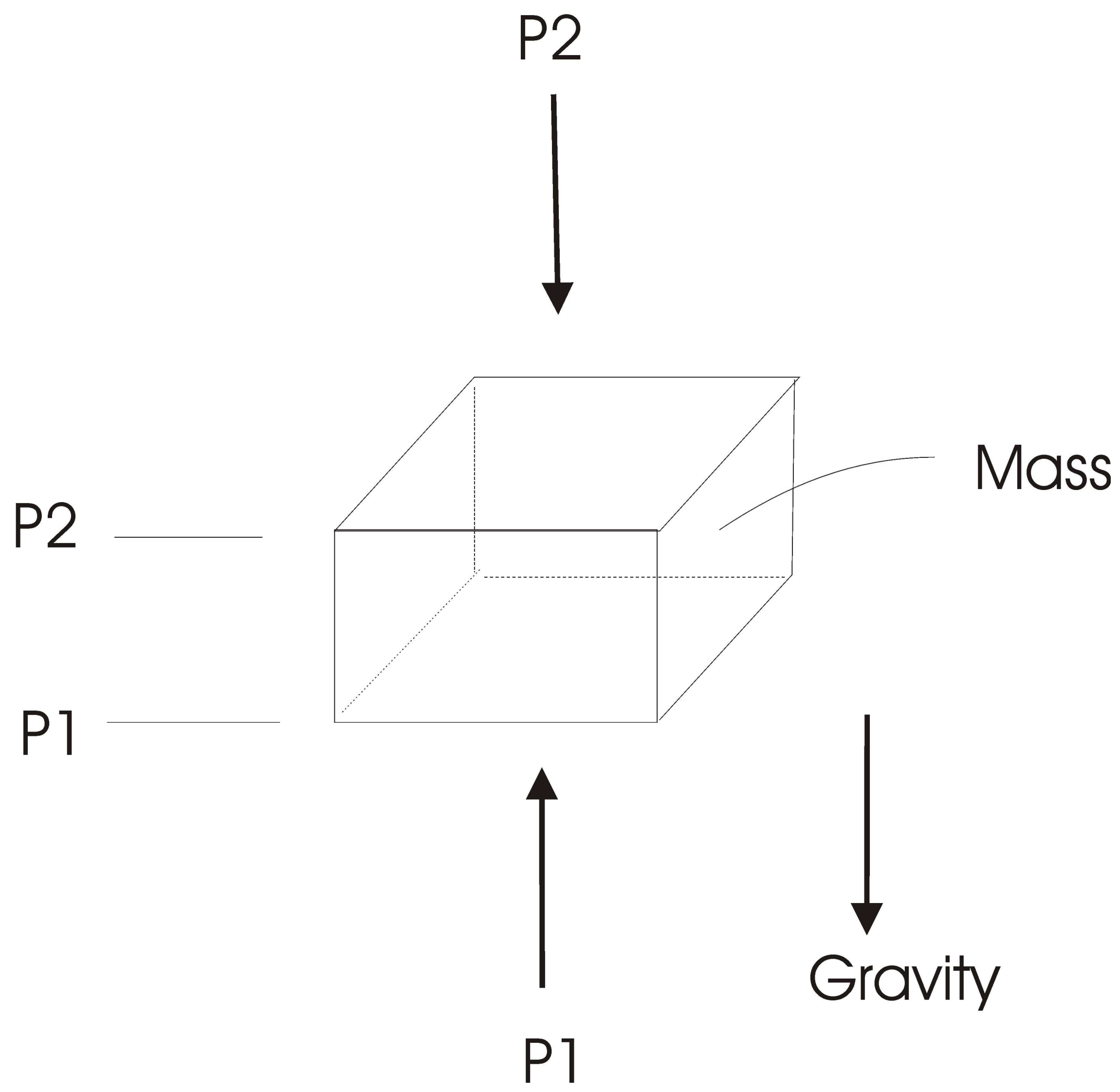
   Pressure is the intensity of force applied either externally or internally (lbs/sq.in.)

Pressure is Isotropic

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



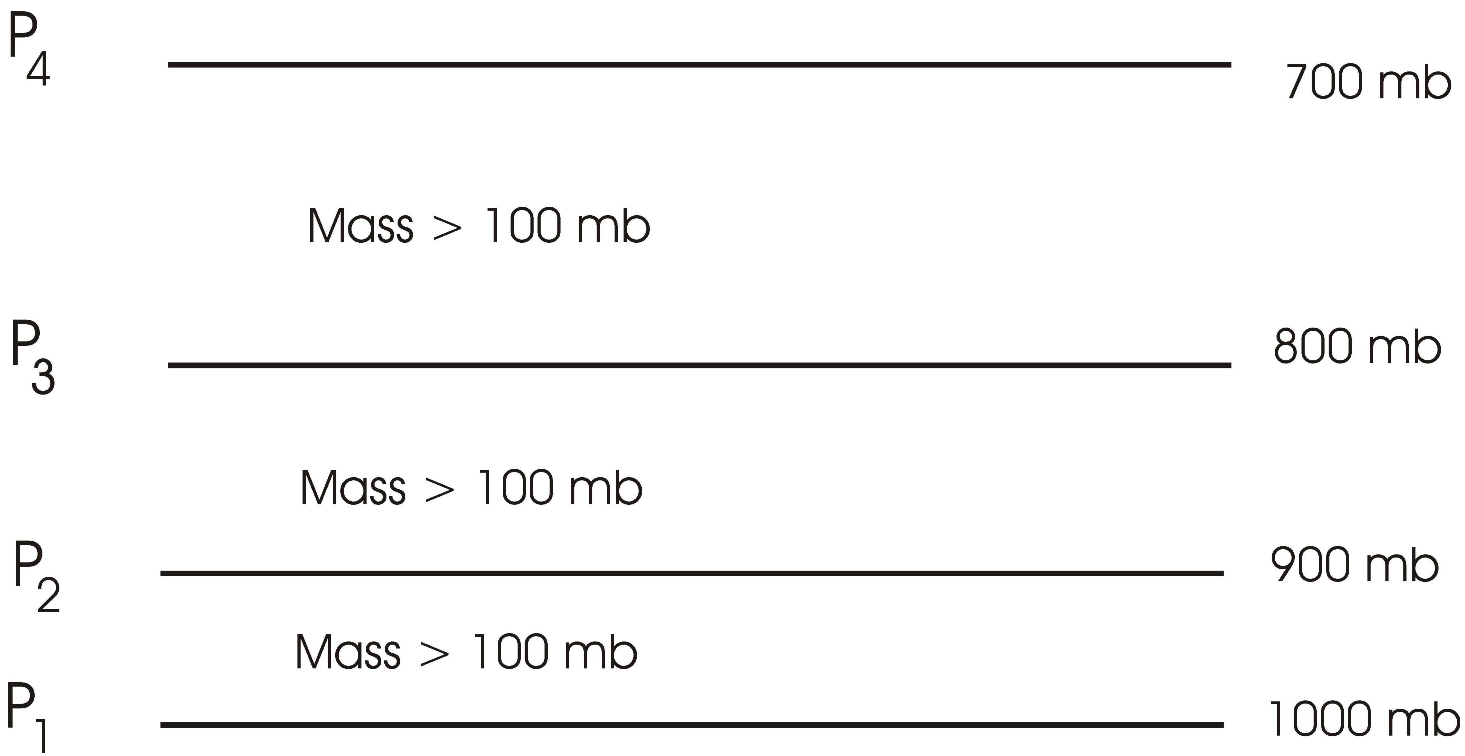
Hydrostatic Equilibrium



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

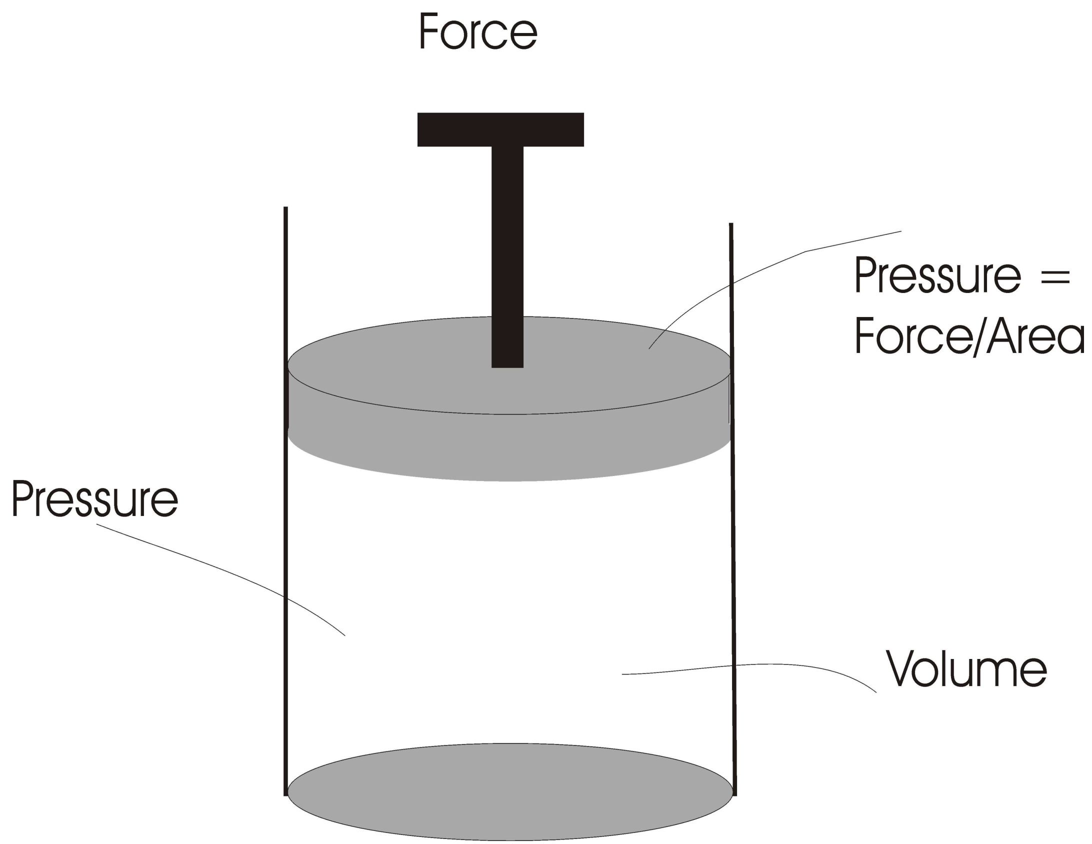
Pressure Layers



Gas Laws

Boyle's Law 1660

Relationship of
Pressure a nd
Volume
Temperature is
constant



Boyle's Law - Data

P	V	P x V
1	1	1
2	½	1
3	1/3	1
4	¼	1

Boyle's Law Summary

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

(Pressure) x (Volume) = Constant Value

Boyle's Law Example

1. Start: P= 1000 mb

   V = 3 m^3
2. P x V = 1000 x 3 = 3000 (constant value)
3. Finish P = 700 mb, ? What is V
4. P x V =3000

   700 x (V) = 3000

   V = 3000/700 = 4.3 m^3

Gas Laws

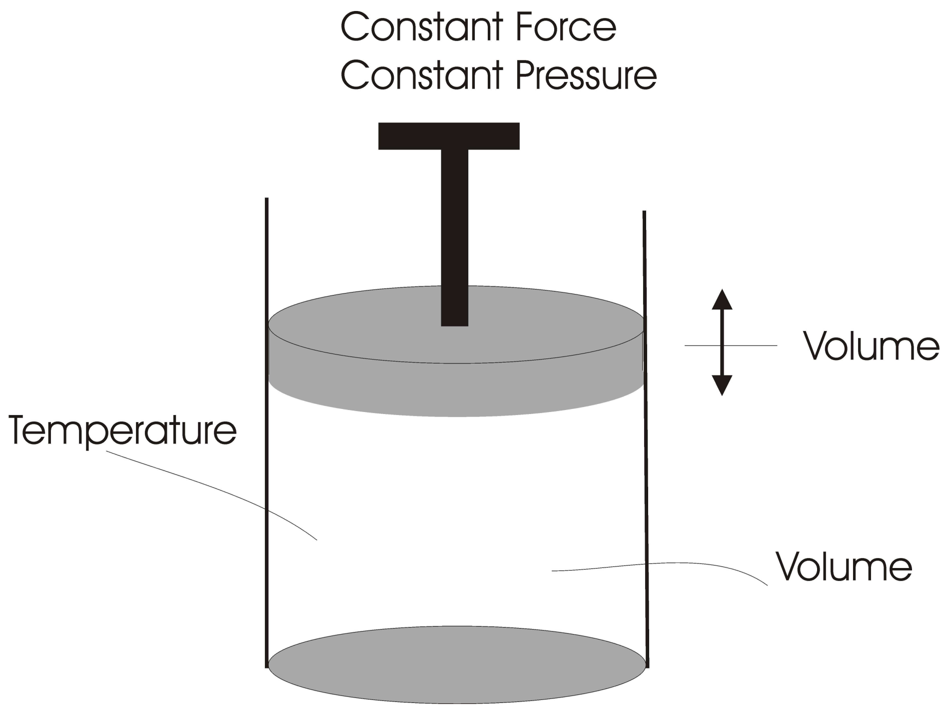
Charles Law

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
½	½	¼	1

Charles’ Law Summary

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

(Volume)/(Temperature) = Constant Value

Charles' Law Example

1. Start: V=5 m^3, T = 200 K
2. V/T = 5/200 = 0.025 (constant value)
3. Finish: T=350 K, ? What is V
4. V/T = 0.025

   V/350 = 0.025

   v = (0.025) x (350) = 8.75 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

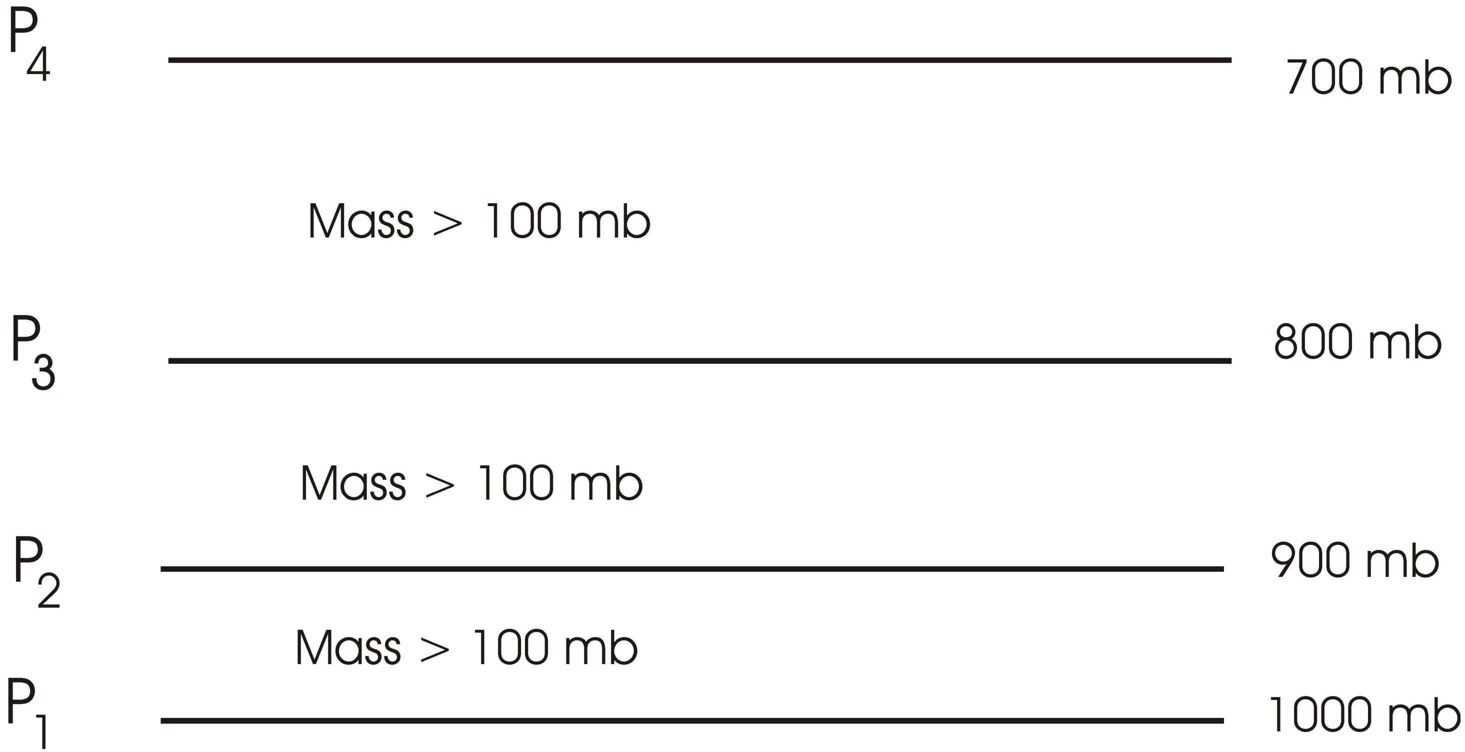
1. Start: P=1000 mb, V= 12 m^3, T=280 K
2. (PxV)/T = (1000x12)/280 = 42.85
3. Finish: P=600 mb, T=240 K, What is V
4. (PxV)/T = 42.85

   (600xV)/240 = 42.85

   2.5xV=42.85

   v = 42.85/2.5 = 17. 1 m^3

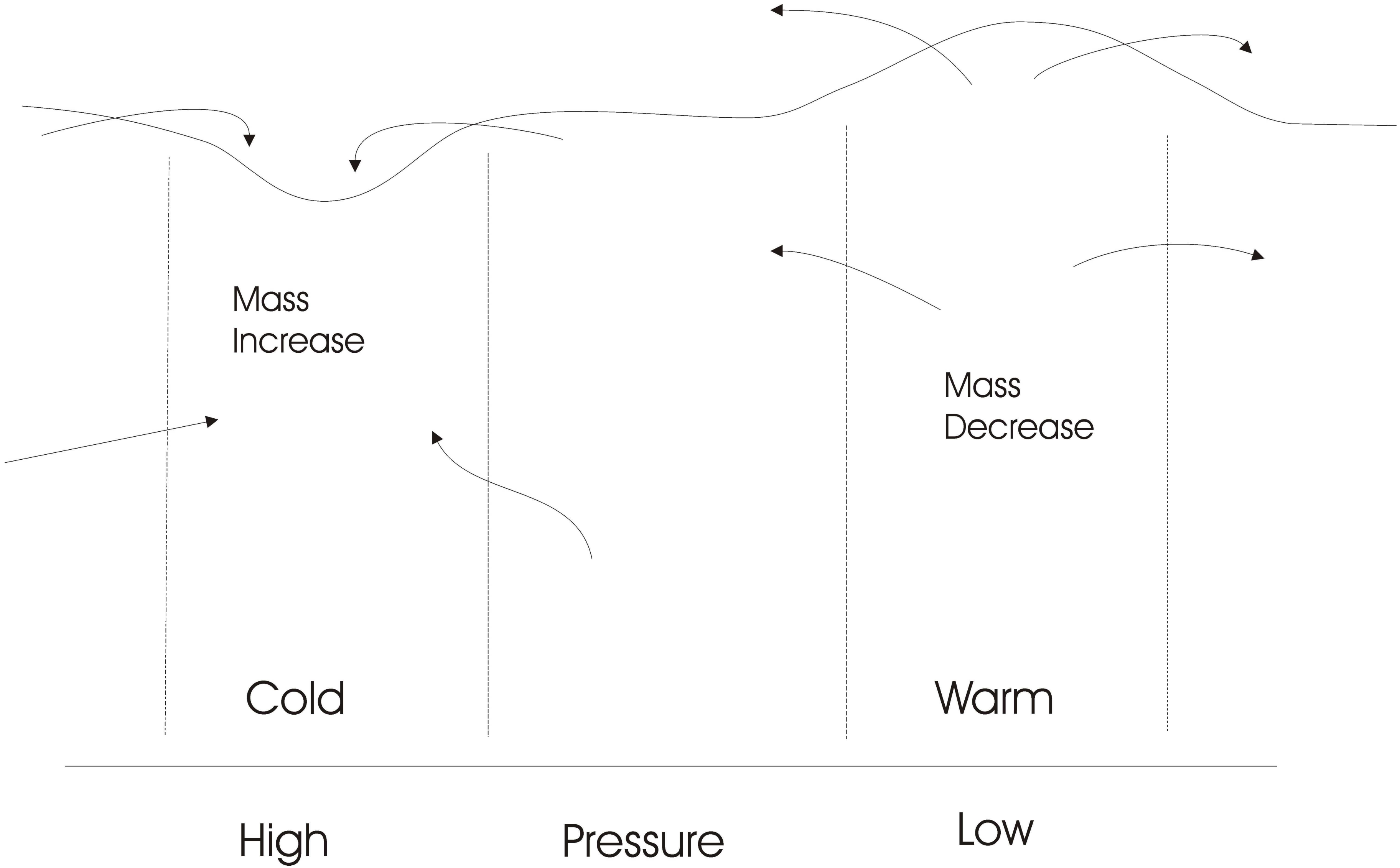
Pressure Layers

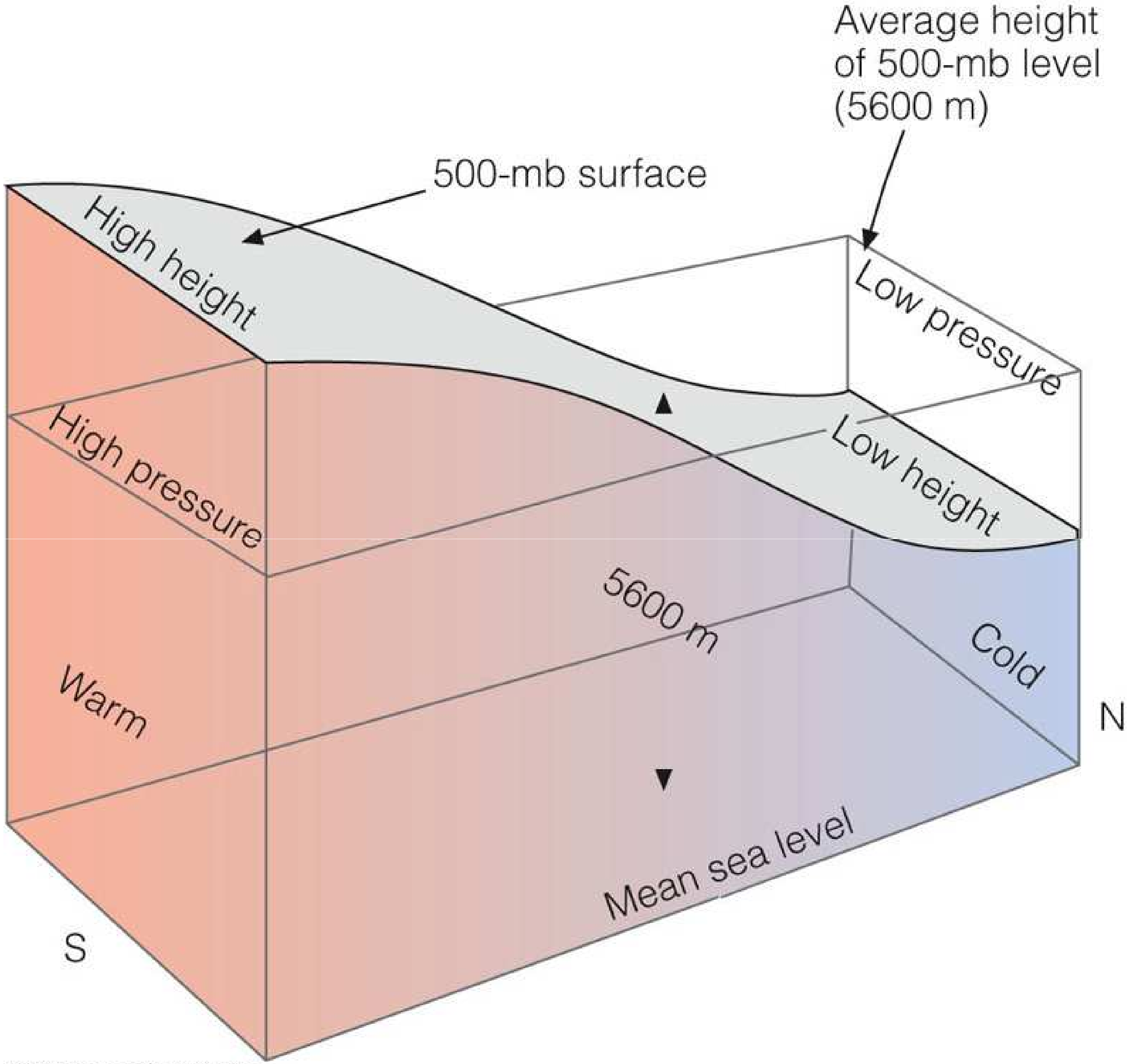


•TABLE 8.1

Common Isobaric Charts and Their Approximate Elevation above Sea Level

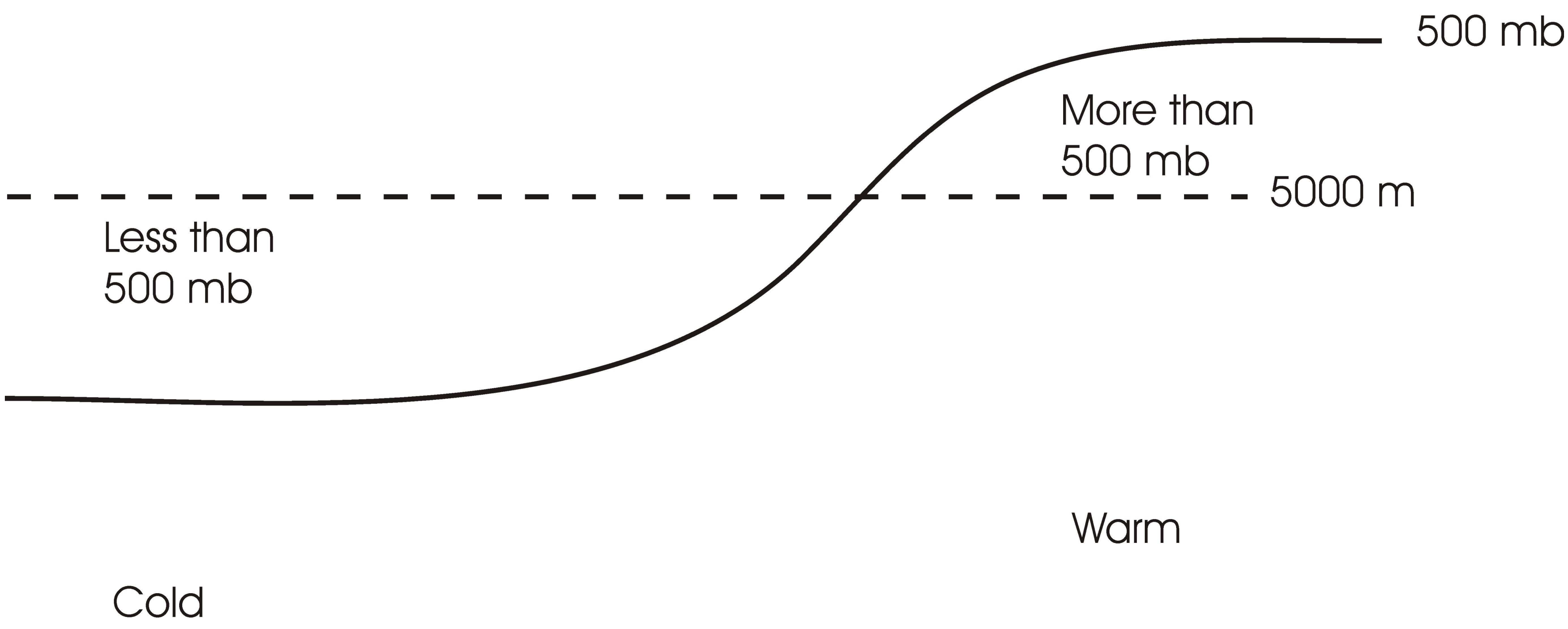
ISOBARIC SURFACE (MB) CHARTS	APPROXIMATE ELEVATION (m)	(ft)
1000	120	400
850	1,460	4,800
700	3,000	9,800
500	5,600	18,400
300	9,180	30,100
200	11,800	38,700
100	16,200	53,200


Mass
Increase
Mass
Decrease
Cold
Warm
High
Pressure
Low



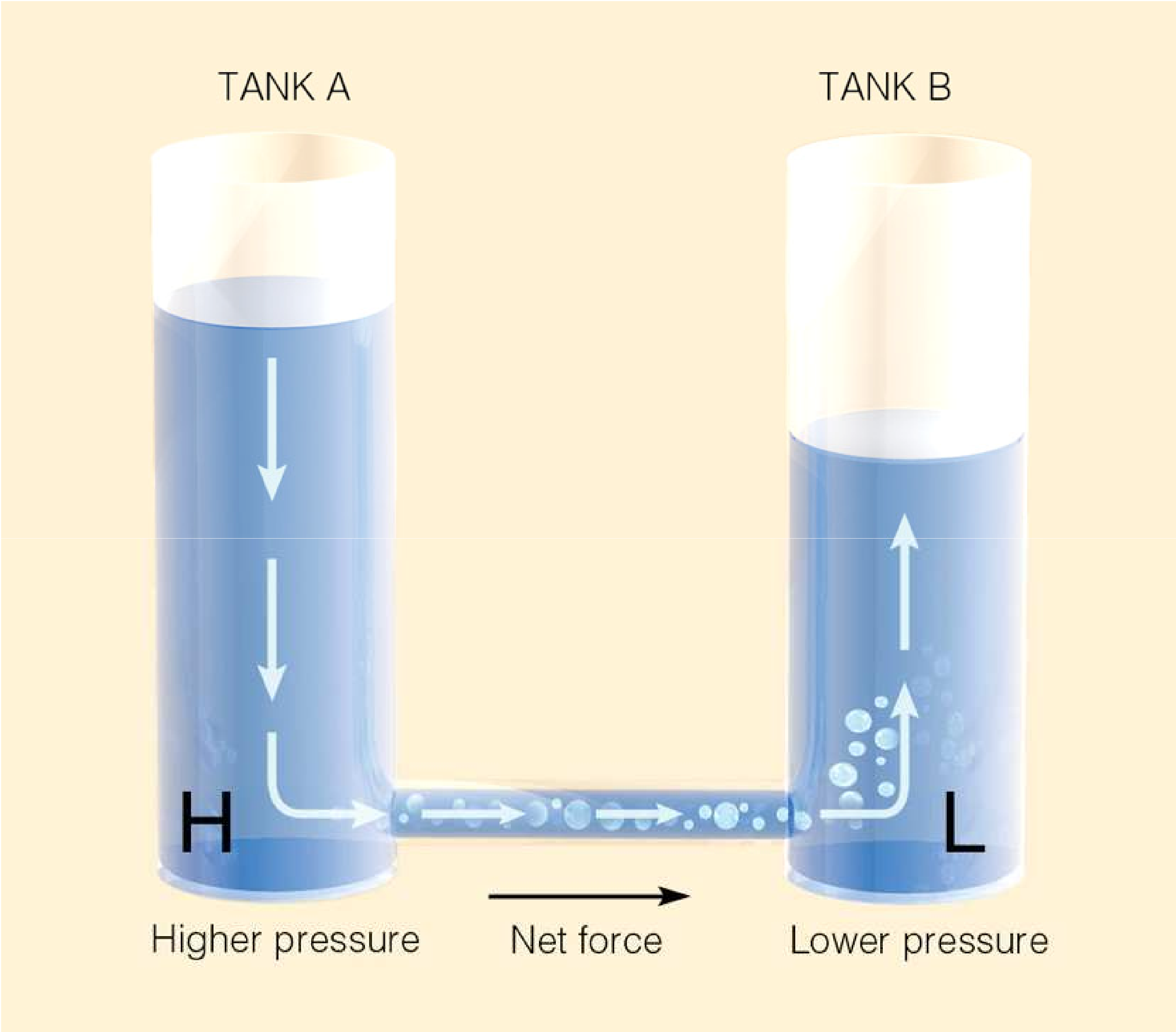
Average height
of 500-mb level
(5600 m)
500-mb surface
High height
Low pressure
High pressure
Low height
5600 m
Cold
Warm
N
Mean sea level
S

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
H
L
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
- $$P_t = P_A + P_B + P_C$$