Unit 8

Gas Laws

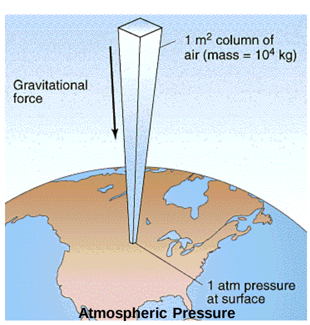
Physical Properties of Gases

- Gases are a state of matter that have no definite volume and take the shape of the container.
- Gas particles can be monatomic (Ne), diatomic (N2), or polyatomic (CH4) – but they all have some common characteristics.

- **Gases have mass.**
- **Gases are compressible.**
- **Gases fill their containers.**
- **Gases diffuse.**
- **Gases exert pressure.**
- **Pressure is related to Temperature**

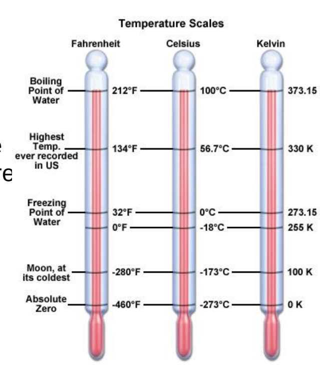
Pressure

- **Pressure** is the force over an area. Units of pressure are:
- kilopascals (kPa) atmospheres (atm)
- Atmospheric pressure is the amount of force that air produces on an object.
- **Table A**
  101.3kPa or 1atm



Temperature

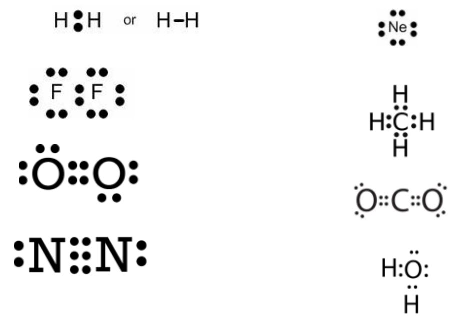
- **Temperature** is the measure of average kinetic energy.
- **Temp. vs. heat**
- Gases will always use the **Kelvin** temperature scale.
- **Table T** conversion formula **K = °C + 273**
- **Table A**
  O°C or 273K



Review

- **Monatomic Gases**
  (The Noble Gases)
  He
  Ne
  Ar
  Kr
  Xe
  Rn
- **Diatomic Gases**
  H_2
  N_2
  O_2
  F_2
  Br_2
  I_2
  Cl_2

Lewis Dot Diagram Review



Reference Tables for Unit

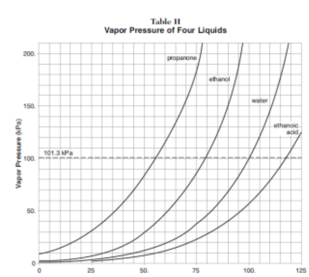
Table A
Standard Temperature and Pressure

Name	Value	Unit
Standard Pressure	101.3 kPa 1 atm	kilopascal atmosphere
Standard Temperature	273 K 0°C	kelvin degree Celsius

Combined Gas Law $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ — P = pressure, V = volume, T = temperature

Temperature K = °C + 273 — K = kelvin, °C = degree Celsius

Boiling Point = Vapor Pressure at standard pressure



Vapor pressure is a physical property of a liquid.

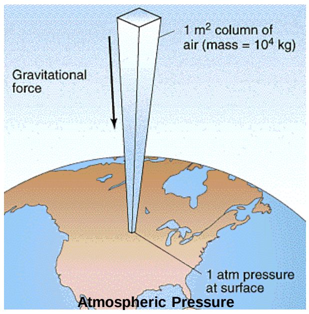
It describes a liquids ability to evaporate or boil.

Which Substance has the strongest forces of attraction? The weakest?
What is the normal boiling point for each substance?
Atmospheric pressure vs. vapor pressure

Pressure

- **Pressure** is the force over an area. Units of pressure are:
- kilopascals (kPa) atmospheres (atm)
- Atmospheric pressure is the amount of force that air produces on an object.
- **Table A**

101.3kPa or 1atm



KMT

- **There is a theory that modern day chemist's use to explain the behaviors and characteristics of ideal gases - the Kinetic Molecular Theory of Matter.**
  - **The theory states that the tiny particles in all forms of matter are in continuous motion.**
- **There are 3 basic assumptions of the KMT as it applies to ideal gases.**
  - **Ideal gases are "perfect" gases that are used as a model to describe characteristics of real gases.**

Kinetic Molecular Theory

- Gas particles move in random motion.
- Gas particles have a weak attraction for eachother.
- Gas particles can be compressed, you can change their volume.
- Gas particles move in a straight line path.
- When particles collide, they transfer energy.

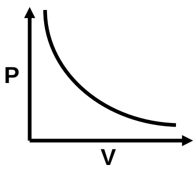
Ideal Gas

- An ideal gas does not exist. It is a model used by scientists to compare real gases.
- An Ideal gas would have particles that are extremely far apart and move very fast. They are so far apart that the volume of each molecule is near zero (negligible).
- Ideal gas molecules have no attraction for each other.

- Pressure-
- Temperature-

A. Boyle's Law

Volume (mL)	Pressure (torr)	P·V (mL·torr)
10.0	760.0	7.60×10^3
20.0	379.6	7.59×10^3
30.0	253.2	7.60×10^3
40.0	191.0	7.64×10^3

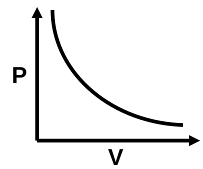


$$PV = k$$

13

A. Boyle's Law

- The pressure and volume of a gas are inversely related
  - at constant mass & temp

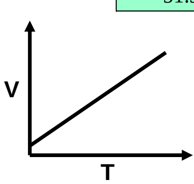


$$PV = k$$

14

B. Charles' Law

Volume (mL)	Temperature (K)	V/T (mL/K)
40.0	273.2	0.146
44.0	298.2	0.148
47.7	323.2	0.148
51.3	348.2	0.147

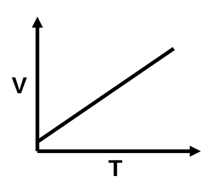


$$\frac{V}{T} = k$$

15

Charles' Law

- The volume and absolute temperature (K) of a gas are directly related
  - at constant mass & pressure



$$\frac{V}{T} = k$$

16

Combined Gas Law

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

Gas Law Problems

- A gas occupies 100. mL at 150. kPa. Find its volume at 200. kPa.

BOYLE'S LAW

GIVEN: P↑ V↓	WORK:
V_1 = 100. mL P_1 = 150. kPa V_2 = ? P_2 = 200. kPa	$P_1V_1\cancel{T_2} = P_2V_2\cancel{T_1}$ (150.kPa)(100.mL)=(200.kPa)V_2 **V_2 = 75.0 mL**

19

Gas Law Problems

- A gas occupies 473 cm^3 at 36°C. Find its volume at 94°C.

CHARLES' LAW

GIVEN: T↑ V↑	WORK:
V_1 = 473 cm^3 T_1 = 36°C = 309K V_2 = ? T_2 = 94°C = 367K	$\cancel{P_1}V_1T_2 = \cancel{P_2}V_2T_1$ (473 cm^3)(367 K)=V_2(309 K) **V_2 = 562 cm^3**

20

Gas Law Problems

- A gas occupies 7.84 cm^3 at 71.8 kPa & 25°C. Find its volume at STP.

COMBINED GAS LAW

GIVEN: P↑ T↓ V↓	WORK:
V_1 = 7.84 cm^3	$P_1V_1T_2 = P_2V_2T_1$
P_1 = 71.8 kPa	
T_1 = 25°C = 298 K	(71.8 kPa)(7.84 cm^3)(273 K) =(101.325 kPa) V_2 (298 K)
V_2 = ?	
P_2 = 101.325 kPa	V_2 = 5.09 cm^3
T_2 = 273 K	21

Regents Questions June 2011

14 The temperature of a sample of matter is a measure of the
(1) average kinetic energy of its particles
(2) average potential energy of its particles
(3) total kinetic energy of its particles
(4) total potential energy of its particles

15 According to the kinetic molecular theory, the particles of an ideal gas
(1) have no potential energy
(2) have strong intermolecular forces
(3) are arranged in a regular, repeated geometric pattern
(4) are separated by great distances, compared to their size

Regents Questions June 2011

Base your answers to questions 69 and 70 on the information below.

Natural gas is a mixture that includes butane, ethane, methane, and propane. Differences in boiling points can be used to separate the components of natural gas. The boiling points at standard pressure for these components are listed in the table below.

Data Table

Component of Natural Gas	Boiling Point at Standard Pressure (°C)
butane	−0.5
ethane	−88.6
methane	−161.6
propane	−42.1

69 Identify a process used to separate the components of natural gas. [1]

70 List the *four* components of natural gas in order of increasing strength of intermolecular forces. [1]

Regents Question June 2011

43 Which temperature change would cause a sample of an ideal gas to double in volume while the pressure is held constant?
(1) from 400. K to 200. K
(2) from 200. K to 400. K
(3) from 400.°C to 200.°C
(4) from 200.°C to 400.°C