GENERAL CHEMISTRY C1404

Cause and effect, chain of events,
All of the chaos makes perfect sense.

Joe Diffie
"Third Rock from the Sun"
Third Rock from the Sun
Sony Records, 1994

GENERAL CHEMISTRY C1404

Spring 2004

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Office Hours: TTh 12:15 - 1:15

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309 Havemeyer

GENERAL CHEMISTRY C1404

Course Structure--Grading

Three Exams:	25 Points each
	February 19, March 25, April 22
Final Exam:	50 Points
Weekly Quizzes:	25 Points
Exam Questions:	15 Points

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Course Structure--Exams and Quizzes

All exams multiple choice. Exam questions based on problems at end of each text chapter. Final exam is cumulative. Final exam divided into two parts, 25 points each, plus three term exams of 25 points each, for a total of five 25-point exam units. Drop the lowest of the scores on these five units. Gives 100 maximum total exam points.

Quizzes given in recitation sections each week except exam weeks. Ten quizzes total. Quizzes are 2.5 points each. Maximum total score 25 points.

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Course Structure--Exam Questions

Submit one multiple-choice exam question, with five answer choices and a worked solution, for each exam unit. One answer choice must be the correct answer; the other four must be answers that would come from conceptual errors or errors associated with incorrect application of relevant formulas. Submit one question for each term exam, two questions for final. <u>None of these student-submitted questions will appear on any exam</u>.

Each exam question is three points. Fifteen points total.

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Course Structure--Exam Question

Exam questions can be your own creation, or drawn from any source other than our text or its supplementary materials. Exam questions must be on the topic of the exam for which they are submitted.

Exam questions to be submitted in your last recitation preceding each exam.

Exam questions graded on basis of topical relevance and appropriateness for exam.

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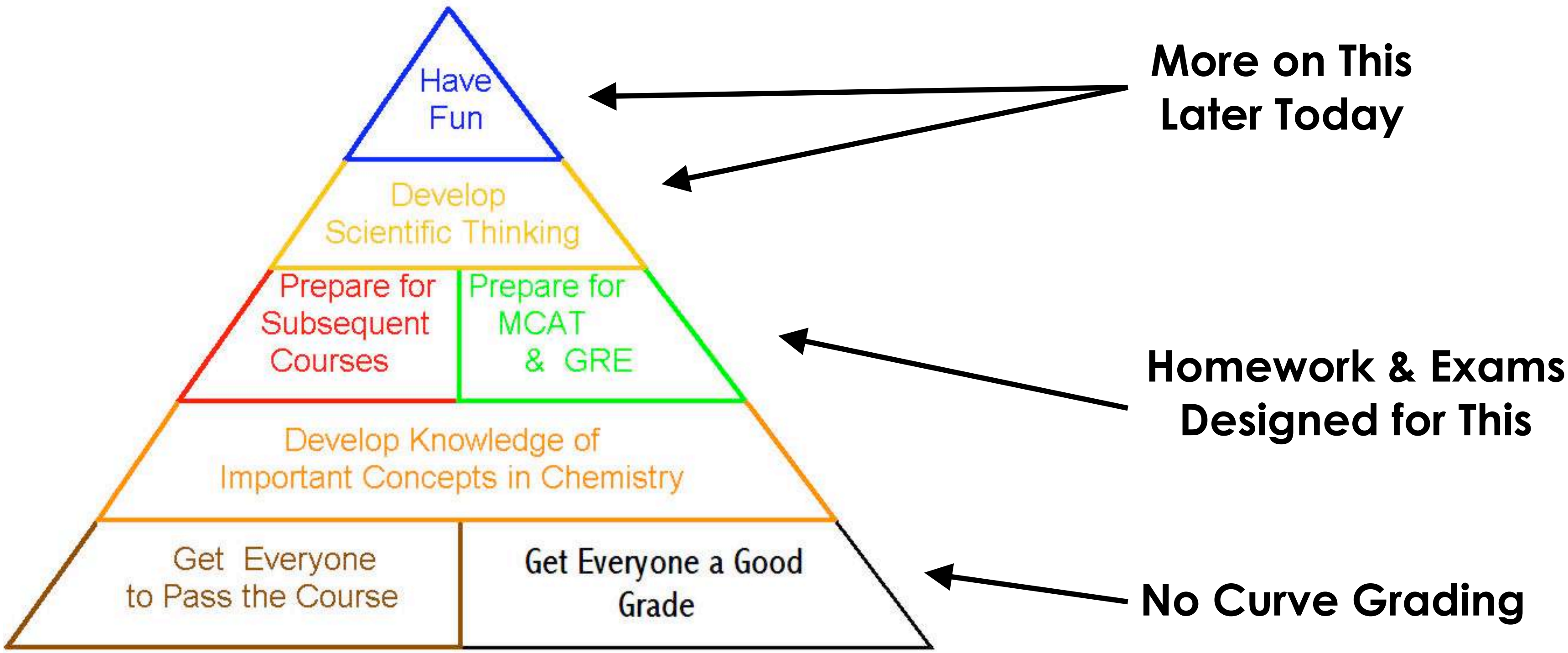
Course Structure--My Goals



GENERAL CHEMISTRY C1404

Topics

Gases • Liquids • Solids • Phase Transitions
Solutions
Equilibrium
Thermodynamics
Redox Chemistry • Electrochemistry
Kinetics
• • •
Atmospheric Chemistry

GENERAL CHEMISTRY C1404

Cause and effect, chain of events,
All of the chaos makes perfect sense.

…when you <u>understand</u> chemistry

GENERAL CHEMISTRY C1404

The Meaning of Life ("Monty Python's The Meaning of Life")

1. Matter is energy.
2. People aren't wearing enough hats.

You only need to know two things to be a plumber. (Anon.)

1. Water doesn't flow uphill.
2. Friday is payday.

SIMPLIFYING CHEMISTRY
THE MICROSCOPIC

1. Atoms (and molecules) are made up of positively charged nuclei and negatively charged electrons.

2. Coulomb's Law describes the interaction between charged particles.

$$V(r) = q_1 q_2 / r$$

3. The Schroedinger Equation gives the possible energy states of atoms (and molecules).

$$-\frac{\hbar^2}{2m}\nabla^2\Psi + V(r)\Psi = E\Psi$$

4. The spin of the electron is 1/2.

Result: The periodic table and the structure of molecules.

SIMPLIFYING CHEMISTRY
THE MACROSCOPIC

5. The energy of a collection of atoms (or molecules) is the sum of the energies of the individual atoms (or molecules).

6. In a collection of atoms (or molecules) there is a distribution of the atoms (or molecules) over their possible energy states, and that distribution is determined by the temperature.

7. Macroscopic samples contain an enormous number of atoms (or molecules).

8. Energy is conserved.

Result: The Three Laws of Thermodynamics

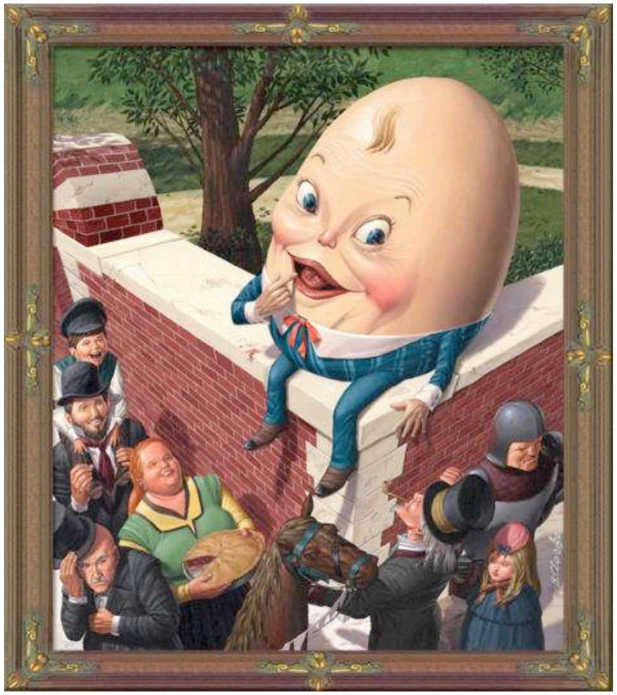
THE ROAD AHEAD

When you don't know where you're goin',
Any road can take you there.

George Harrison
"Any Road"
Brainwashed
Capitol Records, 2002

THE ROAD AHEAD

THE ROAD AHEAD



THE ROAD AHEAD

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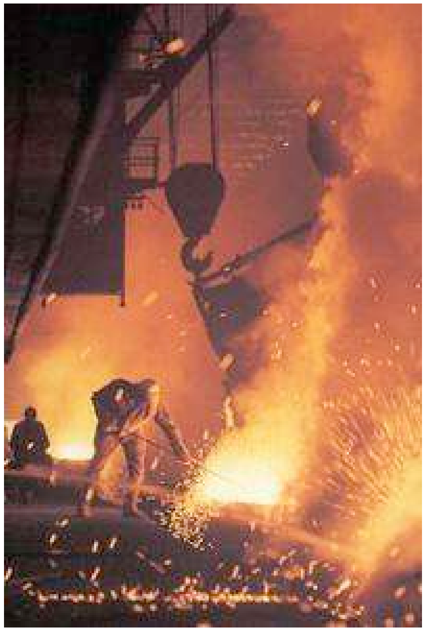

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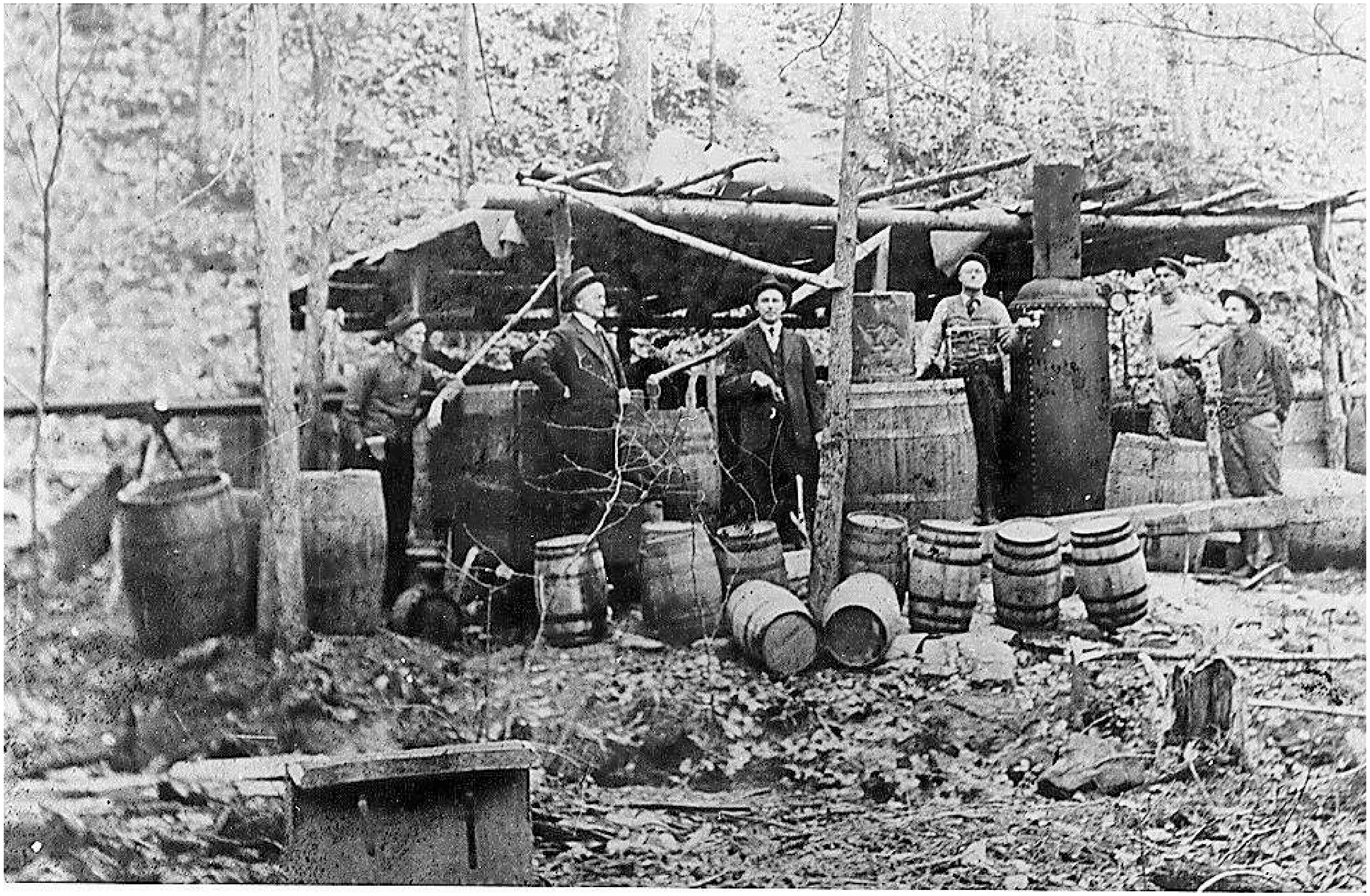


THE ROAD AHEAD

On the road we will meet repeatedly:
C, H_2, N_2, O_2, CH_4, CO_2, H_2O

Important encounters with:
O_3, CF_4, HCl, NH_3, C_2H_5OH, Cu, Zn

Cameo appearances by many others

PHASES OF MATTER

PHASES OF MATTER

All substances exist in three different physical states. These **states** are called **phases**.

Words in **gold** are important.

The three phases are **solid, liquid, and gas**.

The three phase can be defined by their **density**, **compressibility** and **thermal expansivity**.

PROPERTIES OF PHASES

The **density** is the mass per unit volume: **d = m/V.**

Substance/Phase	Density (g cm^{-3})
$H_2O(s)$ at 272 K	0.917
$H_2O(l)$ at 277 K	1.000
$H_2O(g)$ at 1 atm and 298 K	0.000804
Hg(s) at 259 K	14.2
Hg(l) at 259 K	13.1
Hg(g) at 1 atm and 259 K	0.00944

The density of a substance in the gas phase is much, much smaller than that of the solid or liquid phase.

The density of the liquid and solid phases of a substance are very similar.

PROPERTIES OF PHASES

The **compressibility**, κ, is the fractional change in volume as the result of a change in pressure:

$$\kappa = -(\delta V/V)/\delta P.$$

Minus sign to keep κ positive

A little change; δV and δP small compared to V and P

Substance/Phase	κ (atm^{-1})
$H_2O(s)$ at 270 K	0.000053
$H_2O(l)$ at 298 K	0.000045
$H_2O(g)$ at 1 atm and 298 K	1.0

The compressibility of solids and liquids is quite small and much,much smaller than that of gases.

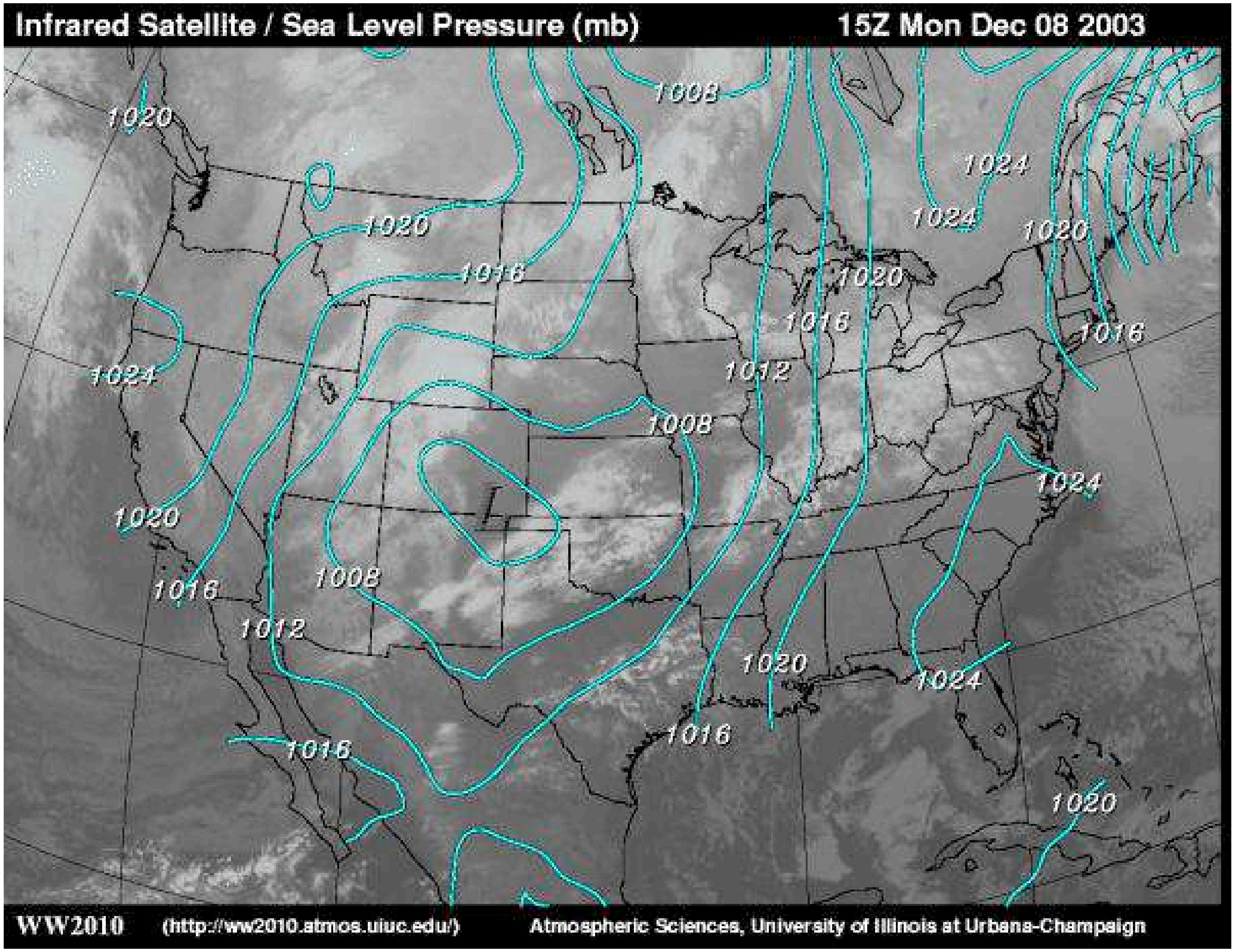
UNDERSTANDING PRESSURE

Pressure is the force per unit area: P = Force/Area.

There are many different units of pressure.

Unit Name	Definition or Equivalency
Pascal (Pa)	1.00 N m^{-2}
Standard Atmosphere (atm)	101,325 Pa
Bar (bar)	100,000 Pa
Torr (torr)	1/760 atm
Millimeter Hg at 273 K (mm Hg)	1/760 atm
Pounds in^{-2} (psi)	1/14.69595 atm

UNDERSTANDING PRESSURE



UNDERSTANDING PRESSURE

Pressure Calculations

The mass of the atmosphere is 5.136×10^{18} kg. The surface area of the earth is 5.101×10^{14} m^2. Calculate atmospheric pressure. (Remember, Force = mass x acceleration.)

Airplanes stay aloft due to the upward force on the wings from the difference in air pressure below and above the wings. For a 450,000 lb airplane with a wing area of 7,000 ft^2, what does this pressure difference have to be to keep the plane aloft?

Answers in next lecture.

PROPERTIES OF PHASES

Compressibility Calculations

Changes in atmospheric pressure associated with low pressure and high pressure air masses are of the order of 0.02 atm. For a pressure increase from 0.99 to 1.01 atm calculate the fractional change in volume for water as a solid, liquid, and gas.

The pressure at the top of Mt. Everest is 0.320 atm. Using compressibility data, estimate the change in density in taking a sample of ice from sea level to the top of Mt.Everest.

Answers in next lecture.

PROPERTIES OF PHASES

The **thermal expansivity**, α, is the fractional change in volume as the result of a change in temperature: $\alpha = (\delta V/V)/\delta T$.

No minus sign.

Different signs!

Substance/Phase	α (K^{-1})
H_2O(s) at 270 K	- 0.00013
H_2O(l) at 298 K	0.00026
H_2O(g) at 1 atm and 298 K	0.0034

The thermal expansivity of solids and liquids is much smaller than that of gases.

MEASURING TEMPERATURE

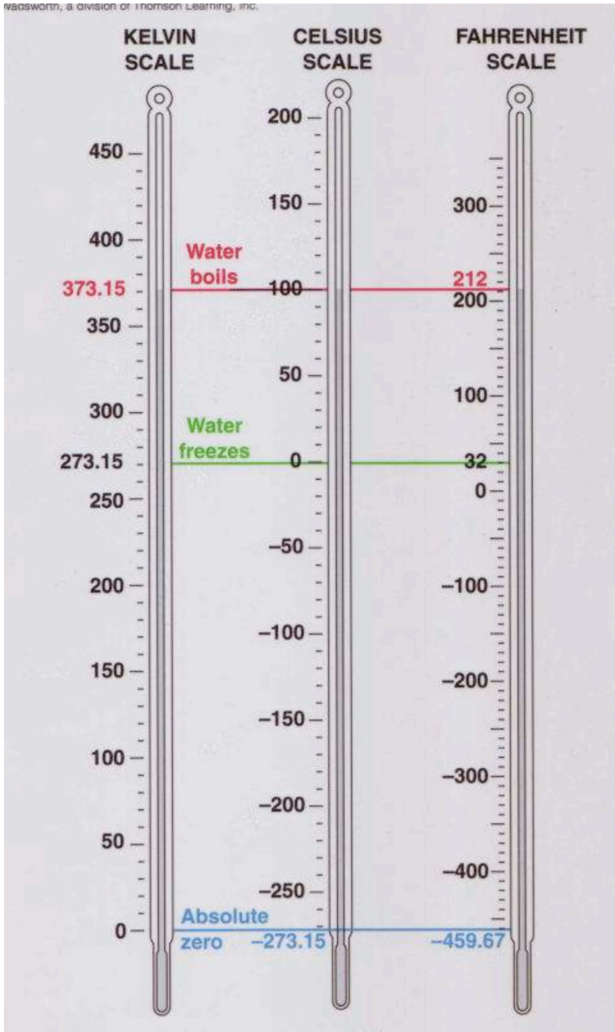
There are many ways to measure temperature. We will describe them in detail when we introduce thermodynamics. For now we will consider only the use of thermometers.

Thermometers rely on the thermal expansion of a liquid in a small tube to measure the temperature. The height of the liquid in the tube reveals the temperature.

Thermometers need to be calibrated.

The calibration uses readily accessible and reproducible conditions as reference.

MEASURING TEMPERATURE



There are three commonly used temperature scales.

Celsius (centigrade) and Fahrenheit use melting point and boiling points of water for calibration.

The Kelvin scale is an absolute scale. It is the fundamental temperature scale of nature.

PROPERTIES OF PHASES

Thermal Expansivity Calculations

The thermal expansivity of mercury is 0.000133 K^{-1}. If 0.00330 cm^3 of mercury is contained in a tube of diameter 0.00450 cm how much will the height of the mercury in the tube increase for a temperature rise of 17 K? (Note: You must assume that the tube itself does not expand.)

Answer in next lecture.

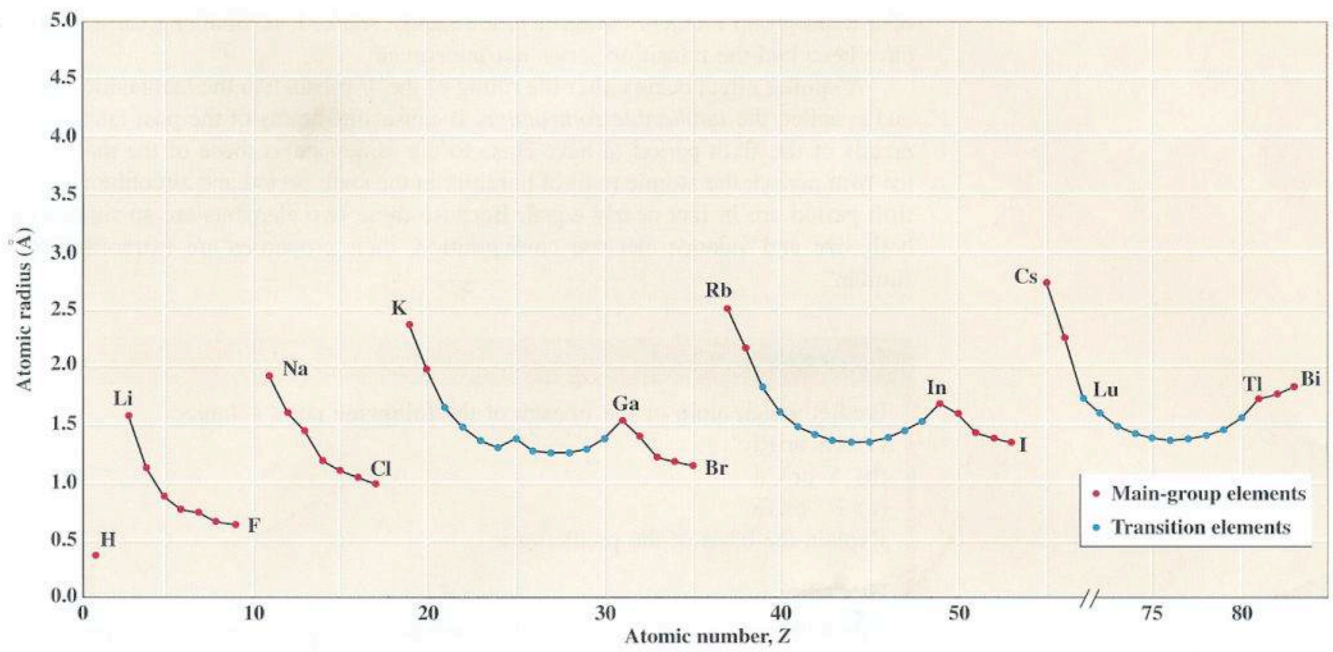
THE EQUATION OF STATE

The compressibility and thermal expansivity of a substance describe how a change in P or T changes V. They can be combined into a general mathematical formula called the **Equation of State** that describes the mathematical relationship among P, V, and T.

The **Equation of State** provides the general relation among P, V, and T for any substance. It can be written as **$P = f(V,T)$**. For the ideal gas that we will describe very soon the Equation of State is **$P = nRT/V$** and is called the **Ideal Gas Law**.

UNDERSTANDING DENSITY

The density of solids and liquids is about the maximum that the atomic and molecular sizes allow.



UNDERSTANDING DENSITY

The density of solids and liquids is about the maximum that the atomic and molecular sizes allow.

Molecules have complex shapes, so size is best expressed by molecular volume.

Molecular volume is established by a variety of measurements, some of which we will encounter and discuss.