WileyPLUS Assignment 4

Chapters 8, 9, 10

Due: Friday, November 27 at 11 pm

WileyPLUS Assignment 5

Chapters 11, 12, 14

Due Wednesday, December 9 at 11 pm

Next Week

Experiment 5: Thermal conductivity of an insulator

PHYS 1020 Final Exam

Friday, December 18, 1:30 - 4:30 pm

Frank Kennedy Brown & Gold Gyms

The whole course

30 multiple choice questions

Formula sheet provided

Seating (see Aurora)

Brown Gym: A - S

Gold Gym: T - Z

Specific Heat

The heat required to warm a mass m by ΔT is:

$$Q = mc\Delta T, \; c = \text{specific heat}$$

Latent Heat

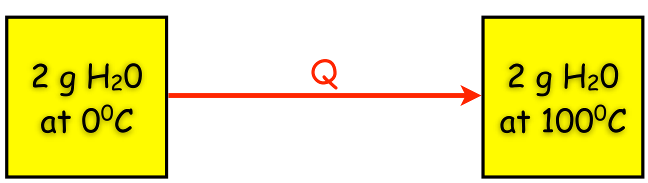
Heat absorbed/released, $Q = mL$, L = latent heat.

Melting/freezing:
Latent heat of fusion L_f = heat absorbed per kilogram on melting and released on freezing.

Boiling/condensing:
Latent heat of vaporization L_v = heat absorbed per kilogram on boiling and released on condensing.

12.88/62: 2 g of liquid water are at 0°C and another 2 g are at 100°C. Heat is removed from the water at 0°C, completely freezing it at 0°C. This heat is used to vaporize some of the water at 100°C. How much liquid water remains?

$L_v = 22.5\times10^5$ J/kg
$L_f = 33.5\times10^4$ J/kg



Heat pump: removes heat from one object and transfers it to another.
Example: refrigerator

Q13, 2005 Final

Clickers!

Which would cause a more serious burn: 30 g of steam or 30 g of liquid water, both at 100°C; and why is this so?

(a) Water, because it is denser than steam.

(b) Steam, because of its specific heat capacity.

(c) Steam, because of its latent heat of vaporization.

(d) Water, because its specific heat is greater than that of steam.

(e) Either one would cause a burn of the same severity since they are both at the same temperature.

Steam releases its latent heat of vaporization, L_v, when it condenses...

2.26 MJ of thermal energy per kg of steam

and then you have water at 100°C...

c) Steam

12.71/65: It is claimed that if a lead bullet goes fast enough, it can melt completely when it comes to a halt suddenly, and all its kinetic energy is converted into heat via friction. Find the minimum speed for this to happen for a bullet at 30°C.

Lead: c = 128 J/(kg.C°)

L_f = 23,200 J/kg, melting point 327.3°C

- Heat mass m of lead from 30°C to 327.3°C
- Melt mass m of lead

Prob. 12.70/87: Occasionally, huge icebergs are found floating on the ocean's currents. Suppose one such iceberg is 120 km long, 35 km wide, and 230 m thick.

(a) How much heat would be required to melt this iceberg (assumed to be at 0 °C) into liquid water at 0 °C? The density of ice is 917 kg/m^3.

(b) The annual energy consumption by the United States is about 1.1×10^{20} J. If this energy were delivered to the iceberg every year, how many years would it take before the ice melted?

Prob. 12.52/102: Three portions of the same liquid are mixed in a container that prevents the exchange of heat with the environment.

Portion A has a mass m and a temperature of 94.0 °C.

Portion B also has a mass m but a temperature of 78.0 °C.

Portion C has a mass m_C and a temperature of 34.0 °C.

What must be the mass of portion C so that the final temperature of the three-portion mixture is T_f = 50.0 °C? Express your answer in terms of m; for example, m_c = 2.20 m.

Prob. 12.46/-

When you drink cold water, your body must expend metabolic energy in order to maintain normal body temperature (37 °C) by warming up the water in your stomach.

Could drinking ice water, then, substitute for exercise as a way to "burn calories?"

Suppose you expend 430 kilocalories during a brisk hour-long walk. How many litres of ice water (0 °C) would you have to drink in order to use up 430 kilocalories of metabolic energy? For comparison, the stomach can hold about 1 litre.

Summary of Temperature and Heat

Temperature: $T\,(^{\circ}\mathrm{C}) = T\,(\mathrm{K}) - 273.15$

Thermal expansion: $\Delta L = \alpha L_0 \Delta T$

$\Delta V = \beta V_0 \Delta T$

Specific heat: $Q = mc\Delta T$

Latent heat: $Q = mL_f$ melting/freezing

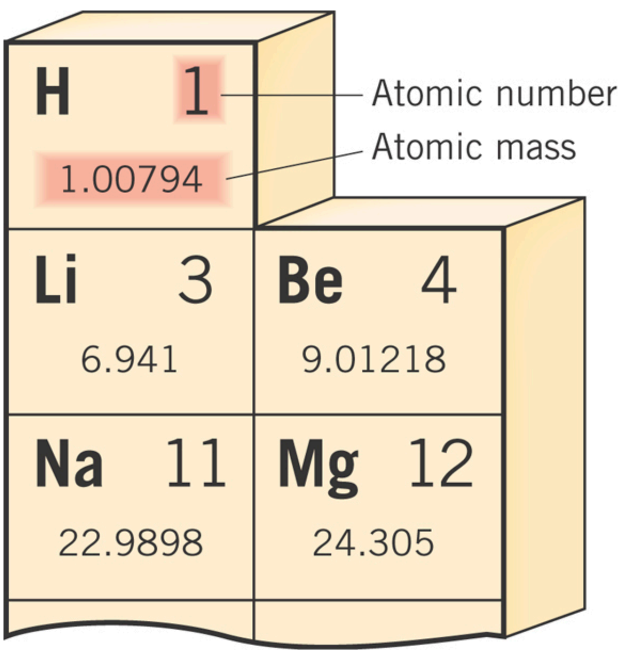
$Q = mL_v$ boiling/condensation

Thermal conduction: $\dfrac{\Delta Q}{\Delta t} = \dfrac{kA(T_1 - T_2)}{L}$

Heat flows from high temperature to low

Chapter 14: Ideal Gas Law and Kinetic Theory of Gases

- Molecular mass, the mole, Avogadro's number
- Ideal gas law
- Kinetic theory of gases



Molecular Mass

Periodic Table: shows

- atomic number
  - identifies chemical element
  - equal to number of protons in the nucleus of the atom
- atomic mass (atomic weight)
  - the mass of the atom in atomic mass units, u
  - the mass is the average over all of the naturally-occurring isotopes of the element

Atomic mass unit (u): the mass of the ^{12}C atom is exactly 12 u

The mass of naturally-occurring carbon is 12.011 u (^{12}C, ^{13}C, ^{14}C)

$1\ u = 1.6605 \times 10^{-27}\ kg$

The Mole, Avogadro's Number

- Molecular mass: the sum of the atomic masses of all of the atoms in the molecule

- Gram-mole: the quantity of atoms or molecules with a mass in grams equal numerically to the atomic or molecular mass. The gram-mole contains Avogadro's number, N_A, of atoms or molecules,

$$N_A = 6.022 \times 10^{23} \text{ atoms or molecules per mole}$$

Atomic mass of Li = 6.941 u, so 1 gram-mole of Li has a mass of 6.941 g and contains N_A atoms

Molecular mass of H_2 = 2 × 1.00794 = 2.01588 u, so 1 gram-mole of H_2 has a mass of 2.01588 g and contains N_A molecules

14.6/5: A mass of 135 g of a certain element is known to contain $N = 30.1 \times 10^{23}$ atoms. What is the element?

The number of moles that are present is $n = N/N_A$ with a total mass of 135 g.

The mass of 1 mole must be:

$$\frac{135}{n} = 135 \times \frac{N_A}{N} = 135 \times \frac{6.022 \times 10^{23}}{30.1 \times 10^{23}} = 27.0 \text{ g}$$

From the table at back of book: atomic mass of Al = 26.9815 u

The element is aluminum

14.5/2: The active ingredient in Claritin has the chemical formula

$$C_{22}H_{23}ClN_2O_2$$

The standard adult dosage utilizes $1.572x10^{19}$ molecules. Determine the mass in grams of the active ingredient in the standard dosage.

Atomic masses (table in back of book):
C: 12.011 H: 1.00794 Cl: 35.453 N: 14.0067 O: 15.9994

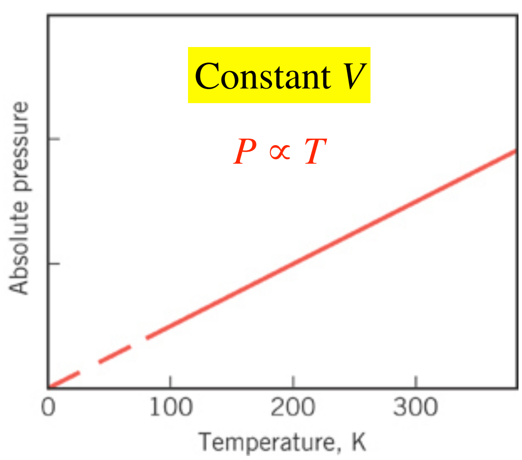
1 gram-mole has a mass of $22 \times M_C + 23 \times M_H + M_{Cl} + 2 \times M_N + 2 \times M_O$
= 382.9 g

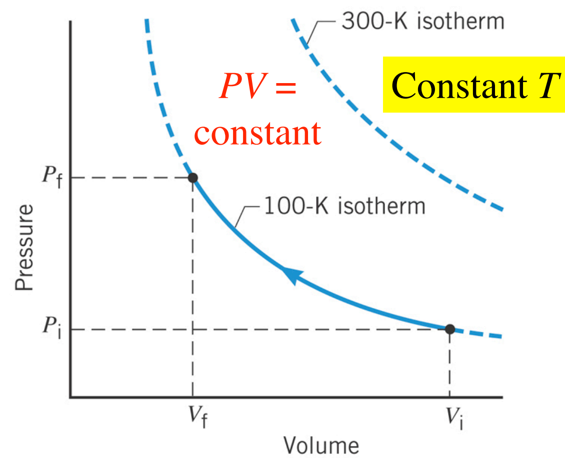
The dosage corresponds to:

$$\frac{1.572 \times 10^{19}}{N_A} = \frac{1.572 \times 10^{19}}{6.022 \times 10^{23}} = 2.61 \times 10^{-5} \text{ moles}$$

Therefore, the mass of the dosage is: $2.61 \times 10^{-5} \times 382.9 = 0.010 \text{ g}$

Ideal Gas Law





Ideal Gas: the atoms or molecules of the gas do not interact with each other, except through elastic collisions. Real gases approximate ideal if the pressure is not too high, so the density of the gas is low.

Then: P ∝ T, if V, is held constant
PV = constant if temperature is constant (Boyle's law)

Ideal Gas Law

The behaviour of an ideal gas is described by the ideal gas law:

$$PV = nRT$$

n = number of moles of gas
R = universal gas constant = 8.314 J/(mol.K)
T in Kelvin

In terms of the number, N, of atoms or molecules of the gas:

$$PV = NkT$$

k = Boltzmann's constant = 1.38×10^{-23} J/K
$N = nN_A$, and $nRT = NkT = nN_AkT$, so

$$k = \frac{R}{N_A}$$

Ideal Gas Law

For 1 mole of an ideal gas at standard temperature and pressure (STP)
[T = 273 K (0°C), P = 101.3 kPa]

the volume of the gas is, for n = 1 mole:

$$V = \frac{RT}{P} = \frac{8.31 \times 273}{1.013 \times 10^5} = 0.0224 \text{ m}^3 = 22.4 \text{ litres}$$

That is, 1 mole of gas at STP occupies 22.4 litres

Clickers!

Question: why do bubbles in a glass of beer grow larger as they move upward?

a) Temperature varies with height.
b) Pressure decreases with height.
c) The number of moles of gas in the bubbles increases with height.

$$V = \frac{nRT}{P}$$

b) Pressure decreases with height

Q 15, 2005 Final: A sample of a monatomic gas is originally at 20°C. What is the final temperature of the gas if both the pressure and the volume are doubled?

14.11/10: It takes 0.16 g of helium to fill a balloon. How many grams of nitrogen would be required to fill the balloon to the same pressure, volume and temperature?

14.15/12: Oxygen for hospital patients is kept in tanks in which the oxygen has a pressure of 65 atmospheres at a temperature of 288 K. The oxygen is administered at a pressure of 1 atmosphere at 297 K. What volume does 1 m^3 of oxygen in the tanks occupy in the patient's room?

14.23/19: The tanks are connected by a valve, which is initially closed. Each tank contains neon gas at the pressure, volume and temperature indicated. When the valve is opened, the contents of the two tanks mix, and the pressure becomes constant throughout.

a) What is the final temperature? (the heat gained by the gas in one tank is equal to the heat lost by the other).

b) What is the final pressure?