Homework:

(1) Read "Proof of Bernoulli's Equation"

(2) Chapter 14: 1, 2, 5, 14, 17, 28, 38, 39, 48, 58, 64, 65, 71

1. A fish maintains its depth in fresh water by adjusting the air content of porous bone or air sacs to make its average density the same as that of the water. Suppose that with its air sacs collapsed, a fish has a density of 1.08 g/cm^3. To what fraction of its expanded body volume must the fish inflate the air sacs to reduce its density to that of water?

- Let the volume of the expanded air sacs be V_s and that of the fish be V_f:

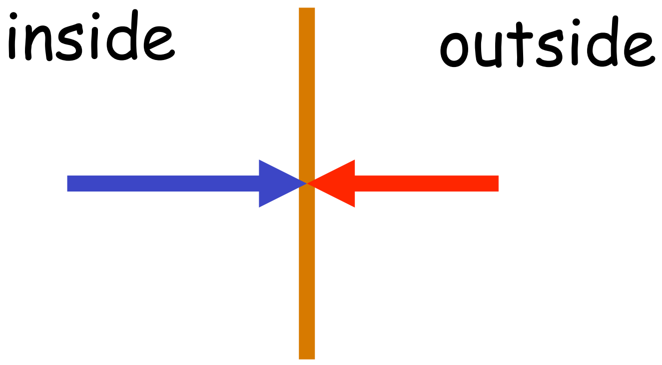
$$\rho_{fish} = \frac{m_{fish}}{V_f} = 1.08\,(\mathrm{g/cm^3})$$

$$\rho_{water} = \frac{m_{fish}}{V_f + V_s} = 1\,(\mathrm{g/cm^3})$$

$$\Rightarrow \quad \frac{V_s}{V_f + V_s} = \frac{\rho_{fish} - \rho_{water}}{\rho_{fish}} \approx 7.4\%$$

5. An office window has dimensions 3.4 m by 2.1 m. As a result of the passage of a storm, the outside air pressure drops to 0.93 atm, but inside the pressure is held at 1.0 atm. What net force pushes out on the window?

1 atm = 1.01×10^5 Pa; Pa = N/m^2



$$F = \Delta P \times S = (1 - 0.93) \times 1.01 \times 10^5 \times (3.4 \times 2.1) \approx 5.1 \times 10^4 (N)$$

14. Calculate the hydrostatic difference in blood pressure between the brain and the foot in a person of height 1.83 m. The density of blood is 1.06×10^3 kg/m^3.

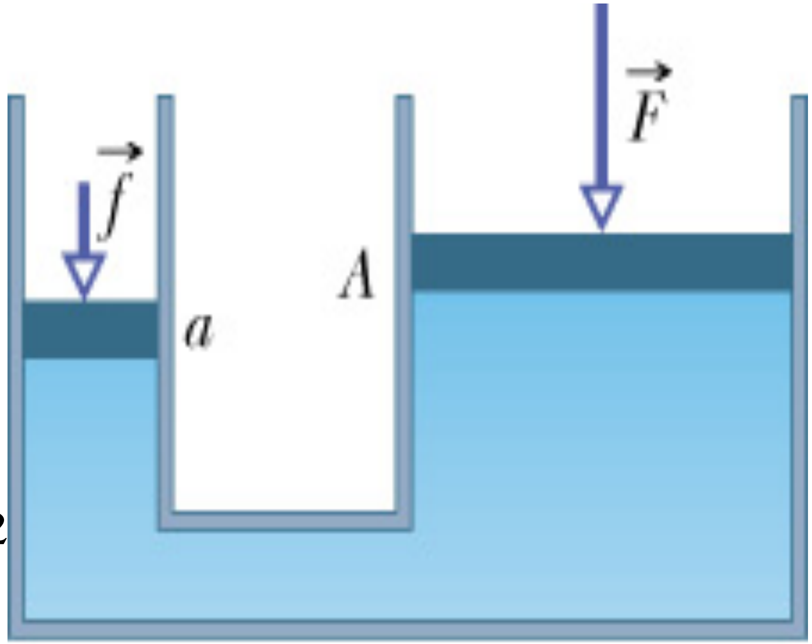
- **The hydrostatic difference in blood pressure is:**

$$\Delta p = \rho g h = 1.06 \times 10^3 \times 9.8 \times 1.83 = 1.9 \times 10^4 \text{(Pa)}$$

28. A piston of cross-sectional area a is used in a hydraulic press to exert a small force of magnitude f on the enclosed liquid. A connecting pipe leads to a larger piston of cross-sectional area A. (a) What force magnitude F will the larger piston sustain without moving? (b) If the piston diameters are 3.8 cm and 53.0 cm, what force magnitude on the small piston will balance a 20.0 kN force on the large piston.

(a) Applying Pascal's principle:

$$\frac{f}{a} = \frac{F}{A} \quad \Rightarrow \quad F = \frac{f\,A}{a}$$

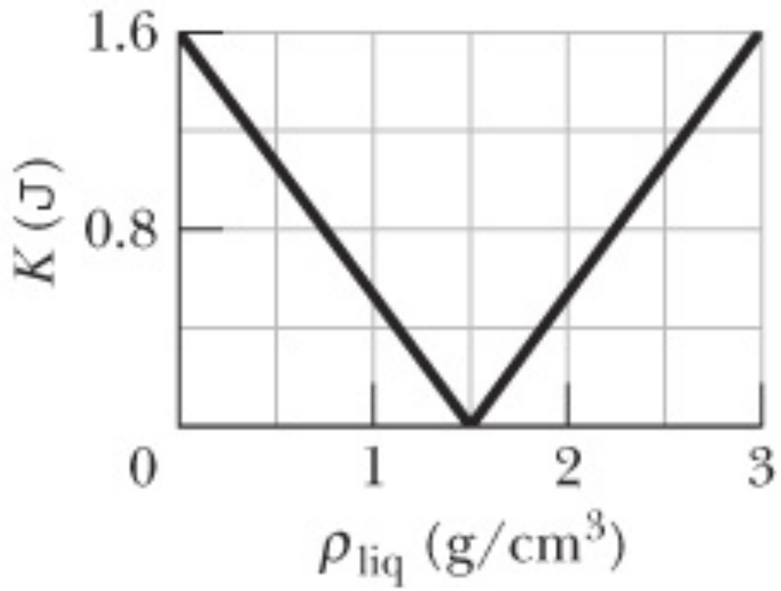


(b) We obtain:

$$f = \frac{F\,a}{A}; \qquad f = \frac{F\,\pi\left(\frac{d}{2}\right)^2}{\pi\left(\frac{D}{2}\right)^2} = F\left(\frac{d}{D}\right)^2$$

$f \approx 103\,(\mathrm{N})$ ➔ f is about 200 smaller than F

38. A small solid ball is released from rest while fully submerged in a liquid and then its kinetic energy is measured when it has moved 4.0 cm in the liquid. Figure (below) gives the results after many liquids are used: The kinetic energy K is plotted versus the liquid density ρ_{lid}. What are (a) the density and (b) the volume of the ball?



(a) An object, which has the same density as the liquid surrounding, won't gain any kinetic energy (K = 0) after releasing from rest: At K = 0, ρ_{lid} = 1.5 g/cm³.
So, ρ_{ball} = 1.5 g/cm³ or 1500 kg/m³

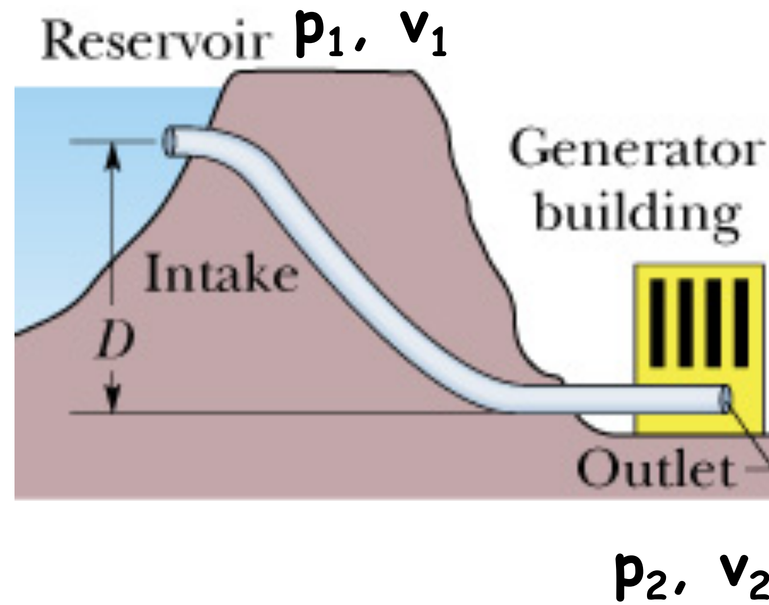
(b) At ρ_{lid} = 0, K = 1.6 J: In this case, the ball is freely falling in vacuum:

$$v^2 = 2gh; \quad K = \frac{1}{2}mv^2$$

$$m = \frac{K}{gh} = \frac{1.6}{9.8 \times 4.0 \times 10^{-2}} = 4.08\,(\text{kg}) \rightarrow \quad V_{ball} = \frac{m}{\rho_{ball}} = 2.72 \times 10^{-3}\,(\text{m}^3)$$

58. The intake in the figure has cross-sectional area of 0.74 m^2 and water flow at 0.40 m/s. At the outlet, distance D = 180 m below the intake, the cross-sectional area is smaller than at the intake and the water flows out at 9.5 m/s. What is the pressure difference between inlet and outlet?

Using Bernoulli's equation:



$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g D = p_2 + \frac{1}{2}\rho v_2^2$$

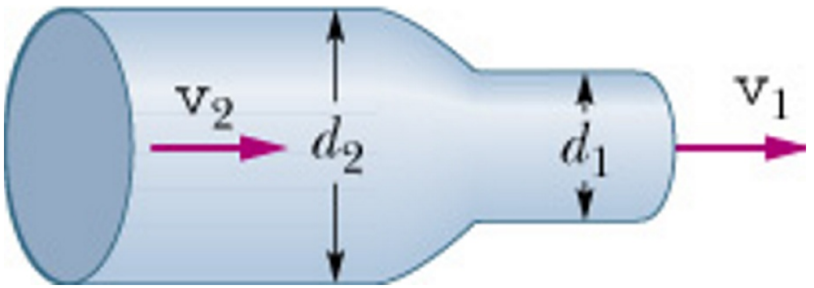
$$\Delta p = p_1 - p_2 = \frac{1}{2}\rho\left(v_2^2 - v_1^2\right) - \rho g D$$

$$\Delta p = \frac{1}{2}\times 1000 \times \left(9.5^2 - 0.4^2\right) - 1000 \times 9.8 \times 180 = -1.72 \times 10^6 (Pa)$$

64. In the figure below, water flows through a horizontal pipe and then out into the atmosphere at a speed v_1=15 m/s. The diameters of the left and right sections of the pipe are 5.0 cm and 3.0 cm. (a) What volume of water flows into the atmosphere during a 10 min period? (b) In the left section of the pipe, what are (b) the speed v_2 and (c) the gauge pressure?

(a) The volume of water during 10 min is:

$$V = v_1 \times t \times \pi \times \frac{d^2}{4} \approx 6.4\,(m^3)$$



(b) Using the equation of continuity, the speed v_2 is:

$$v_2 = \frac{v_1 A_1}{A_2} = \frac{15 \times 3^2}{5^2} = 5.4\,(m/s)$$

(c) The gauge pressure = the absolute pressure – the atmospheric pressure

Using Bernoulli's equation for a horizontal pipe, we have:

$$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$$

$$p_1 = p_0;$$ **where p_0 is the atmospheric pressure**

The gauge pressure of the left section of the pipe is:

$$p_g = p_2 - p_0 = \frac{1}{2}\rho(v_1^2 - v_2^2)$$

$$p_g = \frac{1}{2}10^3 \times (15^2 - 5.4^2) = 0.98 \times 10^5 \,(\mathrm{Pa})$$

or

$$p_g = \frac{0.98 \times 10^5}{1.01 \times 10^5} = 0.97\,(\mathrm{atm})$$

Chapter 2 Heat, Temperature and the First Law of Thermodynamics

2.1. Temperature and the Zeroth Law of Thermodynamics

2.2. Thermal Expansion

2.3. Heat and the Absorption of Heat by Solids and Liquids

2.4. Work and Heat in Thermodynamic Processes

2.5. The First Law of Thermodynamics and Some Special Cases

2.6. Heat Transfer Mechanisms

Overview

- Thermodynamics that is one of the main branches of physics and engineering is the study and application of the thermal energy (commonly called the internal energy) of systems.
- These systems exist in various phases: solid, liquid and gas.
- Temperature is one of the central concepts of thermodynamics.
- Examples of the application of thermodynamics in our life are countless:
    - -The heating of a car engine.
    - -The proper heating and cooling of foods.
    - -The transfer of thermal energy in an El Nino event.
    - -The discrimination in temperature of patients between a benign viral infection and a cancerous growth.

2.1. Temperature and the Zeroth Law of Thermodynamics

A. Temperature:

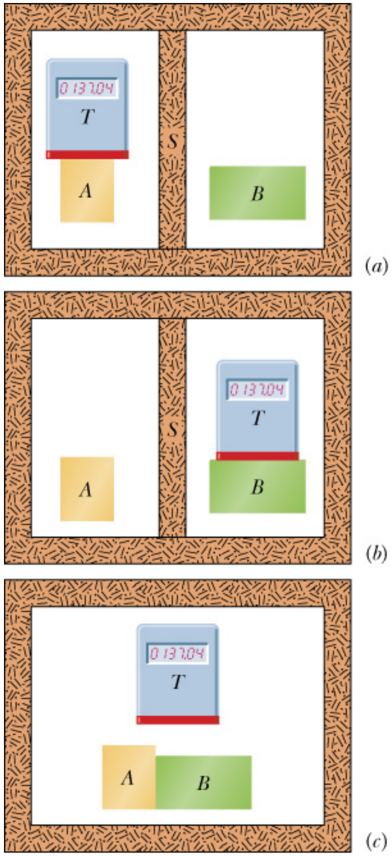
- Temperature is one of the seven SI base quantities.

Unit: Kelvin

- The temperature of a body does have a lower limit of 0 K.
- The temperature of our Universe is about 3 K.

B. The Zeroth Law of Thermodynamics:

- Thermal equilibrium is the condition under which two objects in thermal contact with each other exchange no heat energy. These two objects have the same temperature.



If bodies A and B are each in thermal equilibrium with a third body T, then A and B are in thermal equilibrium with each other.

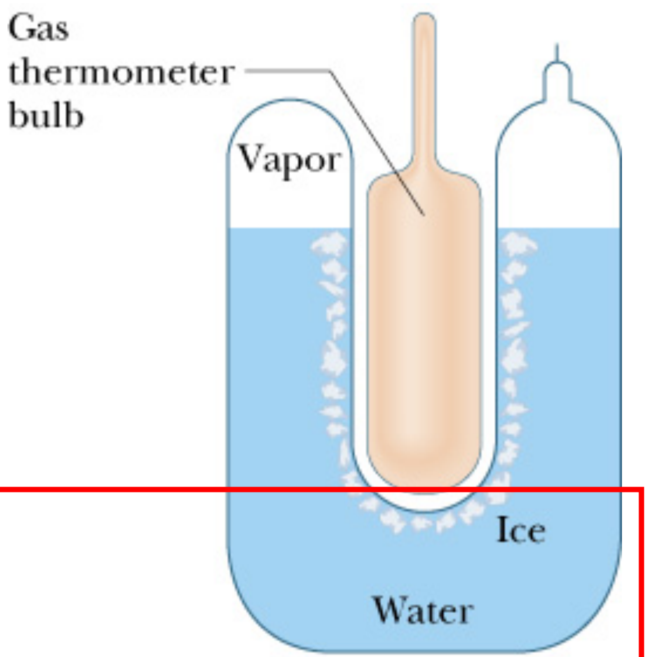
(T is a thermoscope, which is thermally sensitive)

C. Measuring Temperature:

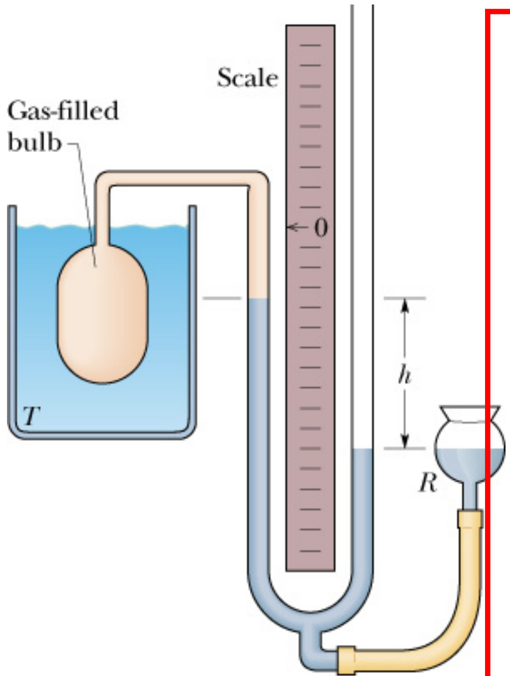
To set up a temperature scale, we need to select a standard fixed point and give it a standard fixed-point temperature.

• The triple point of water: Liquid water, solid ice, and water vapor can coexist in thermal equilibrium, at only one set of values of pressure and temperature.

This triple point has been assigned a value of 273.16 K.



• The constant-Volume Gas Thermometer:



•The temperature of any body in thermal contact with the bulb:

$$T = C\,p$$

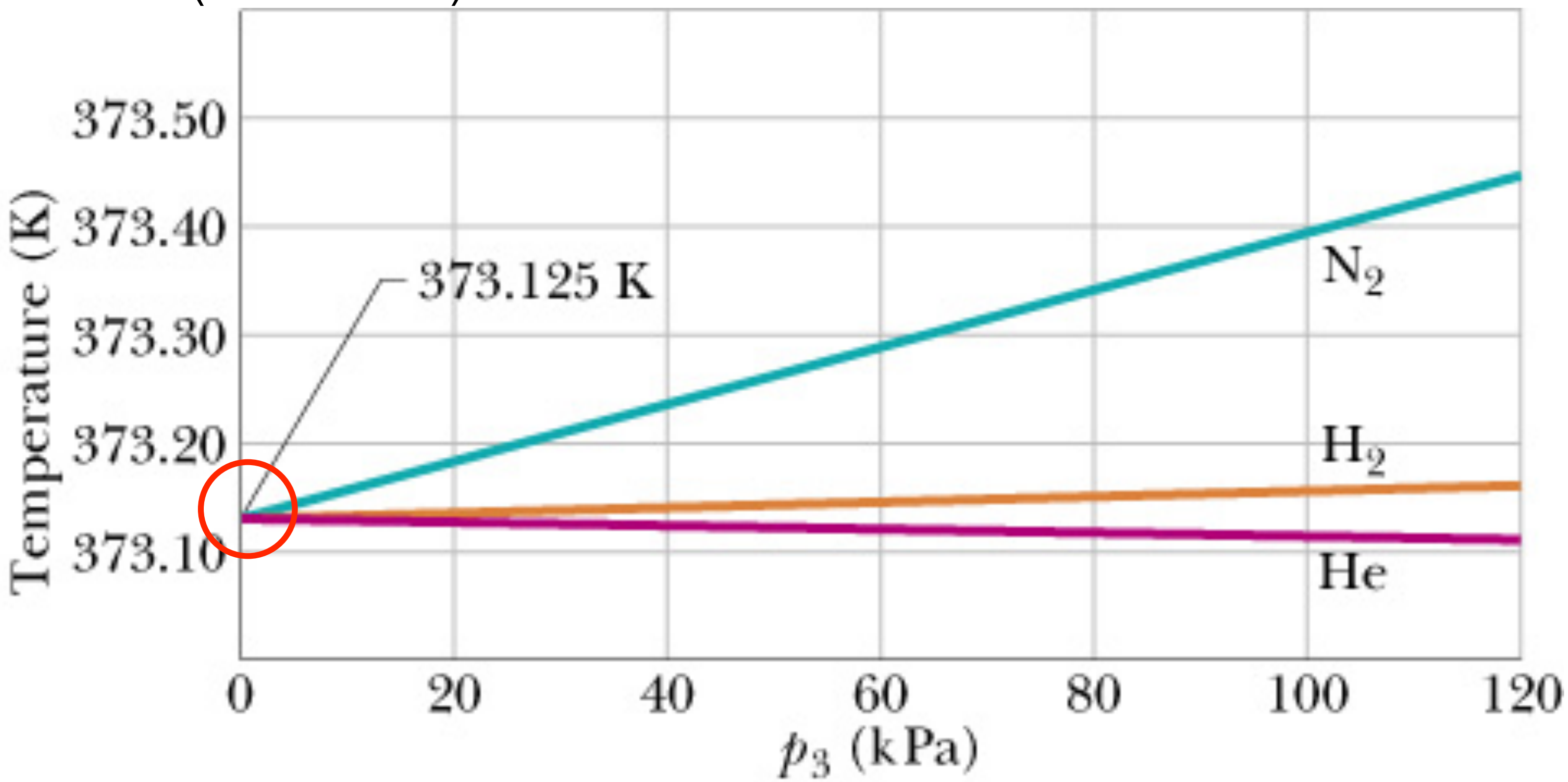
•If we next put the bulb in a triple-point cell: $T_3 = C\,p_3$

$$T = T_3\left(\frac{p}{p_3}\right) = 273.16 \times \left(\frac{p}{p_3}\right)\ (\mathrm{K})$$

T slightly depends on the nature of gas

• If very small amount of gas is used:

$$T = 273.16 \times \left(\lim_{gas \to 0} \frac{p}{p_3} \right) (K)$$



•the boiling point of water nicely converge to a single point if very small amount of gas used

C. The Celsius and Fahrenheit Scales:

- The zero of the Celsius scale is computed by:

$$\boxed{T_C = T - 273.15^0}$$

- The relation between the Celsius and Fahrenheit (used in US) scales is:

$$\boxed{T_F = \frac{9}{5} T_C + 32^0}$$

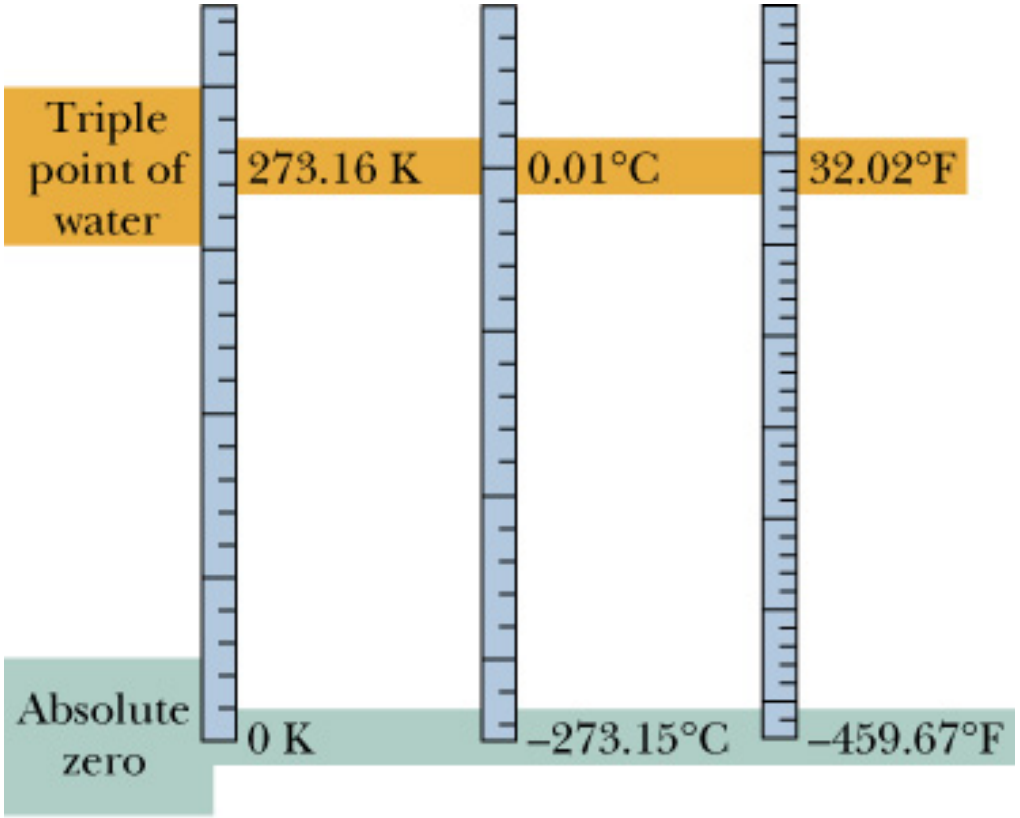
- 0^0 on the Celsius scale measures the same temperature as 32^0 on the Fahrenheit scale:

$$0^0C = 32^0F$$

- A temperature difference of 5 Celsius degrees is equivalent to a temperature difference of 9 Fahrenheit degrees:

$$5\ C^0 = 9\ F^0$$

Note: the degree symbol that appears after C or F means temperature differences.



The Kelvin, Celsius, and Fahrenheit temperature scales are compared.

Homework: 2, 3, 5, 6 (page 500)