
Problem Set 1

Problem 1.4

At what absolute temperature do the Celsius and Fahrenheit temperature scales give the same numerical value? What is the value?

Problem 1.6

Pressures up to 3,000 bar are measured with a dead-weight gauge. The piston diameter is 4 mm. What is the approximate mass in kg of the weights required?

Problem 1.9

The reading on a mercury manometer at 70 degF (open to the atmosphere at one end) is 25.62 inches. The local acceleration of gravity is $32.243 \frac{\text{ft}}{\text{s}^2}$. Atmospheric pressure is 29.86 inches of mercury (in_Hg). What is the absolute pressure in psia being measured? The density of mercury at 70 degF is $13.543 \frac{\text{gm}}{\text{cm}^3}$.

Problem 1.11

Liquids that boil at relatively low temperatures are often stored as liquids under their vapor pressures, which at ambient temperature can be quite large. Thus, n-butane stored as a liquid/vapor system is at a pressure of 2.581 bar for a temperature of 300 K. Large-scale storage ($> 50 \text{ m}^3$) of this kind is sometimes done in spherical tanks. Suggest two reasons why.

Problem 1.12

The first accurate measurements of the properties of high-pressure gases were made by E.H. Amagat in France between 1869 and 1893. Before developing the dead-weight gauge, he worked in a mine shaft, and used a mercury manometer for measurements of pressure to more than 400 bar. Estimate the height of the manometer required.

Problem 1.18

A gas is confined in a 1.25-ft-diameter cylinder by a piston, on which rests a weight. The mass of the piston and weight together is 250 lb_m . The local acceleration of gravity is $32.169 \frac{\text{ft}}{\text{s}^2}$, and the atmospheric pressure is 30.12 inches of Hg (in_Hg).

(a) What is the force in lb_f exerted on the gas by the atmosphere, the piston, and the weight, assuming no friction between the piston and the cylinder?

(b) What is the pressure of the gas in psia?

(c) If the gas in the cylinder is heated, it expands, pushing the piston and weight upward. If the piston and weight are raised 1.7 ft, what is the work done by the gas in $\text{ft} \cdot \text{lb}_f$? What is the change in potential energy of the piston and the weight?

Problem 1.20

Verify that the SI unit of kinetic and potential energy is the joule.

Problem 1.22

The turbines in a hydroelectric plant are fed by water falling from a 50-m height. Assuming 91% efficiency for conversion of potential to electrical energy, and 8% loss of the resulting power in transmission, what is the mass flow rate of water required to power a 200-watt light bulb?

Problem 1.27

Energy costs vary greatly with energy source. For example, coal is about \$35.00/ton, gasoline has a pump price of \$2.75/gallon, and electricity as about \$0.10/kWhr. Conventional practice is to put these on a common basis by expressing them in \$/GJ. For this purpose, assume gross heating values of 29 MJ/kg for coal and 37 GJ/ m^3 for gasoline.

(a) Rank order the three energy sources with respect to energy cost in \$/GJ.

(b) Explain the large disparity in the numerical results of Part (a).

Problem 1.29

A laboratory reports the following vapor-pressure (P^{sat}) data for a particular organic chemical:

t/ °C	P^{sat} / kPa
-18.5	3.18
-9.5	5.48
0.2	9.45
11.8	16.9
23.1	28.2
32.7	41.9
44.4	66.6
52.1	89.5
63.3	129
75.5	187

Correlate the data by fitting them to the Antoine equation:

$$\ln P^{\text{sat}} / \text{kPa} = A - \frac{B}{T / \text{K} + C}$$

That is, find numerical values of parameters A, B, and C by an appropriate regression procedure. Discuss the comparison of correlated and experimental values. What is the predicted normal boiling point of this chemical (i.e., the temperature at which the vapor pressure is 1 atm).