Science Virtual Learning

MPI Physics 240

Thermodynamics 4: Thermal Expansion of Liquids

April 27, 2020

Lesson: MPI Thermodynamics 4 – Thermal Expansion of Liquids
April 27, 2020

Objective: To understand how liquids expand with temperature

This video discusses how liquids expand when their temperature is raised, and works through 2 examples.

https://youtu.be/VxAeBN6_xfM

Video: Thermal Expansion of Liquids

Table 12.1 Coefficients of Thermal Expansion for Solids and Liquids[a]

Substance	Coefficient of Thermal Expansion $(C^\circ)^{-1}$	
	Linear (α)	Volume (β)
Solids		
Aluminum	23×10^{-6}	69×10^{-6}
Brass	19×10^{-6}	57×10^{-6}
Concrete	12×10^{-6}	36×10^{-6}
Copper	17×10^{-6}	51×10^{-6}
Glass (common)	8.5×10^{-6}	26×10^{-6}
Glass (Pyrex)	3.3×10^{-6}	9.9×10^{-6}
Gold	14×10^{-6}	42×10^{-6}
Iron or steel	12×10^{-6}	36×10^{-6}
Lead	29×10^{-6}	87×10^{-6}
Nickel	13×10^{-6}	39×10^{-6}
Quartz (fused)	0.50×10^{-6}	1.5×10^{-6}
Silver	19×10^{-6}	57×10^{-6}
Liquids[b]		
Benzene	—	1240×10^{-6}
Carbon tetrachloride	—	1240×10^{-6}
Ethyl alcohol	—	1120×10^{-6}
Gasoline	—	950×10^{-6}
Mercury	—	182×10^{-6}
Methyl alcohol	—	1200×10^{-6}
Water	—	207×10^{-6}

TABLE 18.1 Average Expansion Coefficients for Some Materials Near Room Temperature

Material (Solids)	Average Linear Expansion Coefficient $(\alpha)(°C)^{-1}$	Material (Liquids and Gases)	Average Volume Expansion Coefficient $(\beta)(°C)^{-1}$
Aluminum	24×10^{-6}	Acetone	1.5×10^{-4}
Brass and bronze	19×10^{-6}	Alcohol, ethyl	1.12×10^{-4}
Concrete	12×10^{-6}	Benzene	1.24×10^{-4}
Copper	17×10^{-6}	Gasoline	9.6×10^{-4}
Glass (ordinary)	9×10^{-6}	Glycerin	4.85×10^{-4}
Glass (Pyrex)	3.2×10^{-6}	Mercury	1.82×10^{-4}
Invar (Ni–Fe alloy)	0.9×10^{-6}	Turpentine	9.0×10^{-4}
Lead	29×10^{-6}	Air[a] at 0°C	3.67×10^{-3}
Steel	11×10^{-6}	Helium[a]	3.665×10^{-3}

[a]Gases do not have a specific value for the volume expansion coefficient because the amount of expansion depends on the type of process through which the gas is taken. The values given here assume the gas undergoes an expansion at constant pressure.

Coefficients of Expansion

A swimming pool has dimensions 10.0 m by 6.00 m by 3.00 m. In the morning, when the temperature is 8.0 °C, it is filled to the top with water. Later in the day, the water heats to 22.0 °C. How much water spills out of the pool? (Ignore the much smaller expansion of the pool itself.)

Expansion of Liquids – Example 1

A 20.0 L (5 gallon) aluminum gasoline can is completely filled with gasoline on a cold day, at -3.0 °C. The can is left in the garage, where it later heats up to 26.0 °C.

a) How much does the volume of the gasoline expand?

b) How much does the volume of the aluminum can expand?

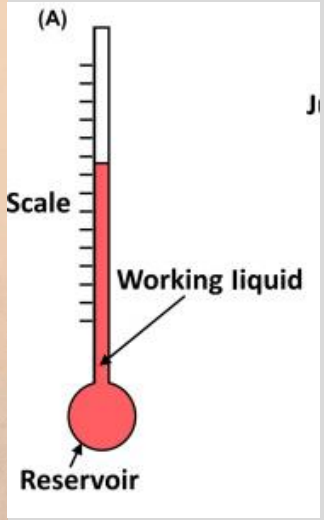
c) Does any gas spill out? If so, how much?

Expansion of Liquids – Example 2

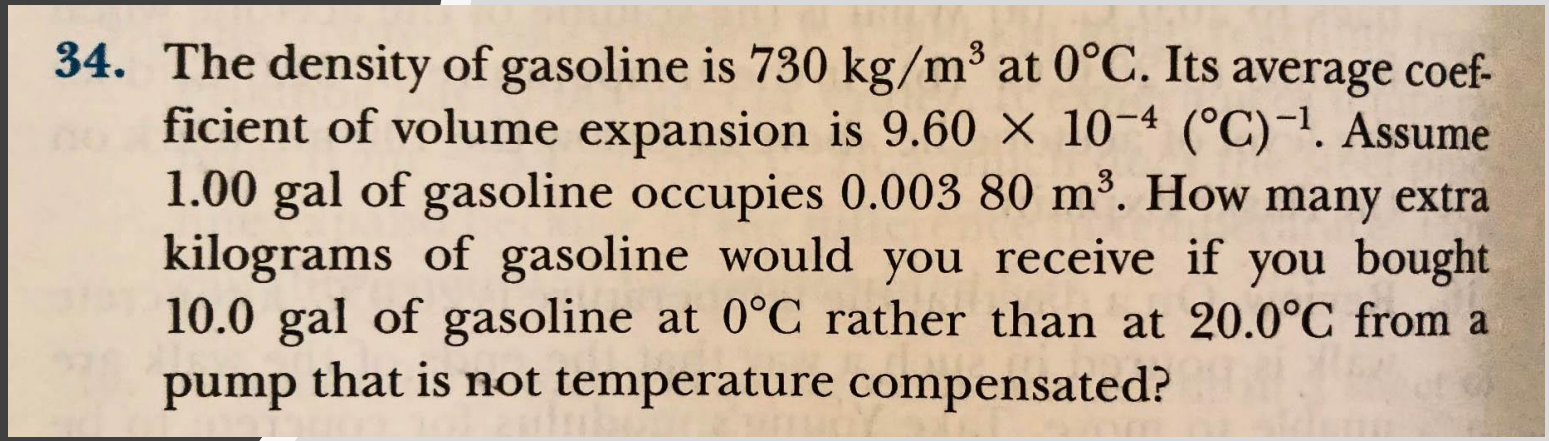
Homework 1

- Try to solve the problem yourself, then watch the solution video:
- https://youtu.be/Oyp49t-KbP4

***38.** GO At the bottom of an old mercury-in-glass thermometer is a 45-mm^3 reservoir filled with mercury. When the thermometer was placed under your tongue, the warmed mercury would expand into a very narrow cylindrical channel, called a capillary, whose radius was 1.7×10^{-2} mm. Marks were placed along the capillary that indicated the temperature. Ignore the thermal expansion of the glass and determine how far (in mm) the mercury would expand into the capillary when the temperature changed by 1.0 C°.



Homework 2



34. The density of gasoline is 730 kg/m^3 at 0°C. Its average coefficient of volume expansion is 9.60×10^{-4} (°C)$^{-1}$. Assume 1.00 gal of gasoline occupies 0.003 80 m^3. How many extra kilograms of gasoline would you receive if you bought 10.0 gal of gasoline at 0°C rather than at 20.0°C from a pump that is not temperature compensated?

- Try to solve the problem yourself, then watch the solution video:
- https://youtu.be/9Rr-XIbqb3M

That’s it!