

# Physics I

## Thermal expansion

**Problem 1.-** You buy 15 gallons of gasoline when the temperature is  $T=15^{\circ}\text{C}$  paying 2.50 dollars per gallon.

a) What is the difference in volume when the temperature reaches  $T=35^{\circ}\text{C}$ ?

b) How much is this difference in dollars?

[ $\beta$  of gasoline is  $950 \times 10^{-6}/^{\circ}\text{C}$ ]

**Solution:**

a)  $\Delta V = \beta V_o \Delta T = (950 \times 10^{-6})(15)(20^{\circ}) = \mathbf{0.285 \text{ gallons}}$

b) Difference in dollars:  $0.285 \times 2.5 = \mathbf{0.71 \text{ dollars}}$

**Problem 1a.-** You top-off the 25-gallon steel gas tank of your truck when the temperature is  $10^{\circ}\text{C}$  and then leave the vehicle in the sun. How much gas spills if the temperature reaches  $35^{\circ}\text{C}$ ? [ $\alpha$  of steel is  $12 \times 10^{-6}/^{\circ}\text{C}$  and  $\beta$  of gasoline is  $950 \times 10^{-6}/^{\circ}\text{C}$ ]

**Solution:** The gasoline will expand by a volume:

$$\Delta V_{\text{gasoline}} = \beta_{\text{gasoline}} V_o \Delta T = (950 \times 10^{-6} / ^{\circ}\text{C})(25 \text{ gallon})(35^{\circ}\text{C} - 10^{\circ}\text{C}) = 0.59 \text{ gallons}$$

But the tank will only expand:

$$\Delta V_{\text{steel}} = \beta_{\text{steel}} V_o \Delta T = (3 \times 12 \times 10^{-6} / ^{\circ}\text{C})(25 \text{ gallon})(35^{\circ}\text{C} - 10^{\circ}\text{C}) = 0.02 \text{ gallons}$$

So, we will spill **0.57 gallons** of gasoline, around 1 dollar worth at current prices.

**Note:** The volume expansion coefficient  $\beta$  is three times as much as the linear coefficient  $\alpha$ , so  $\beta = 3\alpha$ . This only applies to solids because liquids don't have a defined shape.

**Problem 2.-** Mercury is used in thermometers because it expands more than glass when heated, changing the length of the column according to the temperature.

A) Why is water not a good alternative to mercury?

B) Why do we need to use other kind of thermometers below  $-39^{\circ}\text{C}$ ?

**Solution:** A) water solidifies at  $0^{\circ}\text{C}$  and it has the minimum volume at  $4^{\circ}\text{C}$ . Moreover, it could break the glass when freezing.

B) Mercury solidifies at  $-39^{\circ}\text{C}$ .

**Problem 3.-** What happens to the volume of 1 gram of water when it is cooled down from  $4^{\circ}\text{C}$  to  $1^{\circ}\text{C}$ ?

**Solution:** Water expands when cooled down below  $4^{\circ}\text{C}$ .