FLINN SCIENTIFIC

Buoyancy in Air Handout

Discussion

Air is a fluid. Just as in water, an object will be buoyed in air. The degree to which objects are buoyant is related to their density and the density of the fluid. The smaller the density of the fluid, the smaller the buoyant force.

Balances do not directly measure mass of an object. They measure the force an object exerts—its weight. Calibrated masses are used to convert these weights to mass readings.

As long as an object being massed has approximately the same density as the calibrated masses, the mass readings will be accurate. This holds true for most solids and liquids.

For any object being massed on a balance, there are three forces acting on the object: (1) the weight of the object, *mg;* (2) the force of the balance on the object, *N;* and (3) the buoyant force of the air, F_B (see Figure 1).

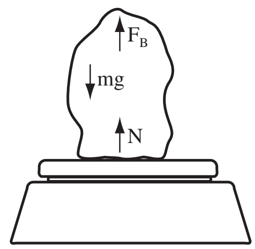

Figure 1.

Since the object on a balance is at rest, the sum of the forces must be equal to zero:

$$F_B + N = mg \qquad \textit{Equation 1}$$

If the actual measured weight on the balance is W_m, then $W_m = N$. Substituting W_m into Equation 3, we get

$$W_m = mg - F_B \qquad \textit{Equation 2}$$

This means that the measured weight in air (W_m) differs from the weight in a vacuum (*mg*) by the buoyant force of the atmosphere on the object (F_B).

The buoyant force is equal to the volume of air displaced by the object, V_a, times the density of air, ρ_a, times the acceleration due to gravity, *g*.

$$F_B = V_a\rho_a g \qquad \textit{Equation 3}$$

Substituting into Equation 2 produces

$$W_m = mg - V_a\rho_a g \qquad \textit{Equation 4}$$

Where m_m is the measured mass on the balance.

Dividing both sides by *g* yields

$$m_m g = mg - V_a\rho_a g \qquad \textit{Equation 5}$$

$$m_m + V_a\rho_a = m$$

For the bottle and balloon in Part 2, the true mass is the same before and after the reaction. The difference between the measured masses is

$$m_m(\text{before}) - m_m(\text{after}) = [V_a(\text{after}) - V_a(\text{before})]r_a \qquad \textit{Equation 6}$$

The volume of air displaced by the production of carbon dioxide is estimated by measuring the diameter of the inflated balloon. If we assume the balloon is a sphere, then the volume is

$$\text{Volume} = 4/3\pi r^3 \qquad \textit{Equation 7}$$

Name____

Data Tables

Data Table A

Trial

1. Mass of weighing dish and sodium bicarbonate __________ g
2. Mass of bottle, acetic acid solution, and cap __________ g
3. Total mass *before* reaction (#1 and #2) __________ g
4. Total mass after reaction __________ g
5. Mass loss or gain (–/+) __________ g

Data Table B

1. Mass of assembly before reaction (Step 10) __________ g
2. Mass of assembly after reaction (Step 14) __________ g
3. Mass loss or gain (–/+) __________ g
4. Diameter of inflated balloon __________ cm

Question and Calculations

1. Use the diameter of the inflated balloon and Equation 6 and 7 to calculate the theoretical change in weight for the Part 2 demonstration. How does this compare with the actual change in weight? The density of air, ρ_a, at 20 °C, is 1.21×10^{-3} g/cm^3.