Experiment 19

Temperature

INTRODUCTION

Temperature can be defined as the degree of hotness or coldness of a body; temperature can also refer to that property of a body that determines the direction of heat flow by conduction. Temperature is also proportional to the average kinetic energy of the random motion of the particles in matter.

Regardless of how temperature is defined, one common way of measuring it is with a mercury-in-glass thermometer. The method of the thermometer's functioning is based on the expansion and contraction effect of heat. Mercury exists in the liquid phase over a large temperature range (melting point, −38.87°C; boiling point, 356.9°C). When a mercury-in-glass thermometer is placed in a gas such as the air, heat is transferred from this gas to the thermometer or from the thermometer to the gas, depending on which is at the higher energy level.

If heat flows from the gas into the glass and the mercury, the glass and the mercury expand to a larger volume and a higher temperature is recorded by the thermometer. If the heat flow is in the reverse direction, the glass and mercury contract and the thermometer records a lower temperature. The coefficient of cubical expansion of mercury is large compared with that of glass; that is, mercury expands much more than glass for each degree change in temperature, so the mercury rises and falls in the glass tube.

A thermometer must be calibrated before a temperature can be recorded accurately. This is done by determining two fixed points (usually the melting point and boiling point of water) on the thermometer, choosing an arbitrary unit of measurement, and marking a scale on the glass bulb.

LEARNING OBJECTIVES

After completing this experiment, you should be able to do the following:

1. Define and explain temperature and state its units of measurement.
2. Calibrate a mercury-in-glass thermometer.
3. Measure temperature with the mercury-in-glass thermometer.

APPARATUS

Nongraduated mercury-in-glass thermometer, 1-L Pyrex glass beaker, tripod base to hold glass beaker, ice cubes, Bunsen burner, marker for making temporary mark on glass, ruler.

EXPERIMENT 19 NAME (print) _____ DATE _____
LAST FIRST

LABORATORY SECTION _____ PARTNER(S) _____

PROCEDURE

1. Fill the glass beaker about half full with tap water. Place the thermometer in water and heat the water to boiling point.
2. Allow the system to reach equilibrium; that is, wait until the mercury reaches its highest point in the glass tube and remains there for a few minutes. This is called the steam point.
3. Mark the steam point with the glass marker provided by the instructor. This should be done carefully and quickly.
4. Place a mixture of ice and water in the plastic beaker and position the thermometer in the mixture. Make sure that there is sufficient water in the beaker so that the entire volume of mercury may be completely submerged.
5. Allow the system to come to equilibrium; that is, wait until the mercury reaches its lowest point in the glass tube and remains there for a few minutes. This is called the ice point.
6. Mark the ice point with a glass marker. Make the mark carefully and quickly, and be careful not to break the thermometer in doing so. Be certain that the mark is placed on the glass tube where you observe the ice point.

   Note: Normally, in calibrating a mercury-in-glass thermometer, the ice and steam points are determined with pure water at standard atmospheric pressure. We have not called for either of these conditions for this experiment.
7. Since the expansion of mercury is fairly linear from 0°C to 100°C, a linear scale can be marked on the glass tube over this temperature range. Using the ruler, mark off a scale on the thermometer between the two fixed points. Assign 0° Celsius to the ice point and 100° Celsius to the steam point. Divide into 10° sections and then mark carefully 10 divisions between 20°C and 30°C. This range on the thermometer will be used in determining the existing air temperature.
8. Determine the existing air temperature in the laboratory with your calibrated thermometer.
   _____ °C
9. Ask the instructor for the location in the laboratory of a standard thermometer. Read and record the existing air temperature of the laboratory.
   _____ °C

QUESTIONS

1. What is the least count of your thermometer? _____
2. What is the percent error of your thermometer in your determination of the existing air temperature in the laboratory? Show your work.

Percent error..... _____

3. Would you expect the steam point on your calibrated thermometer to be higher or lower than a regular standard thermometer? Why?

4. What are the disadvantages of using a water-in-glass thermometer to measure outside air temperature?

5. When a mercury-in-glass thermometer is placed in boiling water, the mercury level falls slightly at first and then begins to rise. Explain this effect. If you have lab time, perform the experiment. Obtain the lab instructor's permission.