6.5.4 Atmospheric Moisture and Hygrometry

Hygrometry may be defined as the study and measurement of the quantity of aqueous vapour in the atmosphere.

Water vapour enters the atmosphere by evaporation while it leaves the atmosphere as rain or snow. Evaporation is a dynamic physical process occurring when the number of molecules of water leaving a surface in a unit of time is greater than the number entering it. The converse indicates precipitation.

Evaporation can be measured using evaporation pans. This consists of a tank 1.8m square and 0.61 m deep sunk into the ground so that the rim projects about 0.08 m above the surrounding ground surface (Fig. 6.7a). The pan is equipped with a gauge to measure the water level. If any precipitation

occurs between observations, allowance is made by subtracting the quantity of rainfall recorded by the rain gauge located near the tank.

Precipitation can be measured using a rain gauge (Fig. 6.7b). A rain gauge can be easily and cheaply made by using a plastic funnel and a bottle. It is best if the bottle is placed in a container with the funnel resting on the rim and further secured on the bottle by a cork or cap. This arrangement makes the bottle stable in windy situations. Then the true rainfall is given by

$$P = \frac{r^2 \times h}{R^2} \qquad (6.12)$$

where P = Precipitation
r = radius of the bottle
h = height of water collected in the bottle
and R = radius of the funnel.

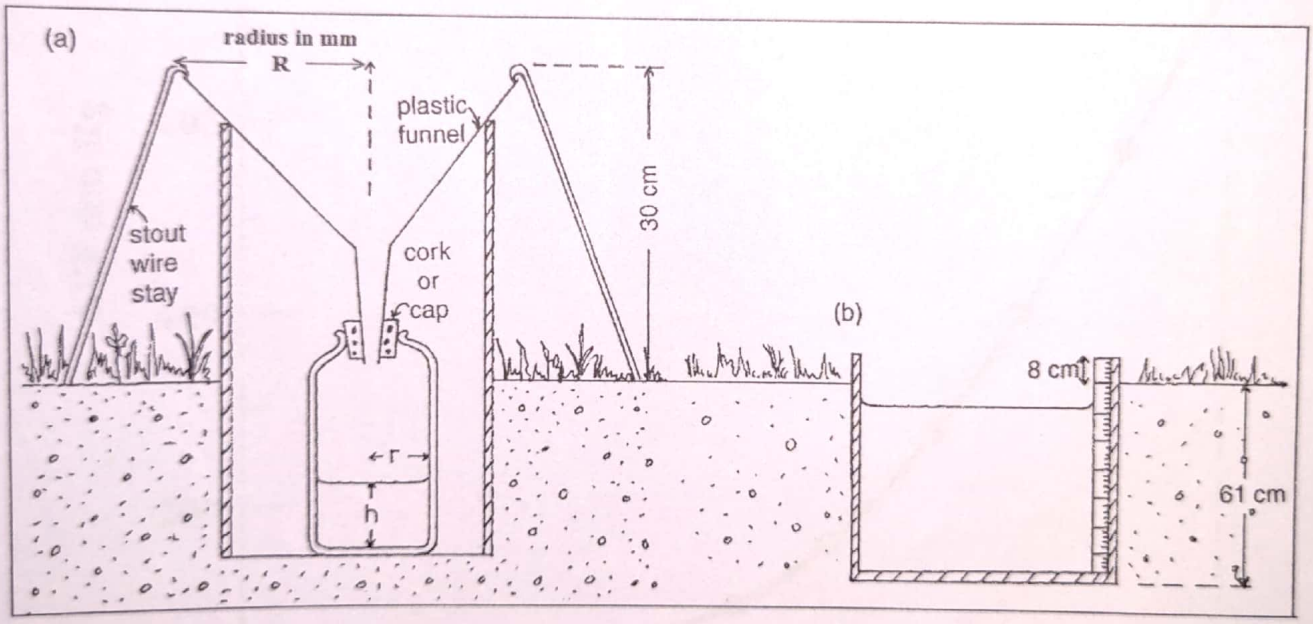

Figure 6.7 Instrument for measurement of (a) precipitation (b) evaporation.

Vapour pressure: The vapour of a liquid formed at any temperature exerts a pressure called the vapour pressure of the liquid, at the corresponding temperature.

Let us suppose that some liquid is poured into a bottle which is then corked up. Owing to evaporation, the space above the liquid begins to fill up with vapour. The vapour molecules move about in all directions and exert pressure when they bounce off the walls of the bottle. They may also strike the surface of the liquid and may re-enter it. Eventually a state of dynamic equilibrium is reached when the rate at which the molecules leave the liquid

is equal to the rate at which others return to it. Thus they are in dynamic equilibrium. Under these conditions the space above the liquid is saturated with vapour, and the pressure exerted is called the saturation vapour pressure (s.v.p). A saturated vapour is one which is in a state of dynamic equilibrium with its own liquid. The saturation vapour is dependent on the temperature but independent of the volume of the vapour. Figure 3.8 and appendix shows the changes in saturation vapour pressure with temperature. The boiling point of a substance is defined as the temperature at which its saturation vapour pressure becomes equal to the external atmospheric pressure.

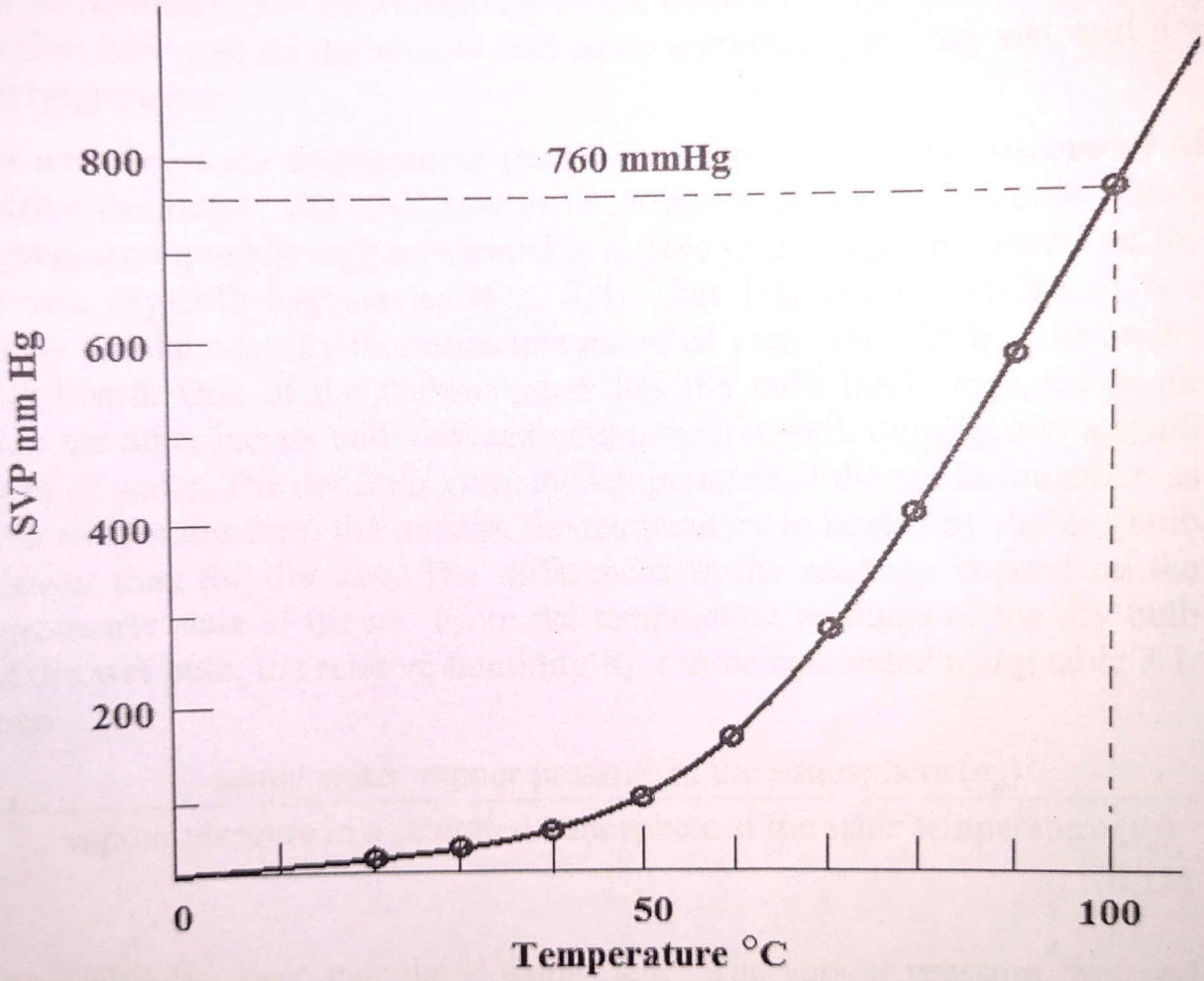

Figure 6.8 Changes in saturation vapour pressure (SVP) with temperature.

Dew point: The dew point is defined as the temperature at which the water vapour present in the air is just sufficient to saturate it.

If a sample of air is cooled without any loss or gain of water vapour, it will eventually reach a temperature at which the air becomes saturated with water vapour. Any cooling below this point will cause condensation or dew formation. This level is termed as the dew point temperature.

Humidity: Humidity gives us information about the amount of aqueous vapour present in the atmosphere at a particular temperature. The humidity can be expressed as absolute and relative.

Absolute humidity: It is defined as the quantity of aqueous vapour actually present in a given volume of the atmospheric air.

Relative humidity: It is defined as the ratio of the mass of water vapour actually present in a given volume of air to the mass of water vapour required to saturate the same volume of air at the air temperature.

There are a number of different methods available for measuring relative humidity. The instruments used are termed as hygrometers. We shall describe here one of the simple and more common type, the wet and dry bulb hygrometer.

Wet and dry-bulb hygrometer (psychrometer) for the measurement of relative humidity: For meteorological purposes the relative humidity may be measured quickly with a reasonable degree of accuracy by means of the wet and dry-bulb hygrometer (Fig. 3.9). This instrument consists of two exactly similar mercury thermometers mounted vertically side by side on the same board. One of the thermometers has the bulb freely exposed to air while the other has its bulb covered with a muslin wick dipping into a small vessel of water. The dry bulb gives the temperature of the air. In the other, as water evaporates from the muslin, the temperature indicated by the wet bulb is lower than the dry one. The differences in the readings depend on the hygrometric state of the air. From the temperature readings of the dry bulb and the wet bulb, the relative humidity R_H can be calculated using table 3.1. Since

$$RH = \frac{\text{actual water vapour pressure in the atmosphere } (e_a)}{\text{vapour pressure in a saturated atmosphere at the same temperature } (e_s)} \quad (6.13)$$

The table has been calculated using and . The vapour pressure, wet and dry bulb temperature, relative humidity and wind speed can be used to calculate the evaporative power of the atmosphere (Penman, 1948; Montieth, 1985; and Ward and Robinson 1990).

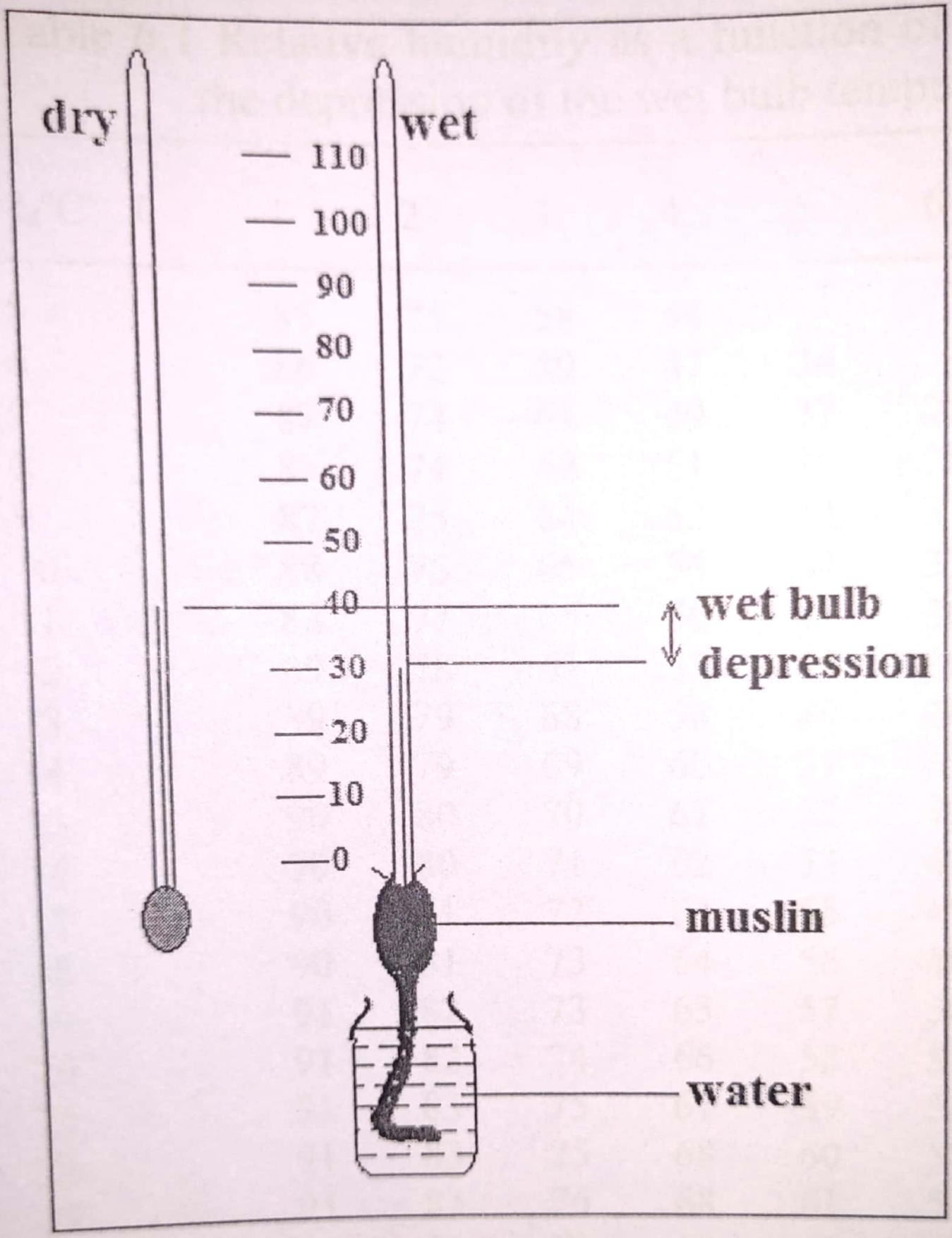

Figure 6.9 Wet and dry bulb hygrometer