We can use θ_e or θ_L to identify and label moist adiabats. Consider an air parcel starting at P = 100 kPa that is saturated but contains no liquid water ($r = r_s = r_T$). For that situation θ_L is equal to its initial temperature T (which also equals its initial potential temperature θ at that pressure). A rising air parcel from this point will conserve θ_L, hence we could label the moist adiabat with this value (Fig. 5.9).

An alternative label starts from same saturated air parcel at P = 100 kPa, but conceptually lifts it to the top of the atmosphere (P = 0). All of the water vapor will have condensed out at that end point, heating the air to a new potential temperature. The potential temperature of the dry adiabat that is tangent to the top of the moist adiabat gives θ_e (Fig. 5.9). [CAUTION: On some thermo diagrams, equivalent potential temperature is given in units of Kelvin.]

In other words, θ_L is the potential temperature at the bottom of the moist adiabat (more precisely, at P = 100 kPa), while θ_e is the potential temperature at the top. Either labeling method is fine — you will probably encounter both methods in thermo diagrams that you get from around the world. In this book, I label lines with values of **liquid-water potential temperature**, θ_L, because it is analogous to the labeling scheme for the dry adiabats.

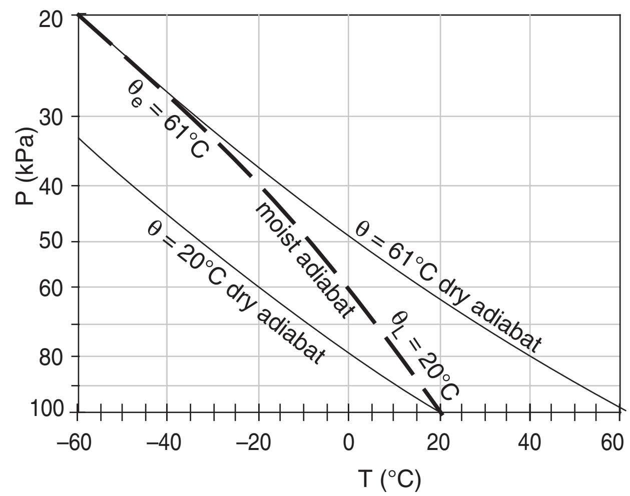

Figure 5.9
Comparison of θ_L and θ_e values for the same moist adiabat.

For **wet-bulb potential temperature**, use Normand's rule on a thermo diagram (Fig. 5.10). Knowing temperature T and dew-point T_d at initial pressure P, and plot these points on a thermo diagram. Next, from the T point, follow a dry adiabat up, and from the T_d point, follow an isohume up. Where they cross is the lifting condensation level LCL.

From that LCL point, follow a saturated adiabat back down to the starting altitude, which gives the **wet-bulb temperature** T_w. If you continue to follow the saturated adiabat down to a reference pressure (P = 100 kPa), the resulting temperature is the **wet-bulb <u>potential</u> temperature** θ_w (see Fig. 5.10). Namely, θ_w equals the θ_L label of the moist adiabat that passes through the LCL point.

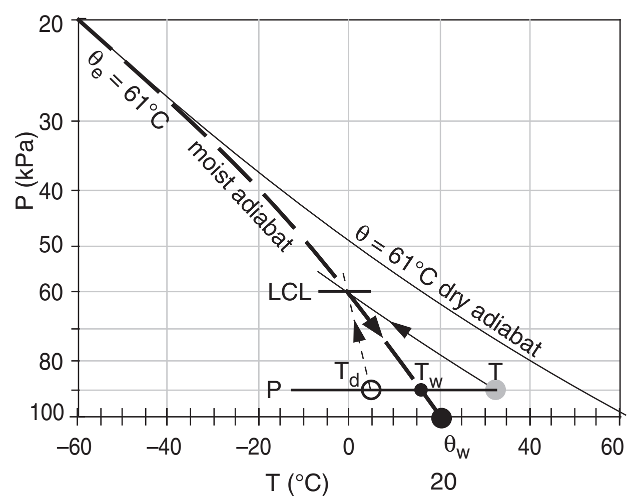

Figure 5.10
Thermo diagram showing how to use Normand's Rule to find wet-bulb potential temperature θ_w, and how it relates to θ_e.

To find θ_e(K) for a moist adiabat if you know its θ_w(K), use:

$$\theta_e = \theta_w \cdot \exp(a_3 \cdot r_s / \theta_w)_o \qquad (5.43a)$$

where a_3 = 2491 K·kg$_{air}$/kg$_{vapor}$, and r_s is saturation mixing ratio (kg$_{vapor}$/kg$_{air}$) at $T = \theta_w$ and P = 100 kPa. This relationship can be approximated by

$$\theta_e(\text{K}) \approx a_o + a_1 \cdot \theta_w(°\text{C}) + a_2 \cdot [\theta_w(°\text{C})]^2 \qquad (5.43b)$$

where a_o = 282, a_1 = 1.35, and a_2 = 0.065, for θ_w in the range of 0 to 30°C (see Fig. 5.11). Also the θ_L label for the moist adiabat passing through the LCL equals this θ_w.

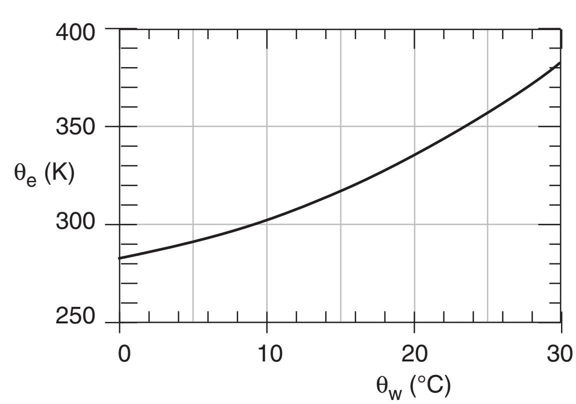

Figure 5.11
Approximate relationship between θ_w and θ_e.