Problems

P 5.1 Since the current into the inverting input terminal of an ideal op-amp is zero, the voltage across the 3.3 MΩ resistor is (2.5)(3.3) or 8.25 V. Therefore the voltmeter reads 8.25 V.

P 5.2

$$v_p = \frac{18}{24}(12) = 9 \text{ V} = v_n$$

$$\frac{v_n - 24}{30} + \frac{v_n - v_o}{20} = 0$$

$$2v_n - 48 + 3v_n - 3v_o = 0$$

$$3v_o = 5v_n - 48$$

$$v_o = (45 - 48)/3 = -1.0 \text{ V}$$

$$i_L = \frac{v_o}{5} \times 10^{-3} = -\frac{1}{5} \times 10^{-3} = -200 \times 10^{-6}$$

$$i_L = -200\,\mu\text{A}$$

P 5.3

$$\frac{v_b - v_a}{20} + \frac{v_b - v_o}{160} = 0, \qquad \text{therefore} \quad v_o = 9v_b - 8v_a$$

[a] $v_a = 1.5$ V, $v_b = 0$ V, $v_o = -12$ V

[b] $v_a = 3.0$ V, $v_b = 0$ V, $v_o = -18$ V (sat)

[c] $v_a = 1.0$ V, $v_b = 2$ V, $v_o = 10$ V

[d] $v_a = 4.0$ V, $v_b = 2$ V, $v_o = -14$ V

[e] $v_a = 6.0$ V, $v_b = 8$ V, $v_o = 18$ V (sat)

[f] If $v_b = 4.5$ V, $v_o = 40.5 - 8v_a = \pm 18$

$$\therefore \quad 2.8125 \leq v_a \leq 7.3125 \text{ V}$$

P 5.4 [a]

$$i_a = \frac{120}{6} \times 10^{-6} = 20\,\mu\text{A}$$

$$v_a = -20 \times 10^3 i_a = -400\,\text{mV}$$

[b]

$$\frac{v_a}{60} + \frac{v_a}{20} + \frac{v_a - v_o}{240} = 0$$

$$\therefore \quad v_o = 17v_a = -6.8 \text{ V}$$