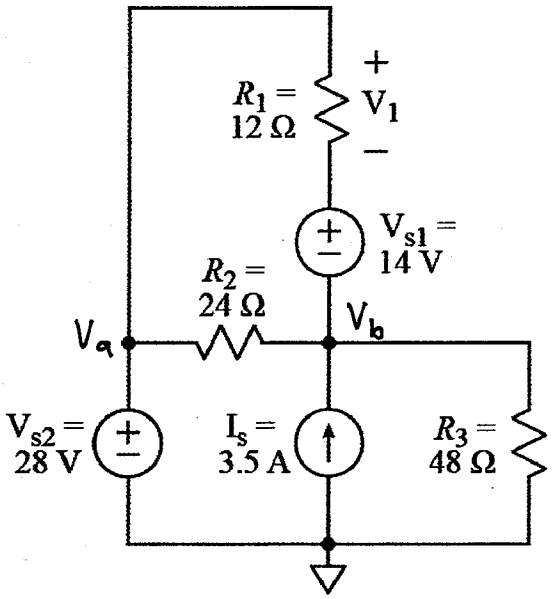
4. (20 points)



Use nodal analysis to find the voltage V_1. You **must** show all the steps of nodal analysis work to get credit, including drawing appropriate symbols and labels on the circuit shown.

sol'n: V_a node = 28V because of V_{s2}

V_b node: $\frac{V_b - 28V}{24\Omega} + \frac{V_b + 14V - 28V}{12\Omega} + \frac{V_b}{48\Omega} = 3.5A$

or $V_b\left(\frac{1}{24\Omega} + \frac{1}{12\Omega} + \frac{1}{48\Omega}\right) = 3.5A + \frac{28V}{24\Omega} + \frac{14V}{12\Omega}$

Multiply both sides by 48Ω:

$V_b\,(2 + 4 + 1) = 3.5A(48\Omega) + 56V + 56V$

$V_b\,(7) = 168V + 56V + 56V = 280V$

$V_b = \frac{280}{7} V = 40V$

$V_1 = 28V - (V_b + 14V) = -26V$