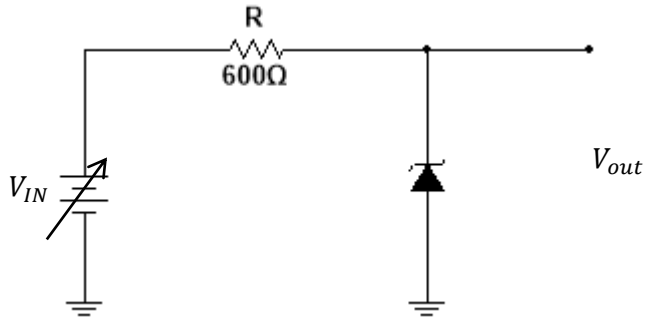
For maximum current (40 mA)

$$V_R = (40mA)(1k\Omega) = 40V$$

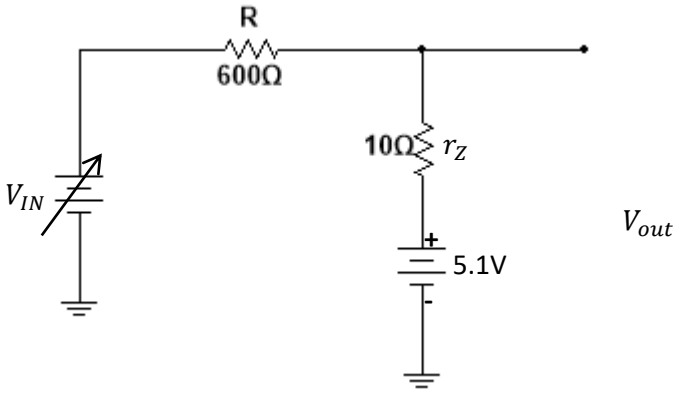
$$V_{IN} = V_R + V_Z = 40V + 10V = 50V$$

- This shows that this Zener diode can regulate an input voltage from 14V to 50V and maintain an approximate 10V output

Example: Determine the minimum and maximum input voltage which can be regulated by the zener diode. Assume $I_{ZK} = 1mA$, $I_{ZM} = 15mA$, $V_Z = 5.1V$, $r_Z = 10\Omega$.



Solution: Equivalent Circuit Model is:



At $I_{ZK} = 1mA$

$$V_{out} = V_Z + I_{ZK}r_Z = 5.1V + (1mA)(10\Omega) = 5.1V + 0.01V = 5.11V$$

$$V_{IN(min)} = I_{ZK}R + V_{out} = (1mA)(600\Omega) + 5.11V$$

$$= 5.71V$$

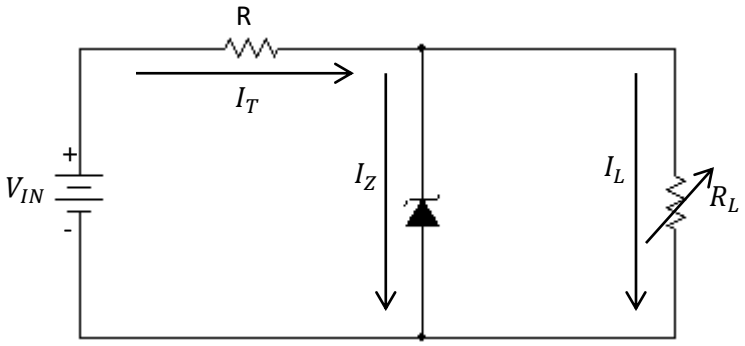
At $I_{ZM} = 15mA$

$$V_{out} = V_Z + I_{ZM}r_Z = 5.1V + (15mA)(10\Omega) = 5.1V + 0.15V = 5.25V$$

$$V_{IN(max)} = I_{ZM}R + V_{out} = (15mA)(600\Omega) + 5.25V = 14.25V$$

B2: Regulation with A Varying Load

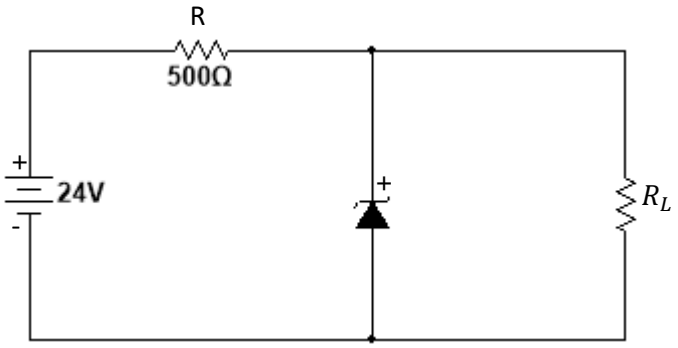
- The following circuit shows zener regulator with a variable load resistor across the terminals.



- The zener maintains regulation (constant voltage across R_L) as long as the zener current is greater than I_{ZK} and less than I_{ZM} . This is called "load regulation''.
- When the output terminals are open ($R_L = \infty$), the load current is zero and all the current is through the zener.
- When the load resistor is connected, part of the total current is through zener and the other part is through R_L .
- As R_L is decreased, I_L goes up and I_Z goes down. The zener diode continues to regulate and I_Z reaches its minimum value I_{ZK} , at this point, the load current is maximum.

Example: Determine the minimum and maximum load currents for which the zener diode in the following circuit will maintain regulation. What the minimum R_L that can be used?

$V_Z = 12V, I_{ZK} = 3mA, I_{ZM} = 90mA,$ $assume\ r_Z$ =0Ω



When $I_L = 0A$, $I_Z = I_{total}$

$$I_Z = \frac{V_{IN} - V_Z}{R} = \frac{24V - 12V}{500\Omega} = 24\ mA$$

Since the value is much less than I_{ZM} , 0A is an acceptable minimum for I_L .

$$I_{L(min)=}0A$$

Maximum value of I_L is when I_Z is at minimum, we can solve for $I_{L(max)}$ as follows:

$$I_{L(max)} = I_T - I_{Z(min)} = 24mA - 3mA = 21mA$$

The minimum value for R_L :

$$R_{L(min)} = \frac{V_Z}{I_{L(max)}} = \frac{12V}{21mA} = 571\Omega$$

Percent Load Regulation

Example: A certain regulator has a no-load output voltage of 6V and a full load output of 5.82V. What is the percentage of load regulation.

Percent load regulation $= \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\% = \frac{6V - 5.82V}{5.82V} \times 100\% = 3.09\%$