Question -1

a. Thermal voltage calculation

To find the thermal voltage (V_T) at 25°c, we use the formula:

$$V_T = \frac{KT}{q}$$

Temperature (T): $25°c + 273 = 298K$

Boltzmann's constant (K): 1.38×10^{-23} J/K

charge of an electron (q): 1.602×10^{-19} C

Substituting the values:

$$V_T = \frac{(1.38 \times 10^{-23} J/K)(298K)}{1.602 \times 10^{-19} C} \approx 25.69\,mV$$

b. Diode Current calculation

Using the ID equation provided:

$$I_D = I_S(e^{V_D/nV_T} - 1)$$

Saturation current (I_S): $40nA = 40 \times 10^{-9}$ A

Ideality factor (n): 2

Applied voltage (V_D): 0.5 V

thermal voltage (V_T): 0.02569 V

$$I_D = 40 \times 10^{-9} \cdot (e^{0.5/(2 \cdot 0.02569)} - 1)$$

$$I_D = 40 \times 10^{-9} \cdot (e^{9.7314} - 1)$$

$$I_D = 40 \times 10^{-9} \cdot (16837.2) \approx 0.673\,mA$$

Question 2

(a) Approximate Model ($V_D = 0.7V$)

$V_D : 0.7V$

$V_R : E - V_D = 30V - 0.7V = 29.3V$

$I_D : V_R / R = 29.3V / 1.5k\Omega = 19.53mA$

(b) Ideal Model ($V_D = 0V$)

$V_D : 0V$

$V_R : E - V_D = 30V - 0V = 30V$

$I_D : V_R / R = 30V / 1.5k\Omega = 20mA$

(c) Yes, the ideal model provides a good approximati in this case. The difference in current is only about 2.4%. This is because the source voltag (30V) is significantly large than the diode's forward voltage drop (0.7V)

question 3

ⓐ Reverse Bias Case:

The battery is oriented with the negative terminal facing the diode's anode. Since the anode is at a lower potential than the cathode the diode is OF

$I = 0A$

ⓑ The 20V source is oriented such that the node connecting the diodes is at -20V relative to ground. Both diodes are Forward Biased because their anodes are grounded (higher potential) and cathodes are at -20V

$I_1 \,(10\Omega): (20V - 0.7V) / 10\Omega = 1.93A$

$I_2 \,(20\Omega): (20V - 0.7V) / 20\Omega = 0.965A$

Total $I: 1.93A + 0.965A = 2.895A$

ⓒ Back-to-Back series Case

The middle branch contains two Si diodes in serie but they are oriented opposing each other. This create an open circuit for the middle branch. The curre I flows through the 10Ω resistor branch only

$I = 10V / 10\Omega = 1A$

Question 4

ⓐ Si and GaAs in parallel

Source : 1 V

Diodes : Si (0.7V) and GaAs (1.2V) in parallel

$V_o = 1V - 0.7V = 0.3V$

$I = V_o / R = 0.3V / 1k\Omega = 0.3 mA$

ⓑ Multi-stage Si Network

path : From +16V through one Si diode, then through a parallel pair of Si diodes, to the output V_o

total diode voltage drop = $0.7V + 0.7V = 1.4V$

$V_o : 16V - 1.4V = 14.6V$

$I = (V_o - (-4V)) / 4.7k\Omega$

$= (14.6 + 4) / 4.7k\Omega$

$= 18.6 / 4.7k\Omega$

$\approx 3.96 mA$