Q 1:

a): 8.64 kWh/day

$$10m^2 \times 1000\,W/m^2 \times 24\,hours = 8.64\,kWh/day$$

b):

$$Total\ cost = initial\ cost + repair\ costs\ during\ lifetime$$

$$Total\ cost = 100\$/m^2 + \sum_{i=0}^{25\%} [100\% + i] \times 50\$/m^2 = 1562.5\$/m^2$$

c):

1. GaN
2. GaAs
3. Si

GaN has the highest V_{oc} of the four materials, followed by GaAs, then Si. This is because GaN has a higher bandgap than GaAs and Si, which allows it to absorb more energy from the sun and thus produce a higher V_{oc}.

d): The author calculates the maximum theoretical conversion efficiency of solar spectrum into electricity using a single layer (junction) material by applying the detailed balance limit of efficiency of p-n junction solar cells. This limit is based on the principle of detailed balance, which states that the ratio of the number of photons absorbed to the number of photons emitted is equal to the ratio of the number of electrons generated to the number of electrons recombined. The author then uses this principle to calculate the maximum theoretical conversion efficiency of a single junction solar cell by taking into account the spectral response of the cell, the bandgap of the material, and the temperature of the cell. The author also considers the effects of non-radiative recombination and surface recombination on the efficiency of the cell.

It is possible that these assumptions could be broken in real-world conditions, as solar cells are not typically operated at thermodynamic equilibrium and may not always be operating at the limit of the detailed balance condition. However, the assumptions used in the calculation provide a useful starting point for understanding the maximum theoretical conversion efficiency of a single junction solar cell.

Q 2:

a):

Radiative Recombination Rate:

$$R_{rad} = A_r n^2$$

Non-Radiative Recombination Rate:

$$R_{non-rad} = B_{nr} n^2$$

Total Recombination Rate:

$$R_{tot} = R_{rad} + R_{non-rad} = (A_r + B_{nr})n^2$$

$A\&B$ are constant that depends on the material properties of the semiconductor and n is the carrier density.

Q 4:

a): The area of the escaping light cone is given by:

$$A_{esc} = 2\pi r^2(1 - \cos\theta_c)$$

$$Escaping\% = \frac{A_{esc}}{2\pi r^2} \times 100\% = 25.5\%$$

c): The resistivity of typical Mg doped GaN after crystal growth is typically in the range of 10^{-3} to 10^{-4} ohm-cm. When the crystal is annealed to 700C, the resistivity decreases due to the increased mobility of the carriers. This is because the annealing process increases the number of free carriers in the crystal, which reduces the resistivity.

1 Q 5:

a): For a LD that emits 270 nm, the active material would need to be a semiconductor material such as gallium nitride (GaN). The composition of the active material would need to be a combination of gallium, nitrogen, and other elements such as aluminum, indium, and magnesium.
For a LD that emits 222 nm, the active material would need to be a semiconductor material such as aluminum nitride (AlN). The composition of the active material would need to be a combination of aluminum, nitrogen, and other elements such as gallium, indium, and magnesium.

2 Q 6:

a): Moore's Law is an observation made by Intel co-founder Gordon Moore in 1965, which states that the number of transistors on a microchip doubles approximately every two years. This has been true for the past 60 years, and has enabled the technology industry to keep up with the ever-increasing demand for faster, more powerful computing devices.
The main reason why Moore's Law has been able to keep up for so long is due to the continuous advancements in semiconductor technology. This has allowed for the miniaturization of transistors, which in turn has enabled the industry to pack more transistors onto a single chip. This has allowed for faster and more powerful computing devices.
The potential limitations of Moore's Law are that it is becoming increasingly difficult to continue to miniaturize transistors. This is due to the fact that the transistors are reaching the physical limits of what is possible. As a result, the industry is looking for alternative solutions such as quantum computing
In my opinion, stacking transistors in microchips vertically may help us keeping up with Moore's law.