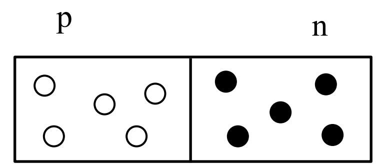
Name ____

Interactive Lecture Demonstration Prediction Sheet
pn-Junctions

Question 1 – pn-junction:
A junction between p-type and n-type semiconductors is shown at the right.
What do the empty circles and the filled circles represent?



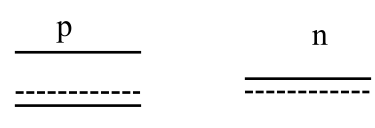
What are their charges?

On the figure, draw the electric field for this junction.

Indicate which side has a higher electric potential (+), and which has a lower electric potential (-).

Which way will the holes move? Which way will the electrons move?

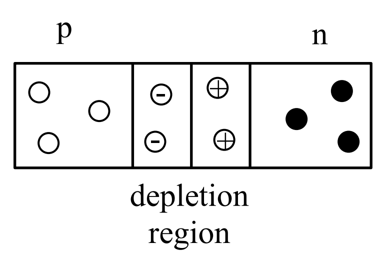
Question 2 – Band Diagrams:
The figure on the right represents the valence and conduction bands of the p-type and n-type semiconductors. Label the conduction (c) and valence (v) bands of both materials.



Why are the bands of the n-type semiconductor drawn lower than that of the p-type semiconductor?

Watch https://www.youtube.com/watch?v=W6QUEq0nUH8; pause at 0:60.

Question 3 – Depletion Region:
When electrons move towards the holes, the electrons and holes combine, creating a junction area with a net neutral charge. This junction area is called the depletion region. When the electrons leave the n-type region, they leave behind positive ions; when the holes leave the p-type region, they leave behind negative ions.



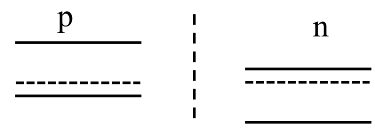
Draw the electric field within the depletion region.

Label which side of the depletion region has a higher V (+), and which has a lower V (-).

As the ΔV in the depletion region increases, predict what will eventually happen to the motion of the electrons and holes.

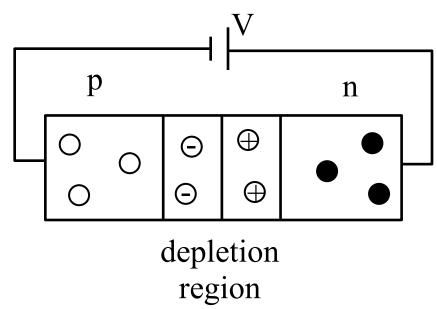
Continue watching https://www.youtube.com/watch?v=W6QUEq0nUH8 from 0:60; pause at 2:39.

Question 4 – Band Diagrams:
The electric potential of the depletion region "bends" the bands. On the band diagram on the right, sketch smooth, curved bands connecting the p and n sides. Think about the effect of the depletion region's V on the bands.



The horizontal dashed lines represent the energy levels of the holes on the p side (acceptor levels), and the electrons on the n side (donor levels). The donor and acceptor levels are a certain distance below/above the conduction/valence bands of the respective sides. Notice that in this case, the donor and acceptor levels are at the same E. That is because, in equilibrium, the electrons and holes both occupy the depletion region levels, and there is no current.

Question 5 – Reverse Bias:
You now apply a potential difference to the pn-junction with the p side connected to -V and the n side connected to +V. This is called <u>reverse bias</u>. Sketch the direction that the holes will try to move, and that the electrons will try to move.



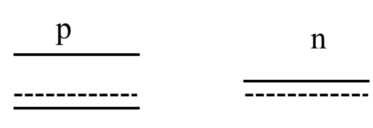
As that happens, what happens to the depletion region?

Since $\Delta V = Ed$, what happens to ΔV in the depletion region?

Label the +V and –V sides of the depletion region, and of the battery. Predict whether there will be a large or small current flow in reverse bias.

Continue https://www.youtube.com/watch?v=W6QUEq0nUH8 from 2:39; pause at 3:19.

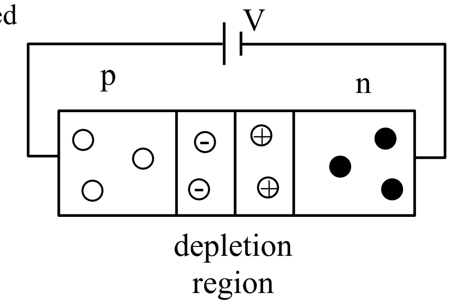
Question 6 – Reverse Bias Band Diagram:
The larger ΔV in the depletion region inhibits the current, and only a very small current flows. In the band diagram for reverse bias of a pn-junction, we don't draw the depletion region as wider in a physical sense, but we do draw it with a larger ΔV between the p and n sides. The no-bias band diagram is shown. Sketch the band diagrams for reverse bias by adjusting either the p or n side of the diagram, and connecting the sides.



In your sketch, remember that the donor/acceptor levels are a fixed ΔV from the respective conduction/valence levels.

Explain how the band diagram shows why there is only a very small current in reverse bias.

Question 7 – Forward Bias:
You now apply a potential difference to the pn-junction with the p side connected to +V and the n side connected to -V. This is called forward bias. Sketch the direction that the holes will try to move, and the electrons will try to move.



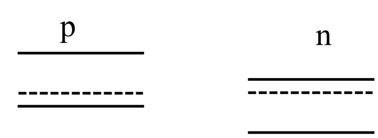
As that happens, what happens to the depletion region?

Since ΔV = Ed, what happens to ΔV in the depletion region?

Predict whether there will be a large or small current flow in forward bias.

Continue https://www.youtube.com/watch?v=W6QUEq0nUH8 from 3:19 until the end.

Question 8 – Forward Bias Band Diagram:
The no-bias band diagram is shown. Sketch the band diagram in forward bias by adjusting either the p or n side of the diagram, and connecting the sides.



In your sketch, remember that the donor/acceptor levels are a fixed ΔV from the respective conduction/valence levels.

Explain how the band diagram shows why there is large current in reverse bias.