Higher Grade Physics

Unit 3 : ELECTRICITY

Electrons At Work

Semiconductors

1. Using band theory, draw a diagram to show the difference between conductors and insulators. Your diagram should show the conduction band, the valence band and the gap between for both types of material.

2. In the following descriptions of energy levels in metals, insulators and semiconductors some words and phrases have been replaced by the letters A to N.

   In a metal the ____**A**____ band is completely filled and the ____**B**____ band is partially filled. The electrons in the ____**C**____ band are free to move under the action of ____**D**____ so the metal has a ____**E**____ conductivity.

   In an insulator there are no free electrons in the ____**F**____ band. The energy gap between the two bands is large and there is not enough energy at room temperature to move electrons from the ____**G**____ band into the ____**H**____ band.
   Insulators have a very ____**I**____ conductivity.

   In a pure semiconductor the energy gap between the valence and conduction bands is ____**J**____ than in a metal. At room temperature there is enough energy to move some electrons from the ____**K**____ band into the ____**L**____ band. As the temperature is increased the number of electrons in the conduction band ____**M**____ so the conductivity of the semiconductor ____**N**____.

   From the table below choose the correct words or phrases to replace the letters.

Letter	*List of replacement word or phrase*
A, B, C, F, G, H, K, L	conduction, valence
D	an electric field, a magnetic field
E, I	low, high
J	bigger, smaller
M, N	decreases, increases

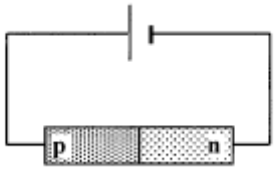
3. The conductivity of a semiconductor material can be increased by a process called ‘doping’.
   (a) Explain what is meant by the conductivity of a material.
   (b) Explain, giving an example, what is meant by ‘doping’ a semiconductor.
   (c) Why does ‘doping’ decrease the resistance of a semiconductor material?

4. (a) If germanium (4 electrons in the outer shell) is doped with phosphorus (5 electrons in the outer shell), what kind of semi-conductor is formed ?

   (b) How can a doped semiconductor of either type still have a neutral overall charge ?

P-N Junctions

5. A p-n junction diode is connected across a d.c. supply as shown.



   (a) Is the diode connected in forward or reverse bias ?

   (b) Describe the movement of both majority charge carriers across the p-n junction ?

   (c) What kind of charge is the only one that actually moves across the junction ?

6. When positive and negative charge carriers recombine at the junction of ordinary diodes and LEDs, quanta of radiation are emitted from the junction.

   (a) Does the junction have to be forward biased or reverse biased for radiation to be emitted?

   (b) What form does this emitted energy take when emitted by:
   (i) an LED
   (ii) an ordinary junction diode?

7. An LED is rated as follows:

operating p.d. 1·8 V, forward current 20 mA

   (a) The LED is to be operated from a 6 V d.c. power supply. Draw a circuit diagram of the circuit, including a protective resistor, which allows the LED to operate at its rated voltage.

   (b) Calculate the resistance of the protective resistor that allows the LED to operate at its rated voltage.

8. The diagram opposite shows a photodiode connected to a voltmeter.

   (a) State the mode that the photodiode is operating in.

   (b) Explain how an e.m.f. is created across the junction when light is incident on it.

   (c) Explain why increasing the light intensity incident on the photodiode increases the e.m.f. produced.