Leaving Cert Physics Long Questions 2018 - 2002

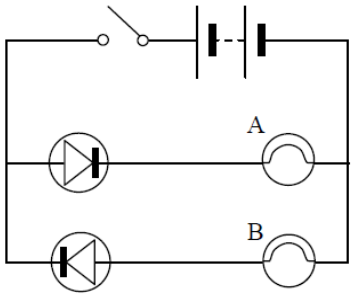
10. *Semiconductors*

Please remember to photocopy 4 pages onto one sheet by going A3→A4 and using back to back on the photocopier

Contents

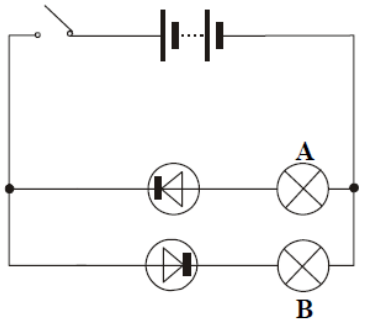
Ordinary level questions

2009 Question 12 (c) [Ordinary Level]



A p-n junction (diode) is formed by doping adjacent layers of a semiconductor.
A depletion layer is formed at their junction.
(i) Explain the underlined terms.
(ii) How is a depletion layer formed?
(iii) The diagram shows two diodes connected to two bulbs A and B, a 6 V supply and a switch. What is observed when the switch is closed?
(iv) Explain why this happens.

2006 Question 12 (d) [Ordinary Level]



(i) A semiconductor material can be doped to form a p-n junction.
Explain the underlined terms.
(ii) Name a material used as a semiconductor.
(iii) The circuit diagram shows 2 semiconductor diodes and 2 bulbs, labelled A and B,connected to a 6 V d.c. supply.
What is observed when the switch is closed?
(iv) Explain why

2003 Question 11 [Ordinary Level]

Read the following passage and answer the accompanying questions.
The operation of semiconductor devices depends on the effects that occur when p-type and n-type semiconductor material are in close contact. This is achieved by taking a single crystal of silicon and doping separate but adjacent layers of it with suitable impurities. The junction between the p-type and the n-type layers is referred to as the *p–n junction* and this is the key to some very important aspects of semiconductor theory.
Devices such as diodes, transistors, silicon-controlled rectifiers, etc., all contain one or more p–n junctions.
("Physics – a teacher's handbook", Dept. of Education and Science.)
(a) What is a semiconductor?
(b) Name a material used in the manufacture of semiconductors.
(c) Name the two types of charge carriers in semiconductors.
(d) What is meant by doping?
(e) Give one difference between a p-type semiconductor and an n-type semiconductor.
(f) What is a p-n junction?
(g) What is a diode?
(h) Give an example of a device that contains a rectifier.

Higher level questions

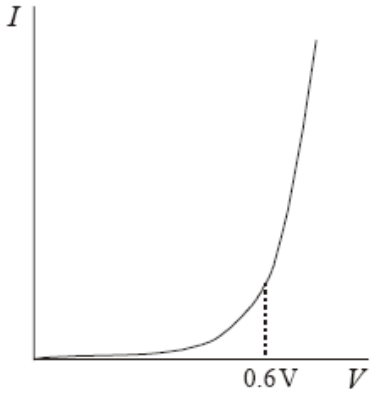
2009 Question 12 (b) [Higher Level]

A semiconductor diode is formed when small quantities of phosphorus and boron are added to adjacent layers of a crystal of silicon to increase its conduction.

(i) Explain how the presence of phosphorus and boron makes the silicon a better conductor.
(ii) What happens at the boundary of the two adjacent layers?
(iii) Describe what happens at the boundary when the semiconductor diode is forward biased
(iv) Describe what happens at the boundary when the semiconductor diode is reverse biased.
(v) Give a use of a semiconductor diode.

2004 Question 12 (d) [Higher Level]

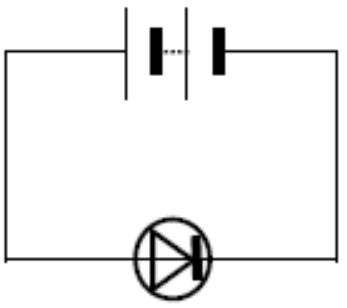
(i) A p-n junction is formed by taking a single crystal of silicon and doping separate but adjacent layers of it. A depletion layer is formed at the junction.
What is doping?
(ii) Explain how a depletion layer is formed at the junction.
(iii) The graph shows the variation of current *I* with potential difference *V* for a p-n junction in forward bias.
Explain, using the graph, how the current varies with the potential difference.
(iv) Why does the p-n junction become a good conductor as the potential difference exceeds 0.6 Volts?



2016 Question 8 [Higher Level]

(i) What is a semiconductor?
(ii) Distinguish between intrinsic and extrinsic conduction in a semiconductor.
(iii) Explain how a pure semiconductor can be converted into (i) a p-type and (ii) an n-type semiconductor.
(iv) A semiconductor p-n junction acts a diode.
Describe, with the aid of a labelled diagram, how a depletion layer is formed at the p-n junction.
(v) What is a depletion layer?
(vi) Indicate on your diagram the sections of the p-n junction that are positively charged, negatively charged and neutral.

(vii) A diode will be damaged if too large a current flows through it when it is connected in forward bias. Explain how a diode might be protected from having too large a current flowing through it when it is connected across a battery, as in the diagram.
(viii) What would be the effect on the current flowing in this diode if the terminals of the battery were reversed? Explain your answer.
(ix) A diode can be used as a rectifier. What is the function of a rectifier?
(x) What property of a diode makes it useful in a rectifier circuit?



Solutions to all higher level questions

2016 Question 8

(i) What is a semiconductor?
Resistivity/conductivity between that of a conductor and an insulator

(ii) Distinguish between intrinsic and extrinsic conduction in a semiconductor.
Intrinsic: pure semiconductor with equal number of electrons & holes
Extrinsic: doped semiconductor with unequal number of electrons & holes

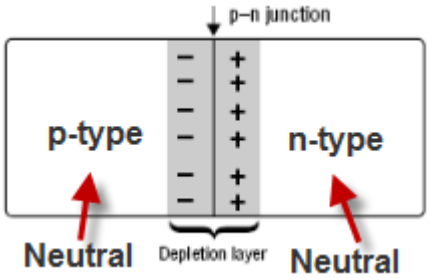
(iii) Explain how a pure semiconductor can be converted into (i) a p-type and (ii) an n-type semiconductor.
p-type: doped with an element with fewer outer electrons / boron
n-type: doped with an element with more outer electrons / phosphorus

(iv) Describe, with the aid of a labelled diagram, how a depletion layer is formed at the p-n junction.
The p-type material is connected to the n-type material.

1. Due to thermal agitation, some free electrons in the n-type material diffuse over to the p-type material, where they combine with nearby positive holes, with the result that the region is depleted of two of its charge carriers.
2. Similarly on the p-type side some positive holes diffuse over to the n-type material, where they too combine with nearby electrons, with the result that the region gets depleted of two more of its charge carriers.
3. The end result is that a depletion region is formed at the junction of the p-type and n-type materials, where there are no free charge carriers. This region therefore acts as an insulator.

(v) What is a depletion layer?
It is a region with no charge carriers / high resistance

(vi) Indicate on your diagram the sections of the p-n junction that are positively charged, negatively charged and neutral.
See diagram



(vii) Explain how a diode might be protected from having too large a current flowing through it when it is connected across a battery, as in the diagram.
Connect a resistor in series

(viii) What would be the effect on the current flowing in this diode if the terminals of the battery were reversed? Explain your answer.
There would be a very small (or zero) current.
The diode is now in reverse bias so there is a very large resistance/depletion layer

(ix) A diode can be used as a rectifier. What is the function of a rectifier?
It converts a.c. to d.c.

(x) What property of a diode makes it useful in a rectifier circuit?
Allows current to flow in one direction only

2009 Question 12 (b)

(i) Explain how the presence of phosphorus and boron makes the silicon a better conductor.
When phosphorus is added more electrons become available as charge carriers.
When boron is added more positive holes become available as charge carriers.

(ii) What happens at the boundary of the two adjacent layers?
Electrons and holes cross the junction cancelling each other out and recombine and as a result there are no free charge carriers.
A depletion layer is therefore formed between the n-type and p-type regions and as a result a junction voltage is created.

(iii) Describe what happens at the boundary when the semiconductor diode is forward biased.
The depletion layer breaks down and the diode conducts.

(iv) Describe what happens at the boundary when the semiconductor diode is reverse biased.
The width of depletion layer gets increased and the region acts as an insulator.

(v) Give a use of a semiconductor diode.
Rectifier

2004 Question 12 (d)

(i) What is doping?
Doping is the addition of a small amount of atoms of another element to a pure semiconductor to increase its conductivity.

(ii) Explain how a depletion layer is formed at the junction.
Electrons from n-type material and holes from p-type material both cross the common junction (caused by thermal agitation) and cancel out with charge carriers on the other side.
As a result a narrow insulating region is formed which now acts as a 'barrier' or depletion layer.

(iii) Explain, using the graph, how the current varies with the potential difference.
Very little current flows between 0 V and 0.6 V
If the potential difference is greater than 0.6 V the current starts to increase very quickly.

(iv) Why does the p-n junction become a good conductor as the potential difference exceeds 0.6 Volts?
The depletion layer is overcome and as a result a large current flows.