

Question 1

(i) electrons and holes; (ii) electrons

(2 × 2; 3)

Question 2

Question 12 (b)

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.

Explain how the presence of phosphorus and boron makes the silicon a better conductor.

more electrons available (as charge carriers when phosphorus is added)

3

more (+) holes (as charge carriers when boron is added)

3

6

What happens at the boundary of the two adjacent layers?

electron and holes cross (junction) // electrons move/migrate

3

no free charge carriers /depletion layer formed // from n-type to p-type (region)

3

junction voltage (created) // junction voltage / depletion layer formed

3

9

Describe what happens at the boundary when the semiconductor diode is

(i) forward biased, (ii) reverse biased.

(i) width of depletion reduced / (diode) conducts / conduction

(ii) width of depletion layer increased / no conduction (any order, once correct) 6 + 3

9

Give a use of a semiconductor diode.

rectifier (any valid use)

4

4

Question 3

(g) What are the charge carriers when an electric current

(i) passes through a semiconductor; (ii) passes through an electrolyte?

(i) electrons and (positive) holes

4

(ii) ions

3

Question 4

Question 4

The following is part of a student's report of an experiment to investigate the variation of current I with potential difference V for a semiconductor diode.

I put the diode in forward bias as shown in the circuit diagram. I increased the potential difference across the diode until a current flowed. I measured the current flowing for different values of the potential difference. I recorded the following data.

V/V	0.60	0.64	0.68	0.72	0.76	0.80
I/mA	2	4	10	18	35	120

Draw a circuit diagram used by the student.

circuit showing battery (or p.s.u.), diode in forward bias, mA or A or current sensor in series, (protective R) 3 x 3
 (-3 for any incorrect insertion or omission e.g. diode in reverse bias)

How did the student vary and measure the potential difference?

(adjust or change or slide) rheostat / potential divider // adjust or use variable power supply unit 3
 (to measure p.d.) voltmeter or voltage sensor (placed across diode) 3

Draw a graph to show how the current varies with the potential difference.

axes labelled I and V 3
 plot 5 points (at least) 3
 correct shape (see graph at page end) 3

Estimate from your graph the junction voltage of the diode.

junction voltage = 0.60 \leftrightarrow 0.78 (V) (unit not required) 3

The student then put the diode in reverse bias and repeated the experiment. What changes did the student make to the initial circuit?

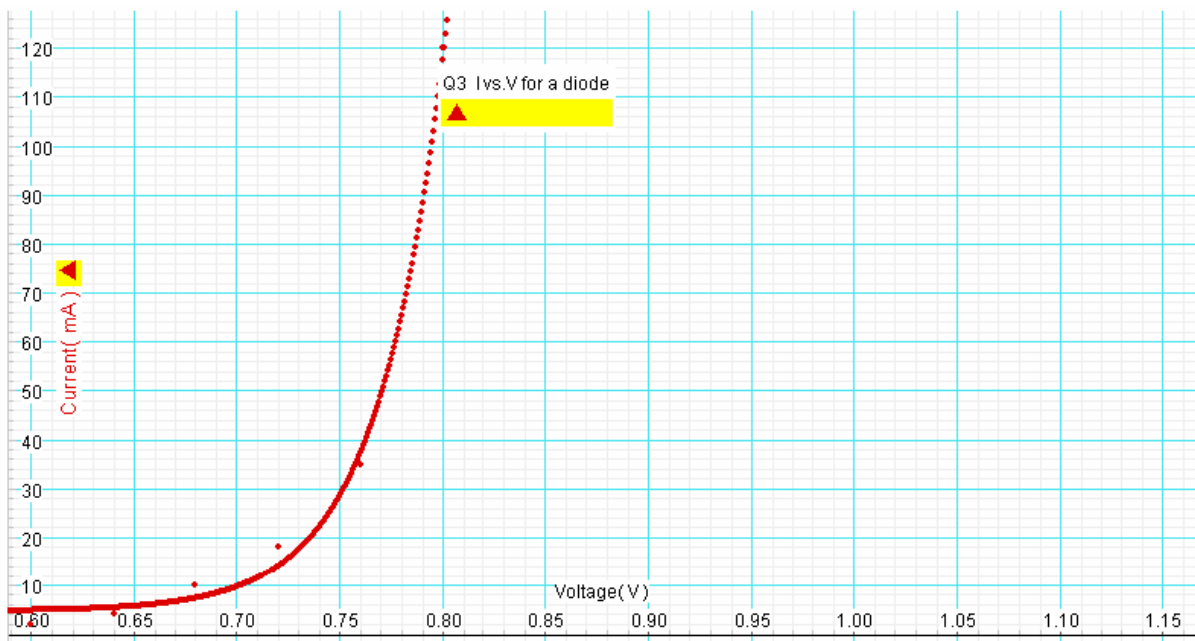
reverse p.s.u / reverse voltmeter / reverse ammeter / replace mA with μA
 / place voltmeter in parallel with the series combination of diode and milliammeter (or μA or A) any two 2 x 3

Alternatively:

reverse the diode / replace mA with a μA / place voltmeter in parallel with the series combination of diode and milliammeter (or μA or A) [any two 2 x 3]

Draw a sketch of the graph obtained for the diode in reverse bias.

axes labelled I and V 3
 correct shape (i.e. showing little or no current as V is increased negatively and maybe indicating a breakdown voltage) 4
 [No graph drawn but statement: "no current flows in reverse bias" 4 marks]



Question 5

(h) Sketch a graph to show the variation of current with potential difference for a semiconductor diode in forward bias. (7)



I V labelled graph with non-linear curve
correct shape

4

3