

Exercise 14 – Electrons at Work

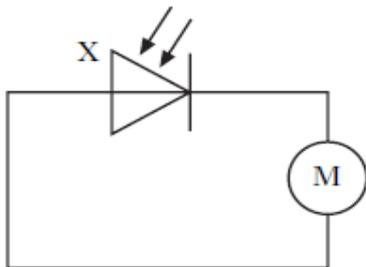
Past Paper Homework Questions

1. A student writes the following statements about n-type semiconductor material.

- I Most charge carriers are negative.
- II The n-type material has a negative charge.
- III Impurity atoms in the material have 5 outer electrons.

Which of these statements is/are true?

- A I only
 - B II only
 - C III only
 - D I and II only
 - E I and III only
2. In the following circuit, component X is used to drive a motor.



Which of the following gives the name of component X and its mode of operation?

	Name of component X	Mode of operation
A	light-emitting diode	photoconductive
B	light-emitting diode	photovoltaic
C	photodiode	photoconductive
D	photodiode	photovoltaic
E	op-amp	inverting

3. Materials are “doped” to produce n-type semiconductor material.

In n-type semiconductor material

- A the majority charge carriers are electrons
- B the majority charge carriers are neutrons
- C the majority charge carriers are protons
- D there are more protons than neutrons
- E there are more electrons than neutrons.

4. The letters X, Y and Z represent three missing words from the following passage.

Materials can be divided into three broad categories according to their electrical resistance.

.....**X**..... have a very high resistance.

.....**Y**..... have a high resistance in their pure form but when small amounts of certain impurities are added, the resistance decreases.

.....**Z**..... have a low resistance.

Which row in the table shows the missing words?

	X	Y	Z
A	conductors	insulators	semi-conductors
B	semi-conductors	insulators	conductors
C	insulators	semi-conductors	conductors
D	conductors	semi-conductors	insulators
E	insulators	conductors	semi-conductors

5. A student writes the following statements about p-type semiconductor material.

I Most charge carriers are positive.

II The p-type material has a positive charge.

III Impurity atoms in the material have 3 outer electrons.

Which of these statements is/are true?

- A I only
- B II only
- C I and II only
- D I and III only
- E I, II and III

6. A p-n junction diode is forward biased.

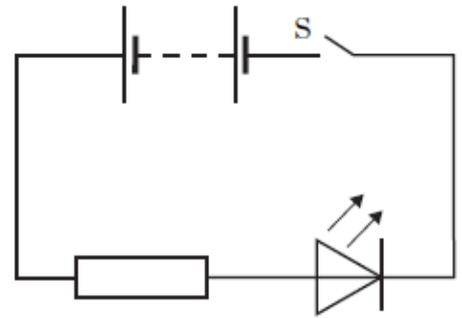
Positive and negative charge carriers recombine in the junction region. This causes the emission of

- A a hole
- B an electron
- C an electron-hole pair
- D a proton
- E a photon.

7. In an n-type semiconductor

- A the majority charge carriers are electrons
- B the majority charge carriers are holes
- C the majority charge carriers are protons
- D there are more protons than electrons
- E there are more electrons than protons.

8. An LED is connected as shown.



When switch S is closed

- A the p-n junction is reverse biased and free charge carriers are produced which may recombine to give quanta of radiation
- B the p-n junction is forward biased and positive and negative charge carriers are produced by the action of light
- C the p-n junction is reverse biased and positive and negative charge carriers are produced by the action of light
- D the p-n junction is forward biased and positive and negative charge carriers may recombine to give quanta of radiation
- E the p-n junction is reverse biased and positive and negative charge carriers may recombine to give quanta of radiation.

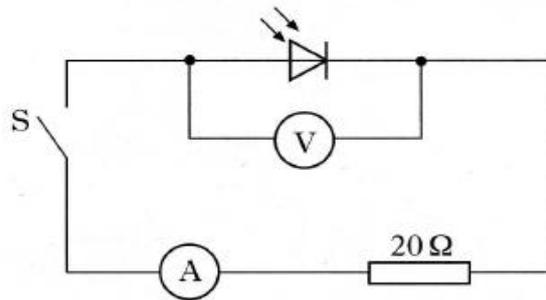
9. A student reads the following passage in a physics dictionary.

“ . . . is a solid state device in which positive and negative charge carriers are produced by the action of light on a p-n junction.”

The passage describes

- A a thermistor
- B a MOSFET
- C a photodiode
- D a laser
- E an LED.

10. A photodiode is connected in a circuit as shown below.



Switch S is open.

Light is shone on to the photodiode.

A reading is obtained on the voltmeter.

- (a) (i) State the mode in which the photodiode is operating.
(ii) Describe the effect of light on the material of which the photodiode is made.
(iii) The intensity of the light on the photodiode is increased.
What happens to the reading on the voltmeter?

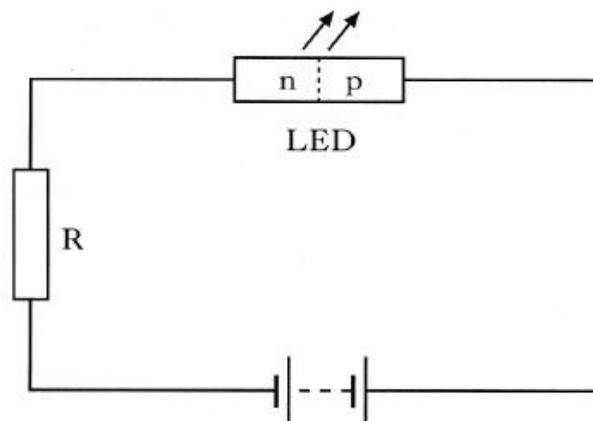
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11. (a) A sample of pure semiconducting material is doped by adding impurity atoms.

How does this addition affect the resistance of the semiconducting material?

1

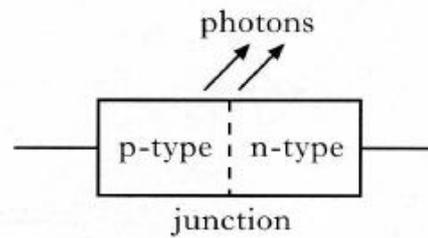
- (b) The circuit below shows a p-n junction diode used as a light emitting diode (LED).



- (i) Explain in terms of the charge carriers how the LED emits light.

2

13. An LED consists of a p-n junction as shown.

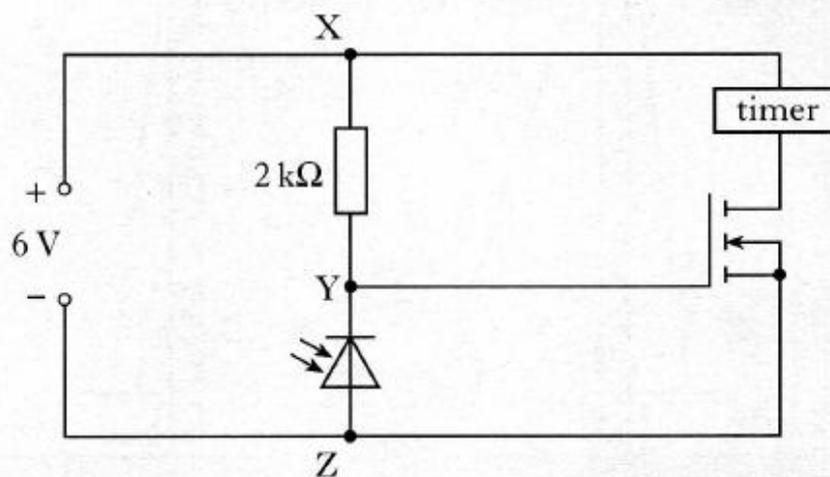


(a) Copy the diagram and add a battery so that the p-n junction is forward-biased. 1

(b) Using the terms *electrons*, *holes* and *photons*, explain how light is produced at the p-n junction of the LED. 1

14. The light gate consists of a lamp shining onto a photodiode.

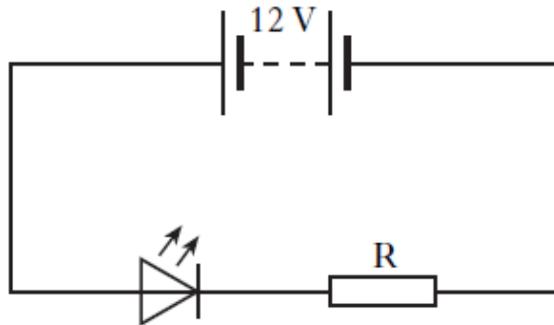
The photodiode forms part of the circuit shown.



(i) In which mode is the photodiode operating? 1

(ii) Explain why the timer only operates while the light beam is broken. 2

15. The brake lights of the car consist of a number of very bright LEDs. An LED from the brake lights is forward biased by connecting it to a 12 V car battery as shown.



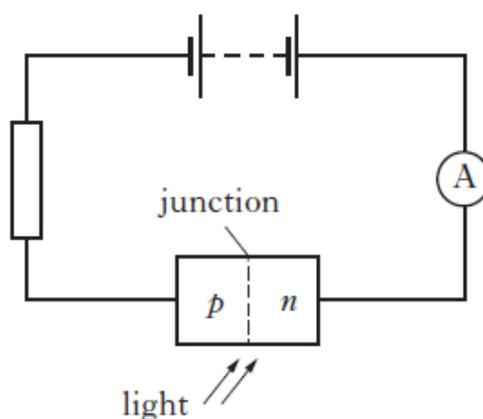
The battery has negligible internal resistance.

- (i) Explain, in terms of charge carriers, how the LED emits light. 1
- (ii) The LED is operating at its rated values of 5.0 V and 2.2 W. Calculate the value of resistor R. 3

16. (a) An n-type semiconductor is formed by adding impurity atoms to a sample of pure semiconductor material.

State the effect that the addition of the impurity atoms has on the resistance of the material. 1

- (b) A p-n junction is used as a photodiode as shown.



- (i) In which mode is the photodiode operating? 1
- (ii) The irradiance of the light on the junction of the photodiode is now increased.

Explain what happens to the current in the circuit. 2

17. A sample of pure semiconductor material has a small amount of impurity atoms added to form a p-type semiconductor.

- a) What is this process called?
- b) How does the addition of the impurity atoms affect the resistance of the material?

2

30 marks