Higher Semiconductors Questions

1. A crystal of silicon is **doped** with arsenic, that is, a small number of silicon atoms are replaced by arsenic atoms.

Arsenic atoms have **5 valency electrons** in the outer shell.

a) **What type** of doping is involved in this case?

b) How will this affect the **resistance** of the semiconductor material and the **current** that flows through it?

2. Materials can be classified as **conductors, semiconductors and insulators**.

a) Give **two examples of each** of the **three groups of materials** listed above.

b) A Physics textbook states that ‘’…… n-type semiconductor material is formed by doping a pure semiconductor with impurity atoms’’.

What is meant by the term ‘’n-type’’ semiconductor material?

3. A **p-type semiconductor** material is produced by adding impurity atoms to a pure semiconductor material.

a) **How many valency electrons** will the impurity atoms have in their outer shell?

b) How will adding these impurity atoms **affect** the **resistance** of the material?

c) **What will the net charge be** on the semiconductor material after adding the impurity atoms?

4. A **n-type semiconductor material** is produced by adding impurity atoms to a pure semiconductor material.

a) **How many valency electrons** will the impurity atoms have in their outer shell?

b) i) Will the valence band be filled with electrons?
ii) Where would any **excess electrons** be found?

c) How will adding these impurity atoms **affect** the **resistance** of the material?

d) **What will the net charge be** on the semiconductor material after adding the impurity atoms?

5. State the names of the **majority charge carriers** in a:

a) **n-type** semiconductor material?

b) **p-type** semiconductor material?

6. a) i) **Draw** a circuit diagram connected in **reverse bias** showing a p-n material and a battery.

ii) **Draw** the equivalent diagram with an **LED** replacing the p-n material.

b) i) State the **order of magnitude** of the **current flow in reverse bias**.

ii) What is the **current flow due to** in this case?

7. a) i) **Draw** a circuit diagram connected in **forward bias** showing a p-n material and a battery.

ii) **Draw** the equivalent diagram with an **LED** replacing the p-n material.

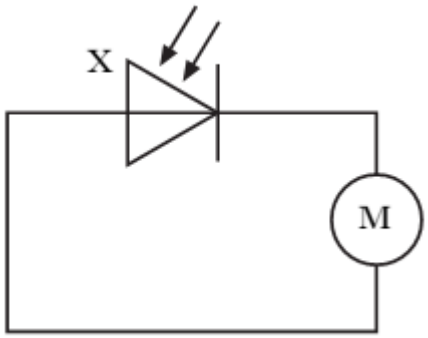
b) i) State the **order of magnitude** of the **current flow in forward bias**.

ii) What is the **current flow due** to in this case?

c) i) **What is given off** when an LED lights up in forward bias?

ii) **In band theory**, what is happening to the electrons when the LED lights up.

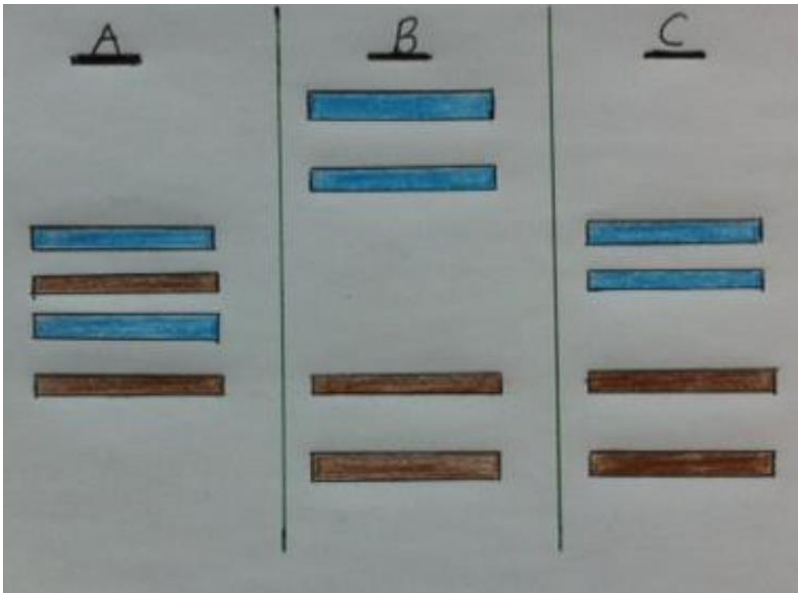
8. In the following circuit component X is used to drive a motor.



a) **Name** component **X**.

b) State the **operation mode** of component **X**.

9.



a) **State the names** of the **three groups** of materials above **A**,**B** and **C**.

b) How would you **compare** the **band gap** between the **semiconductor** and the **insulator**?

c) If a **pure semiconductor material** has an **increase in temperature**, what will happen to:

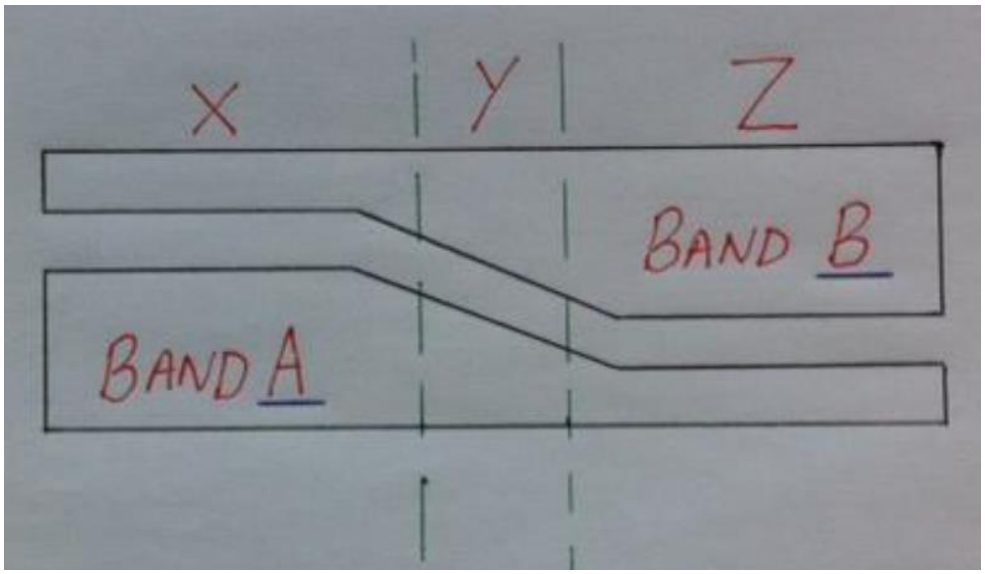
i) The **resistance** of the material.

ii) The **current carrying capabilities** of the material.

iii) Some of the **electrons** in the **valence band**?

10. A single semiconducting crystal can be doped to produce a p-n junction diode.

Band **A** is the **valence band** and band **B** is the **conduction band**.

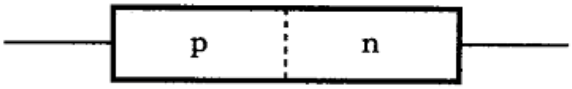


a) Label sections **X**, **Y** and **Z** in the diagram

b) State whether **band A or band B** has a **higher energy level**.

11.

(*a*) The diagram below represents the p–n junction of a light emitting diode (LED).

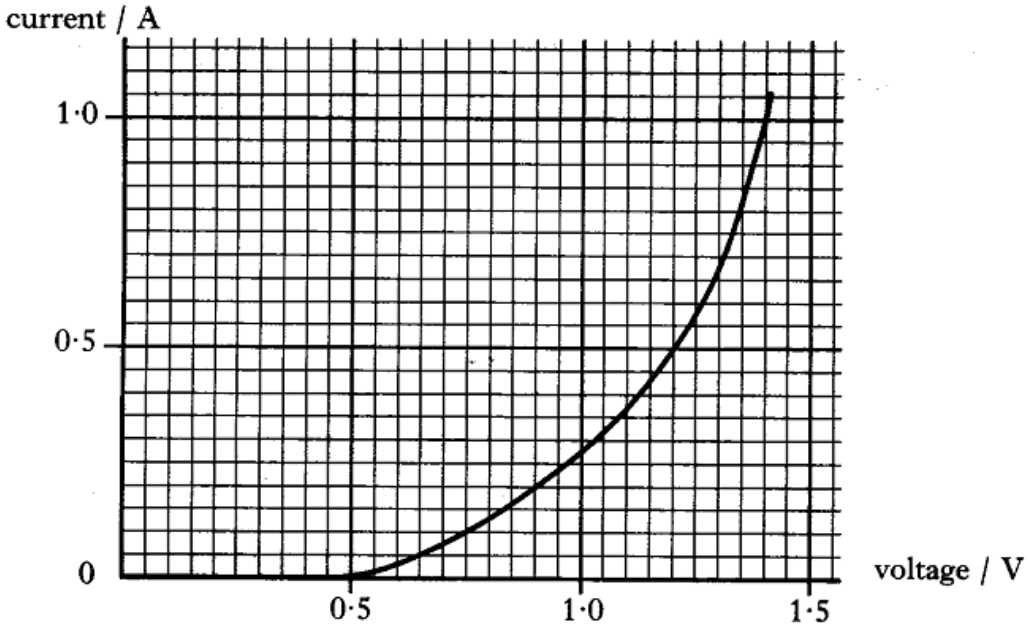


(i) Draw a diagram showing the above p–n junction connected to a battery so that the junction is forward biased.

(ii) When the junction is forward biased, there is a current in the diode. Describe the movement of the charge carriers which produces this current.

(iii) Describe how the charge carriers in the light emitting diode enable light to be produced.

(*b*) The following graph shows the variation of current with voltage for a diode when it is forward biased.



i) What is the **minimum voltage** for this **diode** to **conduct**?

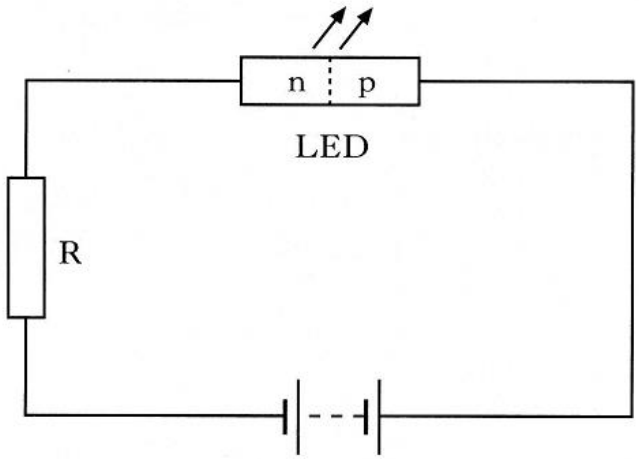
ii) **What happens to the resistance** of the diode as the **voltage is increased** above this minimum value? **(Use information from the graph to justify your answer!!!)**

12.

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

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

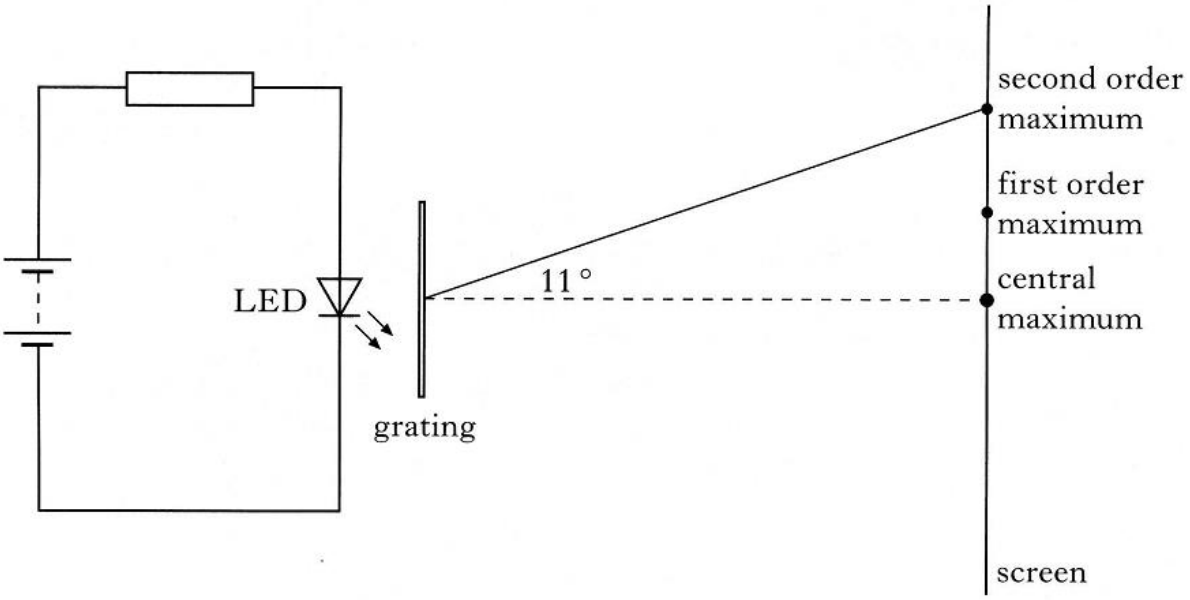
(*b*) The circuit below shows a p-n junction diode used as a light emitting diode (LED).



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

(ii) Monochromatic light from the LED is incident on a grating as shown.

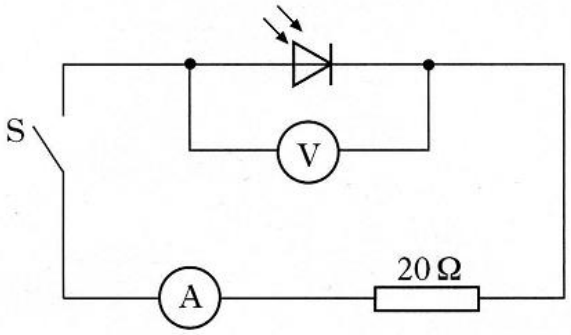
The spacing between lines in the grating is $5{\cdot}0 \times 10^{-6}$ m.



What is the wavelength of the light emitted by the LED?

13.

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?

(*b*) Light of a constant intensity is shone on to the photodiode in the circuit shown above.

The following measurements are obtained with S open and then with S closed.

	S open	S closed
reading on voltmeter/V	0·508	0·040
reading on ammeter/mA	0·00	1·08

(i) What is the value of the e.m.f. produced by the photodiode for this light intensity?

(ii) Calculate the internal resistance of the photodiode for this light intensity.

c) In the circuit above, the 20 Ω resistor is now replaced with a 10 Ω resistor.

The intensity of the light is unchanged.

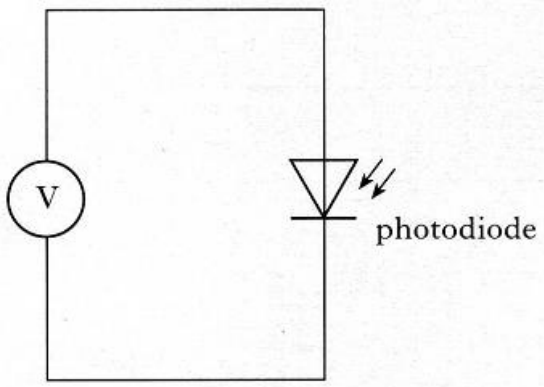
The following measurements are obtained.

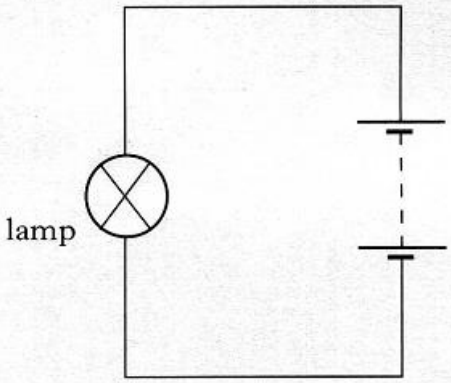
	S open	S closed
reading on voltmeter/V	0·508	0·011

Explain why the reading on the voltmeter, when S is closed, is smaller than the corresponding reading in part (*b*).

14.

The diagram shows a photodiode connected to a voltmeter. A lamp is used to shine light onto the photodiode.



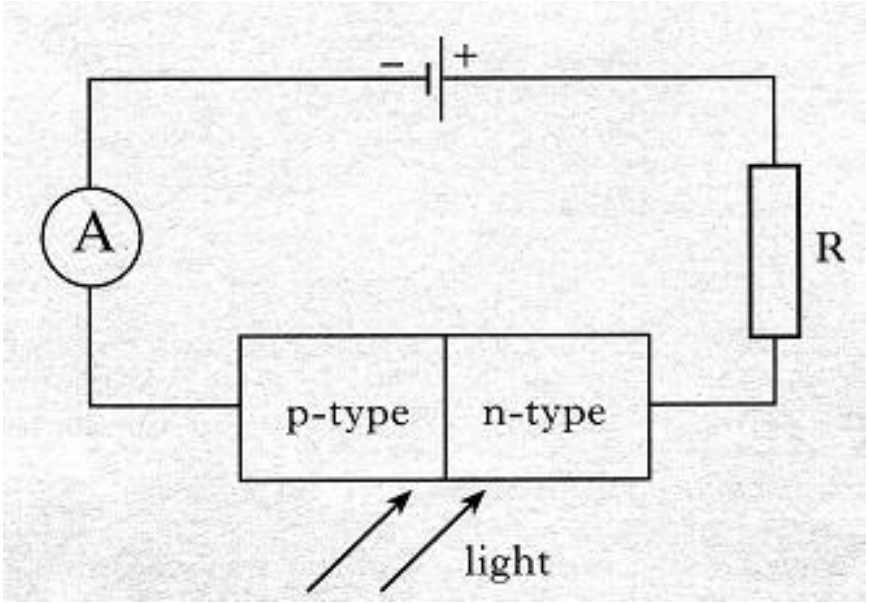


The reading on the voltmeter is 0·5 V.

The lamp is now moved closer to the photodiode.

Using the terms **photons**, **electrons** and **holes**, explain why the voltmeter reading changes.

15. A **p-n junction** is used as a **photodiode** and a voltage is applied across it as shown below.



a) The **irradiance** of the light at the junction **increases**.
Describe and **explain how this affects the current** in the circuit.

b) The **sensitivity** of a certain **photodiode** is **greatest** when the incident photon has an **energy of 2.1 x 10^{-19}J**.

Calculate the wavelength of these photons.