Unit 25 · Solids

WORKSHEET

Full marks 36

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 36

1 Key words [4]

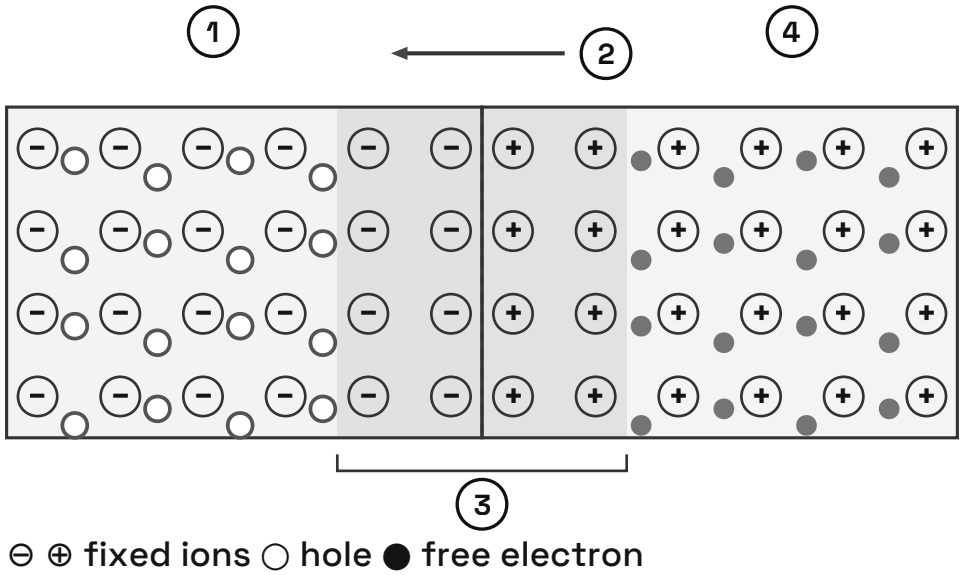
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

donor	**doping**	**gap**	**hole**	**intrinsic**	**p-type**	**proton**	**rectifier**	**transformer**	**valence**

In a solid, the highest band that contains electrons at absolute zero is the _____ band. The range of energies between it and the band above, which no electron can have, is the forbidden band or band _____. An empty state left in the valence band when an electron jumps the gap is a _____. A pure semiconductor, with no other kind of atom in it, is an _____ semiconductor. Adding impurity atoms on purpose to change how well it conducts is called _____. A pentavalent impurity atom, which gives one free electron, is a _____. Silicon doped with a trivalent impurity is a _____ semiconductor. A device that changes alternating current into direct current is a _____.

2 Label the diagram [2]

The diagram shows a p–n junction. Write the labels that belong in place of 1 to 4. Each carries 0.5 mark.



1. _____ 2. _____

3. _____ 4. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. An electron in a hydrogen atom falls from level 4 (−0.85 eV) to level 2 (−3.40 eV). The photon given out has an energy of: [1]

a. 4.25 eV **b.** 2.55 eV
c. 0.85 eV **d.** 3.40 eV

ii. The energy needed to free the electron of a hydrogen atom from its ground state is: [1]

a. 3.40 eV **b.** 1.51 eV
c. 13.6 eV **d.** 0 eV

iii. In a metal, the top band holding electrons is: [1]

a. completely full, with a wide gap above it
b. partly filled, or overlapping the band above
c. completely empty
d. full, with a gap of about 1 eV above it

iv. In a forward-biased p–n junction: [1]

a. the p side is joined to the negative terminal
b. the depletion layer widens
c. the depletion layer narrows and current flows once the supply is above the barrier potential
d. only minority carriers flow

v. A crystal of n-type silicon, as a whole, is: [1]

a. negatively charged **b.** positively charged
c. electrically neutral **d.** negative only when a current flows

4 Very short answers [3]

Write very short answers to the following questions.

a. Name two pentavalent impurities used to make n-type silicon. [1]

b. What are the barrier potentials of silicon and germanium junctions? [1]

c. Why are the energies of hydrogen's levels negative? [1]

5 Short answers [6]

Write short answers to the following questions.

a. How does a hole move in a semiconductor, and why does it count as a positive charge carrier? [2]

b. Why does an LDR's resistance fall in bright light? [2]

c. A phone charger needs a transformer and a rectifier. What does each do? [2]

6 Long answer [4]

Write a long answer to the following question.

Explain how a depletion layer and a barrier potential form when p-type and n-type silicon are joined in one crystal. Why does the junction then let current through one way only?

7 Numerical problems [9]

Solve the following problems. Show your working. Take $h = 6.63 \times 10^{-34}$ J s, $c = 3.0 \times 10^{8}$ m/s and 1 eV = 1.6×10^{-19} J.

a. Find the wavelength of the photon given out when the electron of a hydrogen atom falls from level 4 (−0.85 eV) to level 2 (−3.40 eV). In what part of the spectrum is it? [3]

Answer: _____

b. A silicon crystal (5×10^{28} atoms per m^3) is doped with arsenic, one arsenic atom for every million silicon atoms. [3]

i. How many free electrons per cubic meter does the doping give?

ii. How many times more is this than the 10^{16} per m^3 of pure silicon at room temperature? What type of semiconductor is it?

Answer: _____

c. What is the shortest wavelength of light that can ionize a hydrogen atom from its ground state? [3]

Answer: _____

8 Think [3]

A copper wire and a piece of pure germanium are both cooled from room temperature towards absolute zero. Describe and explain what happens to the resistance of each.

9 Activity: Hot and cold resistance

(not marked)

With a multimeter on its resistance setting, measure a small NTC thermistor and a coil of thin copper wire (or a small lamp's filament, cold) in iced water, at room temperature and in warm water.

	in iced water	at room temperature	in warm water
thermistor (Ω)			
copper coil (Ω)			

Which one's resistance falls as it warms? Explain each result with the band theory.