Unit 25 · Solids

HARDER PRACTICE QUESTIONS

Full marks 26

Write your answers on separate paper. Show your working. Take $h = 6.63 \times 10^{-34}$ J s, $c = 3.0 \times 10^{8}$ m/s, 1 eV $= 1.6 \times 10^{-19}$ J, and the energy levels of hydrogen $E_n = -13.6/n^2$ eV.

1 Spot the error [3]

Find the mistake in the working and correct it.

Kritika was asked how much energy frees the electron of a hydrogen atom in its first excited state. She wrote:
"The first excited state is n = 1, so the energy needed is **13.6 eV**."

2 Work backwards [3]

An LDR responds to light of wavelengths up to 700 nm, but not beyond. Find the band gap of its material in eV. Would it respond to the cadmium sulphide LDR's 520 nm green light?

3 Check the readings [3]

A table gives the energies of hydrogen's levels:

n	1	2	3	4	5
E (eV)	−13.6	−3.40	−1.51	−0.95	−0.54

Which value is wrong? Give the right one, and the energy of the photon an electron gives out falling from that level to level 2.

4 Least and most [3]

An electron in hydrogen's level 3 can fall to a lower level in one or more jumps.

i. List every photon energy it can give out.

ii. Which gives the longest wavelength? Find it.

5 Estimate it [2]

A cubic meter of pure silicon at room temperature has about 10^{16} electrons in its conduction band, out of about 10^{29} in its bonds. Roughly how many bonds are broken in a 1 cm^3 chip, and what fraction is that?

6 Predict, then explain [3]

Write your prediction first, then explain it.

A silicon diode is connected in series with a lamp and a 6 V battery so that the lamp lights. Predict what happens when the battery is turned round, and when it is replaced by a 0.5 V cell the right way round. Then explain.

7 Which explanation? [2]

Silicon's resistance falls as it warms. Pratik says it is because its atoms vibrate less when hot. Binita says it is because more electrons jump the band gap. Who is right? Explain.

8 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

> Sudip wrote: “p-type silicon is positively charged, because it has more holes. In an insulator the band gap is about 1 eV. An electron in hydrogen can have any energy between −13.6 eV and −3.40 eV.”

9 Think [2]

Silicon solar cells use all visible light, but a cadmium sulphide LDR doesn't respond to red light. Explain, using their band gaps (silicon 1.12 eV, cadmium sulphide 2.4 eV).

10 Make your own [2]

Choose an impurity and a doping level (one impurity atom for every N silicon atoms) of your own. Say what type of semiconductor it makes, and find its majority carriers per cubic meter, taking 5×10^{28} silicon atoms per m^3.