CLASS XII – PHYSICS (042)
PRACTICE PAPER – CHAPTER 14: SEMICONDUCTOR ELECTRONICS: MATERIALS, DEVICES AND SIMPLE CIRCUITS

Academic Session 2026–27

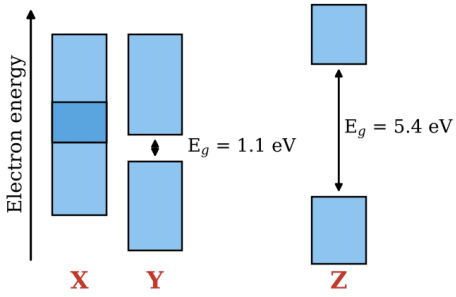
Maximum Marks : 35 **Time Allowed : 1 hour 15 minutes**

General Instructions

(1) There are 18 questions in all. All questions are compulsory.
(2) The question paper has five sections: Section A, B, C, D and E.
(3) Section A (Q.1–9) has seven MCQs and two Assertion–Reasoning questions of 1 mark each. Section B (Q.10–13) has four questions of 2 marks each. Section C (Q.14–16) has three questions of 3 marks each. Section D (Q.17) is one case study based question of 4 marks. Section E (Q.18) is one long answer question of 5 marks.
(4) There is no overall choice. An internal choice is provided in Q.12 (Section B), Q.15 (Section C), Q.17 part (iv) (Section D) and Q.18 (Section E). Attempt only one of the choices in such questions.
(5) Use of calculators is not allowed.
(6) Use the data given in each question; no other constants are needed. Take the threshold (cut-in) voltage of a silicon diode as 0.7 V and of a germanium diode as 0.2 V, and treat an ideal diode as a perfect conductor in forward bias and a perfect insulator in reverse bias.

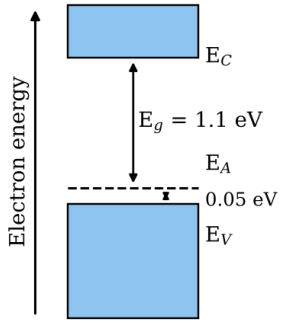
SECTION A (9 × 1 = 9)

1. The energy-band diagrams of three solids X, Y and Z are shown. The solids X, Y and Z are respectively **1**



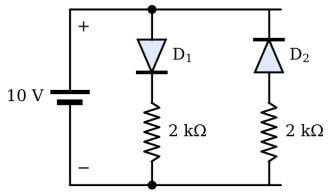
(a) insulator, semiconductor, metal
(b) semiconductor, metal, insulator
(c) metal, semiconductor, insulator
(d) metal, insulator, semiconductor

2. The energy-band diagram of a doped silicon crystal is shown, with an impurity level just above the top of the valence band. The crystal is **1**



(a) p-type, with holes as the majority carriers and a trivalent dopant
(b) p-type, with electrons as the majority carriers and a pentavalent dopant
(c) n-type, with electrons as the majority carriers and a trivalent dopant
(d) n-type, with holes as the majority carriers and a pentavalent dopant

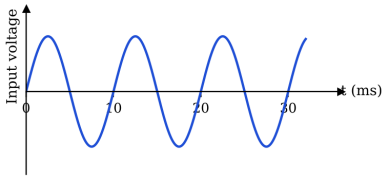
3. In the circuit shown, D_1 and D_2 are ideal diodes. The current drawn from the 10 V battery is **1**



(a) 2.5 mA
(b) 10 mA
(c) 20 mA
(d) 5 mA

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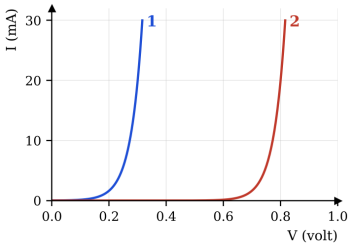
4. The input voltage applied to a full-wave rectifier (between one end of the secondary and the centre tap) is shown. The frequency of the pulsating output of the rectifier is **1**



(a) 100 Hz
(b) 200 Hz
(c) 50 Hz
(d) 400 Hz

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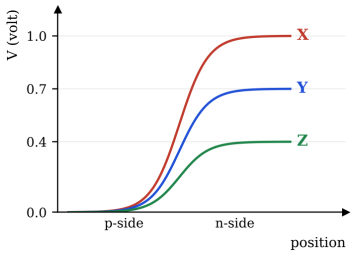
5. The forward characteristics of two junction diodes 1 and 2 are shown. The diodes 1 and 2 are respectively made of **1**



(a) silicon and germanium
(b) silicon and silicon
(c) germanium and silicon
(d) germanium and germanium

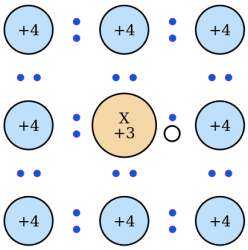
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6. The graph shows the potential barrier of a p-n junction under three conditions: no bias (barrier height 0.7 V), a forward bias of 0.3 V and a reverse bias of 0.3 V, though not necessarily in this order. The curves X, Y and Z correspond respectively to **1**



(a) reverse bias, no bias, forward bias
(b) forward bias, no bias, reverse bias
(c) no bias, forward bias, reverse bias
(d) reverse bias, forward bias, no bias

7. A two-dimensional model of a doped silicon crystal is shown. The atom X has a +3 core. The crystal is **1**



(a) n-type and X is a donor atom
(b) p-type and X is a donor atom
(c) n-type and X is an acceptor atom
(d) p-type and X is an acceptor atom

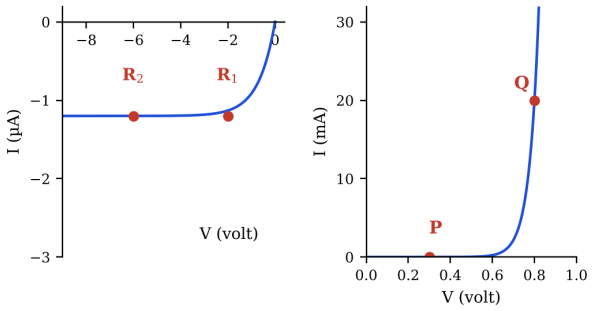
For Questions 8 and 9, a statement of Assertion (A) is followed by a statement of Reason (R). Select the correct answer from the options below.
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

8. **Assertion (A):** The forward current of a p-n junction diode is in mA, while its reverse current is only in µA. **1**
Reason (R): Forward current is due to majority carriers crossing the lowered barrier, whereas reverse current is due to minority carriers drifting across the junction.

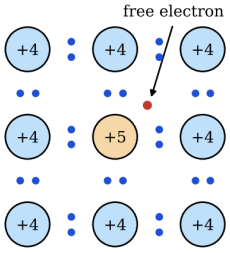
9. **Assertion (A):** A pure semiconductor behaves like an insulator at 0 K. **1**
Reason (R): At 0 K the conduction band of a semiconductor is partially filled with electrons.

SECTION B (4 × 2 = 8)

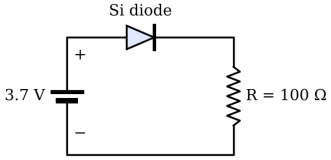
10. The figure shows the characteristic of a silicon diode: the forward current in mA and the reverse current in µA. (a) Why is the current almost zero at the point P although the diode is forward biased? (b) Why is the current at R_1 and at R_2 almost the same, though the reverse voltage at R_2 is three times that at R_1? **2**



11. A silicon crystal doped with a pentavalent impurity is shown. (a) Name the type of the semiconductor and give one example of such a dopant. (b) The intrinsic carrier concentration of silicon is $n_i = 2 \times 10^{16}\ m^{-3}$ and the donor concentration is $2 \times 10^{22}\ m^{-3}$. Find the hole concentration. **2**



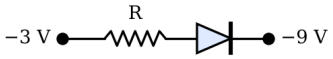
12. **(A)** A silicon diode is connected to a 3.7 V cell and a 100 Ω resistor as shown. Find (a) the current in the circuit and (b) the power dissipated in the resistor. **2**



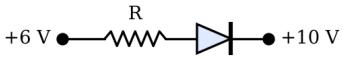
OR

(B) A diode is connected in two circuits (i) and (ii) with the potentials shown at the ends. State, with reason, whether the diode is forward or reverse biased in each case.

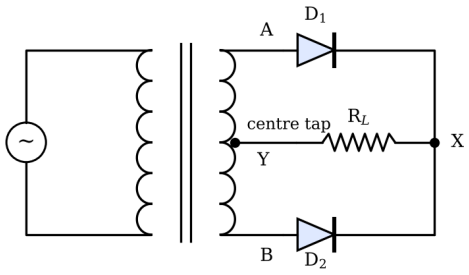
(i)



(ii)

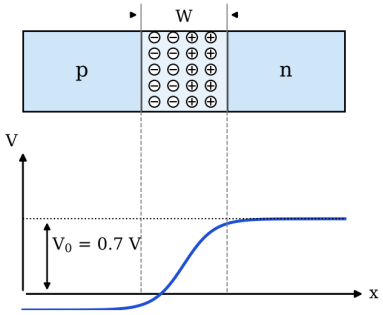


13. A rectifier circuit with a centre-tap transformer is shown. (a) During the half cycle in which the end A is positive with respect to the centre tap, which diode conducts, and in which direction (X to Y or Y to X) is the current in R_L? (b) Name the component that should be connected across R_L to obtain a steady dc output, and state its role. **2**

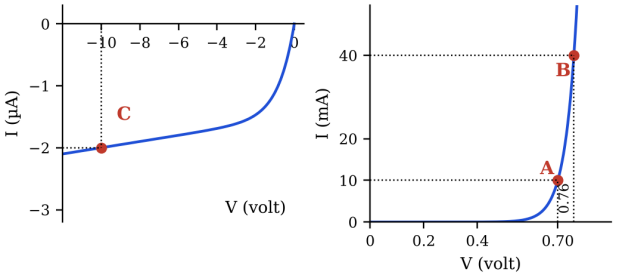


SECTION C (3 × 3 = 9)

14. A p-n junction in equilibrium and its barrier potential are shown. (a) Name the carriers whose diffusion forms the depletion region, and state the charge left behind on each side of the junction. (b) Find the effective barrier height when a forward bias of 0.3 V and a reverse bias of 0.3 V is applied. (c) How do the diffusion current and the drift current compare in equilibrium, and what is the net current? **3**

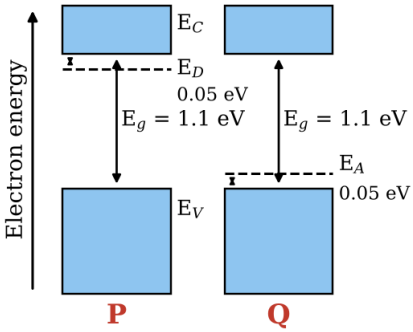


15. **(A)** The forward and reverse characteristics of a silicon diode are shown. Using the points A, B and C, calculate (a) the forward dynamic resistance $r_f = \Delta V/\Delta I$ between A and B, (b) the reverse resistance $r_r = V/I$ at C, and (c) the ratio r_r/r_f. What does this ratio tell you about the use of the diode? **3**

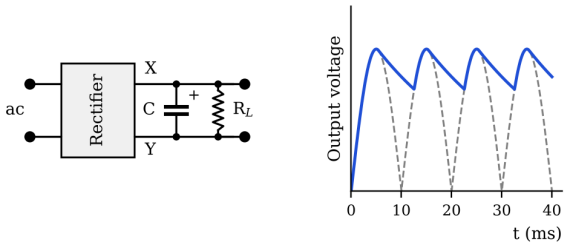


OR

(B) Two doped silicon crystals P and Q have the energy bands shown. (a) Identify P and Q and name the majority carriers in each. (b) Why do the electrons of the impurity level reach the conduction band easily at room temperature, while very few electrons cross the band gap from the valence band? (c) In P the electron concentration is 4×10^{21} m^{-3} and $n_i = 2 \times 10^{16}$ m^{-3}. Find the hole concentration.

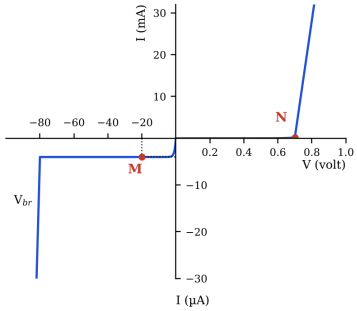


16. A full-wave rectifier with a capacitor filter is shown with its output waveform; the dashed curve is the output without the capacitor. The input frequency is 50 Hz, $R_L = 10$ kΩ and $C = 100$ μF. (a) Explain how the capacitor smooths the output. (b) Find the time constant $R_L C$. (c) Compare it with the time between two successive pulses of the rectified output and state what this implies for the output voltage. **3**



SECTION D (1 × 4 = 4)

17. **Case Study.** A student studies a junction diode by connecting it to a variable supply, using a milliammeter in forward bias and a microammeter in reverse bias. The graph he obtains is shown. The forward current starts rising sharply at the point N. In reverse bias the current stays almost constant up to the voltage V_{br}. M is a point on the reverse characteristic with V = −20 V and I = −4 µA. Answer the following: **4**



(i) The forward current is in mA and the reverse current is in µA because

(a) forward: minority carriers; reverse: majority carriers

(b) both are due to majority carriers, but reverse bias raises the barrier

(c) forward: majority carriers crossing the lowered barrier; reverse: minority carriers

(d) forward: holes only; reverse: electrons only

(ii) The point N gives the cut-in voltage. The diode is made of

(a) silicon, since cut-in is about 0.7 V (b) germanium, since cut-in is about 0.7 V

(c) silicon, since cut-in is about 0.2 V (d) germanium, since cut-in is about 0.2 V

(iii) When the reverse voltage is increased from 20 V to 60 V (below V_{br}), the depletion region and the reverse current

(a) narrows and the current increases (b) narrows and the current stays constant

(c) widens and the current stays almost constant (d) stays the same and the current increases

(iv) The diode is connected in forward bias with a 2.7 V cell and a 200 Ω resistor in series. The current is

(a) 13.5 mA (b) 10 mA (c) 3.5 mA (d) 20 mA

OR

(iv) The resistance of the diode at the point M is

(a) 5×10^6 Ω (b) 5×10^3 Ω (c) 8×10^6 Ω (d) 2×10^5 Ω

SECTION E (1 × 5 = 5)

18. **(A)** (a) Draw the circuit diagram of a half-wave rectifier using a p-n junction diode. Explain its working with the input and output waveforms. (3) **5**
(b) A transformer secondary gives a peak voltage of 10 V to an ideal diode in series with a load of 500 Ω. If the input frequency is 50 Hz, find the peak load current and the frequency of the output. (2)

OR

(B) (a) Draw the circuit diagram of a full-wave rectifier using two diodes and a centre-tap transformer. Explain its working with the waveforms. (3)
(b) Each half of the centre-tap secondary gives a peak voltage of 12 V. The diodes are ideal, R_L = 400 Ω and the input frequency is 50 Hz. Find the peak load current and the frequency of the output. (2)

— End of Question Paper —