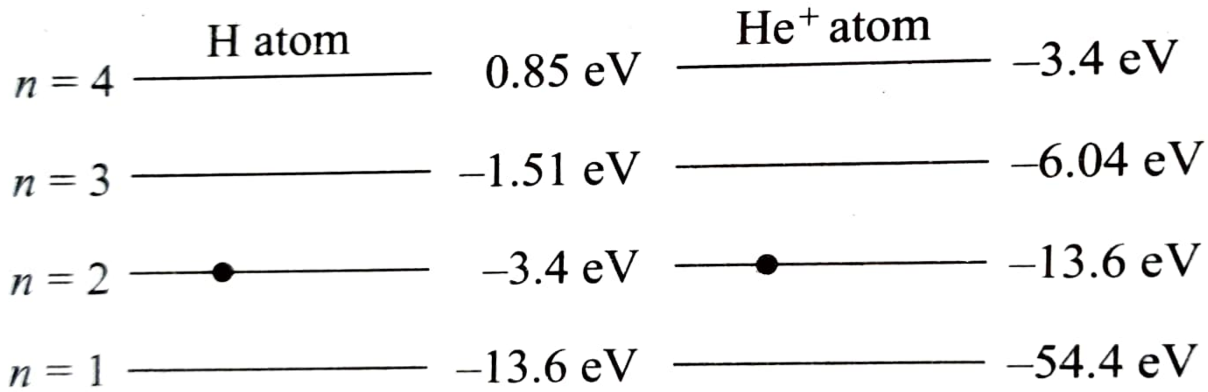
For Problems 1–3

In a mixture of H–He^+ gas (He^+ is singly ionized He atom), H atoms and He^+ ions are excited to their respective first excited states. Subsequently, H atoms transfer their total excitation energy to He^+ ions (by collisions). Assume that the Bohr model of atom is exactly valid. **(IIT JEE, 2008)**



1. The quantum number n of the state finally populated in He^+ ions is

   a. 2 **b.** 3 **c.** 4 **d.** 5

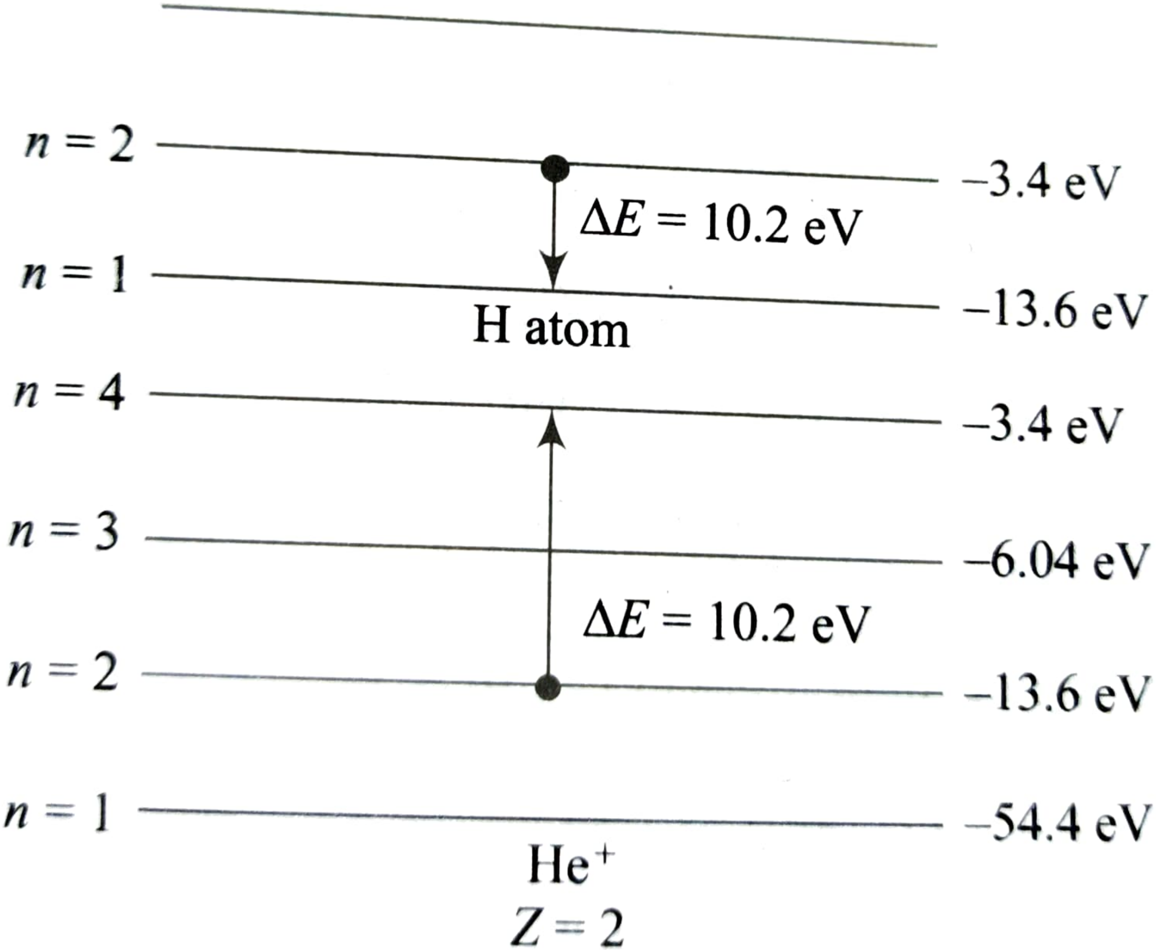
2. The wavelength of light emitted in the visible region by He^+ ions after collisions with H atoms is

   a. 6.5×10^{-7} m **b.** 5.6×10^{-7} m
   c. 4.8×10^{-7} m **d.** 4.0×10^{-7} m

3. The ratio of the kinetic energy of the $n = 2$ electron for the H atom to that of He^+ ion is

   a. $\frac{1}{4}$ **b.** $\frac{1}{2}$ **c.** 1 **d.** 2

1. c.



n = 2
n = 1
ΔE = 10.2 eV
–3.4 eV
–13.6 eV
H atom
n = 4
n = 3
n = 2
n = 1
–3.4 eV
–6.04 eV
ΔE = 10.2 eV
–13.6 eV
–54.4 eV
He+
Z = 2

Energy given by H atom in transition from $n = 2$ to $n = 1$ is equal to energy taken by He^+ atom in transition from $n = 2$ to $n = 4$.

2. c. Visible light lies in the range, $\lambda_1 = 4000$ Å to $\lambda_2 = 7000$ Å. Energy of photons corresponding to these wavelengths (in eV) would be:

$$E_1 = \frac{12375}{4000} = 3.09 \text{ eV}, \quad \text{and}$$

$$E_2 = \frac{900}{11R} = 1.77 \text{ eV}$$

From energy level diagram of He^+ atom, we can see that in transition from $n = 4$ to $n = 3$, energy of photon released will lie between E_1 and E_2.

$$\Delta E_{43} = -3.4 - (-6.04)$$
$$= 2.64 \text{ eV}$$

Wavelength of photon corresponding to this energy,

$$\lambda = \frac{12375}{264} \text{ Å} = 4687.5 \text{ Å}$$
$$= 4.68 \times 10^{-7} \text{ m}$$

3. a. Kinetic energy, $K \propto Z^2$

$$\frac{K_H}{K_{He^+}} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$