

PRACTICE PAPER

1*

Time allowed : 2 hours

Maximum marks : 35

General Instructions :

- All questions are compulsory. There are 16 questions in all.
- This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
- Section A contains five very short answer questions and two assertion reasoning MCQs of 1 mark each. Section B has one case based question of 4 marks, Section C contains four short answer questions of 2 marks each, Section D contains two short answer questions of 3 marks each and Section E contains two long answer questions of 5 marks each.
- There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.

SECTION - A

All questions are compulsory. In case of internal choices, attempt any one of them.

- Ultraviolet radiations of different frequencies ν_1 and ν_2 are incident on two photosensitive materials having work functions W_1 and W_2 ($W_1 > W_2$) respectively. The kinetic energy of the emitted electrons is same in both the cases. Which one of the two radiations will be of higher frequency?
- State de Broglie hypothesis. Is it applicable for moving electron of hydrogen atom ?

OR

Calculate the de-Broglie wavelength of the electron orbiting in the $n = 2$ state of hydrogen atom.

- Plot a graph showing variation of current versus voltage for the material Gas.
- If A is the angle of prism, r angle of refraction, then what is the condition for minimum deviation?

OR

Find the magnifying power of a convex lens of focal length 10 cm when the image is formed at the near point.

- In a double slit experiment, when light of wavelength 400 nm was used, the angular width of the first minima formed on a screen placed 1 m away, was found to be 0.2° . What will be the angular width of the first minima, if the entire experimental apparatus is immersed in water? ($\mu_{\text{water}} = 4/3$)

For question numbers 6-7, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

- Both A and R are true and R is the correct explanation of A
 - Both A and R are true but R is not the correct explanation of A
 - A is true but R is false
 - A is false and R is also false
- Assertion (A)** : The depletion layer in the p - n junction is free from mobile charge carriers.
Reason (R) : There is no electric field across the junction barrier.
 - Assertion (A)** : Young's double slit experiment can be performed using a source of white light.
Reason (R) : The wavelength of red light is less than the wavelength of other colours in white light.

SECTION - B

Question 8 is a Case Study based question and it is compulsory. Attempt any 4 sub parts from this question. Each part carries 1 mark.

Refraction through Spherical Surfaces

- Refraction of light is the change in the path of light as it passes obliquely from one transparent medium to another medium. According to law of refraction $\frac{\sin i}{\sin r} = \mu_2$, where μ_2 is called refractive index of second medium with

respect to first medium. From refraction at a convex spherical surface, we have $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$. Similarly from refraction at a concave spherical surface when object lies in the rarer medium, we have $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$ and when object lies in the denser medium, we have $\frac{\mu_1}{v} - \frac{\mu_2}{u} = \frac{\mu_1 - \mu_2}{R}$.

- (i) Refractive index of a medium depends upon
- (a) nature of the medium (b) wavelength of the light used
(c) temperature (d) all of these
- (ii) A ray of light of frequency 5×10^{14} Hz is passed through a liquid. The wavelength of light measured inside the liquid is found to be 450×10^{-9} m. The refractive index of the liquid is
- (a) 1.33 (b) 2.52 (c) 2.22 (d) 0.75
- (iii) A ray of light is incident at an angle of 60° on one face of a rectangular glass slab of refractive index 1.5. The angle of refraction is
- (a) $\sin^{-1}(0.95)$ (b) $\sin^{-1}(0.58)$ (c) $\sin^{-1}(0.79)$ (d) $\sin^{-1}(0.86)$
- (iv) A point object is placed at the centre of a glass sphere of radius 6 cm and refractive index 1.5. The distance of the virtual image from the surface of sphere is
- (a) 2 cm (b) 4 cm (c) 6 cm (d) 12 cm
- (v) In refraction, light waves are bent on passing from one medium to the second medium because in the second medium
- (a) the frequency is different (b) the co-efficient of elasticity is different
(c) the speed is different (d) the amplitude is smaller.

SECTION - C

All questions are compulsory. In case of internal choices, attempt anyone.

9. Calculate the energy in fusion reaction: ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He} + n$, where B.E. of ${}^2_1\text{H} = 2.23$ MeV and of ${}^3_2\text{He} = 7.73$ MeV.
10. The work function for a certain metal is 4.2 eV. Will metal give photoelectric emission for incident radiation of wavelength 330 nm ?

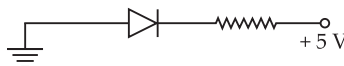
OR

If the momentum of an electron is changed by p , then the de Broglie wavelength associated with it changes by 0.5%. What will be the initial momentum of electron ?

11. A plane electromagnetic wave travels in vacuum along z -direction. What can you say about the direction of electric and magnetic field vectors?
12. The forbidden energy gap in semiconductors, insulators and metals are E_s , E_i , and E_m respectively. Arrange these in descending order. The band gap in silicon is 1.12 eV. What is the maximum wavelength of light that can be emitted by it?

OR

In the following diagram, is the junction diode forward biased or reverse biased?



SECTION - D

All questions are compulsory. In case of internal choices, attempt any one.

13. Write any two distinguishing features between conductors, semiconductors and insulators on the basis of energy band diagrams.
14. A convex lens made of a material of refractive index μ_1 is kept in a medium of refractive index μ_2 . Parallel rays of light are incident on the lens. Complete the path of rays of light emerging from the convex lens if
- (a) $\mu_1 > \mu_2$ (b) $\mu_1 = \mu_2$ (c) $\mu_1 < \mu_2$

OR

The radius of curvature of the curved surface of a plano-convex lens is 20 cm. If the refractive index of the material of the lens be 1.5, then show that it will act as a convex lens irrespective of the side on which the object lies.

SECTION - E

All questions are compulsory. In case of internal choices, attempt any one.

15. A parallel beam of monochromatic light falls normally on a narrow slit of width 'a' to produce a diffraction pattern on the screen placed parallel to the plane of the slit.

Use Huygens principle to explain that

- the central bright maxima is twice as wide as the other maxima.
- the intensity falls as we move to successive maxima away from the centre of on either side.

OR

- (a) Two monochromatic waves emanating from two coherent sources have the displacements represented by $y_1 = a \cos \omega t$ and $y_2 = a \cos (\omega t + \phi)$

where ϕ is the phase difference between the two displacements. Show that the resultant intensity at a point due to their superposition is given by $I = 4 I_0 \cos^2 \phi/2$, where $I_0 = a^2$.

- (b) Hence obtain the conditions for constructive and destructive interference.

16. (a) Using Bohr's atomic model, derive the expression for the radius of n^{th} orbit of the revolving electron in a hydrogen atom.

- (b) Write two important limitations of Rutherford nuclear model of the atom.

OR

- (a) Using de Broglie's hypothesis, explain with the help of a suitable diagram, Bohr's second postulate of quantization of energy levels in a hydrogen atom.

- (b) The ground state energy of hydrogen atom is -13.6 eV. What are the kinetic and potential energies of the electron in this state?

ANSWERS

$$1. \quad \frac{1}{2} m v_{\max}^2 = h\nu_1 - W_1 = h\nu_2 - W_2$$

$$\text{or } h(\nu_1 - \nu_2) = W_1 - W_2$$

$$\text{or } h(\nu_1 - \nu_2) = \text{positive}$$

$$\text{or } \nu_1 - \nu_2 = \text{positive}$$

$$\text{so } \nu_1 > \nu_2$$

2. de-Broglie hypothesis : It states that a moving particle sometimes acts as a wave and sometimes as a particle or a wave is associated with moving particle which controls the particle in every respect. The wave associated with moving particle is called matter wave or de-Broglie wave whose wavelength is given by

$$\lambda = \frac{h}{mv}$$

where m and v are the mass and velocity of the particle and h is Planck's constant.

Yes, it is applicable for moving electron of hydrogen atom.

OR

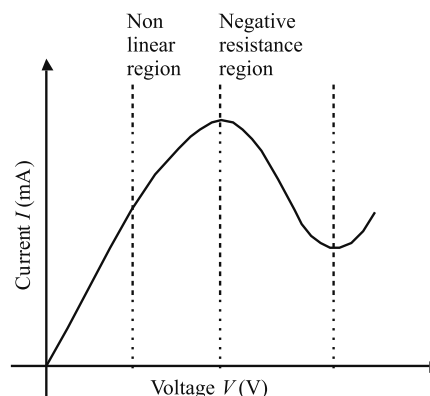
Kinetic energy of the electron in the second state of hydrogen atom

$$E_K = \frac{13.6 \text{ eV}}{n^2} = \frac{13.6 \text{ eV}}{4} = 3.4 \times 1.6 \times 10^{-19} \text{ J}$$

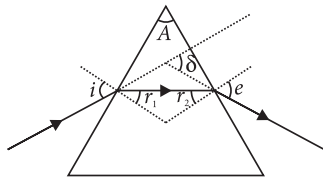
$$\text{de Broglie wavelength } \lambda = \frac{h}{\sqrt{2mE_K}}$$

$$= \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 3.4 \times 1.6 \times 10^{-19}}} = 0.67 \text{ nm}$$

3. Variation of current versus voltage for Gas.



4.

As $r_1 + r_2 = A$ At minimum deviation, $r_1 = r_2 = r$ $\therefore 2r = A$

OR

(d) : When the final image is formed at the near point,

the magnifying power is $m = 1 + \frac{D}{f}$ where D is the least distance of distinct vision and f is the focal length of the convex lens.Here, $D = 25$ cm, $f = 10$ cm

$$\therefore m = 1 + \frac{25 \text{ cm}}{10 \text{ cm}} = 1 + 2.5 = 3.5$$

5. Angular width for first minima in Young's double slit experiment, $\theta = \frac{\lambda}{a}$ For given value of a , $\theta \propto \lambda$

$$\frac{\theta}{\theta_w} = \frac{\lambda}{\lambda_w} = \frac{\lambda}{\lambda} = \mu \Rightarrow \theta_w = \frac{\theta}{\mu} = \frac{0.2^\circ}{\frac{4}{3}} = 0.15^\circ$$

6. (c) : Due to diffusion of holes from the p -region to the n -region and of electrons from the n -region to the p -region an electric field is set up across the junction barrier. Once the depletion layer is formed it is in equilibrium and becomes free of mobile charge carriers.

7. (c) : When source in Young's double slit experiment is of white light, the central fringe is white as all colours meet there in phase.

8. (i) (d) : Refractive index of a medium depends upon nature and temperature of the medium, wavelength of light.

(ii) (a) : Here $\nu = 5 \times 10^{14}$ Hz; $\lambda = 450 \times 10^{-9}$ m

$$c = 3 \times 10^8 \text{ m s}^{-1}$$

Refractive index of the liquid,

$$\mu = \frac{c}{\nu \lambda} = \frac{3 \times 10^8}{5 \times 10^{14} \times 450 \times 10^{-9}}$$

$$\mu = 1.33$$

(iii) (b) : Here $i = 60^\circ$; $\mu = 1.5$ By Snell's law, $\mu = \frac{\sin i}{\sin r}$

$$\sin r = \frac{\sin i}{\mu} = \frac{\sin 60^\circ}{1.5} = \frac{0.866}{1.5}$$

$$\sin r = 0.5773 \text{ or } r = \sin^{-1}(0.58)$$

(iv) (c): As object is at the centre of the sphere, the image must be at the centre only.

 \therefore Distance of virtual image from centre of sphere = 6 cm.

(v) (c) : Speed of light in second medium is different than that in first medium

9. Fusion reaction, ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He} + n$

Energy released = final B.E. - initial B.E.

$$= 7.73 - (2.23 + 2.23) = 3.27 \text{ MeV.}$$

10. Let us calculate the energy associated with incident photons

$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{330 \times 10^{-9}} = 6.027 \times 10^{-19} \text{ J}$$

$$\text{or } E = \frac{6.027 \times 10^{-19}}{1.6 \times 10^{-19}} \text{ J} = 3.77 \text{ eV}$$

So, energy of incident photons *i.e.*, 3.77 eV is less than work function, hence emission will not take place.

OR

de Broglie wavelength associated with an electron is

$$\lambda = \frac{h}{p} \text{ or } p = \frac{h}{\lambda}$$

$$\therefore \frac{\Delta p}{p} = -\frac{\Delta \lambda}{\lambda} \Rightarrow \frac{p}{p_{\text{initial}}} = \frac{0.5}{100}$$

$$p_{\text{initial}} = 200 p$$

11. The electric and magnetic field vectors \vec{E} and \vec{B} are perpendicular to each other and also perpendicular to the direction of propagation of the electromagnetic wave. If a plane electromagnetic wave is propagating along the z -direction, then the electric field is along x -axis, and magnetic field is along y -axis.12. Here, $E_i > E_s > E_m$

$$\text{As, } E = h\nu = \frac{hc}{\lambda}$$

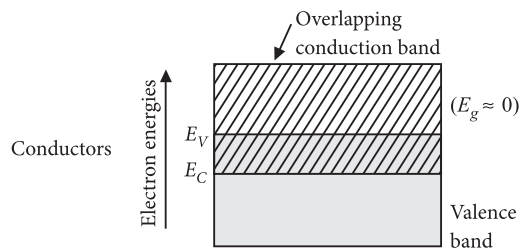
$$\text{or } \lambda = \frac{hc}{E} = \frac{6.67 \times 10^{-34} \times 3 \times 10^8}{1.12 \times 1.6 \times 10^{-19}}$$

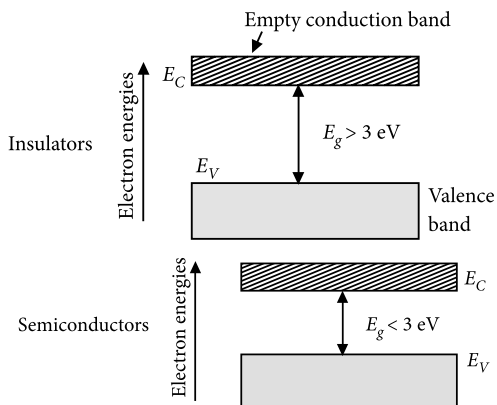
$$\lambda = 1.11 \times 10^{-6} \text{ m}$$

OR

Voltage at p side is less than voltage at n side of the diode so it is in reverse bias.

13. The band diagram for conductors, semiconductors and insulators are given as follows:

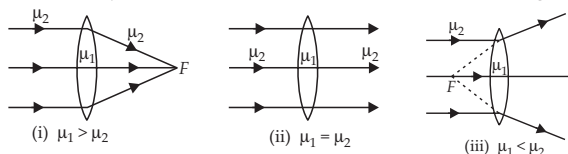




Two distinguishing features :

- (i) In conductors, the valence band and conduction band tend to overlap (or nearly overlap) while in insulators they are separated by a large energy gap and in semiconductors they are separated by a small energy gap.
- (ii) The conduction band of a conductor has a large number of electrons available for electrical conduction. However, the conduction band of insulators is almost empty while that of the semiconductor has only a (very) small number of such electrons available for electrical conduction.

14. In case (a) $\mu_1 > \mu_2$, the lens behaves as convergent lens.
 In case (b) $\mu_1 = \mu_2$, the lens behaves as a plane plate.
 In case (c) $\mu_1 < \mu_2$, the lens behaves as a divergent lens.
 The path of rays in all the three cases is shown in the figure.



OR

Here, $\mu = 1.5$

If object lies on plane side;

$$R_1 = \infty, R_2 = -20 \text{ cm}$$

$$\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

$$= (1.5 - 1) \left(\frac{1}{\infty} + \frac{1}{20} \right) = \frac{1}{40}$$

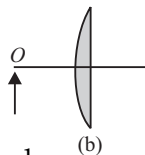
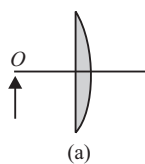
$f = +40 \text{ cm}$. The lens behaves as convex lens.

If object lies on its curved side. Then

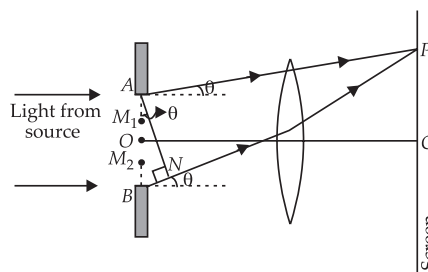
$$R_1 = 20 \text{ cm}, R_2 = \infty$$

$$\frac{1}{f'} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right) = (1.5 - 1) \left(\frac{1}{20} - \frac{1}{\infty} \right) = \frac{1}{40}$$

$f' = 40 \text{ cm}$. The lens behaves as convex lens.



15. (i)



Consider a parallel beam of monochromatic light is incident normally on a single slit AB of width a as shown in the figure. According to Huygens principle every point of slit acts as a source of secondary wavelets spreading in all directions. The mid point of the slit is O . A straight line through O perpendicular to the slit plane meets the screen at C . At the central point C on the screen, the angle θ is zero. All path differences are zero and hence all the parts of the slit contribute in phase. This gives maximum intensity at C .

Consider a point P on the screen.

The observation point is now taken at P .

Secondary minima : Now we divide the slit into two equal halves AO and OB , each of width $\frac{a}{2}$. For every point, M_1 in AO , there is a corresponding point M_2 in OB , such that

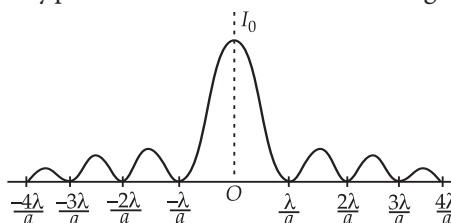
$$M_1 M_2 = \frac{a}{2}. \text{ The path difference between waves arriving at } P \text{ and starting from } M_1 \text{ and } M_2 \text{ will be } \frac{a}{2} \sin \theta = \frac{\lambda}{2}. \text{ } a \sin \theta = \lambda$$

In general, for secondary minima

$a \sin \theta = n \lambda$ where $n = \pm 1, \pm 2, \pm 3, \dots$. Secondary maxima :

Similarly it can be shown that for secondary maxima $a \sin \theta = (2n + 1) \frac{\lambda}{2}$ where $n = \pm 1, \pm 2, \dots$

The intensity pattern on the screen is shown in the given figure.



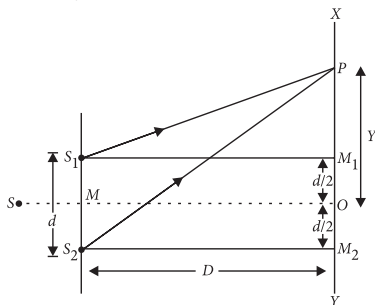
Width of central maximum $= \frac{2D\lambda}{a}$

(ii) The reason is that the intensity of the central maximum is due to the constructive interference of wavelets from all parts of the slit, the first secondary maximum is due to the contribution of wavelets from one third part of the slit (wavelets from remaining two parts interfere destructively), the second secondary maximum is due to the contribution of wavelets from the one fifth part only (the remaining four parts interfere destructively) and so on. Hence the intensity of secondary

maximum decreases with the increase in the order n of the maximum.

OR

(a) $y_1 = a \cos \omega t, y_2 = a \cos (\omega t + \phi)$



where ϕ is phase difference between them.

Resultant displacement at point P will be,

$$y = y_1 + y_2 = a \cos \omega t + a \cos(\omega t + \phi)$$

$$= a [\cos \omega t + \cos (\omega t + \phi)]$$

$$= a \left[2 \cos \frac{(\omega t + \omega t + \phi)}{2} \cos \frac{(\omega t - \omega t - \phi)}{2} \right]$$

$$y = 2a \cos \left(\omega t + \frac{\phi}{2} \right) \cos \left(\frac{\phi}{2} \right) \quad \dots(i)$$

Let $y = 2a \cos \left(\frac{\phi}{2} \right) = A$, the equation (i) becomes

$$y = A \cos \left(\omega t + \frac{\phi}{2} \right)$$

where A is amplitude of resultant wave,

$$\text{Now, } A = 2a \cos \left(\frac{\phi}{2} \right)$$

$$\text{On squaring, } A^2 = 4a^2 \cos^2 \left(\frac{\phi}{2} \right)$$

$$\text{Hence, resultant intensity, } I = 4I_0 \cos^2 \left(\frac{\phi}{2} \right)$$

(b) Condition for constructive interference, $\cos \Delta\phi = +1$

$$2\pi \frac{\Delta x}{\lambda} = 0, 2\pi, 4\pi \dots \text{ or } \Delta x = n\lambda; n = 0, 1, 2, 3, \dots$$

Condition for destructive interference, $\cos \Delta\phi = -1$

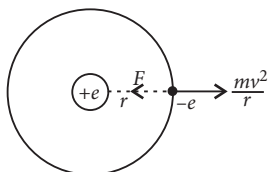
$$2\pi \frac{\Delta x}{\lambda} = \pi, 3\pi, 5\pi \dots \text{ or } x = (2n - 1) \lambda/2$$

where $n = 1, 2, 3 \dots$

16. (a) Radius of n^{th} orbit of hydrogen atom : In H -atom, an electron having charge $-e$ revolves around the nucleus of charge $+e$ in a circular orbit of radius r , such that necessary centripetal force is provided by the electrostatic force of attraction between the electron and nucleus.

$$\text{i.e., } \frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0} \frac{e \cdot e}{r^2}$$

$$\text{or } mv^2 = \frac{1}{4\pi\epsilon_0} \frac{e^2}{r} \quad \dots(i)$$



From Bohr's quantization condition

$$mvr = \frac{nh}{2\pi} \text{ or } v = \frac{nh}{2\pi mr} \quad \dots(ii)$$

Using equation (ii) in (i), we get

$$m \cdot \left(\frac{nh}{2\pi mr} \right)^2 = \frac{1}{4\pi\epsilon_0} \frac{e^2}{r} \text{ or } \frac{m \cdot n^2 h^2}{4\pi^2 m^2 r^2} = \frac{1}{4\pi\epsilon_0} \frac{e^2}{r}$$

$$\text{or } r = \frac{n^2 h^2 \epsilon_0}{\pi m e^2} \quad \dots(iii)$$

where $n = 1, 2, 3, \dots$ is principal quantum number.

Equation (iii), gives the radius of n^{th} orbit of H -atom. So the radii of the orbits increase proportionally with n^2 i.e., $[r \propto n^2]$. Radius of first orbit of H -atom is called Bohr radius a_0 and is given by

$$a_0 = \frac{h^2 \epsilon_0}{\pi m e^2} \text{ for } n = 1 \text{ or } a_0 = 0.529 \text{ \AA}$$

So, radius of n^{th} orbit of H -atom then becomes

$$r = n^2 \times 0.529 \text{ \AA}$$

(b) The two important limitations of Rutherford nuclear model of the atom are :

(i) This model cannot explain about the stability of matter.

(ii) It cannot explain the characteristic line spectra of atoms of different elements.

OR

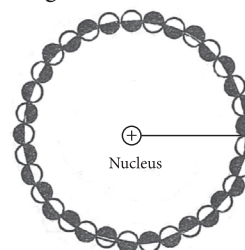
(a) According to de Broglie, a stationary orbit is that which contains an integral number of de Broglie waves associated with the revolving electron.

For an electron revolving in n^{th} circular orbit of radius r_n ,

Total distance covered = Circumference of the orbit = $2\pi r_n$

\therefore For the permissible orbit, $2\pi r_n = n\lambda$

According to de-Broglie,



$$\lambda = \frac{h}{mv_n}$$

where v_n is speed of electron revolving in n^{th} orbit.

$$\therefore 2\pi r_n = \frac{nh}{mv_n} \text{ or } mv_n r_n = \frac{nh}{2\pi} = n \left(\frac{h}{2\pi} \right)$$

(b) For ground state, $n = 1$

$$E = \frac{-13.6}{n^2} = \frac{-13.6}{1^2} = -13.6 \text{ eV}$$

$$\therefore \text{K.E.} = -E = -(-13.6) = 13.6 \text{ eV}$$

$$\therefore \text{P.E.} = 2E$$

$$\therefore \text{P.E.} = 2(-13.6) = -27.2 \text{ eV}$$

