Atomic Structure

DPP-2 Solutions

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1.

Sol. A **proton** is one of the fundamental particles of atoms. A **photon** is a quantum of light energy (EM radiations). A **quantum** is a bundle of energy of a definite magnitude; but it need not be necessarily Light energy.

2. **(a) $1.43\times10^6\ m^{-1}$, $2.5\times10^6\ m^{-1}$**

(b) 1.71×10^5 J/mol, 2.99×10^5 J/mol

(c) 2.84×10^{-12} erg/photon, 4.97×10^{-12} ergs

(d) 4.29×10^{14} Hz, 7.5×10^{14} Hz

(e) 40.8 KCal/mol, 71.5 KCal/mol.

Sol. (a) $\bar{\nu}$ for Longest $\lambda = \dfrac{1}{7000\times10^{-10}}$

$= 1.43\times10^6\ m^{-1}$

$\bar{\nu}$ for shortest $\lambda = \dfrac{1}{4000\times10^{-10}}$

$= 2.5\times10^6\ m^{-1}$

(b) $E_{minimum} = \dfrac{hc}{\lambda_{longest}}$

$= \dfrac{6.63\times10^{-34}\times3\times10^8}{7000\times10^{-10}}$ J/photon

$= 2.84\times10^{-19}$ J/photon

$= 2.84\times10^{-19}\times6.022\times10^{23}$

$= 1.71\times10^5$ J/mol

$E_{maximum} = \dfrac{hc}{\lambda_{shortest}}$

$\dfrac{6.63\times10^{-34}\times3\times10^8}{4000\times10^{-10}}$

$= 4.97\times10^{-19}$ J/photon

$= 4.97\times10^{-19}\times6.022\times10^{23}$ J/mol

$= 2.99\times10^5$ J/mol

(c) $E_{minimum} = \dfrac{hc}{\lambda_{longest}}$

$\dfrac{6.63\times10^{-34}\times3\times10^8}{7000\times10^{-10}}$

$= 2.84\times10^{-19}$ J/photon

$= 2.84\times10^{-19}\times10^7$ erg/photon

$= 2.84\times10^{-12}$ erg/photon

$E_{maximum} = \dfrac{hc}{\lambda_{shortest}}$

$= \dfrac{6.63\times10^{-34}\times3\times10^8}{4000\times10^{-10}}$

$= 4.97\times10^{-19}$ J/photon

$= 4.97\times10^{-19}\times10^7$ erg/photon

$= 4.97\times10^{-12}$ erg/photon

(d) $\nu_{shortest} = \dfrac{c}{\lambda_{longest}} = \dfrac{3\times10^8}{7000\times10^{-10}}$

$= 4.29\times10^{14}$ hz

$\nu_{longest} = \dfrac{c}{\lambda_{shortest}} = \dfrac{3\times10^8}{4000\times10^{-10}}$

$= 7.5\times10^{14}$ Hz

(e) $E_{minimum} = 1.71\times10^5$ J/mol

$= \dfrac{1.71\times10^5}{4.18}$ cal/mol

$= 40.8$ KCal/mol

$E_{maximum} = \dfrac{2.99\times10^5}{4.18}$ cal/mol

$= 71.5$ KCal/mol

3. **KE = 5.7×10^{-17}J**

Sol. $\nu_0 = 1.13\times10^{+17}$ Hz

$\therefore E_{th} = 6.63\times10^{-34}\times1.13\times10^{17} = 7.5\times10^{-17}$ J.

$E_{incident} = \dfrac{hc}{\lambda} = \dfrac{6.63\times10^{-34}\times3\times10^8}{15\times10^{-10}} = 1.32\times10^{-16}$J

$\therefore$ KE $= (1.32\times10^{-16}) - (7.5\times10^{-17})$

$= 5.7\times10^{-17}$J

4. **KE = 1.326×10^{-18}J**

Sol. $\nu_{incident} = 3\times10^{15}$Hz

$\nu_{th} = 1.0\times10^{15}$Hz.

$\therefore$ KE $= h(\nu_{incident} - \nu_{th})$

$= 6.63\times10^{-34}\times2\times10^{15}$

$\therefore$ KE $= 1.326\times10^{-18}$J

5.

Sol. According to planck's quantum theory, EM radiations consist of packets of energy and by Einstein's explanation one electron absorbs only one packet of energy and if the energy is not sufficient to excite an electron from a metal surface then no photo electric emission is observed. Since the 2 photons of red Light do not have the required energy, hence the observation.

6. **4.767×10^{-18}J**

Sol. Given, $E_{th} = 7.52\times10^{-19}$J

$\lambda_{incident} = 360$Å

$\therefore E_{incident} = \dfrac{6.63\times10^{-34}\times3\times10^8}{360\times10^{-10}}$

$= 5.525\times10^{-18}$ J

$\therefore$ KE $= E_{inci} - E_{th}$

$= 4.767\times10^{-18}$J

7. **173.7 nm**

Sol. $E_{diss} = 498$ KJ/mol

$E_{diss} = \dfrac{498\times10^3}{6.022\times10^{23}}$ J/bond

$E_{diss} = 8.27\times10^{-19}$ J/bond

Let 1 normal 'O' atom has zero energy

Then other oxygen atom has = (1.967 + 0) eV

= 1.967 eV

= $1.967 \times 1.6 \times 10^{-19}$ J

= 3.1472×10^{-19} J

For photochemical dissociation, total energy required is :-

$E_T = E_{diss} + 3.1472 \times 10^{-19}$

$= (8.27 \times 10^{-19}) + (3.1472 \times 10^{-19})$

$= 1.14 \times 10^{-18}$ J

$$E_T = \frac{hc}{\lambda}$$

$$\lambda = \frac{6.6\times10^{-34}\times3\times10^{8}}{1.14\times10^{-18}}$$

$\lambda = 1.737 \times 10^{-7}$ m

= 173.7 nm.

8. **(a) 3.99×10^{-10} J/mol**

Sol. (a) ν = 1Hz.

$\therefore$ E = 6.63×10^{-34} J/atom.

$\therefore$ E = $6.63 \times 10^{-34} \times 6.022 \times 10^{23}$

= 3.99×10^{-10} J/mol

(b) If energy = 1eV. = 1.6×10^{-19} J

$$\therefore \quad \nu = \frac{1.6\times10^{-19}}{6.63\times10^{-34}} = 2.413\times10^{14}\text{Hz}$$

$\therefore$ 1eV of energy corresponds to 2.413×10^{14}Hz for a photon.

9. **(a) 1.6×10^{-19}J, (b) 23 KCal/mol.**

(c) 96.4 KJ/mol.

Sol. (a) 1eV = 1.6×10^{-19}J

(b) $$1\text{eV} = \frac{1.6\times10^{-19}\times6.02\times10^{23}}{4.18}\text{Cal/mol}$$

= 23 KCal/mol.

(c) 1eV = 23×4.18 KJ/mol

= 96.4 KJ/mol.

10 **2.012×10^{16} photons**

Sol. $$E = \frac{nhc}{\lambda}$$

$$1 = \frac{n\times6.63\times10^{-34}\times3\times10^{8}}{4000\times10^{-12}}$$

n = 2.012×10^{16} photons.

11. **(i) 4.95×10^{-19} J (3.09 eV), (ii) 0.96 eV, (iii) 5.81×10^{5} ms^{-1}**

Sol. W_0 = 2.13 eV

= $2.13 \times 1.6 \times 10^{-19}$ J

= 3.408×10^{-19} J

(i) $$E_{incident} = \frac{hc}{\lambda}$$

$$E_{incident} = \frac{6.6\times10^{34}\times3\times10^{8}}{4\times10^{-7}}$$

$$E_{incident} = 4.95\times10^{-19}\text{J}.$$

$$= \frac{4.95\times10^{-19}}{1.6\times10^{-19}}\text{eV.} = 3.09 \text{ eV}$$

(ii) KE = (3.09 – 2.13) eV

= 0.96 eV

(iii) KE = 0.96 eV

= $0.96 \times 1.6 \times 10^{-19}$ J

= 1.536×10^{-19} J

$$KE = \frac{1}{2}m_e v^2$$

$$v = \sqrt{\frac{2\,KE}{m_e}}$$

$$= \sqrt{\frac{2\times1.536\times10^{-19}}{9.1\times10^{-31}}} = 5.81 \times 10^{5} \text{ m/s.}$$

12. **494 kJ mol^{-1}**

$$E = \frac{hc}{\lambda}$$

$$= \frac{6.63\times10^{-34}\times3\times10^{8}}{242\times10^{-9}}\text{J/atom}$$

= 8.22×10^{-19} J/atom

= $8.22 \times 10^{-19} \times 6.02 \times 10^{23}$ J/mol

= 494 kJ/mol.

13. **(d)**

$$E = \frac{hc}{\lambda}$$

$$\frac{E\,(2000\text{ Å})}{E\,(4000\text{ Å})} = \frac{\lambda\,(4000\text{ Å})}{\lambda\,(2000\text{ Å})} = \frac{2}{1}$$

14. **(d)**

$E_{incident} = E_{threshold}$ + K.E.

$$E_{incident} = E_{threshold} + \frac{3}{4}E_{incident}$$

$$\frac{1}{4}E_{incident} = E_{threshold}$$

$$\frac{1}{4}h\nu_{incident} = h\nu_{threshold}$$

$$\nu_{threshold} = \frac{\nu_{incident}}{4}$$

$$= \frac{3.2\times10^{16}}{4}$$

$= 8\times10^{15}$ hz.

15. **(a)** **16. (a)**

17. **(d)**

E = hν

Units of h = J – s

= kg m^2 s^{-1}

Angular momentum = mvr

= kg m^2 s^{-1}

18. **(a)**

c = $\nu\lambda$

$$\nu = \frac{3\times10^{8}}{600\times10^{-9}}$$

= 5×10^{14} Hz