DPP – (X-Rays)

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Q 1. A material whose K absorption edge is 0.15 Å is irradiated with 0.1 Å X-rays. The maximum kinetic energy of photoelectrons that are emitted from K-shell is –
(a) 41 KeV (b) 51 KeV (c) 61 KeV (d) 71 KeV

Q 2. For a given material, the energy and wavelength of characteristic x-ray satisfy–
(a) E(Ka) > E(Kb) > E(Kg)
(b) E(Ma) > E(La) > E(Ka)
(c) λ(Ka) > λ(Kb) > λ(Kg)
(d) λ(Ma) > λ(La) > λ(Ka)

COMPREHENSION (Q3 to Q5)
A tungsten target (z = 74) is bombarded by electrons in an X-ray tube. The K, L and M atomic X-rays energy levels for tungsten are 69.5, 11.3 and 2.3 keV

Q 3. The minimum value of the accelerating potential that will permit the production of the characteristic kβ and kα lines of tungsten–
(a) 69.5 kV (b) 58.2 kV (c) 67.2 kV (d) 11.3 Kv

Q 4. For the same accelerating potential, what is λ_{min}?
(a) 16.9 pm (b) 17.9 pm (c) 18.9 pm (d) 19.9 pm

Q 5. What is kβ wavelength ?
(a) 16.5 pm (b) 17.5 pm (c) 18.5 pm (d) 21.5 pm

Q 6. K_α wavelength emitted by an atom of atomic number Z =11 is λ. Find the atomic number for an atom that emits K_α radiation with wavelength 4 λ :
(a) Z = 6 (b) Z = 4 (c) Z = 11 (d) Z = 44

Q 7. X-rays will not show the phenomenon of :
(a) diffraction (b) polarisation
(c) deflection by electric field (d) interference

Q 8. The wavelength of K_α X-rays produced by an X-ray tube is 0.76 A°. The atomic number of the anticathode material is
(a) 82 (b) 41 (c) 20 (d) 10

Q 9. The minimum wavelength of X-ray that can be produced in a Coolidge tube depends on
(a) the metal used as the target
(b) the intensity of the electron beam striking the target
(c) the current flowing through the filament
(d) the potential difference between the cathode and the anode

Q 10. If the potential difference applied across a Coolidge tube is increased,
(a) the wavelength of the K_α line will increase
(b) the wavelength of the K_β line will decrease
(c) the difference in wavelength between the K_α and K_β lines will decrease
(d) none of the above

Q 11. If the voltage applied to a X-ray tube is being increased $\eta = 1.5$ times, the short wave limit of the X-ray continuous spectrum shifts by
$\Delta\lambda = 26$ pm. Find the initial voltage applied to the tube.
(a) 10 KV
(b) 12 KV
(c) 14 KV
(d) 16 KV

Q 12. The potential difference applied to an X-ray tube is 5 kV and the current through it is 3.2 mA. Then the number of electrons striking the target per second is
(a) 2×10^{16} (b) 5×10^{6} (c) 1×10^{17} (d) 4×10^{15}

Q13. When the voltage applied to an X-ray tube is increased from $V_1 = 10$ kV to $V_2 = 20$ kV, the wavelength interval between the K_α line and the short-wave cut off of the continuous X-ray spectrum increases by a factor $\eta = 3.0$. Find the atomic number of the element of which the tube's anticathode is made.
(a) 11
(b) 20
(c) 29
(d) 38

Q 14. If a potential difference of 20,000 volts is applied across an X-ray tube, the cut-off wavelength will be
(a) 6.21×10^{-10} m (b) 6.21×10^{-11} m
(c) 6.21×10^{-12} m (d) 3.1×10^{-11} m

Q 15. Which of the following pairs constitute very similar radiations?
(a) Hard ultraviolet rays and soft X-rays
(b) Soft ultraviolet rays and hard X-rays
(c) Very hard X-rays and low-frequency y-rays
(d) Soft X-rays and y-rays

Q 16. When an electron moving at a high speed strikes a metal surface, which of the following are possible?
(a) The entire energy of the electron may be converted into an X-ray photon.

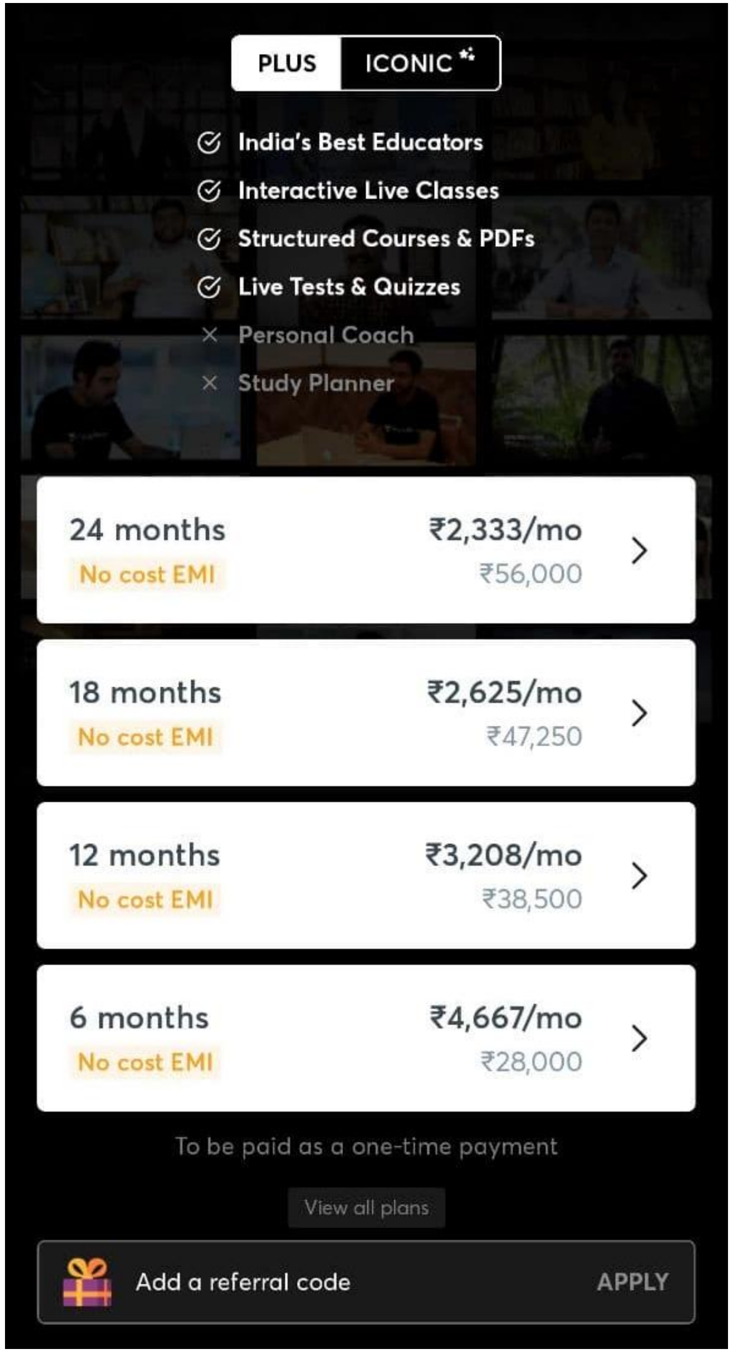
(b) Any fraction of the energy of the electron may be converted into an X-ray photon.
(c) The entire energy of the electron may get converted to heat.
(d) The electron may undergo elastic collision with the metal surface

Q 17. The wavelength of K_α X-rays for lead isotopes Pb^{208}, Pb^{206}, Pb^{204} are λ_1, λ_2 and λ_3 respectively. Then :

(a) $\lambda_1 = \lambda_2 = \lambda_3$
(b) $\lambda_1 > \lambda_2 > \lambda_3$
(c) $\lambda_1 < \lambda_2 < \lambda_3$
(d) $\lambda_2 = \sqrt{\lambda_1 \lambda_2}$

Answer Key

Q.1 a	Q.2 c,d	Q.3 a	Q.4 b	Q.5 c
Q.6 a	Q.7 c	Q.8 b	Q.9 d	Q.10 d
Q.11 d	Q.12 a	Q.13 c	Q.14 b	Q.15 a,c
Q.16 a,b,c	Q.17 a,d			



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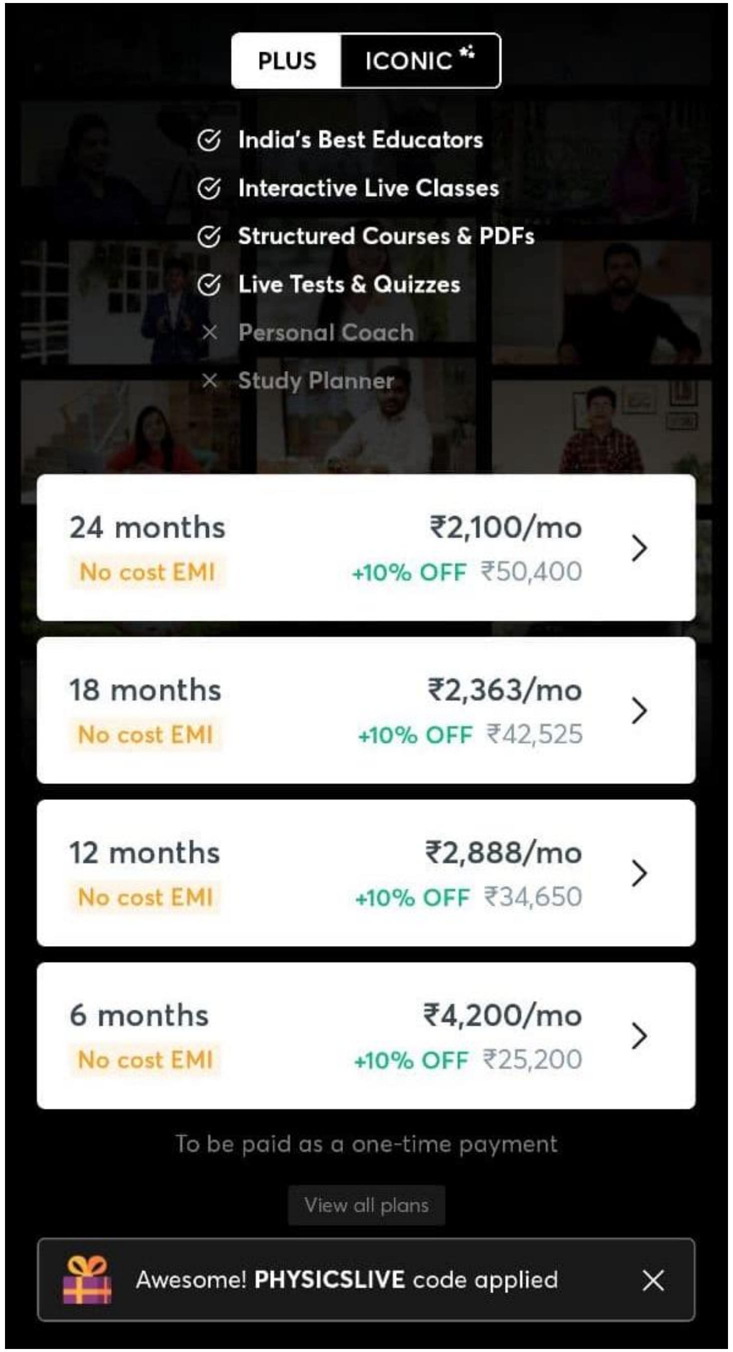

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Physics DPP - Solution

DPP: X- Ray

By Physicsaholics Team

Q1) A material whose K absorption edge is 0.15 Å is irradiated with 0.1 Å X-rays. The maximum kinetic energy of photoelectrons that are emitted from K-shell is -

Energy required to remove K shell electron $= \frac{hc}{\lambda} = \frac{12400 \text{ Å eV}}{.15 \text{ Å}}$

$= \frac{124 \text{ keV}}{.15}$

$= \frac{1240}{15} \text{ keV} = 82.7 \text{ keV}$

Energy of photon $= \frac{12400 \text{ Å eV}}{.1 \text{ Å}} = 124 \text{ keV}$

(a) 41 KeV (b) 51 KeV (c) 61 KeV (d) 71 KeV

Maximum KE of photoelectron

$= (124 - 82.7) \text{ keV}$

$= 41 \text{ keV}$

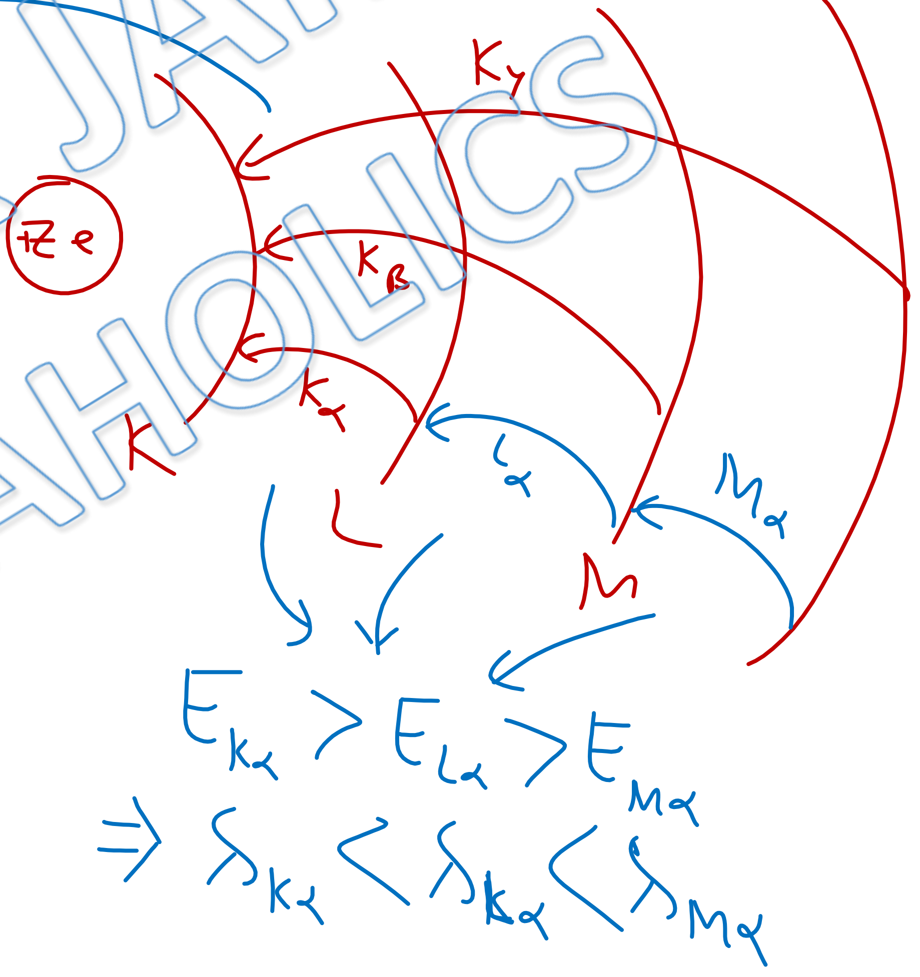
Q2) For a given material, the energy and wavelength of characteristic x-ray satisfy–

(a) E(Kα) > E(Kβ) > E(Kγ)

(b) E(Mα) > E(Lα) > E(Kα)

(c) λ(Kα) > λ(Kβ) > λ(Kγ)

(d) λ(Mα) > λ(Lα) > λ(Kα)



COMPREHENSION (Q3 to Q5)

A tungsten target (z = 74) is bombarded by electrons in an X-ray tube. The K, L and M atomic X-rays energy levels for tungsten are 69.5, 11.3 and 2.3 keV

Q3. The minimum value of the accelerating potential that will permit the production of the characteristic $k\beta$ and $k\alpha$ lines of tungsten–

(a) 69.5 kV (b) 58.2 kV (c) 67.2 kV (d) 11.3 kV

To remove K shell electron energy required

= 69.5 Kev

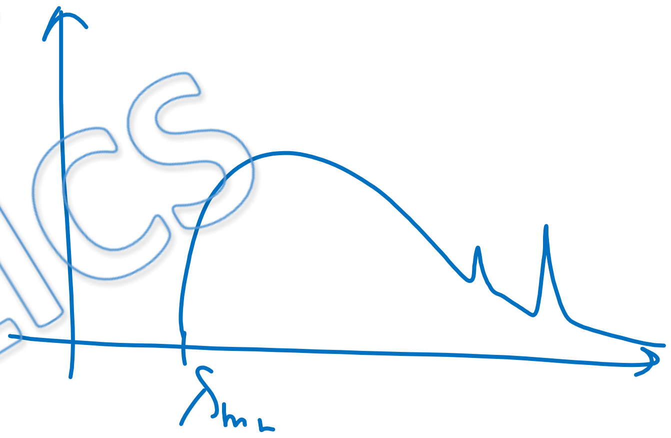
Required accelerating potential = 69 5 KV

Q4) For the same accelerating potential, what is λ_{min}?

$$\lambda_{min} = \frac{hc}{eV} = \frac{12400\ \text{Å eV}}{69.5\ \text{KeV}}$$

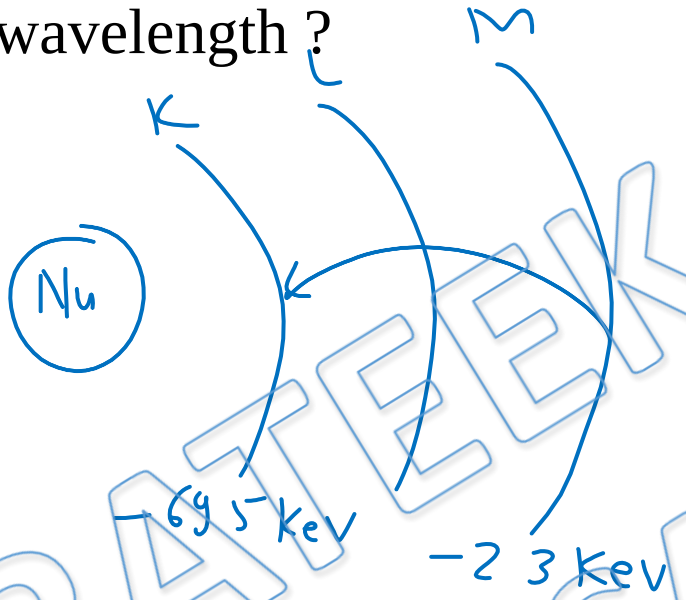
$$= \frac{1240000\ \text{pm}}{69.5 \times 10^3}$$

$$\simeq 17.9\ \text{pm}$$



(a) 16.9 pm (b) 17.9 pm (c) 18.9 pm (d) 19.9 pm

Q5) What is kβ wavelength ?



Energy of photon $= (69.5 - 2.3)\ \text{KeV}$

$= 67.2\ \text{KeV}$

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

$= \frac{12400\ \text{pm eV}}{67.2\ \text{KeV}}$

(a) 16.5 pm (b) 17.5 pm (c) 18.5 pm (d) 21.5 pm

Q6) K_α wavelength emitted by an atom of atomic number Z =11 is λ. Find the atomic number for an atom that emits K_α radiation with wavelength 4 λ :

$\sqrt{\nu} = a(Z-b)$ for K_α, $b = 1$

$\nu = a^2(Z-b)^2$

(a) Z = 6 (b) Z = 4 (c) Z = 11 (d) Z = 44

$\frac{c}{\lambda} = a^2(11-1)^2$

$\frac{c}{4\lambda} = a^2(Z-1)^2$

$\Rightarrow 4 = \frac{100}{(Z-1)^2}$

$(Z-1)^2 = 25$

$Z-1 = 5$

$Z = 6$

Q7) X-rays will not show the phenomenon of :

(a) diffraction
(b) polarisation
(c) deflection by electric field
(d) interference

Q8) The wavelength of K_α X-rays produced by an X-ray tube is 0.76 A°. The atomic number of the anticathode material is

$$\sqrt{\nu} = a(Z-b) \quad \text{for } K_\alpha,\ a = \sqrt{\frac{3Rc}{4}},\ b = 1$$

$$\nu = a^2 (Z-b)^2$$

$$\Rightarrow \frac{c}{.76\times10^{-10}} = \frac{3Rc}{4}(Z-1)^2$$

$$.76 \times 33 = 2.508$$

(a) 82 (b) 41 (c) 20 (d) 10

$$(Z-1)^2 = \frac{4}{3\times.76\times1.1\times10^{7}\times10^{-10}} = \frac{4000}{.76\times33}$$

$$= \frac{4000}{2.5} = \frac{40000}{25}$$

$$Z-1 = \frac{200}{5} = 40 \Rightarrow Z = 41$$

Q9) The minimum wavelength of X-ray that can be produced in a Coolidge tube depends on

$$\lambda_{min} = \frac{hc}{eV}$$

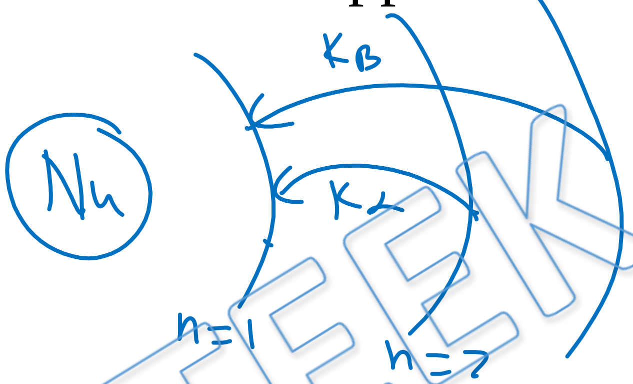
(a) the metal used as the target

(b) the intensity of the electron beam striking the target

(c) the current flowing through the filament

(d) the potential difference between the cathode and the anode

Q10) If the potential difference applied across a Coolidge tube is increased,



(a) the wavelength of the K_α line will increase
(b) the wavelength of the K_β line will decrease
(c) the difference in wavelength between the K_α and K_β lines will decrease
(d) none of the above

Q11) If the voltage applied to a X-ray tube is being increased $\eta = 1.5$ times, the short wave limit of the X-ray continuous spectrum shifts by $\Delta\lambda = 26$ pm. Find the initial voltage applied to the tube.

(a) 10 KV

(b) 12 KV

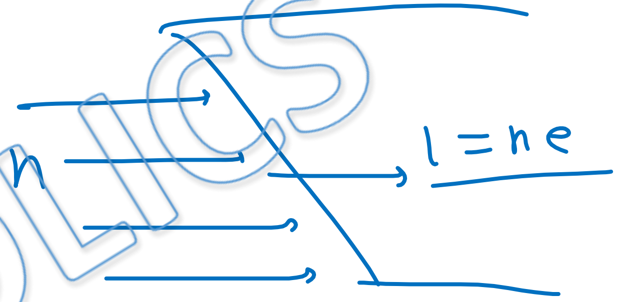
(c) 14 KV

(d) 16 KV

Q12) The potential difference applied to an X-ray tube is 5 kV and the current through it is 3.2 mA. Then the number of electrons striking the target per second is

$$n = \frac{i}{e} = \frac{3.2 \times 10^{-3}}{1.6 \times 10^{-19}}$$

$$= 2 \times 10^{16}$$



(a) 2×10^{16} (b) 5×10^{6} (c) 1×10^{17} (d) 4×10^{15}

Q13) When the voltage applied to an X-ray tube is increased from V_1 = 10 kV to V_2 = 20 kV, the wavelength interval between the K_α line and the short-wave cut off of the continuous X-ray spectrum increases by a factor η = 3.0. Find the atomic number of the element of which the tube's anticathode is made.

Initial $\lambda_{min} = \frac{hc}{eV} = \frac{12400\,\text{Å eV}}{10\ \text{keV}} = 1.24$ Å

final $\lambda_{min} = \frac{12400\,\text{Å eV}}{20\ \text{keV}} = \frac{1.24}{2} = .62$ Å

wavelength of K_α

$\lambda - .62 = 3(\lambda - 1.24)$

$\Rightarrow \lambda - .62 = 3\lambda - 3.72 \Rightarrow 2\lambda = 3.1$

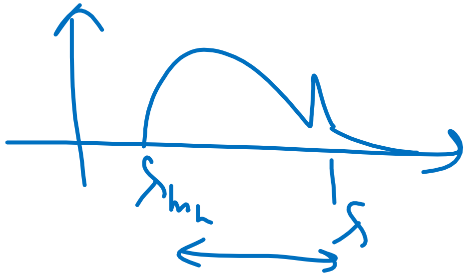
$\Rightarrow \lambda = 1.55$ Å

(a) 11

(b) 20

(c) 29 ✓

(d) 38



Ans. c

$$\sqrt{\nu} = a(Z-b) \Rightarrow \nu = a^2(Z-b)^2$$

$$\Rightarrow \frac{c}{155 \times 10^{-10}} = \frac{3 \times 11 \times 10^7 c}{4}(Z-1)^2$$

$$\Rightarrow (Z-1)^2 = \frac{4}{155 \times 3 \times 11 \times \underbrace{10^{-10} \times 10^7}} = \frac{4000}{155 \times 33}$$

$$(Z-1)^2 = \frac{40000}{155 \times 33} = \frac{40000}{51.15}$$

$$\Rightarrow Z-1 \simeq \frac{200}{7} \simeq 28$$

$$\Rightarrow Z = 29$$

$$\begin{array}{r} 155 \times 33 \\ \hline 465 \\ 4650 \\ \hline 51.15 \end{array}$$

Q14) If a potential difference of 20,000 volts is applied across an X-ray tube, the cut-off wavelength will be

$$\lambda_{cutoff} = \frac{hc}{eV} = \frac{12400\ \text{Å}\ eV}{20000\ eV} = \frac{1240 \times 10^{-11}}{200} = 62 \times 10^{-11}$$

(a) 6.21×10^{-10} m

(b) 6.21×10^{-11} m

(c) 6.21×10^{-12} m

(d) 3.1×10^{-11} m

Q15) Which of the following pairs constitute very similar radiations?

(a) Hard ultraviolet rays and soft X-rays
(b) Soft ultraviolet rays and hard X-rays
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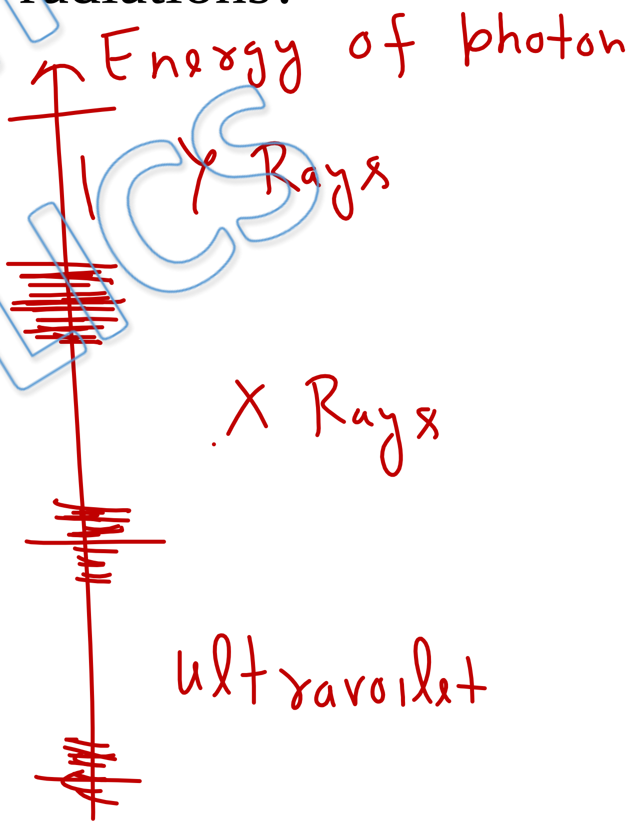

Q16) When an electron moving at a high speed strikes a metal surface, which of the following are possible?

(a) The entire energy of the electron may be converted into an X-ray photon.

(b) Any fraction of the energy of the electron may be converted into an X-ray photon.

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(d) The electron may undergo elastic collision with the metal surface.

Q17) The wavelength of K_α X-rays for lead isotopes Pb^{208}, Pb^{206}, Pb^{204} are λ_1, λ_2 and λ_3 respectively. Then :

$\sqrt{\nu} = a(z-b)$

$\sqrt{\frac{c}{\lambda}} = a(z-b)$

same

same

(a) $\lambda_1 = \lambda_2 = \lambda_3$

(b) $\lambda_1 > \lambda_2 > \lambda_3$

(c) $\lambda_1 < \lambda_2 < \lambda_3$

(d) $\lambda_2 = \sqrt{\lambda_1 \lambda_2}$

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Chalo Niklo