X-ray

$\frac{1}{2}mv_{max}^2 = eV = hf_{max} = h\frac{c}{\lambda_{min}}$

λ_{min} = shortest (cut off) wavelength of x-ray
f_{max} = maximum (cut off) frequency of x-ray
V = accelerating Potential
v_{max} = maximum velocity of incident electron

Total Power: $P = VI$

✓ number of electrons striking per second on the target: $\frac{N}{t} = \frac{I}{e}$ $\quad I$ = tube current

$\frac{1}{2}mv^2 = eV = hf = h\frac{c}{\lambda}$ ← To find velocity of electron, frequency and wavelength of X-ray.

Bragg's law: $2d\sin\theta = n\lambda$

Here,
d = lattice spacing; crystal spacing; planar spacing [unit is m]
θ = glancing angle $= 90 - i$ [unit is degree]
n = order of diffraction or reflection; $n = 1,2,3, \ldots\ldots$
For first order, $n = 1$
For second order, $n = 2$ and so on … …
λ = wavelength of x − ray [unit is m]

1. a. What are X-rays? Describe modern method for the production of X-rays. 3
   b. The production of the X-ray is the inverse process of photoelectric effect. 2
   c. How can you control the intensity and penetrating power (quality) of X-ray? 2
   d. Electrons in X-ray tube is accelerated by p.d. of $10KV$. If an electron produces one photon on impact with target, what is the minimum wavelength of X-rays? What is the velocity with which the electron hit the target? 2
   e. An x-ray tube works at dc potential difference of 50 KV. Only 0.4% of the energy of cathode rays (electrons) is converted into X-rays and heat is generated in the target at the rate of 600 watt. Estimate the current passed into the tube and the number of the electrons striking the target per second. [Mass of electron= $9 \times 10^{-31}Kg$, charge of $e = 1.6 \times 10^{-1}\ C$.] 3
   f. An x-ray tube works at a dc potential difference of 50 KV and the current through tube is 0.5 mA. Find:
      i. The number of electrons hitting the target per second. [*Ans:* 3.12×10^{15} ***electrons/sec***]
      ii. The energy falling the target per second as the KE of electrons. [*Ans:* $25\ Watts$]
      iii. The cut off wavelength of x-ray emitted. [*Ans:* $2.5 \times 10^{-11}m$]
      ($e = 1.6 \times 10^{-19}C$, $c = 3 \times 10^8\ m/s$, $h = 6.62 \times 10^{-34}\ Js$)
2. a. State Bragg's law of X-ray diffraction. Explain how this can be used to determine the crystal plane spacing. 3
   b. Can X-ray diffraction experiment be performed by an ordinary grating? Explain. 2
   c. X-rays of wavelength 0.36 A^0 is diffracted by a crystal at a glancing angle of 4.8^0. Find the spacing of the atomic planes in the crystal. 2
   d. X-rays are incident on a crystal of crystal spacing $3.08 \times 10^{-8}\ cm$ such that first order reflection takes place at glancing angle 12^0. Calculate the glancing angle for second order maximum. 2
   e. Can Bragg's law be verified with the yellow light? 2

Radioactivity

Activity (A) = Rate of distegration $\left(\frac{dN}{dt}\right)$

Units of activity:
1. Curie $1Ci = 3.7 \times 10^{10}\ dis/sec$
2. Rutherford: $1Rd = 10^6\ dis/sec$
3. Becquerel: $1Bq = 1\ dis/sec$

N_o = initial number of atoms
N = current number of atoms = number of undecayed atoms
$N_o - N$ = **number of decayed atoms**

Energy is released due to decay.
Total energy $= (N_o - N) \times$ **single energy**

Avogadro's Hypothesis:
✓ To convert mass into number
✓ To convert number into mass.

Example: for C^{14}
14 gram $= 6.023 \times 10^{23}$ atoms
And
6.023×10^{23} atoms = 14 grams

○ Decay Law: $A = \lambda N$

○ **Decay Equation:**

Number: $N = N_o e^{-\lambda t}$ | $t = \frac{1}{\lambda}\ln\left(\frac{N_o}{N}\right)$

Activity: $A = A_o e^{-\lambda t}$ | $t = \frac{1}{\lambda}\ln\left(\frac{A_o}{A}\right)$

mass: $m = m_o e^{-\lambda t}$ | $t = \frac{1}{\lambda}\ln\left(\frac{m_o}{m}\right)$

$$\frac{N}{N_o} = \left[\frac{1}{2}\right]^{t/T_{\frac{1}{2}}}$$

Half- life: $T_{1/2} = \frac{0.693}{\lambda}$ | Mean life: $\bar{T} = \frac{1}{\lambda}$

Types of radioactivity:
1. ***α − decay***: New nucleus is formed in which atomic number decreases by 2 and mass number decreases by 4.
2. ***β−decay***: New nucleus is formed in which atomic number increases by 1 and mass number remains constant.
3. ***γ − decay***: No new nucleus is formed.

1. a. What is radioactivity? How will you identify alpha beta and gamma radiation by simple experiment?
   b. Heavy unstable nucleus usually decay by emitting an alpha or beta particle why do they not usually emit a single proton or neutron?
   c. A nucleus contains no electrons, yet jet it ejects them. Explain
   d. How does a daughter nucleus differ from its parent nucleus when it emits
      i. alpha particle ii. beta particle iii. gamma particle
   e. Define the term decay constant. Write the laws of radioactivity and hence establish decay equation.
   f. What is half-life? How is half-life related to decay constant.
   g. A radioactive sample has a half-life of 8.3×10^4 years. Calculate disintegration constant and time taken for 25% of its activity to disappear. [**14.42 min**] 2
   h. Find the half-life of U^{238}, if 1 gram of it emits 1.24×10^4 α −particles per second. Avogadro's number $= 6.025 \times 10^{25}$. [4.5×10^9 ***years***] 2
   i. Half-life of Ra-226 is 1620 years. Estimate its mass when its activity is 0.5 Ci. [**0.52grm**] 2
2. a. If a radioactive nucleus has a half-life of one year, will it be completely decayed at the end of two years? Explain. 2
   b. If the half-life period of a radioactive substance is 2 days, after how many days will 1/64 th of the substance be left behind? [**12 days**] 2
   c. If 4 grams of a radioactive material of half-life period of 10 years disintegrates, find out mean life of the given sample. [**14.4** years] 2
   d. A radioactive source which has the half-life of 130 days, contain initially 10^{20} atoms and the energy released per disintegration is $8 \times 10^{-13}J$. Calculate the activity of the source after 260 days have elapsed and total energy released during this period. [$6 \times 10^7 J$] 2
   e. What is radiocarbon dating? How can you estimate the age of ancient object by radiocarbon dating?