[Time: Three Hours] **[Marks: 100]**

N. B.: (1) **All** questions are **compulsory**.
(2) **Figures** to the **right** indicate **full** marks.
(3) Draw **neat** diagrams wherever **necessary**.
(5) Symbols have usual meaning unless otherwise stated.
(5) Use of **non-programmable** calculator is allowed.

Q.1. A) **Select the correct alternative** **12**

(i) 10 g of radioactive material of half-life 15 years is kept in store for 20 years. The disintegrated material is _____

a. 9.5 g b. 3.96 g
c. 6.04 g d. 4.03 g

(ii) The sodium nucleus $_{11}Na^{23}$contains _____

a. 11 electrons b. 12 protons
c. 23 protons d. 12 neutrons

(iii) The minimum energy required for pair production is _____

a.0.511keV b.1.022 MeV
c.0.511MeV d.5.11keV

(iv) The average energy needed to ionize gas (eg. air) is of the order of a few _____

a.keV b.MeV
c.tens of eV d.hundreds of eV

(v) Wavelength of matter waves is _____

a. $\lambda = \frac{p}{hc}$ b. $\lambda = \frac{pc}{h}$
c. $\lambda = \frac{p}{h}$ d. $\lambda = h/p$

(vi) In Compton effect, the wavelength of the scattered ray is always _____ that of the incident ray.

a. greater than b. less than
c. greater than or equal to d. less than or equal to

B) **Answer in one sentence** **3**

(i) What are isotones?

(ii) Define nuclear fusion.

(iii) How can we control the penetration power of X-rays?

C) **Fill in the blanks** **5**

(i) A radioactive nucleus $_{92}X^{235}$decays to $_{91}Y^{231}$. Radiations emitted are _____

(ii) Half-life of ^{210}Bi is 5 days. If we start with 50,000 atom of this isotope, the number of atoms left over after 10 days will be _____

(iii) If the Q value of a nuclear reaction is positive then the reaction is termed as _____

(iv) A nuclear reaction in which the projectile picks up a nucleon from the target is termed as _____ reaction.

(v) The gain in energy of a photon that falls in a gravitational field is manifested as increase in _____

Q. 2 A) **Attempt ANY ONE** **8**

(i) On the basis of Rutherford's alpha scattering experiment, how will you estimate the size of the nucleus?

(ii) State the law of successive disintegration of radioactive substance. Explain transient equilibrium.

B) **Attempt ANY ONE** **8**

(i) Define and explain binding of a nucleus. Sketch the graph of binding energy per nucleon against mass number. Explain its characteristic features.

(ii) State and explain law of radioactive decay. Hence obtain the expression for half-life period.

C) **Attempt ANY ONE** 4

(i) Find the distance of closest approach, when alpha particles of energy 5.48 MeV are bombarded on ^{79}Au.

(ii) In natural carbon the abundance of ^{14}C is 1.3×10^{-12} and 5730 years is its half-life time. Calculate the number of disintegration/hour in 1 gram of natural carbon.

Q. 3 A) **Attempt ANY ONE** **8**

(i) Using the concept of compound nucleus formation, derive an expression for the threshold energy of a nuclear reaction.

(ii) Explain the construction and working of a GM counter.

B) **Attempt ANY ONE** **8**

(i) Derive an expression for Geiger rule i.e. $V_0^3 = CR$ where V_0 is initial velocity of the emitted particle and R is the range of the particle and C is a constant for the particular medium in which the range is defined.

(ii) Derive an expression for the nuclear disintegration energy i.e. balance of mass and energy in a nuclear reaction (Q-value)

C) **Attempt ANY ONE** 4

(i) Calculate the Q value for the reaction: $Pb^{210}(Fe^{54}, Fe^{56})Pb^{208}$
Given: The masses of Pb^{208}= 207.976641 amu,
Fe^{56}= 55.934939 amu, Fe^{54}= 53.939612 amu,
Pb^{210}=209.984178 amu, 1 amu = 931.5 MeV

(ii) A neutron beam is incident on a stationary target of F^{19}atoms. The reaction $F^{19}(n,p)O^{19}$has a Q-value of -3.9 MeV. Calculate the lowest neutron energy that will make this reaction possible. Assume the masses of nuclei are equal to their mass numbers expressed in "amu". Given: 1 amu=931.5 MeV

Q. 4 **A)** **Attempt ANY ONE** **8**

(i) Describe Laue's experiment on X-ray diffraction.

(ii) What is Compton effect? Write the experimental determination of the Compton shift.

B) **Attempt ANY ONE** **8**

(i) Give the elementary proof of Heisenberg's Uncertainty Principle.

(ii) Describe continuous and characteristic X-ray Spectra.

C) **Attempt ANY ONE** 4

(i) A bullet of mass 20 gm is moving with a speed of 350 m/s, measured with accuracy of 0.05%. Calculate the uncertainty in the location of the bullet.

(ii) X-ray tube emits X-rays with minimum wavelength 0.1 A^o. What is the operating voltage of the tube?

Q. 5 **Attempt ANY FOUR** **20**

(i) The number of first daughter element is given by; $N_2 = \frac{\lambda_1 N_0}{\lambda_2 - \lambda_1}\left[e^{-\lambda_1 t} - e^{\lambda_2 t}\right]$. Estimate the time ($t_m$) taken by second daughter to attend maximum.

(ii) Write a short note on nuclear charge and nuclear density.

(iii) Find the Q-value for the following reaction $N^{14}(\alpha, p)O^{17}$. The masses of the nuclei are given as mass of nitrogen = 14.00753 amu, mass of oxygen = 17.0045 amu, mass of alpha particle = 4.00387 amu and mass of proton is 1.00814 amu.
Given: 1 amu=931.5 MeV

(iv) Write short note on nuclear fission and nuclear fusion.

(v) Derive Bragg's equation for crystals.

(vi) In Compton scattering experiment, X-rays are scattered at angle 60^o with respect to the incident beam. If the wavelength of scattered X-ray is 3.022 A^o, calculate the wavelength of incident rays.
