[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) The binding energy of the nucleus is measure of its _____
a. Charge b. Mass
c. Momentum d. Stability

(ii) The energy which must be supplied to the nucleus to break it into its constituent nucleons is _____
a. potential energy b. packing fraction
c. binding energy d. kinetic energy

(iii) A gamma ray of energy 3.022MeV undergoes pair production, the kinetic energy of the resulting electron and positron _____
a. is 1.00 MeV each b. is 1.5 MeV for electron and 0.5 MeV for positron
c. is 0.5 MeV for electron and 1.5 MeV for positron d. cannot be determined.

(iv) The nuclear disintegration energy for the nuclear reaction denoted by *X(x, y)Y* (assuming target nucleus is at rest) is _____
a. $E_y+E_Y-E_x$ b. $E_y+E_x-E_Y$
c. $E_y-E_Y-E_x$ d. none of these.

(v) In the black body spectrum, as the temperature of body is increased, the peak wavelength shifts towards the _____ value.
a. smaller b. larger
c. no change d. infinite

(vi) Laue pattern is obtained due to _____ of X-rays at lattice planes
a. refraction b. dispersion
c. diffraction d. reflection

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

(i) What are isotopes?
(ii) Define stopping power
(iii) State Wien's displacement law.

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

(i) Ionizing power of β–particles is _____ than α–particles.
(ii) The ratio of half-life times of two elements A and B is $\frac{T_A}{T_B}$, the ratio of their respective decay constants $\frac{\lambda_A}{\lambda_B}$ will be _____
(iii) For an endothermic nuclear reaction, the Q value is _____

(iv) The breaking up of a heavy nucleus into two to more nuclei of comparable masses is called as _____

(v) The coefficient of reflection of perfectly black body is _____

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

(i) In case of successive disintegration of radioactive substance (A→B→C), if number of daughter nuclei (B) is given by;

$$N_2 = \frac{\lambda_1 N_0}{\lambda_2 - \lambda_1}\left[e^{-\lambda_1 t} - e^{\lambda_2 t}\right]$$

Then obtain number of atoms of stable granddaughter (C).

(ii) Define and explain mass defect and binding energy. Using graph, explain the variation of binding energy per nucleon with mass number.

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

(i) Explain Rutherford's alpha scattering experiment to determine the size of a nucleus.

(ii) State the law of radioactive transformations. Explain the phenomenon of carbon dating.

C) **Attempt ANY ONE.** 4

(i) Determine the minimum energy in MeV needed to break helium into free neutron and proton. Masses in amu are,
M(p) = 1.007825, M(n) = 1.008665, M(He) = 4.002603.

(ii) If a sample of radium has half-life time of the order of 22 years, find the time taken by a sample to decrease to 10%.

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

(i) Explain construction and working of a GM counter.

(ii) Derive an expression for the nuclear disintegration energy.

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 the solution of the Q-equation.
Given:

$$Q = E_y\left(1 + \frac{m_y}{M_Y}\right) - E_x\left(1 - \frac{m_x}{M_Y}\right) - \frac{2}{M_Y}\sqrt{m_x m_y E_x E_y}\cos\theta$$

where, E_y,E_x denote the kinetic energies of the ejectile and projectile respectively, m_y,m_x denote the masses of the ejectile and projectile respectively, M_Y is the mass of the residual nucleus and θ is the angle between the projectile and the ejectile directions of motion.

C) **Attempt ANY ONE** 4

(i) 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 -3.9MeV. Calculate the lowest neutron energy that will make this reaction possible.

Assume that the masses of the nuclei are equal to their atomic mass number expressed in "amu".

(ii) Calculate the amount of energy released when 238 gm of U^{238} fissions. Given that Avogadro's number is 6.023×10^{23} and the energy released when one atom of U^{238} fissions is 200MeV.

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

(i) What is Compton effect? Derive an expression for Compton shift.

(ii) With the help of Davisson Germer's experiment show the confirmations of the de Broglie hypothesis of matter waves.

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

(i) State and explain Heisenberg's Uncertainty Principle. Hence, show that an electron cannot exist in the nucleus.

(ii) Explain in detail the production of X-rays.

C) **Attempt ANY ONE** 4

(i) A black body emits maximum energy at wavelength $2x10^{-5}$ m when the temperature of black body is 90°C. If its temperature is increased to 200°C, calculate the wavelength at which the maximum energy will be emitted.

(ii) Using Uncertainty Principle, calculate the uncertainty in position of an electron, moving with 0.005% accuracy along x-axis with a speed of 340 m/s.

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

(i) Explain secular radioactive equilibrium.

(ii) Define packing fraction. Explain the features of packing fraction as a function of mass number.

(iii) Write a note on nuclear fission and nuclear fusion.

(iv) Explain construction of ionization chamber with neat labelled diagram.

(v) In Compton scattering experiment, X-rays of wavelength 3 A° are scattered at angle 60° with respect to the incident beam. Calculate the wavelength of scattered rays. Given: $\frac{h}{m_0 c} = 0.024 \times 10^{-10}$

(vi) What are matter waves? Give any four characteristics of matter waves.
