Q. No. 1 : Heavier nuclei have more neutrons than protons.

→ REASONS:

(i) Strong Nuclear Force: Protons in the nucleus repel each other due to like charges. Strong nuclear force holds protons and neutrons together in the nucleus. Neutrons add to attractive force without adding to electrostatic repulsion. Addition of more neutron helps to overcome electrostatic repulsion.

(ii) Balance of Forces: With greater neutrons, a balance between repulsion and strong force is achieved making nucleus stable.

(iii) Isotope Variation: Different isotopes of an element have same atomic number (protons) but neutrons may vary.

→ CONCLUSION: Number of protons and neutrons in a nucleus affect its stability and overall behaviour.

Q. No. 2 : → Half Life of Radium: Half life of Radium is 1600 yrs meaning it decays to half of initial amount after each 1600 years

→ Radio Active Decay Law: Radioactive decay law is given by $N = N_0 e^{-\lambda t}$

→ Time Taken for Complete Decay: Time required for complete decay is **infinity**

→ Mathematically: $N = N_0 e^{-\lambda t}$ as $t = \infty$ we can also write $N = N_0 \left(\frac{1}{2}\right)^{t/T_{1/2}}$ where $\left(\frac{1}{2}\right)^{t/T_{1/2}}$ becomes zero if $t = \infty$ thus

$$N = N_0 \times 0$$

→ Life of Universe: Life of universe **is not infinity** thus all Radium hasn't been decayed.

→ CONCLUSION: Infinite time is required to remove Ra from universe moreover $_{92}U^{238}$ also decays into Radium.

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Q. No. 3 : No, it's not possible to predict when sample will decay.

→REASONS:

(i) Probabilistic Nature of Radioactive Decay: Exact timing of when a specific nucleus will decay is inherently unpredictable. Radioactive decay is governed by probabilistic principles. Half life is the time it takes for half of a sample to decay.

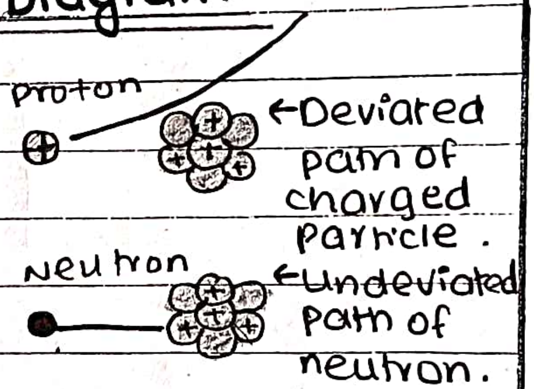
(ii) Uncertainty at Microscopic Level: Behaviour of individual nuclei is subject to quantum mechanics. Quantum principles prevent us from precisely predicting when a particular nucleus will undergo decay.

(iii) Trillion Nuclei in a Radioactive material: A block of radioactive material will contain many trillions of nuclei and not all nuclei are likely to decay at same time.

→CONCLUSION: Radiactive decay is a highly haphazard process.

Q. No. 4 : →REASONS:

Diagram:



(i) Neutral Charge: Neutrons carry no nuclear charge. Lack of charge reduces electrostatic repulsion with the target nucleus.

(ii) Penetrating Power: Neutrons are highly penetrative allowing them to traverse the electron cloud surrounding nucleus without being deflected. This increases likelyhood of reaching the nucleus and inducing a reaction.

(iii) Induction of Fission Reactions: Neutrons can induce fission reactions causing nucleus to split releasing more neutrons and significant amount of energy.

→CONCLUSION: These properties make them highly effective projectiles.

Q. No. 5: → Proton-Neutron Balance: The choice between β- or β+ decay depends on the balance of protons and neutrons in the nucleus generally if,

(i) Neutron activated nuclide has excess of neutrons:
β- decay is favoured **Reaction:** ${}_{Z}X^{A} \rightarrow {}_{Z+1}X^{A} + {}^{0}_{-1}\beta +$ antineutrino $+ Q$
neutron is converted into proton, -β and antineutrino are emitted

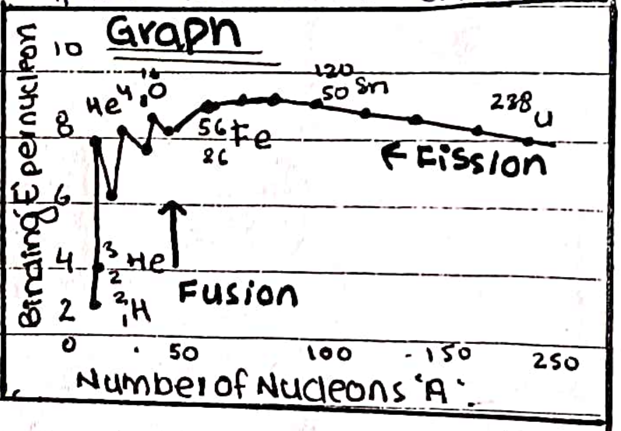
(ii) Neutron activated nuclide has excess of protons:
β+ decay is favoured **Reaction:** ${}_{Z}X^{A} \rightarrow {}_{Z-1}X^{A} + {}_{+1}\beta^{0} +$ neutrino $+ Q$
Proton's converted into neutron & a +β and neutrino are emitted.

→ Nature of Neutron Activated Nuclei: As neutron activated nuclei contain more neutrons, so they emit β^- rather than β^+ particle.

→ Conclusion: The preference for β^- or β^+ decay is driven by the nucleus's quest for more stable configuration.

Q. No. 6: → REASONS: Stability depends upon balance between forces

(i) Small Nuclei: Fewer Neutrons cause repulsive electrostatic forces between protons to become more significant. Proton-Proton repulsion makes nucleus unstable.



(ii) Large Nuclei: Increased protons increase coulomb repulsion due to which large number of nuclei are required to contribute to attractive strong force without adding to electrostatic repulsion. Unstable neutron to proton ratio may result making nucleus unstable.

Other factors: Surface effects in smaller nuclei cause unstability. Shell structure may also affect stability.

→ CONCLUSION: Stability is an interplay of various nuclear forces and structural considerations.

Q. No. 7: Due to differences in design and intended purpose, nuclear reactors aren't explosive like nuclear bombs

→**EXPLANATION: (i) Control Mechanisms:** Moderators and control rods regulate rate of fission reactions. Multiple barrier scheme is adopted in reactors.

(ii) Fuel Enrichment: Low enriched Uranium with U^{235} concentration 3-5% is used as reactor fuel, this is significantly lower than enrichment levels over 90% required for a nuclear reactor.

(iii) Neutron Moderation and Energy Release: Neutron moderation slows down neutrons moreover reactors are designed to release energy steadily over a long period.

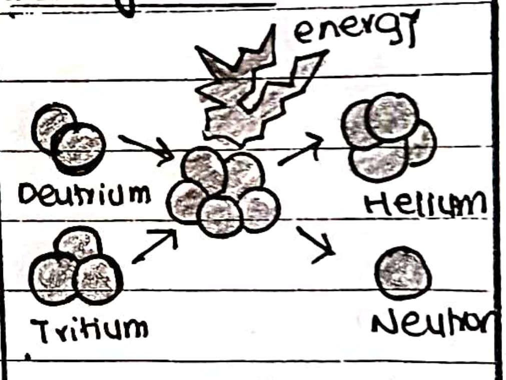
→**CONCLUSION:** Thus intent and design of nuclear reactors is for peaceful energy production on the other hand bombs are designed for obliterate destruction purposes.

Q. No. 8: →**Fusion Reaction:** In fusion reaction, two light nuclei merge to form a single heavier nucleus

Reaction: $^2_1H + ^3_1H \rightarrow ^4_2He + n^1_0 + 24MeV$

→**Mass of Resulting Nucleus:** Total mass of resulting nucleus is less than the mass of two original nuclei

Diagram:



▲Fusion Reaction

→**Einstein Energy Mass Equation:** The difference of mass Δm of two original nuclei and the resulting single nucleus appears as energy. **Mathematically:** $\Delta E = \Delta mc^2$

Mass and energy are interconvertable.

→**Conclusion:** Thus it can be concluded that in order to conserve mass, energy is released as a result of fusion process.

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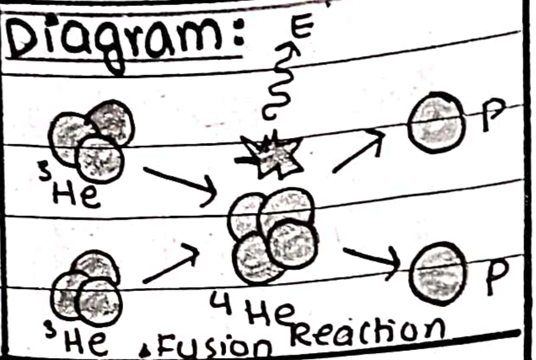
Q. No. 9: → FACTORS MAKING FUSION REACTION DIFFICULT

(i) Overcoming Repulsive Forces:

Fusion of two light nuclei requires work to be done against electrostatic force of repulsion between the positively charged light nuclei. For this purpose, nuclei are moved towards each other with very high velocity and high kinetic Energy.

Diagram:



(ii) High Temprature Requirement: Temprature about 10 million degrees celsius is required for fission as at this temprature nuclei attain sufficient kinetic energy.

(iii) Economic Viability: Fusion reactors which are economically competitive with other energy sources are a challenge to develope.

→ **CONCLUSION:** These challenges are faced by fusion reactions.

Q. No. :