Nuclear Reactions – Outcomes

- Discuss conservation in nuclear reactions.
- Discuss the prediction of the neutrino.
- Solve problems about nuclear reactions.
- Describe the Cockcroft and Walton experiment.
- Solve problems about the experiment.
- Explain why the experiment was noteworthy.
Conservation

- In nuclear reactions, mass/energy, momentum, and charge are all conserved.
- In beta decay, momentum appeared to not be conserved.
- e.g. \( ^{14}_6\text{C} \rightarrow ^{14}_7\text{N} + _{-1}^0\text{e} \) conserves charge and mass/energy, but not momentum.
Neutrino

- Wolfgang Pauli (of exclusion principle fame) proposed that an undetected third tiny neutral particle was emitted, calling it the neutrino, \( \nu \).
- This neutrino carried away the missing momentum.
- The neutrino was observed experimentally in 1956.
Cockcroft and Walton

- Protons released from top (hydrogen discharge tube).
- Protons accelerated through high voltage.
- Protons strike lithium target.
- Lithium splits into two parts, moving in opposite directions to conserve momentum.
- $\frac{7}{3}Li + \frac{1}{1}H \rightarrow \frac{4}{2}He + \frac{4}{2}He + \text{energy}$
Cockcroft and Walton – Significance

- First artificial splitting of the nucleus.
- First transmutation (changing one element to another) using artificially accelerated particles.
- This won the Nobel Prize for Physics!
- Walton was Irish and won the only Irish Nobel Prize in Science until 2015.
When lithium-7 is bombarded with a proton, two alpha particles are produced. How much energy is released in this reaction?

- $m_{Li-7} = 1.165007 \times 10^{-26} \text{ kg}$
- $m_p = 1.673493 \times 10^{-27} \text{ kg}$
- $m_\alpha = 6.646322 \times 10^{-27} \text{ kg}$