HSC PHYSICS ASSESSMENT TASK 3

RESEARCH TASK – Depth Study Nuclear Physics

TOPIC: Module 8: From the Universe to the Atom

Weighting: 25%

Due Date: In-class Monday 15th June Period 3 & 4, Week 8, Term 2

Task overview:

You will sit an "open book" exam on the outcomes, skills and content from the HSC Physics syllabus. You may bring to this exam **ONE A4 piece of paper*** of notes that you may consult in the exam. This task not only aims to assess your knowledge and understanding, but also encourages a thorough preparation of the course notes ready for the HSC examination along with a focus on summarising key information.

You MUST include a reference list for your research. *You are permitted a separate piece of paper for your reference list.*

** The ONE A4 piece of paper can have writing on both sides of the paper and can be either hand-written or typed using a word processor.*

Context: Beginning in the late 19th and early 20th centuries, experimental discoveries revolutionised the accepted understanding of the nature of matter on an atomic scale. Experimental investigations of the nucleus have led to an understanding of radioactive decay, the ability to extract energy from nuclear fission and fusion, and a deeper understanding of the atomic model.

This task aims at achieving the following outcomes within the context of the Properties of the Nucleus

Outcomes:

A student:

- analyses and evaluates primary and secondary data and information PH11/12-5
- solves scientific problems using primary and secondary data, critical thinking skills and scientific processes PH11/12-6
- communicates scientific understanding using suitable language and terminology for a specific audience or purpose PH11/12-7
- explains and analyses the evidence supporting the relationship between astronomical events and the nucleosynthesis of atoms and relates these to the development of the current model of the atom PH12-15

To conduct your research for this task you should:

- Identify, access, summarise and collate appropriate information from a wide range of resources, including but not limited to popular scientific journals, digital technologies, the internet and books.
- All resources must be included in the bibliography and must be properly referenced using APA referencing style.
- Identify and apply appropriate mathematical formulae and concepts where relevant.
- Ensure that the information and formulas you have gathered as part of the research task are from valid and reliable sources.
- Include symbols, formulas and pictorial representations where appropriate to help you present information clearly and succinctly.

Your research should allow you to answer questions on the following content to answer the Inquiry Question: How can the energy of the atomic nucleus be harnessed? (hint: tick off each point as you go so that you know that you have covered the content)

- Identify elements from the periodic table of elements
- Identify components of the nucleus (protons and neutrons) as nucleons and contrast their properties.
- Define the term ‘transmutation’ and relate it to the spontaneous decay of an unstable nucleus.
- Outline the properties of alpha, beta and gamma radiation emitted from nuclear decay.
- Construct nuclear reaction equations for both alpha and beta decay (positive and negative) reactions.
- Outline the concept of half-life in radioactive decay and use appropriate equations to make quantitative predictions about the activity or amount of a radioactive sample.
- Explain the concept of mass defect using Einstein’s equivalence between mass and energy.
- Solve problems and analyse information to calculate the mass defect, binding energy and energy released during a fission reaction.
- Explain the basic principles of a fission reactor, focusing on the main parts of a reactor and their specific function.
- Model and explain the processes of nuclear fission for a controlled and uncontrolled nuclear chain reaction.

Below is the syllabus content for the inquiry question. You should refer to the summary above and the below syllabus content points when conducting your research. (hint: when researching the above information you should have covered everything below. Tick off each point as you go so that you know that you have covered the content)

Properties of the Nucleus

Inquiry question: How can the energy of the atomic nucleus be harnessed?

Students:

- analyse the spontaneous decay of unstable nuclei, and the properties of the alpha, beta and gamma radiation emitted (ACSPH028, ACSPH030)
- examine the model of half-life in radioactive decay and make quantitative predictions about the activity or amount of a radioactive sample using the following relationships:
  - $N_t = N_o e^{-\lambda t}$
  - $\lambda = \frac{ln2}{t_{1/2}}$

  where $N_t =$ number of particles at time t, $N_0 =$ number of particles present at $t = 0$, $\lambda =$ decay constant, $t_{1/2} =$ time for half the radioactive amount to decay (ACSPH029)
- model and explain the process of nuclear fission, including the concepts of controlled and uncontrolled chain reactions, and account for the release of energy in the process (ACSPH033, ACSPH034)
- analyse relationships that represent conservation of mass-energy in spontaneous and artificial nuclear transmutations, including alpha decay, beta decay, nuclear fission and nuclear fusion (ACSPH032)
- account for the release of energy in the process of nuclear fusion (ACSPH035, ACSPH036)
- predict quantitatively the energy released in nuclear decays or transmutations, including nuclear fission and nuclear fusion, by applying: (ACSPH031, ACSPH035, ACSPH036)
  - the law of conservation of energy
  - mass defect
  - binding energy
  - Einstein's mass–energy equivalence relationship $E = mc^2$