Unit Planner: Atomic, nuclear and particle Physics
IB Physics 11

Tuesday, 30 June 2015, 11:22AM

Last Updated: Sunday, May 24, 2015 by Shabih Fatima

Fatima, Shabih; Sahid, Rukhaidah; Yusuf, Berna

Inquiry - establishing purpose of the unit

Unit description and texts

DP Assessment Criteria

https://ibphysics2016.wikispaces.com/Internal+Assessment

IB Learner Profile

- Inquirers
- Knowledgeable
- Thinkers
- Communicators
- Open-minded
- Caring
- Risk-takers
- Reflective

Diploma Programme Aims

DP Group 4: Physics (1st Assessments 2016)

DP - Age 16-18

Aims

The aims enable students, through the overarching theme of the Nature of science, to:

appreciate scientific study and creativity within a global

Diploma Programme Syllabus Content

Syllabus - Topic 7: Atomic, nuclear and particle physics (Core)

7.1 – Discrete energy and radioactivity - Nature of science

Show details

Accidental discovery: Radioactivity was discovered by accident when Becquerel developed photographic film that had accidentally been exposed to radiation from radioactive rocks. The marks on the photographic film seen by Becquerel probably would not lead to anything further for most people. What Becquerel did was to correlate the presence of the marks with the presence of the radioactive rocks and investigate the situation further. (1.4)

7.1 – Discrete energy and radioactivity - Understandings

Discrete energy and discrete energy levels

Transitions between energy levels

Diploma Programme Objectives

DP Group 4: Physics (1st Assessments 2016)

DP - Age 16-18

Assessment objectives

1a. Demonstrate knowledge and understanding of facts, concepts and terminology

1b. Demonstrate knowledge and understanding of methodologies and techniques

1c. Demonstrate

context through stimulating and challenging opportunities

acquire a body of knowledge, methods and techniques that characterize science and technology

apply and use a body of knowledge, methods and techniques that characterize science and technology

develop an ability to analyse, evaluate and synthesize scientific information

develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities

develop experimental and investigative scientific skills including the use of current technologies

develop and apply 21st-century communication skills in the study of science

Radioactive decay

Fundamental forces and their properties

Alpha particles, beta particles and gamma rays

Half-life

Absorption characteristics of decay particles

Isotopes

Background radiation

7.1 – Discrete energy and radioactivity - Applications and skills

Describing the emission and absorption spectrum of common gases

Solving problems involving atomic spectra, including calculating the wavelength of photons emitted during atomic transitions

Completing decay equations for alpha and beta decay

Determining the half-life of a nuclide from a decay curve

Investigating half-life experimentally (or by simulation)

7.1 – Discrete energy and radioactivity - Guidance

Students will be required to solve problems on radioactive decay involving only integral numbers of half-lives

Students will be expected to include the neutrino and antineutrino in beta decay equations

7.2 – Nuclear reactions - Nature of science

Show details

Patterns, trends and discrepancies: Graphs of binding energy per nucleon and of neutron number versus proton number reveal unmistakable patterns. This allows scientists to make predictions of isotope characteristics based on these graphs. (3.1)

7.2 – Nuclear reactions - Understandings

The unified atomic mass unit

Mass defect and nuclear binding energy

knowledge and understanding of communicating scientific information.

2a. Apply facts, concepts and terminology

2b. Apply methodologies and techniques

2c. Apply methods of communicating scientific information.

3a. Formulate, analyse and evaluate hypotheses, research questions and predictions

3b. Formulate, analyse and evaluate methodologies and techniques

3c. Formulate, analyse and evaluate primary and secondary data

3d. Formulate, analyse and evaluate scientific explanations.

4. Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations.

become critically aware, as global citizens, of the ethical implications of using science and technology	Nuclear fission and nuclear fusion **7.2 – Nuclear reactions - Applications and skills** Solving problems involving mass defect and binding energy Solving problems involving the energy released in radioactive decay, nuclear fission and nuclear fusion
develop an appreciation of the possibilities and limitations of science and technology	Sketching and interpreting the general shape of the curve of average binding energy per nucleon against nucleon number **7.2 – Nuclear reactions - Guidance**
develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge.	Students must be able to calculate changes in terms of mass or binding energy Binding energy may be defined in terms of energy required to completely separate the nucleons or the energy released when a nucleus is formed from its nucleons **7.3 – The structure of matter - Nature of science** Show details Predictions: Our present understanding of matter is called the Standard Model, consisting of six quarks and six leptons. Quarks were postulated on a completely mathematical basis in order to explain patterns in properties of particles. (1.9) Collaboration: It was much later that large-scale collaborative experimentation led to the discovery of the predicted fundamental particles. (4.3) **7.3 – The structure of matter - Understandings** Quarks, leptons and their antiparticles Hadrons, baryons and mesons The conservation laws of charge, baryon number, lepton number and strangeness The nature and range of the strong nuclear force, weak nuclear force and electromagnetic force Exchange particles Feynman diagrams Confinement

The Higgs boson

7.3 – The structure of matter - Applications and skills

Describing the Rutherford-Geiger-Marsden experiment that led to the discovery of the nucleus

Applying conservation laws in particle reactions

Describing protons and neutrons in terms of quarks

Comparing the interaction strengths of the fundamental forces, including gravity

Describing the mediation of the fundamental forces through exchange particles

Sketching and interpreting simple Feynman diagrams

Describing why free quarks are not observed

7.3 – The structure of matter - Guidance

A qualitative description of the standard model is required

DP Group 4:Physics (1st Exams 2009)

DP - Age 16-18

Syllabus - Atomic and nuclear physics

Half-life

7.2.6 State that radioactive decay is a random and spontaneous process and that the rate of decay decreases exponentially with time.

7.2.7 Define the term radioactive half-life.

7.2.8 Determine the half-life of a nuclide from a decay curve.

7.2.9 Solve radioactive decay problems involving integral numbers of half-lives.

7.3 Nuclear reactions, fission and fusion Nuclear reactions

7.3.1 Describe and give an example of an artificial (induced) transmutation.

7.3.2 Construct and complete nuclear

equations.

7.3.3 Define the term unified atomic mass unit. ⊗

7.3.4 Apply the Einstein mass–energy equivalence relationship. ⊗

7.3.5 Define the concepts of mass defect, binding energy and binding energy per nucleon. ⊗

7.3.6 Draw and annotate a graph showing the variation with nucleon number of the binding energy per nucleon. ⊗

7.3.7 Solve problems involving mass defect and binding energy. ⊗

Fission and fusion

7.3.8 Describe the processes of nuclear fission and nuclear fusion. ⊗

7.3.9 Apply the graph in 7.3.6 to account for the energy release in the processes of fission and fusion. ⊗

7.3.10 State that nuclear fusion is the main source of the Sun's energy. ⊗

7.3.11 Solve problems involving fission and fusion reactions. ⊗

Transfer Goals

List here one to three big, overarching, long-term goals for this unit. Transfer goals are the major goals that ask students to "transfer" or apply, their knowledge, skills, and concepts at the end of the unit under new/different circumstances, and on their own without scaffolding from the teacher.

Action - teaching and learning through inquiry

Content/skills/concepts - essential understandings

Central Idea / Content

Students will know the following content:

Students will develop the following skills:

Students will grasp the following concepts:

Learning Process

Check the boxes for any pedagogical approaches used during the unit. Aim for a variety of approaches to help facilitate learning.

Learning experiences and strategies/planning for self-supporting learning:

Weekly Instructional Strategies & Activities

Week 1:

- Draw structure of various atoms
- Describe Rutherford's model of the atom
- Outline 4 limitations in Rutherford's simple atomic model
- **Use Phet simulation on Rutherford's model**
- Describe how atomic spectra provide evidence for the atomic energy levels
- watch video on Rutherford model of atom

Week 2:

- Identify the continuous, emission and absorption spectra
- Calculate the gravitational force between protons in a nucleus
- Calculate the electrostatic force between 2 protons in the nucleus
- Define the terms nuclide, isotope, nucleon, proton number and neutron number
- Solve IB past paper problems

Week 3:

- Define the term unified atomic mass unit, binding energy and binding energy per nucleon.
- Solving problems involving mass defects and binding energy
- Explain Binding energy
- Calculate binding energy of various isotopes
- draw binding energy curve and label it
- Calculate half life of isotopes
- Drawing half life curves
- Solving problems involving integral number of half lives
- **Calculating Half life simulation using die**
- Data Analysis activity (Thorium)
- Solving problems involving mass defects and binding energy
- Solving problem on fission and fusion reactions
- **Phet simulation on fission**
- Topic test

Week 4:

- **Use Phet simulation on alpha and beta decay**
- Describe the phenomenon of natural radioactive decay.
- Describe the properties of alpha, beta and gamma radiations
- Outline the biological effects of ionizing radiations
- Define the term Radioactive Half-life
- **Calculate the half-life of M&Ms and use data sheet to record data and analyse it**
- **Data analysis activity on Thorium**
- **Solve IB past paper problems**
- **You tube video on radioactivity**

Week 5:

- Define Nuclear fission and fusion

- Describe the difference between an elementary particle and a composite particle.
- Describe the concepts underlying the difference between hadrons and leptons
- Explain the reason that led Enrico Fermi to predict the existance of the neutrino.
- **You tube video on elementary particles**
-
-

Formative Assessment

Summative Assessment

Radioactive decay simulation
Formative: Performance: Lab Assignment
8 Standards Assessed

-

Data Analysis activity
Formative: Written: Report
2 Standards Assessed

-

Test
Summative: Test: Written
12 Standards Assessed

-

Differentiation(s)

Approach (s) to Learning

Check the boxes for any explicit approaches to learning connections made during the unit. For more information on ATL, please see the guide.

Language and Learning

Check the boxes for any explicit language and learning connections made during the unit. For more information on the IB's approach to language and learning, please see the guide.

TOK Connections

Check the boxes for any explicit TOK connections made during the unit

CAS Connections

Check the boxes for any explicit CAS connections. If you check any of the boxes, provide a brief note in the "details" section explaining how students engaged in CAS for this unit.

Resources

List and attach (if applicable) any resources used in this unit

- Phet simulations (physics)
- Selected questions from exercises in the relevant chapters in student textbook and Dot point Physics
- Physics yr 11 teachers resource and assessment disk
- Academic teacher resources
- IBO teacher support materials
- http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/ruther14.swf
- Hewitt, P 2001, *Conceptual Physics*, Pearson Education, USA.
- Lofts, G et al. 2005, *Jacaranda Physics 2*, 2nd edn (including CD-ROM), John Wiley & Sons Australia Ltd, Brisbane.
- Crocodile physics website
- http://www.exploratorium.edu/snacks/radioactive_decay/index.html

Reflection - Considering the planning, process and impact of the inquiry

What worked well

List the portions of the unit (content, assessment, planning) that were successful

What didn't work well

List the portions of the unit (content, assessment, planning) that were not as successful as hoped

Notes/Changes/Suggestions:

Teacher Notes

List any notes, suggestions, or considerations for the future teaching of this unit

- Students should be able to describe a simple model involving electrons kept in orbit around the nucleus as a result of the electrostatic attraction between the electrons and the nucleus.
- A qualitative description of the Geiger–Marsden experiment and an interpretation of the results are all that is required.
- Students should be familiar with emission and absorption spectra, but the details of atomic models are not required. Students should

understand that light is not a continuous wave but is emitted as “packets” or “photons” of energy, each of energy hf.

- Students need only know about the Coulomb interaction between protons and the strong, short-range nuclear interaction between nucleons.
- The inclusion of the antineutrino in $\beta-$ decay is required.
- Students should be familiar with the direct and indirect effects of radiation on structures within cells. A simple account of short-term and long-term effects of radiation on the body is required.
- An explanation in terms of relative numbers of protons and neutrons and the forces involved is all that is required.
- Exponential decay need not be treated analytically. It is sufficient to know that any quantity that reduces to half its initial value in a constant time decays exponentially. The nature of the decay is independent of the initial amount.
- Students must be familiar with the units MeV c^{-2} and

			GeV c^{-2} for mass • Students should be familiar with binding energies plotted as positive quantities.