Module 2 – Road to fusion

FuseNet educational materials for secondary school

Teacher's manual v.1.0

General introduction

Energy plays a fundamental role in our modern society. With the increasing growth of technologies and the number of users of all these technologies, the world's energy demands are estimated to increase continuously. If we should continue the processes of generating energy then eventually the demand will be higher than we could possibly offer. Therefore, this series of lessons will provide insight into a possible future energy solution: nuclear fusion.

This lesson series start with module 1 fusion basics, which will provide the students with the required basics to work with and understand all the other modules. **Therefore, module 2 *Road to fusion* can be used when the content of module 1 has been introduced.**

This series of lessons is intended for pre-university education: level ISCED 3-4.

Using the modules

The student readers consist of different lesson materials: the bright coloured boxes, which are called 'aside', will provide extra explanations of the underlying topics. These are optional to use in the classroom.

The light-coloured boxes provide classroom exercises. These can be used during class for further discussion and can serve as a check to test whether the students understand the material.

Next to the module there are also additional exercises. These exercises are scaled from * until ***, in which * corresponds to introductory problems and *** corresponds to more challenging problems.

The full content of a modules consists of:

- A student reader
    - including classroom exercises
- Additional exercises
- A PowerPoint
    - Including classroom exercises
- Teacher manual
    - Including the following appendices
        - Table of constants and conversion factors
        - Answers to the classroom exercises
        - Answers to the additional exercises

Content of the teacher manual

Chapter 1: Learning objectives

At the end of this module, students are able to:

- Understand the complex connection between science and society
- Explain how fusion was discovered
- Identify different types of basic fusion devices
- Construct a timeline of first machines
- Identify the international conflicts and collaborations that affected the development of fusion
- Discuss why fusion has suffered from delays
- Understand the need for bigger and more complex fusion devices
- Explain how the ITER project was started
- Summarize the goals of the ITER project

Chapter 2: Closely related subjects or lessons

Next to the subjects of Module 1 the following concepts are assumed to be known:

- The Cold War
    - The involved countries
    - The result of the Cold War
- The second world war
    - The influence of WWII on the relationships between countries in general
    - The influence of WWII on the relation between United States and Soviet Union

This knowledge is not required to start this module but can help to reach more depth in explaining the different choices, inventions and problems.

- *Ethics*
    - *The existence of a code of conduct*
    - *The role of ethics in Physics, politics and during wartime*
- *Economics*
    - *The difference in wealth between countries*
- *Politics*
    - *The influence of national politics on the perceived importance of topics, such as climate change or energy*

Chapter 3: Topics of Module 2 per chapter

This module will start with the discoveries concerning fusion during the early 1900's and will end with the current situation and a future perspective. It will give a linear view on the historical, scientific and social perspectives of fusion. In all the chapters the content and influence of the Cold War and WWII can be noticed. Due to the historical nature of this module, the focus of this module is not just on the involved physics. Still, two scientific topics which are treated in depth in this module are pinches and (gradient) drifts.

1. The discovery of fusion
    - The Sun
        - Energy production
        - Proton-proton chain
        - Quantum tunnelling
    - Scattering
2. First devices
    - Pinch devices
        - Z-Pinch
        - Θ-Pinch
    - Stellarators
        - Pump-out
    - Tokamak
        - Thomson scattering
    - Electricity
        - Current
    - Electromagnetism
        - Solenoid
        - Magnetic field strength
        - gradient drift
    - Plasma
        - Plasma confinement
3. Improvements
    - Scientific breakeven
        - Q-factor
    - Funding
        - The need for energy
        - Oil embargo
    - Instabilities
    - Radiation
        - alpha
        - beta
        - gamma
4. ITER
    - History
    - Peace projects
        - ISS
        - CERN
        - ITER
    - Goals
        - Society related
        - Science related
    - Future

Chapter 4: Brief summary of module 2

The goal of this module is to increase a student's knowledge on the relationship between science and society. This relation is complex and can depend on politics, stakeholders and funding.

Chapter 1 gives an introduction into the origin and discovery of fusion energy. From the sun we learned that energy is emitted during nuclear reactions in a process called the proton-proton chain (p-p chain). These chains will convert 4 hydrogen nuclei into 1 helium nucleus. For these p-p chains to occur naturally, the temperature in the Sun needed to be much larger than it was estimated to be. However, the introduction of quantum mechanics led to the discovery of the phenomenon of quantum tunnelling, which allows for fusion reactions to occur in the Sun at the estimated temperatures. With this knowledge people tried to make these reactions possible on Earth and used it to produce energy. During these experiments, however, scientists found out that scattering was much more likely than fusion.

Chapter 2 is about the first devices which start to appear around the time of WWII and the Cold War. During that period of time three countries were mainly involved in fusion experimentation: the UK, the US and the Soviet Union. The building of fusion devices and experimentation with these devises really started to increase after 1950 due to (government) funding. However, to prevent possible side effects such as espionage and the possibility of making bombs, the development of these machine was kept really secret. Three main discoveries were made: pinch devices, the stellarator and the tokamak. The development of each of these machines is briefly discussed. The working principle of pinch devices can be treated in depth for advanced students by using classroom exercise 2.2. Also, students can use additional exercise A.3 to gain more insight into the phenomenon of plasma drift, by learning about the gradient drift.

Chapter 3 focuses on the road to improvement. With all the new discoveries regarding the tokamak and the physical aspects (e.g., magnets) many countries started to improve the tokamak by themselves for multiple reasons. However, each improvement led to new problems like size and instabilities. To cope with these problems the individual countries started to work together in one big project: ITER was started.

Chapter 4, the last chapter, focuses on ITER and the future of fusion. ITER started as a cooperation during the cold war by the US, Soviet Union, Japan and Europe. During the long negotiations of many years, some countries joined the cooperation, while others disappeared and some reappeared later. In 2006 the agreement was signed and they started building the project. In 2025 the first experiments will start. The project of ITER and the experiments will be finished in 2050. ITER wants to go beyond scientific breakeven, prove that fusion is safe and will hope to provide the most fusion power that has been possible until now. It is important to make the difference between fusion power and electricity generated by fusion power. Fusion is not converted into electricity with a 100% efficiency!

Chapter 5: Basic lesson schemes

Like in the first module, there are basic lesson schemes for direct use. However, due to the content of the module there is only one lesson scheme for both average and advanced students. One of a 15 minutes class and one for a lesson of one hour. The goal of these lesson schemes is to give an idea of a lesson and to decrease the preparation for the teacher. Feel free to adapt the scheme to your own lesson plan. However, it is good to know that this module is written chronologically. Therefore, the road to fusion has to be given in a specific order.

For both lesson schemes the student activities, preparation and classroom ideas are the same.

The student activities involve listening, discussing, asking questions and working on the exercises.

Preparation for this lesson involves:

- Downloading the PowerPoint
- Making the student reader and additional exercises available for students

Ideas for classroom: Discuss! Try to open a discussion about the social aspects of fusion. What could happen with the knowledge of fusion (and other related scientific topics)? Was the reason for secrecy about fusion just? Was the secrecy in fusion ethically correct?

15-min introductory lesson

The goal is to show the students the discovery of fusion and the questions which arose in the process of discovery and to show the first devices.

The material that is needed only covers the first chapter of the module; page 1 until 8, up to and including classroom exercise 2.1 and 2.2. Furthermore, slides 1 until 12 of the PowerPoint can be used.

Duration	Teacher activity	Materials	Student activity
2 min	Introduction of the topic	Chapter 1: PowerPoint slide 1 and 2	Listen
5 min	Discuss classroom exercise 2.1 with the students who have questions.	Chapter 1: PowerPoint slide 3 until 7	Work in pairs: discuss the road to the solution
5 min	Presenting the timeline and zoom in on the scientific aspect of pinches	Chapter 1 and 2: PowerPoint slide 8 until 10	Listen, ask questions,
3 min	Discuss classroom exercise. 2.2a and b	Chapter 2: PowerPoint slide 11	Work in pairs: discuss the road to the solution.

1-hour lesson

The one-hour lesson is an extension of the 15 minutes lesson.

The material that is needed only covers the first chapter of the module; page 1 until 8, up to and including classroom exercise 2.1 and 2.2. Furthermore, slides 1 until 12 of the PowerPoint can be used.

Duration	Teacher activity	Materials	Student activity
2 min	Introduction of the topic	Chapter 1: PowerPoint slide 1 and 2	Listen
5 min	Discuss classroom exercise 2.1 with the students who have questions.	Chapter 1: PowerPoint slide 3 until 7	Work in pairs: discuss the road to the solution.
5 min	Presenting the timeline and zoom in on the scientific aspect of pinches	Chapter 1 and 2: PowerPoint slide 8 until 10	Listen, ask questions
3 min	Discuss classroom exercise. 2.2	Chapter 2: PowerPoint slide 11 and 12	Work in pairs: discuss the road to the solution
8 min	Presenting the different devices. Try to discuss why there was secrecy according to the students (slide 13).	Chapter 2: PowerPoint slide 13 until 16	Listen, ask questions, classroom discussion
4 min	Let the students work at classroom exercise. 2.3 and discuss in class.	Chapter 2: PowerPoint slide 17 and 18	Work in pairs on the assignment.
5 min	Presenting chapter 2 and 3	Chapter 2 and 3: PowerPoint slide 19 until 21	Listen, ask questions
3 min	Discuss classroom exercise. 2.4	Chapter 2: PowerPoint slide 22 and 23	Work alone on the exercise.
2 min	Presenting chapter 3	Chapter 3: PowerPoint slide 24	Listen, ask questions
1 min	Presenting chapter 4	Chapter 4: PowerPoint slide 25	Listen, ask questions
5 min	Discuss classroom exercise. 2.5	Chapter 2: PowerPoint slide 26 and 27	Classroom wide discussion
2 min	Presenting chapter 4	Chapter 4: PowerPoint slide 28	Listen, ask questions

5 min	Discuss classroom exercise. 2.6	Chapter 2: PowerPoint slide 29 and 30	Work in pairs on the classroom exercise
2 min	Presenting chapter 4	Chapter 4: PowerPoint slide 31	Listen, ask questions
5 min	Discuss classroom exercise. 2.7	Chapter 2: PowerPoint slide 32 and 33	Classroom wide discussion
3 min	Presenting the goals of ITER and closing the module	Chapter 4: PowerPoint slide 34 and 35	Listen, ask questions

Chapter 6: Use of PowerPoint and other materials

There is a PowerPoint (for each module) available at the site. https://fusenet.eu/education/material.

The PowerPoint consists of the whole module, including the classroom exercises and answers, and can be used directly in class. There are some extra pictures used to explain the topics. If there is a possible YouTube video of Phet which can be used for a topic, the link can be found in the notes of the corresponding slide. For an overview of extra material see chapter 7. You can adapt the PowerPoint to the topics which are treated in the classroom.

To introduce the different topics of module 2, it is possible to give the students a preparation exercise at home per topic. This could be one or more of the * exercises of the additional exercises. For the preparation also some subjects from 'further references for study and fun' can be used. See chapter 7.

Chapter 7: Further references for study and fun for module 2:

For teachers

The following contains general background information (in English) for teachers of this module. This is merely intended to use for your own knowledge and understanding of the subject. It is possible to use this content in the classroom but then it has to be adapted to the level of the students.
Some sites will give information about the topics covered or related to this module. Other sites also give pictures, exercises (with or without answers) and extra lecture notes. Under each URL there is a short introduction of what can be found.

a. FuseNet website - https://www.fusenet.eu/education/material Here you can find the other four modules. Furthermore, there are also theoretical papers, courses and experiments of topics related to this lesson series.
b. Transmutation Effects observed with Heavy Hydrogen – nature
   https://www.nature.com/articles/133413a0
   OLIPHANT, M., HARTECK, P. & RUTHERFORD Transmutation Effects observed with Heavy Hydrogen. *Nature* **133,** 413 (1934). https://doi.org/10.1038/133413a0
   A paper about effects of bombarding hydrogen on other ions
c. https://www.nature.com/articles/4351142a
   Butler, D. Japan consoled with contracts as France snares fusion project. *Nature* **435,** 1142 (2005). https://doi.org/10.1038/4351142a
   A short article about the dissection of the location of ITERs tokomak.

For teachers and students

At the end of the module, you can find further reading material. The material in this chapter can be used as an extra explanation for the students in class. Some URLs give a more in-depth look on the different topics or give an example of an experiment. After each URL information will be provided about the content and possible use.

Chapter 1:

- Science channel - How does fusion power the sun?
  https://www.youtube.com/watch?v=W1ZQ4JBv3-Y duration 1:59 minutes
  sun: nuclear fusion in the Sun explained
- Business insider – Here's what will happen when our sun dies
  https://www.youtube.com/watch?v=p24SQlhJVZo duration 1:52 minutes
- UNSW Physics – Nucleosynthesis: the Proton-Proton Chain
  https://www.youtube.com/watch?v=vCD3ca_W8z8 duration 4:00 minutes
  The proton-proton chain explained for advanced students.
- Minute physics – What is quantum tunnelling?
  https://www.youtube.com/watch?v=cTodS8hkSDg 1:04 minuten.
  Gives an introduction into quantumtunneling

Chapter 2:

- Neutron Studios- Plasma compression (Z-Pinch) part 1/3
  https://www.youtube.com/watch?v=RRc7u8XN1fg Duration 4:10 minutes
  Shows experiment of the plasma Pinch

Chapter 3:

- Cognito – GCSE Physics – Alpha, Beta and Gamma radiation #33
  https://www.youtube.com/watch?v=VeXpMijpazE
  Explanation of the three types of radiation and the effect of this radiation: penetration though materials and ionisation.

Chapter 4:

- Golem -http://golem.fjfi.cvut.cz/wikiraw/TrainingCourses/PlasmaSchools/ASPNF.th/18/
  A project where you can control a tokamak remotely.
- ITER
  https://www.iter.org/
  Site of ITER where information, pictures and explanation can be found about the history, the goals, the Tokomak and much more!

Appendix A: Table of constants and conversion factors

Quantity	Quantity	Conversion factor to SI units
Energy[1]	1 Calorie	4.184 J
Energy[3]	1 toe	$4.2 * 10^{10}$ J
Energy[1]	1 kWh	$3.6 * 10^{6}$ J
Mass[1]	1 Ton	$1.0 * 10^{3}$ kg
Mass [1]	1 amu/u/ame	$1.66 * 10^{-27}$ kg
Temperature[1]	0 °C	273.15 K
Pressure[1]	1 bar	$1.0 * 10^{5}$ Pa

Table A.1 conversion factors

Quantity	
Core temperature Sun[2]	$1.571*10^{7}$ K
Surface temperature Sun[1]	5780 K
(mean)Density Sun[2]	1408 kg/m^3
Core density[2]	$1.622*10^{5}$ kg/m^3
Core pressure Sun[2]	$2.477*10^{11}$ bar
Surface temperature Earth[1]	295 K
(mean) Density Earth[2]	5514 kg/m^3
Mass electron[1]	$9.109 *10^{-31}$ kg
Charge electron[1]	$1.602*10^{-19}$ C
Mass proton[1]	$1.673*10^{-27}$ kg
Charge proton[1]	$1.602*10^{-19}$ C
Mass neutron[1]	$1.675*10^{-27}$ kg

Table A.2 constants

[1] Noordhoff uitgevers & NVON (2021). *Binas HAVO/VWO Informatieboek 6de editie (6e havo/vwo)* (01 ed.). Groningen, Nederland: Noordhoff Uitgevers.

[2] Sun Fact Sheet. (2018). Retrieved 13 July 2021, from https://nssdc.gsfc.nasa.gov/planetary/factsheet/sunfact.html

[3] IEA Unit converter and glossary, for common energy units. From https://www.iea.org/reports/unit-converter-and-glossary

Appendix B: Solutions to classroom exercises

Classroom exercise 2.1

a. The Sun has a mass of about $1.989 \cdot 10^{30}$ kg. The mass of a single proton is 1.007 amu. Assuming that the entire Sun was made of protons, how many protons are there in the Sun? (Remember that 1 amu is equal to $1.661 \cdot 10^{-27}$ kg.)

There are $1.1896*10^{57}$ protons in the sun

This can be calculated by dividing the mass of the sun by the mass of the proton. It is needed to uses the same units. $1.989*10^{30}$ kg=$1.19795 *10^{57}$ amu. Dividing the mass of the sun (in amu) by the mass of the proton (in amu) leads to $1.1896*10^{57}$ protons.

b. The energy released during the PP-chain is 26.73 MeV per Helium atom produced. How much energy can be gained if all protons in the Sun were to fuse to helium? (Remember that 1 MeV is equal $1.602 \cdot 10^{-13}$ J)

Gained energy is $1.274*10^{45}$ Joule.

The gained energy of the sun can be calculated with the number of protons and the Energy produced by one Helium atom. Remember that there are four protons needed to make one Helium atom. So, the number of protons calculated at assignment a should be divided by four to calculate the amount of Helium atoms. These leads to $2.974 *10^{56}$ Helium atoms. Each Helium atom releases 26.73 MeV, which is $4.282146*10^{-12}$ Joule. Therefore, the amount of energy is $2.974 *10^{56}*4.282146*10^{-12}$=$1.274*10^{45}$ Joule.

c. How long can the Sun shine, if it radiates this energy away at a constant power of $3.828 \cdot 10^{26}$ W?

$3.328*10^{18}$ seconds, or $1.05*10^{11}$ year.

The time is depended on the energy of the sun, calculated at assignment B and the Power of the Sun. $t = \frac{E}{P}$. The Energy $1.274*10^{45}$ Joule divided by a power of $3.828 *10^{26}$ Watt leads to a time of $3.328*10^{18}$ seconds, or $1.05*10^{11}$ year.

d. Astronomers expect that the Sun will only be able to fuse 10% of its protons, before it will go to the next phase in stellar life. Can you think of a reason why the Sun would not be able to fuse all the protons?

Multiple answers are correct.

An example of an answers would be:

- *Due to fusion of the protons the pressure and density of the Sun will change and therefore the fusion conditions get worse. The leftover protons are not able to fuse anymore.*
- *Electron degeneracy*

e. Do you expect the Sun to shine for so long? Why (not)? Discuss with your neighbours.

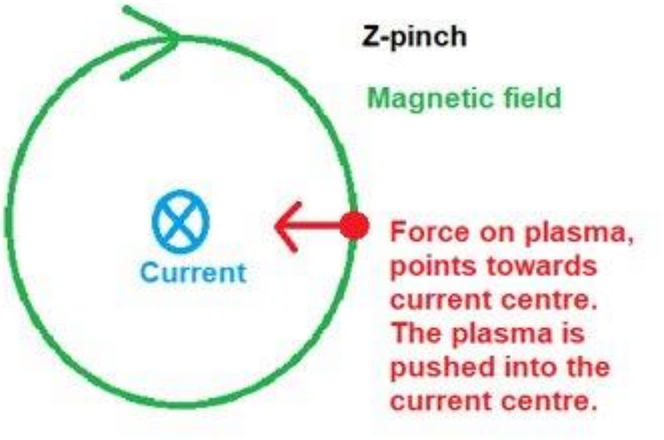
Classroom exercise 2.2

a. What force causes the plasma to squeeze together?

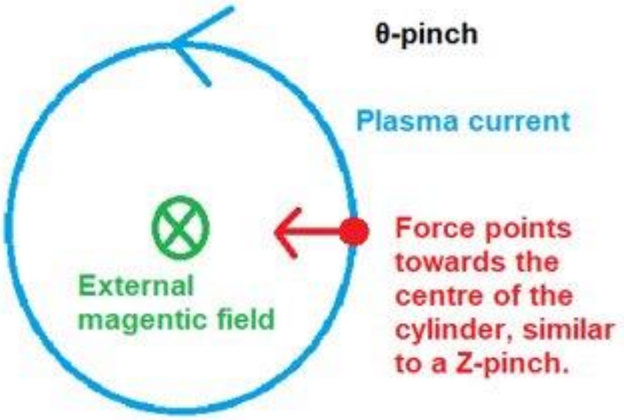
The Lorentz force.

There is a sign difference in charge, this causes voltage and current in the plasma. If these are higher than the ionisation energy of the gas it causes the gas to ionise. This causes a magnetic field perpendicular to the current. The magnetic field, chare and current will forces to squeeze the plasma due to the Lorentz force. (The relation: $F_l = B * q * v$ and $F_l = B * I * l$)

b. For a z-pinch, can you draw in a figure the direction of the magnetic field from the plasma current and the force on the plasma near the centre of the current, if the direction of the current is into the paper?

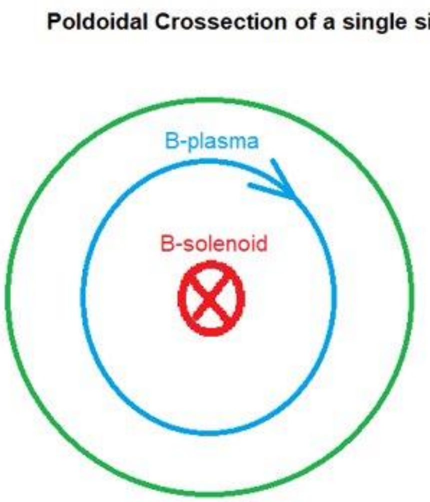


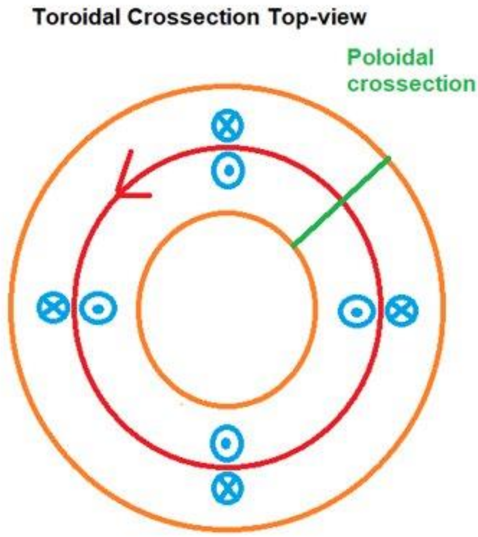
c. Now For a θ-pinch, can you draw the direction of the plasma current and the force, if the direction of the magnetic field is into the paper?



Classroom exercise 2.3

Sketch in a poloidal cross section the direction of the magnetic field created by the solenoid and the field direction of the magnetic field created by the plasma current. Now do the same but in the toroidal cross section.





Classroom exercise 2.4

A big difference between stellarators and tokamaks is how long they can operate. Modern stellarators are able to operate a plasma for up to 30 minutes. Tokamaks on the other hand are limited by their pulse duration. The pulse duration can be calculated by $t_{pulse} = \frac{\psi - L_p I_p}{V_{loop}}$. For ITER, the values for these quantities are ψ =250 Vs, $L_p = 12.5\mu Vs/A$, $I_p = 16\ MA$ and $V_{loop} = 0.1\ V$. How long do ITER's pulses last?

Filling in the numbers in the given formulae: $t_{pulse} = \frac{250 - 12.5 * 10^{-6} * 16 * 10^{6}}{0.1}$ *leads to* $t_{pulse} = 500$ *seconds. This is 8.3 minutes therefore it is much less than the stellarators.*

Classroom exercise 2.5

ITER is a good example of what advantages and disadvantage there are when many parties work on the same project. What do you expect that these advantages are? What about the disadvantages? Discuss this with your neighbour.

Multiple answers are correct.

An example of answer would be:

- *Some advantages are that the strengths of knowledge of different countries can be combined*
- *Some disadvantages are that everyone wants a big part in the development and this can lead to really long negotiations.*

Classroom exercise 2.6

It has been mentioned that ITER is big, but how big are we really talking about? On the website of ITER, there are many interesting numbers given on the facts and figures page (https://www.iter.org/factsfigures).

Here you will also find that the inside of the torus where the plasma will be in has a volume of about 830 Cubic meters. Do you have a feeling for how big this is?

How many humans (65 litre) can you fit in ITER? How about elephants (47 m3)?

830 cubic meters is the volumetric equivalent of 12769 humans or about 18 elephants

Classroom exercise 2.7

Another important milestone happened in 2012. That year, ITER was granted a license to work as a Basic Nuclear Installation. The reaction products of the D-T reaction are Helium-4 and a neutron. Neither of those are radioactive. Why would ITER need a Basic Nuclear Installation licence?

Example answer: tritium is radioactive. Additionally, some materials can become radioactive thanks to the exposure to the neutrons created by the fusion reactions. This is why not every material is allowed to be used for the construction of a fusion reactor. For more info, please visit module 4 of this series. (Please note that this is a hard question for your students if they had to answer this on their own. They may need some guidance to get to the right answer, hence why this is written as a discussion answer)

Appendix C: Solutions to additional exercises v.1.0

Additional exercise A.1

a. the first three reactions must occur twice and the latter one only once.

Since the second equation is the only one involving electrons, all electrons used are used in this reaction. Since only one electron is used per reaction, the second reaction must occur twice to ensure that 2 electrons are used. Reaction 2 uses also two positrons, but those don't appear in the net result. Therefore, these must be obtained from a different reaction. To produce 2 protons, reaction 1 must occur twice. This however produces 2 deuterons. Letting reaction 3 occur two times, get us rid of the deuterons, but this produces two 2 helium-2 ions. These can be transformed into helium-4 ions by using the last reaction 1. We therefore conclude, that the first three reactions must occur twice and the latter one only once.

b. Answer: A=6 and B=2

When these reactions are added in this combination, we get as net result $4\ p + 2\ e^- \rightarrow {}^4_2He^{2+} + 6\ \gamma + 2\ \nu_e$. *This means that A =6 and B=2.*

Additional exercise A.2

Scattering means that particles bounce of each other elastically. The accelerated particles hit their targets without fusing and change directions. Not only does chancing direction make some of the particles hit the walls instead of the targets, but the particles also lose some of their energy. This energy is absorbed by the target and converted in heat, that is way too low to enable fusion and thus wasted. So, every time an accelerated particle scatters, energy is wasted and less fusion happens.

Additional exercise A.3

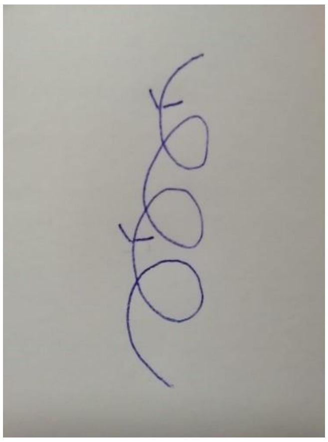
a. The particle on the right is in a stronger magnetic field.

When the magnetic field is stronger, the forces that causes them to gyrate is stronger. This means that they turn faster, which results in a smaller gyro radius. We therefore expect that the particle on the right is in a stronger magnetic field then the particle on the left.

b. If the field is stronger on the right side, then the field increases from left to right.

c. there is no closed orbit anymore and the motion will look like a corkscrew. The ions will rotate anticlockwise

It will no longer be a closed orbit but become more like a sort corkscrew that has been pushed flat. The ions rotate anti-clockwise, the particles moves downwards when it is on the left side of its trajectory and moves upwards during the right part of its trajectory. Because the field is weaker when it is more on the left side, the radius during the downwards moving part will be larger than the radius during the upwards moving part of the trajectory. During each cycle, it will therefore move *more downwards than upwards. Hence the particles drift downwards.*



Additional exercise A.4

Design names	Pinch	Stellerator	Tokamak
country	UK	US	Soviet Union
inventors	-	Lyman Spitzer	Andrei Sakharov & Igor Tamm
Names	Zeta, Scylla	Model A, Model B, Model C	T-1, T-2, T-3

Additional exercise A.5

a. The tokamak uses a plasma current to generate rotational transform. The stellarator on the other hand uses special geometries of the machine to add rotational transform.
b. Because the plasma current in the tokamak is generated inductively, it cannot be used for long periods of time. A stellarator does not need plasma currents and can therefore run for much longer. (8 minutes vs 30 minutes)

Additional exercise A.6

a. The Q-factor is the energy produced by fusion reactions divided by the energy needed to operate the fusion reactor (heat the plasma, power the magnets, etc.) It is important to achieve Q>1, because that would mean that more energy is generated then that we use.
b. Not necessarily. Q>1 means that there is more fusion energy produced than energy needed to operate the tokamak. The fusion energy however, usually is collected in the form of heat instead of electricity. To determine the gain in electricity, Q must be multiplied with the conversion efficiency from heat to electricity. This conversion can bring the total gain below 1 again, if Q is not big enough. There are also some additional problems that future reactors can face, which are discussed in module 5.

Additional exercise A.7 and A.8

There is no Answer because it depends on the country and person. Discuss the findings and opinions in class.