Physics
Leaving Certificate
Higher Level

Past Exam Questions on
Nuclear Energy

Q5 Part (i) Section B 2013

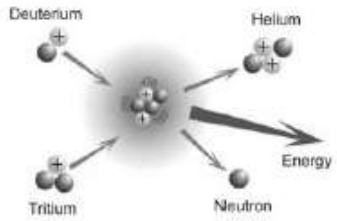
(*i*) Give one benefit of switching from fossil fuels to nuclear power for the generation of electricity. Explain your answer.

Q8 Section B 2012

Nuclear fission reactors are used as an energy source in many parts of the world, but it is only recently that the use of nuclear fusion as a possible power source is achieving some encouraging results.
The ITER nuclear facility at Caderache in south-east France is a global collaboration that has been formed to "demonstrate that fusion is an energy source of the future". It is expected to begin testing in 2016.

Energy can be produced in a fusion reaction by combining a deuterium and a tritium nucleus as follows:

$$^{2}_{1}\mathbf{H} + ^{3}_{1}\mathbf{H} \rightarrow ^{4}_{2}\mathbf{He} + \mathbf{n} + \mathbf{energy}$$



(i) Distinguish between nuclear fission and nuclear fusion. (12)
(ii) What are the advantages of fusion over fission in terms of fuel sources and reaction products? (12)
(iii) How much energy is produced when a deuterium nucleus ($^{2}_{1}\mathbf{H}$), combines with a tritium nucleus ($^{3}_{1}\mathbf{H}$)? (18)
(iv) Calculate the force of repulsion between a deuterium and a tritium nucleus when they are 2 nm apart in free space. (9)
(v) Fusion can only take place at very high temperatures. Explain why. (5)

Q12 Part (b) Section B 2010

(*b*) The following reaction occurs in a nuclear reactor:

$$^{235}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{141}\mathrm{Ba} + \mathrm{X} + 3^{1}_{0}\mathrm{n} + 202.5\ \mathrm{MeV}$$

(i) Identify the element X. (6)
(ii) Calculate the mass difference between the reactants and the products in the reaction. (9)
(iii) What is a chain reaction?
Give one condition necessary for a chain reaction to occur. (9)
(iv) Give one environmental impact associated with a nuclear reactor. (4)

(speed of light = 3.0×10^{8} m s^{-1}; 1eV = 1.6×10^{-19} J)

Q11 Section B 2008

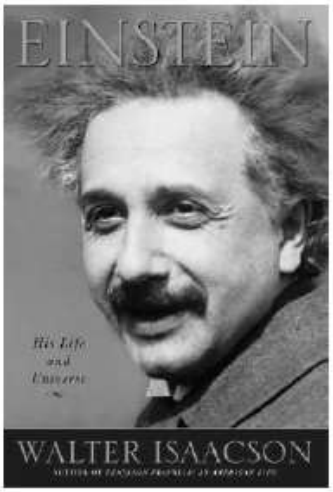
11. Read the following passage and answer the accompanying questions.

The Miracle Year: 1905

"There is nothing new to be discovered in physics now," Lord Kelvin reportedly said in 1900. He was wrong.

Isaac Newton had laid the foundations of classical physics in the late seventeenth century. He developed laws that described a mechanical universe: a falling apple and an orbiting moon governed by the same rules of gravity, mass, force and motion. In the mid-1800s, Newtonian mechanics was joined by another great advance. Michael Faraday discovered the properties of electric and magnetic fields. James Clerk Maxwell subsequently showed how changing electric and magnetic fields united to form electromagnetic radiation.

Physics was upended in the early twentieth century by Albert Einstein. In 1905 he devised a revolutionary quantum theory of light to explain the photoelectric effect, helped prove the existence of atoms, united the concepts of space and time, and produced science's best-known equation.



(Adapted from "Einstein: His Life and Universe"; Isaacson; 2007)

(*a*) The SI unit is named in honour of Lord Kelvin.
What is the temperature of the boiling point of water in kelvin? (7)

(*b*) Define the newton, the unit of force. (7)

(*c*) A force of 9 kN is applied to a golf ball by a golf club.
The ball and club are in contact for 0.6 ms.
Using Newton's laws of motion, calculate the change in momentum of the ball. (7)

(*d*) Name three different electromagnetic radiations. (7)

(*e*) What is the photoelectric effect? (7)

(*f*) Why was the quantum theory of light revolutionary? (7)

(*g*) High-energy radiation of frequency 3.3×10^{14} Hz is used in medicine.
What is the energy of a photon of this radiation? (7)

(*h*) 100 MJ of energy are released in a nuclear reaction.
Calculate the loss of mass during the reaction. (7)

(Planck constant = 6.6×10^{-34} J s; speed of light = 3.0×10^{8} m s^{-1})

Q12 Part (c) Section B 2008

(*c*)

In 1939 Lise Meitner discovered that the uranium isotope U–238 undergoes fission when struck by a slow neutron.
Barium–139 and krypton–97 nuclei are emitted along with three neutrons.

Write a nuclear reaction to represent the reaction. (12)

In a nuclear fission reactor, neutrons are slowed down after being emitted.
Why are the neutrons slowed down?
How are they slowed down? (9)

Fission reactors are being suggested as a partial solution to Ireland's energy needs.
Give one positive and one negative environmental impact of fission reactors. (7)

Q11 Section B 2007

11. Read the following passage and answer the accompanying questions.

At present, nuclear fission reactors supply a sixth of the world's electricity. Along with hydroelectric stations they are the major source of 'carbon-free' energy today. Nuclear reactors have shown remarkable reliability and efficiency even though the development of nuclear technology was held back by the nuclear accidents at Chernobyl and Three Mile Island.
A nuclear revival is possible. The global reserves of uranium could support a much larger number of reactors than exist today. Nuclear power generation could increase from three hundred gigawatts today to one thousand gigawatts by the year 2050, saving the earth from 1.5 billion tonnes of carbon emissions a year. Already more than twenty gigawatts of nuclear capacity have come online since 2000. Nuclear power would significantly contribute to the stabilisation of greenhouse gas emissions.

The type of reactor that will continue to dominate for the next two decades is the light water reactor, which uses ordinary water (as opposed to heavy water, containing deuterium) as the coolant and moderator.

Solar cells, wind turbines and biofuels are becoming viable energy sources. Solar cells use semiconductor materials, such as silicon, to convert sunlight into electricity, but at the moment they provide only 0.15% of the world's energy needs. Yet sunlight could be harnessed to supply 5000 times as much energy as the world currently consumes.

(Adapted from "Scientific American; Energy's Future beyond Carbon"; September 2006)

(a) What is nuclear fission? (7)

(b) How much energy is generated worldwide every minute by nuclear power today? (7)

(c) At present, why is a fission reactor a more viable source of energy than a fusion reactor? (7)

(d) Deuterium is an isotope of hydrogen, what is an isotope? (7)

(e) What is the function of a moderator in a fission reactor? (7)

(f) Why is silicon a semiconductor? (7)

(g) A large number of solar cells are joined together in series and cover an area of 20 m^2. The efficiency of the solar cells is 20%. If the solar constant is 1400 W m^{-2}, what is the maximum power generated by the solar cells? (7)

(h) What is the source of the sun's energy? (7)

Q8 Section B 2006

8. Distinguish between fission and fusion. (12)

The core of our sun is extremely hot and acts as a fusion reactor. Why are large temperatures required for fusion to occur? (5)

In the sun a series of different fusion reactions take place. In one of the reactions, 2 isotopes of helium, each with a mass number of 3, combine to form another isotope of helium with the release of 2 protons.
Write an equation for this nuclear reaction. (12)


picture of sun from skylab

Controlled nuclear fusion has been achieved on earth using the following reaction.

$$^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \longrightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$$

What condition is necessary for this reaction to take place on earth?
Calculate the energy released during this reaction. (18)

Give one benefit of a terrestrial fusion reactor under each of the following headings:

(i) fuel;
(ii) energy;
(iii) pollution. (9)

(speed of light = 2.998×10^{-8} m s^{-1}; mass of hydrogen-2 nucleus = 3.342×10^{-27} kg; mass of hydrogen-3 nucleus = 5.004×10^{-27} kg; mass of helium nucleus = 6.644×10^{-27} kg; mass of neutron = 1.674×10^{-27} kg)