G.C.E. A/L Examination June - 2016

Conducted by Field Work Centre, Thondaimanaru
In Collaboration with
Zonal Department of Education Jaffna.

FWC

Grade :- 13 (2016) **Physics - II**

Part - II - Essay

Answer only four questions

5)

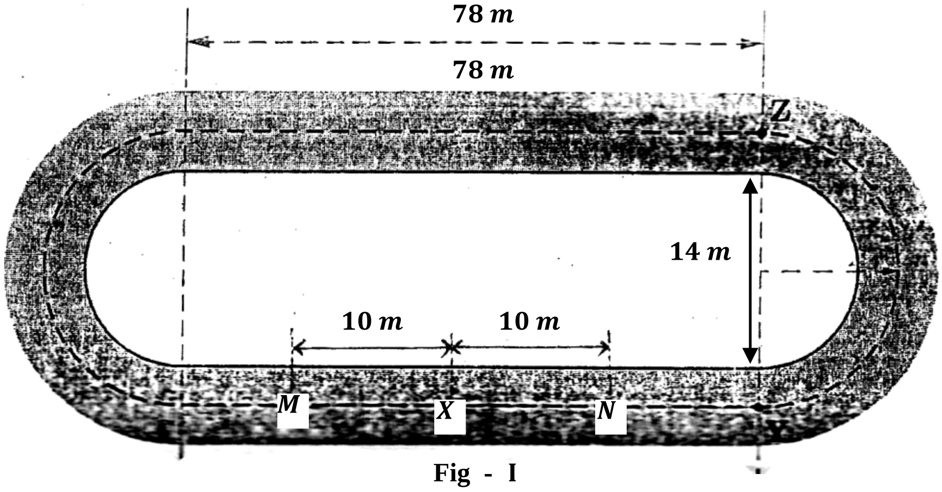


Fig - I

As shown in figure (I), a 200m racing track has two straight sections and two semicircular sections. The centre X, of a straight track is the starting and finishing point. A 4×200m relay event took place in this track. The speed-time graph of group G, which participated in the relay, is given in figure (II). The area MN on the track is where the baton is passed on to the next player. In the graph, 21s, 40.5s and 60.5s denote the time when baton is transferred.

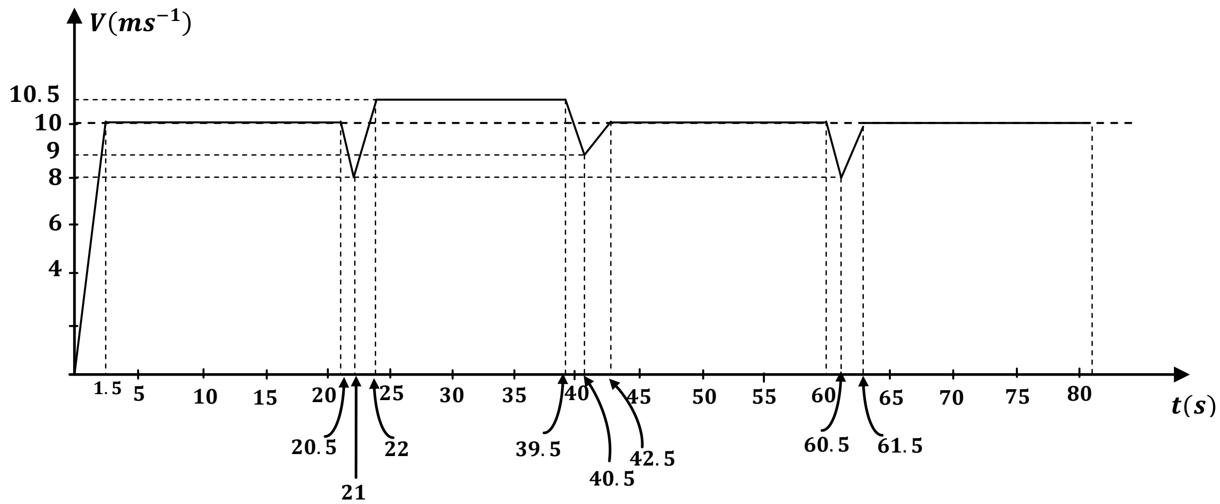


Fig - II

a)

i) Separately find the distance that each of the first three runners ran.

ii) If the distance ran by the last runner is 202m, find the time taken to complete the 4×200m relay race.

iii) Of these four runners, which one had the highest average speed?

iv) What is the total time taken for the first athlete to run the two semicircular portions of the track?

v) If the maximum speeds of these athletes do not change, give two strategies that they can follow to finish the race in minimum time.

b)

i) How does a runner obtain the force he needs to run? Copy the figure of the runner shown here onto your answer script and denote that force on the athlete. 

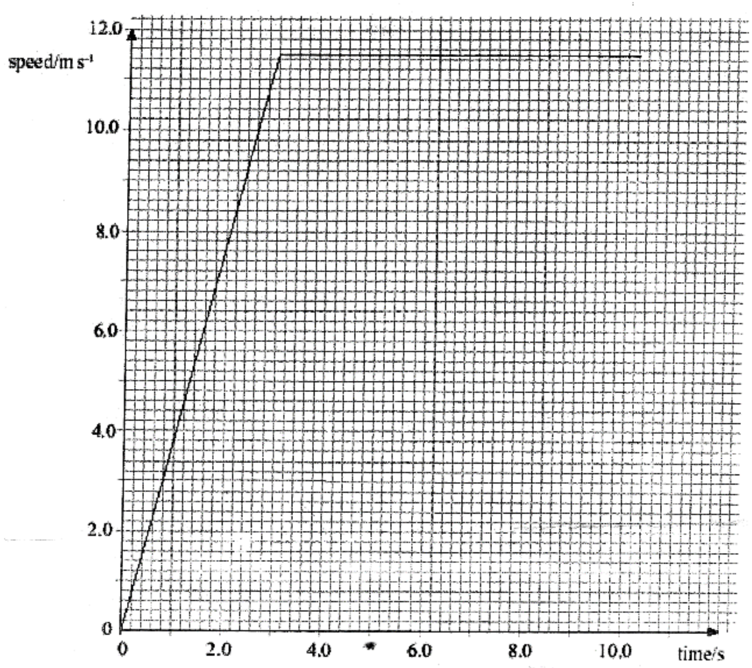
ii) If the mass of the first athlete is 60kg, during the first 1.5s what is the magnitude of the force mentioned in b(i)?

iii) What is the magnitude of the angle that the athlete makes with the horizontal?

iv) When the athlete runs on a straight track, why does he run with uniform speed despite obtaining the force mentioned in b(i)?

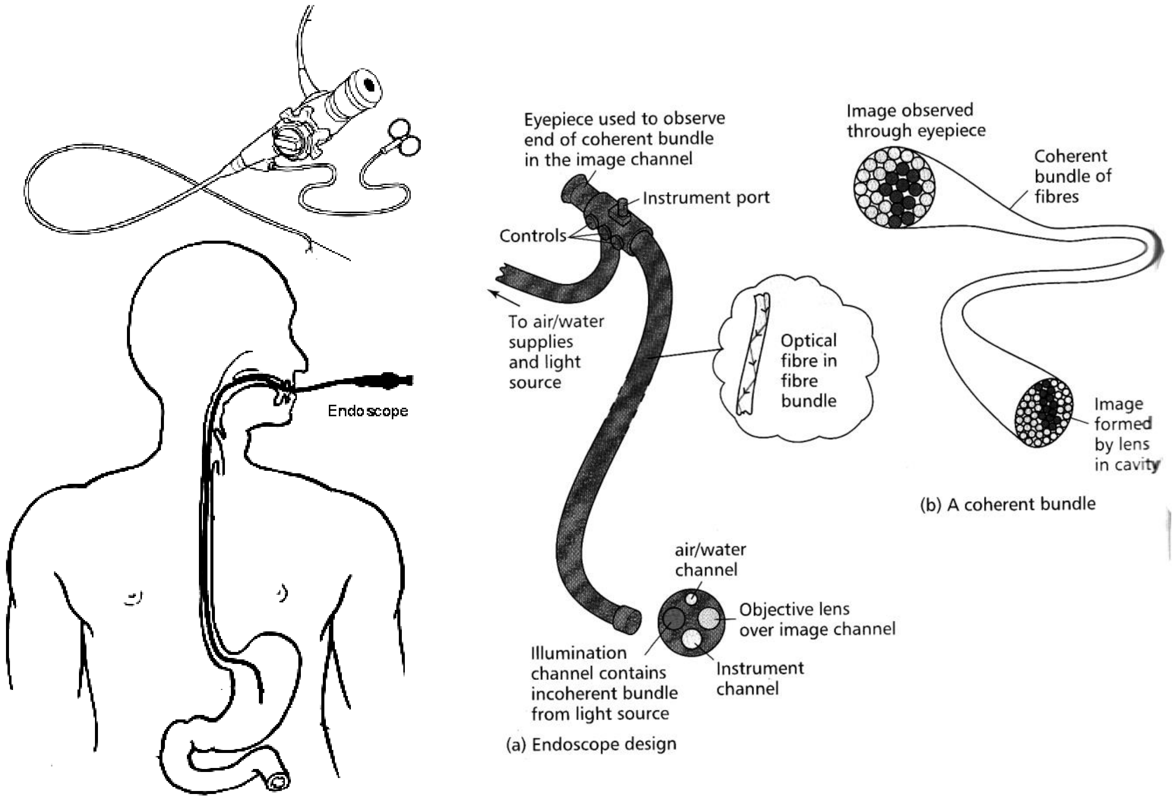
v) When this first athlete runs on the semicircular track, what is the centripetal force acting on him? How does he obtain this force?

c) Figure (III) shows a section of the speed-time graph of the first athlete of the H team which takes part in this race. At which second will this athlete catch up with the first athlete of the G team?



6)

a) Endoscopes are commonly used in medicine for the purpose of viewing some internal organs. One end of the endoscope has a small lens. The image of the internal organ formed by this lens is conducted by total internal reflection, through the optical fibers in the endoscope, to the other end of the endoscope. The photons in the laser light have the same energy and they all travel in parallel to one another. As a result, Laser light is highly monochromatic and parallel. In conjunction with a laser, the endoscope may also be used for surgery.



i) Explain how an endoscope allows a surgeon to view the stomach.

ii) What properties of laser light make it suitable to be used as a scalpel?

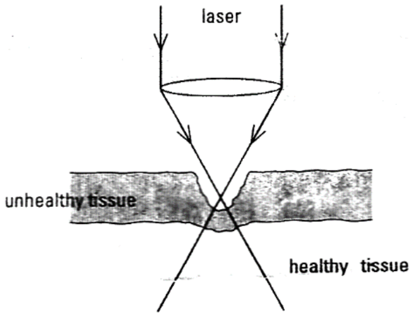
iii) Suggest a physical process which occurs in soft tissue exposed to laser light to enable the light to act as a scalpel.

b) In a process known as spot welding, a pulsed laser is used to repair small tears in the retina. The power of the laser light prior to entry into a bundle of optical fibres is 125W. 40% of the incident power is not transmitted through the fibres.

i) Calculate the light intensity in W mm^{-2} of the laser beam when it is focused in to an area of $1.5 \times 10^{-3} mm^2$ of the retina.

ii) The duration of each pulse of laser light is $0.5ms$. Calculate the energy supplied to the retina in one pulse.

c) The figure illustrates laser light being used to destroy unhealthy tissues.



i) Explain why one some tissue in the laser beam is destroyed.

ii) Suggest one advantage of using a lens of short focal length for the removal of a thin layer of tissue.

7) Read the paragraph carefully and answer the questions given below.

The human heart is the pump that circulates blood throughout the body. The left ventricle of the heart pumps blood into the aorta, which is the main artery of the human body. This blood is then distributed among several arteries and capillaries and sent to the different parts of the body. The normal heartbeat for a person at rest is 70 beats/minute.

The Poiseuille's equation is often used for approximate calculations of blood flow in human body. The flow of blood through vessels need not be a streamline flow. An empirical equation could be used to check whether the flow is streamline or not. If the liquid of viscosity η and density ρ, flows through a pipe of diameter D with velocity v, the Reynolds number N_R will be defined as follows.

$$N_R = \frac{Dv\rho}{\eta}$$

It has been verified experimentally that during streamline flow, the number N_R will be less than 2000.

a) .

i) Identifying the symbols, write down the Poiseuille's equation for the flow of viscous liquid through a tube.

ii) State two reasons why Poiseuille's equation is not strictly valid for the flow of blood through arteries.

b) Suppose that a volume of 70cm^3 blood is pumped into the aorta on each beat of the heart.

i) Calculate the average volume of flow rate of blood through the aorta when the person is at rest.

ii) If the diameter of the aorta is 1cm, calculate the average speed of blood in the aorta. State any assumptions that you have made.

c)
   i) Verify that the Reynolds number N_R is dimensionless.
   ii) Justify, showing necessary calculations, that the blood flow in part (b) is laminar. Assume that the viscosity and density of blood at body temperature are $4 \times 10^{-3} Nsm^{-2}$ and $1050 kgm^{-3}$ respectively.

d) Now, consider the flow of blood through a horizontally situated artery with uniform cross section, having radius 2mm. The length of the artery is 20cm. the average rate of blood flow has been estimated to be 2.5 $cm^3 s^{-1}$.
   i) Calculate the pressure difference between the two ends of the artery.
   ii) Calculate the rate of work done by the heart in pumping blood through this artery.

8) This question is about the design of a new propulsion system for driving a boat at sea.

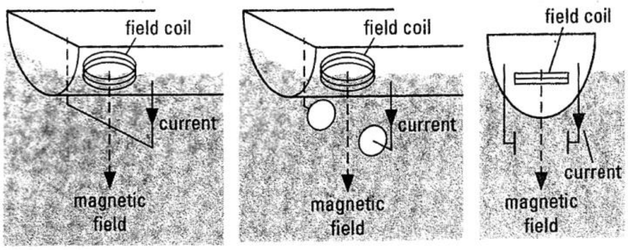


Fig - I **Fig - II**

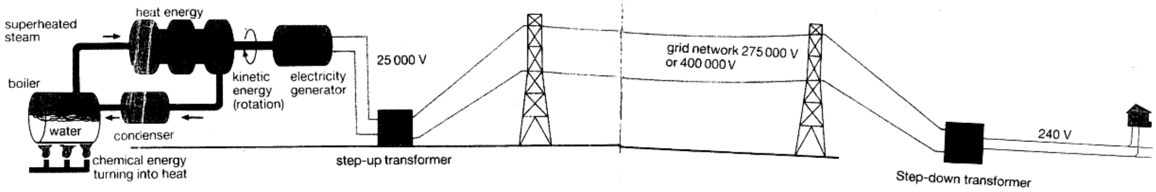
a)
   i) Write the equation for the force acting on a moving charge placed in a magnetic field.
   ii) Write the equation for the force acting on the current carrying conductor placed in a magnetic field.

b) **The first proposal** – As shown in figure (I) copper bar is fixed under the boat and a large current is passed through it. A large electromagnet produces a vertical magnetic field, as shown in the figure.
   i) State the direction of the force on the bar when the current is flowing as shown in the diagram.
   ii) Which law did you use in part (i)?
   iii) Give two ways of increasing the force on the bar.
   iv) Explain briefly whether this system will work.

c) **The second proposal** - As shown in figure (II), this proposal suggests passing a current through the water instead of through the copper bar using an electrode system. Each electrode face has a surface area of $0.75m^2$ and they are $1.5m$ apart. The drag force on the boat, which has a mass of $150000kg$, is $12000N$ when it moves at $8ms^{-1}$. The current used is to be 1000A.
   i) What is meant by ionization? Explain how this enables a current to flow in seawater.
   ii) Explain why the boat moves when a current is passed through the seawater.
   iii) What is the strength of the magnetic field required so that the thrust is sufficient to maintain a constant speed of $8ms^{-1}$?

9) **Answer either part (A) or part (B).**

(A)



You may have seen a sign at the bottom of an electricity pylon saying "Danger. High voltage". Power is transmitted around the country at voltages as high as 400 000V. This has a very good reason- to save a lot of energy.

Figure 1 suggests two ways of transmitting 25MW power from a Yorkshire power station to the midlands.

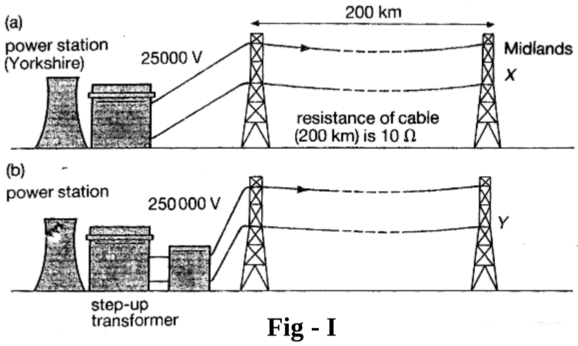


Fig - I

a)

i) Power can be transmitted through the power cables at a supply voltage of 25000V.

ii) Power can be transmitted through the power cables after the voltage is stepped up to 250000V.

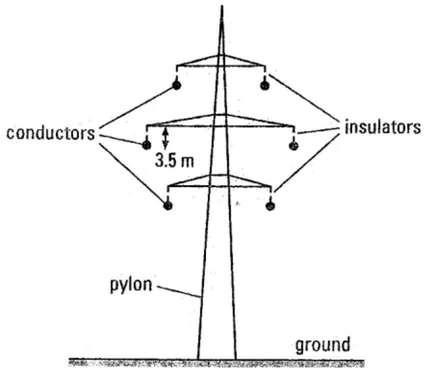
How much power would be wasted in heating the cables in each case, given that 200km of cable has a resistance of 10Ω.

b) .

i) Explain why the electricity supply in your home is AC rather than DC.

ii) Use the data in figure 1 to calculate the voltage at each point X and Y.

c) The figure shows how electric power is transmitted from generating stations to consumers on high-voltage overhead power lines, supported by metal pylons, which are earthed. Each conductor is suspended vertically below the pylon structure by an insulator which is 3.5 m long. The distribution voltage is 380kV r.m.s. It may be assumed that the voltage applied to each conductor has sinusoidal waveform.



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i) Calculate the peak voltage supplied to each of the conductors.

ii) Estimate the magnitude of the maximum electric field strength between a conductor and the pylon structure, if the field could be assumed to be uniform. (Neglect the magnetic field induced in one conductor by another)

d) Under certain atmospheric conditions it is possible to hear sharp crackling sounds coming from the region around the conductors.

i) State the atmospheric conditions under which the effect will become more pronounced. Explain your answer.

ii) Suggest an explanation for this effect.

9) **(B)**

i) Mention how the junction field effect transistor (JFET) differs from a bipolar transistor in each of the following factors.

i) Number of p-n junctions

ii) Charge carriers

iii) Whether the factor controlling the function is potential difference or current flow

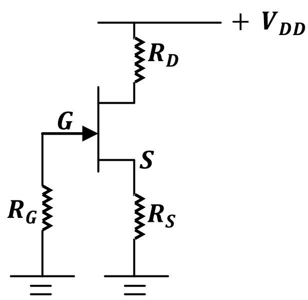
ii)

i) Draw the output characteristic curves of an n-channel junction field effect transistor.

ii) Which factor is kept constant when drawing a characteristic curve of this output?

iii) Denote the linear region, saturated region and cutoff region on your graph.

iii) Figure (I) shows a circuit used to bias an n-channel junction field effect transistor. Resistors R_G and R_S are connected to the earth and resistor R_D is connected to the direct power supply V_{DD}.

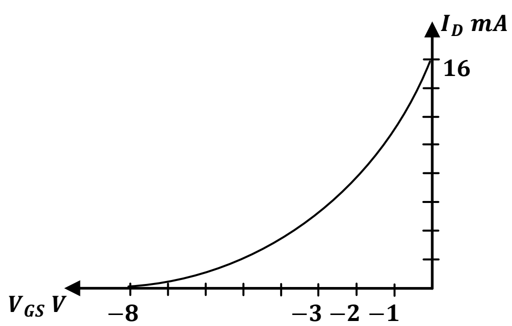


i) Reason out and explain that gate voltage V_G=0.

ii) Show that drain current $I_D = \frac{-V_{GS}}{R_S}$.

iii) Write an equation for the drain-source voltage, V_{DS}, in terms of V_{DD}, I_D, R_D and R_S.

iv) The transfer characteristics curve of this junction field effect transistor is shown in figure (II).



Consider that the biasing condition in part (b) is to be arranged such that I_D=6mA. To achieve this, the following conditions are maintained. V_{DD}=10V, R_D=500Ω and R_G=1MΩ.

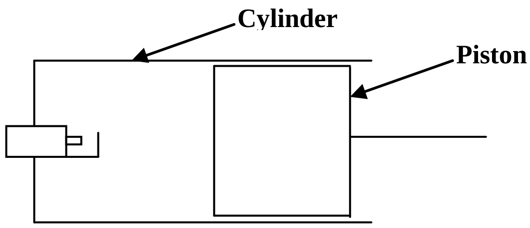
i) Find the value of the pinch off voltage ($V_{GS(off)}$) and the maximum value of the saturated drain current ($I_{DS(sat)}$).

ii) Copy figure (II) onto your answer script and denote the operating point of this biased state as Q.

iii) Calculate the value of R_S and from that, calculate $V_{DS.}$

10) **Answer either part (A) or (B).**

(A)



A cylinder and piston of a vehicle are shown in the diagram. The initial volume and temperature of the system are $100cm^3$ and 27^oC respectively. The area of cross section of this piston is $20cm^2$. Air is taken into it with a pressure of 1×10^5Pa. the total weight of the cylinder and its content is $1kg$. Its specific heat capacity is $250Jkg^{-1}K^{-1}$. Now, heat is produced by burning the air within the cylinder. Air, which is taken in at 30^oC reaches a temperature of 177°C, pushes the piston, and is then released from the system. Fresh air is taken into the cylinder at 30^oC and the system returns to its initial volume and pressure. This process happens 750 times per minute. From 27^oC, the system reaches a stable state of 177^oC in one minute. For the following process, the piston is at 177°C.

Universal gas constant $R = 8.3Jkg^{-1}K^{-1}$

The molecular mass of air = $30gmol^{-1}$

The specific heat capacity of air = $1000Jkg^{-1}K^{-1}$

i) What is the mass of air trapped in the piston each time?

ii) Find the heat gained by the air in one minute.

iii) Find the heat gained by the cylinder system in one minute.

iv) What is the rate of heat supplied to this system? (Neglect the heat loss to the environment)

v) What is the additional pressure exerted on the piston when air inside is heated from 27°C to 177°C?

vi) The piston is pushed outwards so that the pressure inside returns to 1×10^5Pa. At the constat temperature (177°C) what is the increase in volume of the gas?

vii) What is the rate of work done by the gas?

viii) Water at 27°C is allowed to flow around the cylinder in order to maintain its temperature stably at 177°C. When it flows completely around the cylinder and leaves, its temperature is 87°C. What is the rate of mass flow of the water? (Assume that the cylinder continuously gains heat as mentioned in part (c). The specific heat capacity of water is $4200Jkg^{-1}K^{-1}$)

ix) In the appliance mentioned in part (h) (radiator) why is water allowed to flow through a long tube that is folded many times?

x) What is the property of water that caused it to be selected in part (h)?

10) (B)

Stars glow spontaneously when the nuclear energy in them is converted to other forms, such as heat energy and light energy, due to nuclear fusion reactions. Sun is the closest star to Earth. During the nuclear fusion reaction taking placing in the sun, four hydrogen atoms are converted into one helium atom and two positrons (e^+).

When heavy, unstable atoms are hit by neutrons moving with sufficient velocity, nuclear fission occurs. During nuclear fusion and nuclear fission reactions a part of the mass is destroyed and converted to energy according to the following equation. $E = \Delta mc^2$. Δm is the destroyed mass, and c is the speed of light. ($c = 3\times10^8 ms^{-1}$)

a)

i) Write two differences between nuclear fusion and nuclear fission.

ii) Write the equation of nuclear reaction for the energy emitted from the sun.

iii) Calculate the amount of energy released during the nuclear fusion of hydrogen atoms. The masses of hydrogen, helium and positron are 1.007825u, 4.002603u and 5.55×10^{-4}u respectively.

$1u = 1.66\times10^{-27}kg = 931MeV/C^2$ ($1eV = 1.6\times10^{-19}J$)

iv) At which rate should hydrogen be consumed in order to produce energy at a rate of 1MW?

b)

i) During nuclear fission reactions, instead of protons, why are neutrons used to collide with the atoms?

ii) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{148}_{57}La + {}^{85}_{35}Br + x{}^{1}_{0}n$

Mass of ${}^{235}_{92}U = 392.617 \times 10^{-27}kg$

Mass of ${}^{1}_{0}n = 1.6 \times 10^{-27}kg$

Mass of ${}^{148}_{57}La = 247.16 \times 10^{-27}kg$

Mass of ${}^{85}_{35}Br = 141.78 \times 10^{-27}kg$

Avogadro's number $= 6 \times 10^{23}\ mol^{-1}$

Relative atomic mass of U $= 235$

Calculate the number of neutrons released in the above reaction.

iii) Calculate the mass reduction occurring during one reaction.

iv) How much energy is produced during one reaction?

v) If 10% of the total energy released is converted to heat energy and this, in turn, is converted into electricity with 25% efficiency, what is the mass of Uranium used in 1s to produce 300MW of electricity?