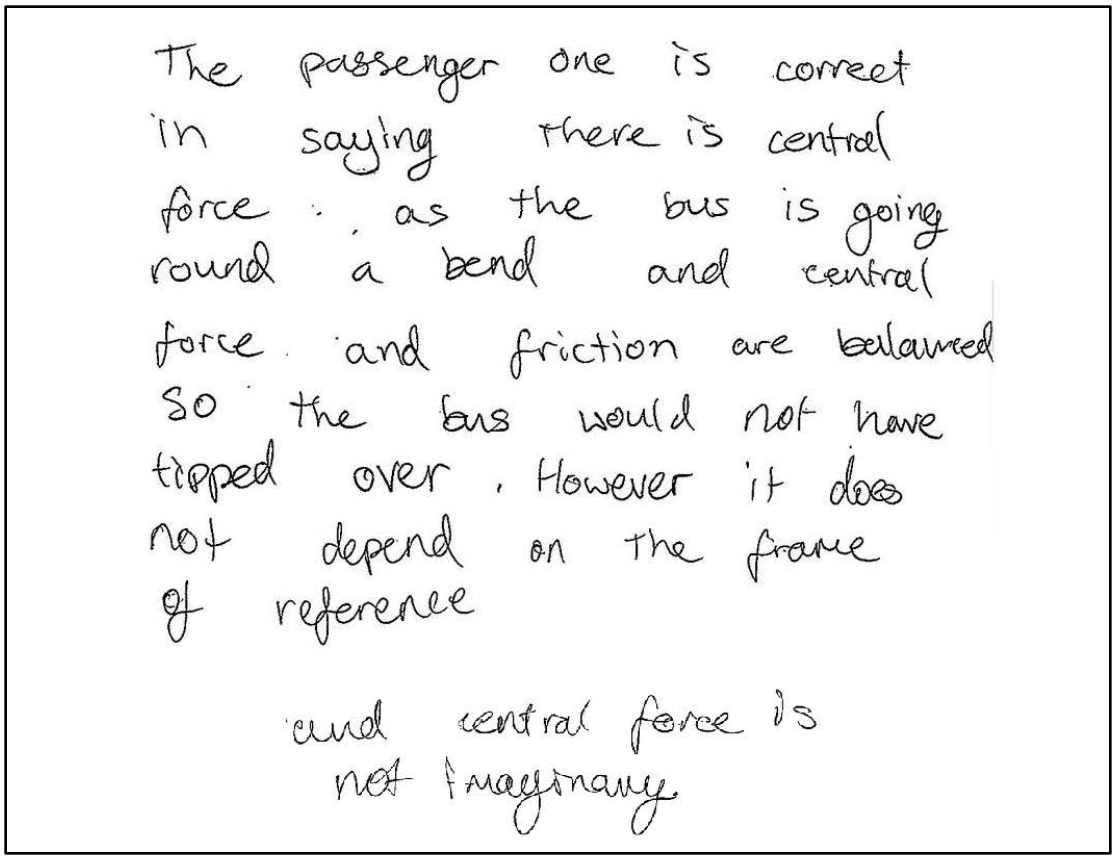
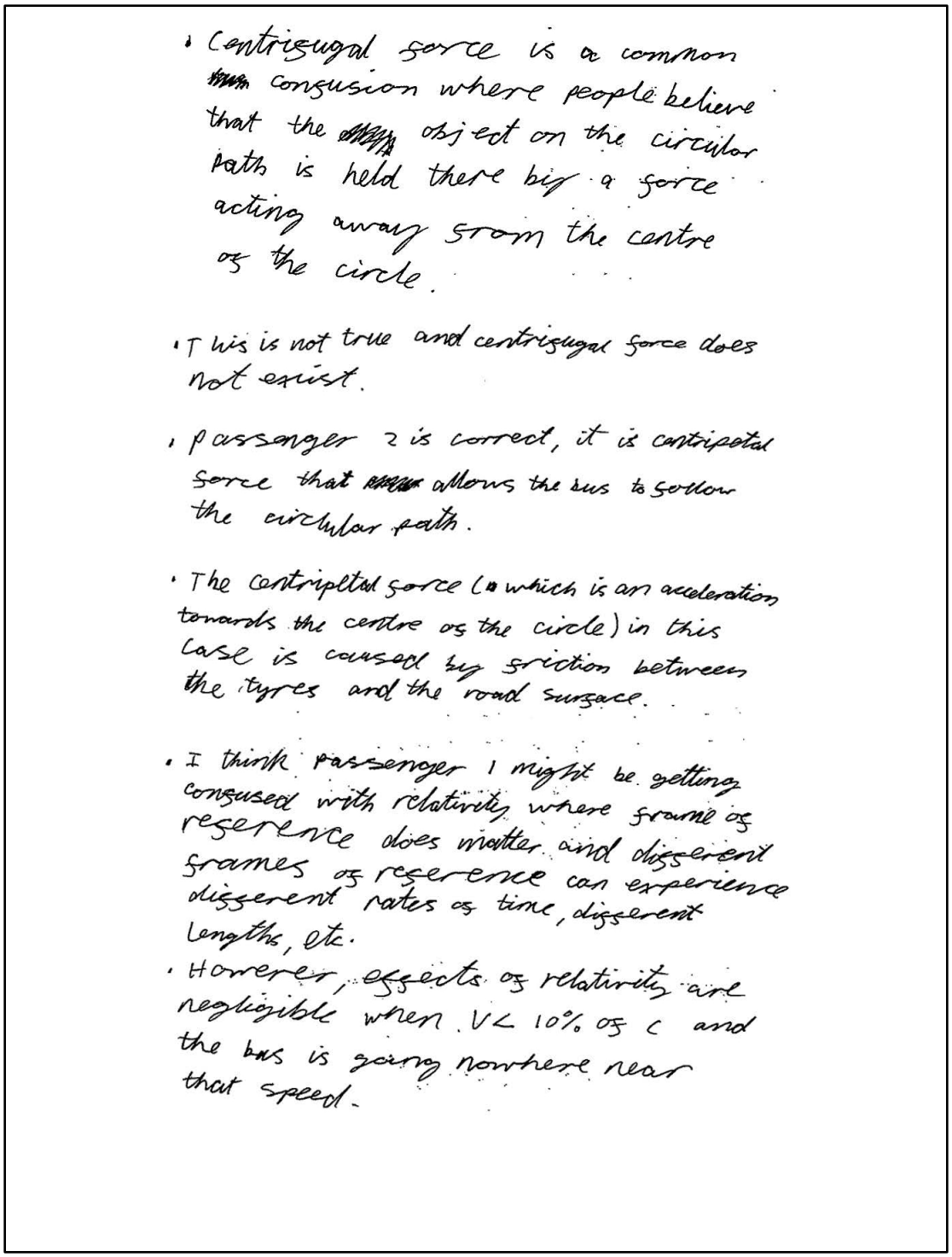
Candidate evidence

Question 4

Response 1



Response 2



- Centrifugal force is a common confusion where people believe that the object on the circular path is held there by a force acting away from the centre of the circle.

- This is not true and centrifugal force does not exist.

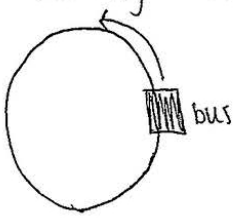
- passenger 2 is correct, it is centripetal force that allows the bus to follow the circular path.

- The centripetal force (a which is an acceleration towards the centre of the circle) in this case is caused by friction between the tyres and the road surface.

- I think passenger 1 might be getting confused with relativity where frame of reference does matter and different frames of reference can experience different rates of time, different lengths, etc.
- However, effects of relativity are negligible when $v < 10\%$ of c and the bus is going nowhere near that speed.

Response 3

Passenger 2 is almost correct.
A centrifugal force is a "fictitious" force.
When a bus goes round a tight bend, we feel a push but actually we are simply following a straight line path until the bus's 'reaction' force keeps us turning with the bus.



When the bus goes around a circular path, it is the centripetal force acting towards the centre of the circle. This can be found by

$$F_c = \frac{mv^2}{r} \text{ or } F = mr\omega^2$$

The minimum velocity required can be found by equating the formulae for weight and centripetal force.

$$W = F_c$$
$$mg = \frac{mv^2}{r}$$
$$g = \frac{v^2}{r}$$
$$v = \sqrt{gr}$$

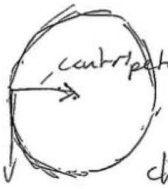
where g = acceleration due to gravity

Therefore the bus must have been travelling faster than its minimum velocity since it slightly tipped and lost contact with the ground

Response 4

Passenger two is correct during the conversation. As although it may appear as if there is a centrifugal force pushing you outwards this does not actually exist as it is just an illusion as passenger two states.

Instead what is happening is centripetal force which is a force which pulls you towards the centre of the circle allowing the bus to move round the bend. what is perceived as centrifugal force is actually just the force from your tangential velocity moving out from the circle

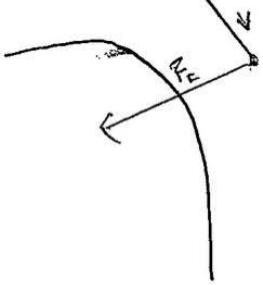


passenger one is incorrect

Because the bus is changing direction it is accelerating despite it maintaining a constant speed as acceleration is a vector with both magnitude and direction as a result it is in a non-inertial frame of reference which occurs during acceleration whilst an inertial frame of reference occurs at constant speed

Response 5

Passenger 2 is correct. In the above scenario, the bus is going around the bend by accelerating towards the centre of it. Hence, a centripetal force is acting. The force of friction is acting as this force, and is keeping the bus around the corner.



However, if the speed at which the bus enters the corner is too great, it may not make it, and instead move off at a tangent to the corner.

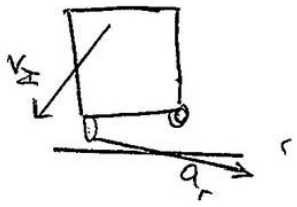
When passenger 1 says that the centrifugal force is acting on the bus, they are incorrect. Centrifugal force is an imaginary force that is felt by bodies ~~in the~~ ~~where~~ ~~the normal reaction force~~ is ~~less~~ than the ~~the~~ experiencing a centripetal force.

The bus nearly tipped as the wheels are accelerating towards the centre of the corner ~~where~~ but the top of the bus ~~is~~ isn't, it is still travelling inertially.

/cont

Response 5 (continued)

As such, the wheels would accelerate away from the top of the bus, causing it to tip.
As well as this, passenger's note about frames of reference doesn't make sense, as everyone on the bus has the same frame of reference.

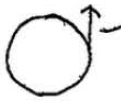


Response 6

1. Centrifugal force isn't a real acting force its just a simplification of other real forces.
2. It wouldn't tip over the bus, the centripetal force is partly why the bus stays on course.
3. Passenger 2 is on the right tracks. because its most likely friction from the tyres making the turn.
4. It doesn't depend on reference, its just a way to map it out.

Response 7

Centrifugal force is not a force as a in it self but is seen result of centripetal force. When the bus turns the bend, the friction between the tyres and the road provides the centripetal force which allows the bus to turn the corner. This force acts towards the centre of the corner. The sensation of being pushed outwards is a result of a objects tendency of follow a straight path as it turns.



This is experienced as a force pushing you outward or the fictious 'centrifugal force'.

Response 8

Passenger One is wrong. Passenger two is correct.

(notes: • friction. • weight. • F_c. • ~~bus~~ • Angles.

• Centripetal force does not exist. Centripetal force says that an object is thrown to the outside of ~~an~~ a circular path, when it is instead centripetal force acting towards the centre of the path that is responsible for circular motion.

In this situation, the bus tips over slightly at an angle. This is equivalent to going around a banked track.

The weight has no effect on the ~~tend~~ ability of the bus to make it around the bend, as it's component will be almost ~~negligible~~. the same as the buses own weight

/cont

Response 8 (continued)

The friction supplies the centripetal force. The tyres, when they turn, ~~push~~ cause the bus to take on a new path, ~~as~~ but in order to do so, the friction applied by the tyres must be great enough to equal the required centripetal force. ($F_c = \frac{mv^2}{r}$).

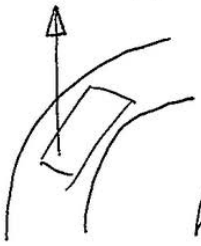
~~If the bus~~ As the bus tipped, this implies that the tyres just managed to meet the required friction needed, as the driver was speeding, so the value of v was large $\therefore$ the value of F_c needed would also be very large.

Response 9

$$F = \frac{mv^2}{r}$$

Response 10

The perceived Centrifugal force by passenger one is imaginary however he is still experiencing a force. As the bus turns round the bend since P1 is not linked to the bus they continue on at a tangent to the path the bus is following so the force exerted on them is likely from their seatbelt or the walls of the bus stopping him from continuing on his tangential path



Question 9

Response 1

The concept of protons borrowing energy is due to its uncertainty principle and its ~~value~~ amount of energy being uncertain. If its uncertainty in time were large, the uncertainty in energy is small and vice-versa.

Response 2

An example of a fusion reaction is the proton-proton chain. The steps are described below: it occurs in the sun during hydrogen to helium fusion in the main sequence.

Step 1: 2 hydrogen nuclei fuse to form a deuterium nuclei. A positron and a neutrino are released.

Step 2: The deuterium fuses with a proton and releases a gamma ray to form a helium-3

Step 3: Two helium-3 fuse to produce helium-4 and release two protons

The electrostatic potential is the work done in moving a unit positive charge from infinity to that point. The electrostatic potential energy is the force per unit positive charge at that point.

Therefore, the electrostatic potential must be overcome in order to move close to another charge.

However, the Heisenberg uncertainty principle states that it is impossible to accurately determine the exact position and momentum of a quantum particle at the same instant.

Thus, it is true that in quantum tunneling, electrons can "borrow" energy and get past a potential barrier that it otherwise would not have been able to cross.

Therefore, there is a small probability that electrons could appear in places it shouldn't be.

This phenomenom was found by the double slit experiment. It found that when passed through a double slit, an interference pattern was produced: and so electrons can behave as waves.

However, when a detector was placed at the slits to observe the electron path, no interference pattern was produced.

When light above the threshold frequency hits a metal surface, electrons can be ejected. This is known as the photoelectric effect and backs up the particle nature of electrons. The above concepts are known as wave particle duality.

Response 3

When protons undergo fusion they get close enough that the strong force takes over which is a lot stronger than the electrostatic force at very small distances (molecular distances).

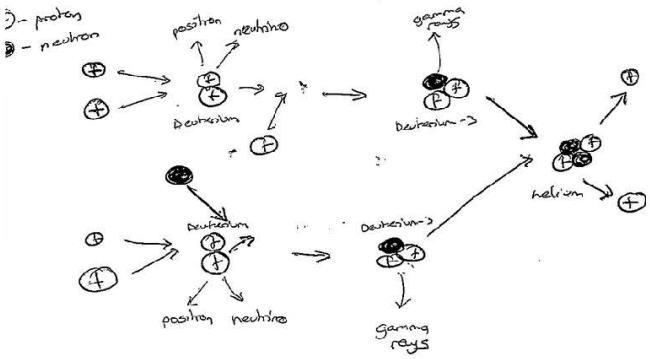
Heisenberg's uncertainty principle states the following equation.

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

This means that if energy is borrowed in order to satisfy this equation the period of the proton's decay is a lot smaller. This is why quantum tunnelling occurs as the fusion needs to happen instantly.

In the sun fusion takes place. This happens due to the extreme temperature in the core.

The fusion in the sun is from hydrogen to helium.



Response 4

It is true that for fusion to occur, the particles must be in contact, so like charges repulsion must be overcome.

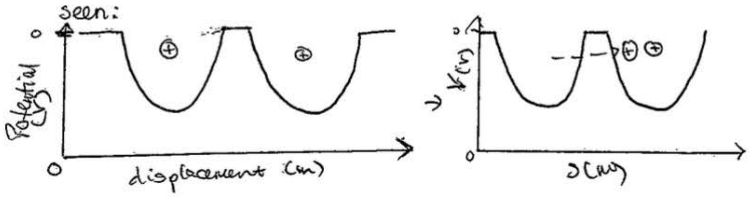
Due to the alike charges of two protons, they will repel each other.

A proton is not a quantum particle so cannot quantum tunnel.
quantum tunnelling occurs through solids, not "through electrostatic forces"

Response 5

"Electrostatic repulsion must be overcome"
- This is true as the particles need to come in contact to interfere, and hence fuse.

"protons can tunnel through electrostatic forces".
- ~~This is true but wording is off~~. This is worded awkwardly. The protons can tunnel through their potential wells to interact with each other as seen:



This is made possible by Heinzburg's uncertainty principle, $\Delta E \Delta t \geq \frac{h}{4\pi}$.

In order to escape it's potential well and interact a photon needs sufficient energy. However, heinzburg stipulated that there is a minimum uncertainty in the energy of a particle and the time it is at. So, ~~the less specific~~ more precise the measurement of the time the proton is in, the less precise the measurement of energy. So,

as the student said, the proton can "borrow" energy from another point in time and so can ~~[illegible]~~ escape its potential well. If this were not the case, then fusion would have to occur at a higher temperature as the protons would need sufficient kinetic energy to overcome this repulsion. So, the student's notes are correct.

Response 6

The Heisenberg uncertainty states that the exact position and the exact momentum cannot both be known at the same time. Therefore for this reaction to take place, only the protons positions will be known in that time.

This excerpt is correct as two protons, both with positive charges, will repel each other as like forces do not attract to each other.

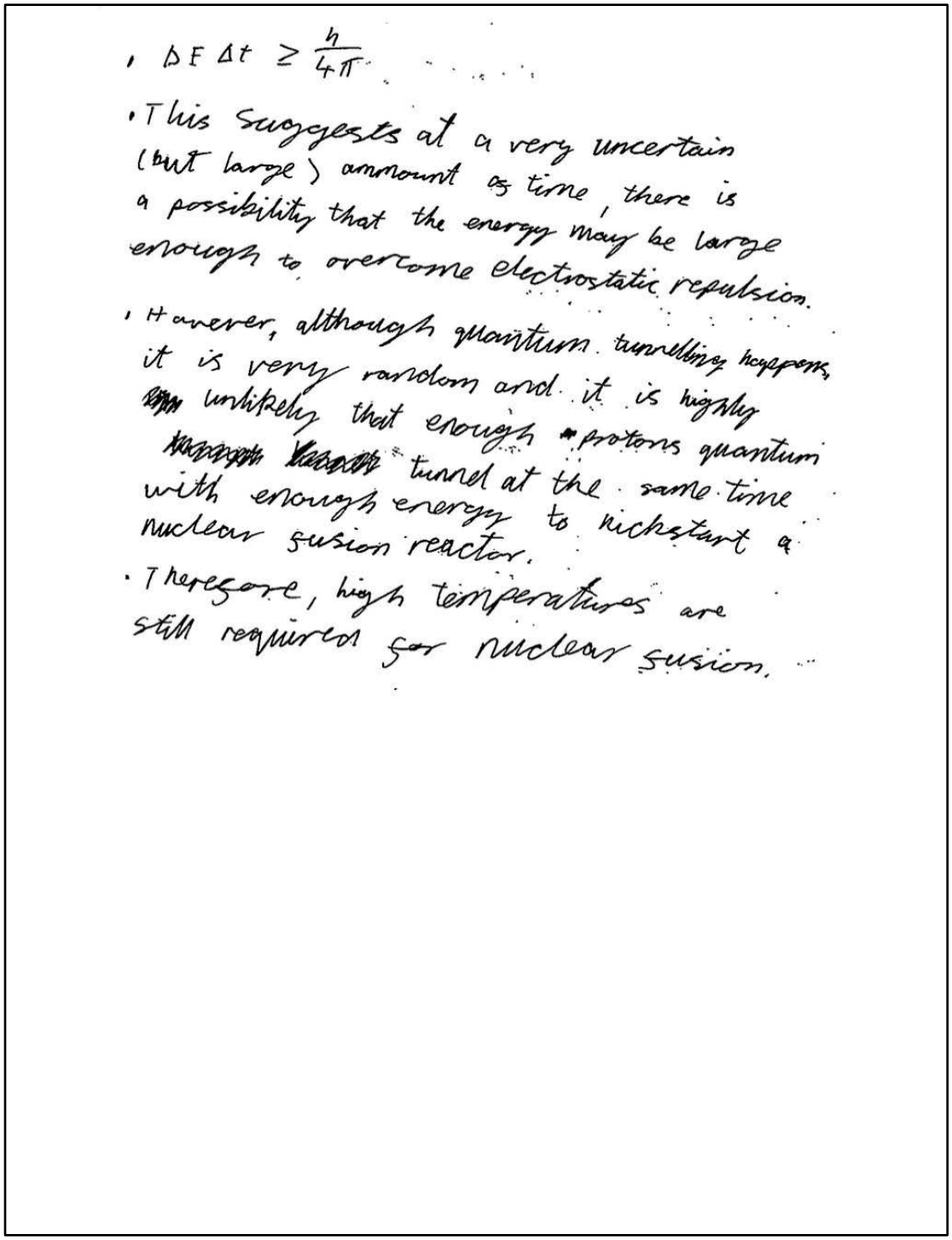
~~Other~~ 'Borrowing' energy means that the two protons will be sharing the energies they have resulting in an overall greater energy but smaller energies among the single protons. This means each proton has a lower energy and thus requires lower temperatures for reactions to occur.

Response 7

The Heisenberg uncertainty principle states that $\Delta E \Delta t \geq \frac{h}{4\pi}$. Where h is Planck's Constant. This means that, as the energy increases, the particle's lifetime must decrease. So, if a particle was to gain energy by decreasing its lifetime, it could theoretically allow the except to be true.

Protons do repel each other because of the force between them - in a nucleus, this is overcome by the strong nuclear force.

Response 8

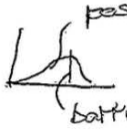

• $\Delta E \Delta t \geq \frac{h}{4\pi}$
• This suggests at a very uncertain (but large) amount of time, there is a possibility that the energy may be large enough to overcome electrostatic repulsion.
• However, although quantum tunnelling happens, it is very random and it is highly unlikely that enough protons quantum tunnel at the same time with enough energy to kickstart a nuclear fusion reactor.
• Therefore, high temperatures are still required for nuclear fusion.

Response 9

Quantum tunneling is the way in which fusion occurs within the sun. At the core, temperatures required for fusion are about 10% those required. However, quantum tunneling can occur and protons can get close enough the to fuse. This is because

$\Delta E \Delta t \geq \frac{h}{4\pi}$, if the time a proton is in an excited state is known to a high degree of precision, the uncertainty, ΔE is high. This means protons can have enough energy to fuse and overcome electrostatic forces. Similarly, protons can also behave like waves, this means their exact position is not known but is described mathematically as a wave function ψ. You can only know where they most likely are at any given time as a consequence of the Heisenberg uncertainty principle. This means protons can tunnel beyond barriers.

possibility of finding proton



barrier.

Response 10

For fusion to occur
electrostatic must be overcome. The
two protons have to be able
to touch For fusion to occur
They will repel each other but if
they have sufficient energy they are
able to overcome the electrostatic
repulsion and fuse.