Understanding Standards – Higher Physics, Open-ended Questions

General Information

An open-ended question is one to which there is not a specific or unique answer. An open-ended question allows candidates to answer in their own chosen way.

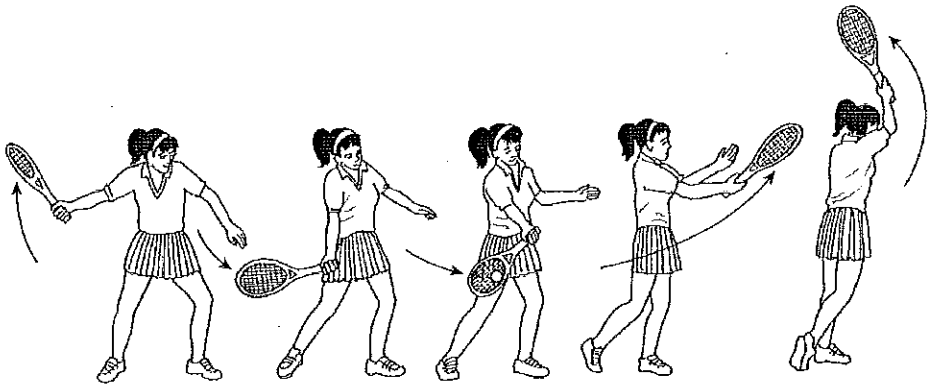
Candidates should use the opportunity to show to a marker that they know which areas of Physics are relevant. They should also provide some discussion and/or analysis to demonstrate the depth of their understanding of that knowledge.

There is no 'checklist' that is used by markers to allocate marks to a particular answer. Each candidate's answer is considered as a 'whole' and it is allocated a mark depending on the level of understanding demonstrated. Zero marks are awarded if the answer demonstrates 'no understanding' of relevant Physics. The answer receives one mark if it shows 'limited understanding', two marks for 'reasonable understanding' and three marks for 'good understanding'.

It is recognised that each mark actually represents a 'range' of quality. For example, it is possible for one answer to be slightly better than another but for both answers to be awarded a '2'. This can happen when both answers are deemed to show better than limited understanding but neither is good enough to receive a '3'.

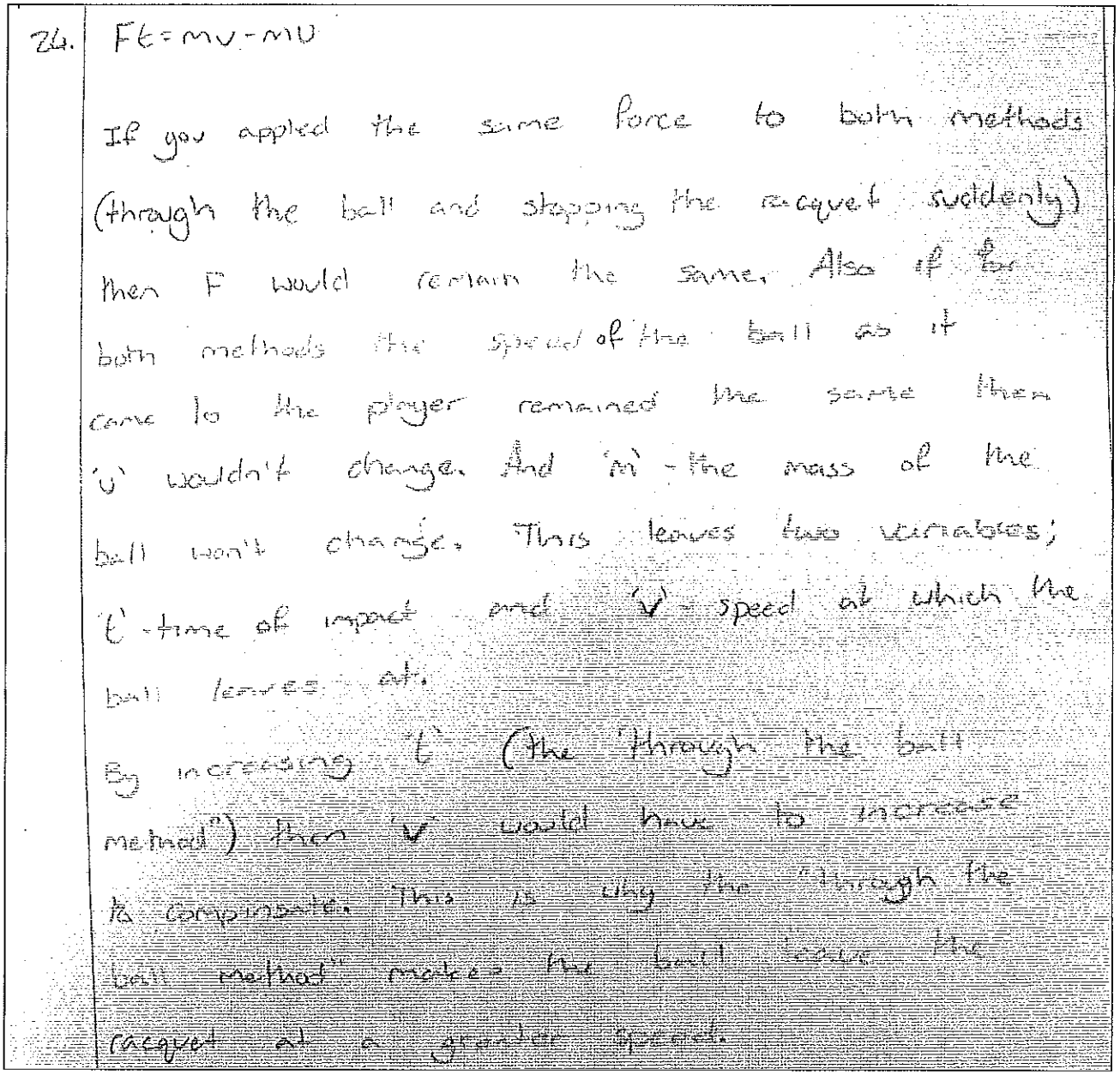
2012, question 24

Tennis players are coached to swing "through the ball" when striking it rather than stopping the tennis racquet suddenly.



Use your knowledge of physics to comment on why this causes the ball to leave the racquet with a greater speed.

Candidate Answer 1:



24. $Ft = mv - mu$

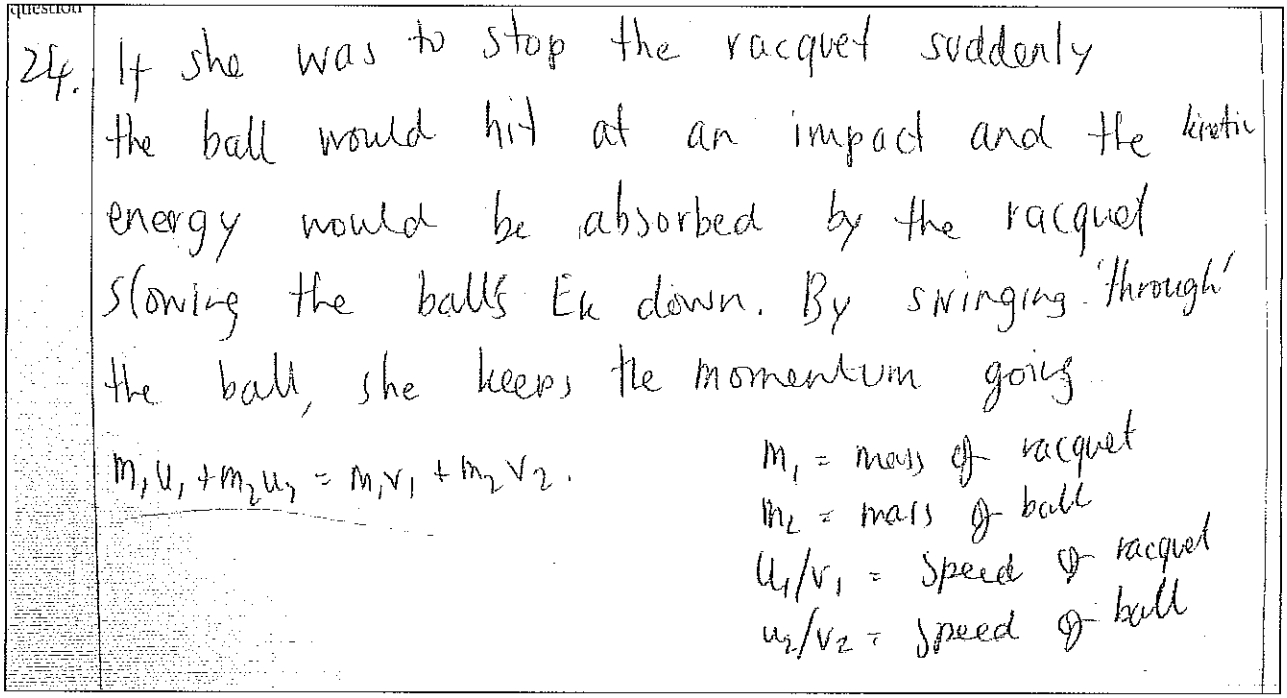
If you applied the same force to both methods (through the ball and stopping the racquet suddenly) then F would remain the same. Also if for both methods the speed of the ball as it came to the player remained the same then 'u' wouldn't change. And 'm' - the mass of the ball won't change. This leaves two variables; 't' - time of impact and 'v' - speed at which the ball leaves. etc.

By increasing 't' (the 'through the ball method') then 'v' would have to increase to compensate. This is why the 'through the ball method' makes the ball leave the racquet at a greater speed.

Mark Awarded: 3

Comment:
This is a very thorough, complete and well argued analysis. This answer shows very good understanding of relevant physics. However, it should be noted that 'only' good understanding needs to be demonstrated for the full three marks to be awarded.

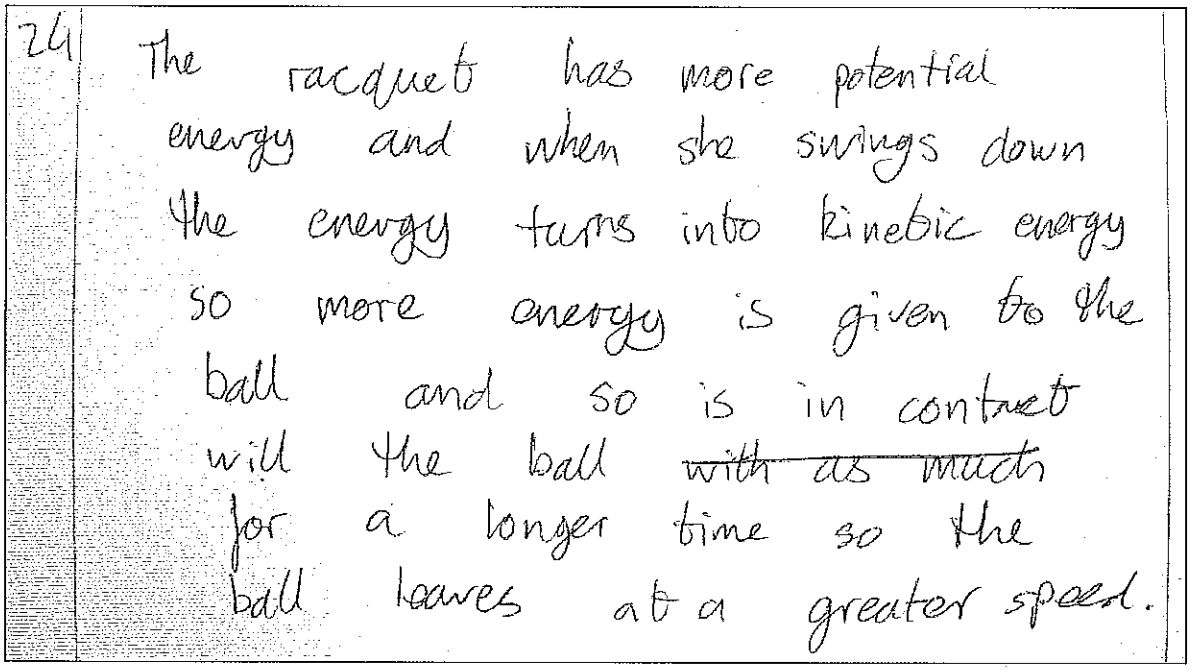
Candidate Answer 2:



Mark Awarded: 0

Comment:
Although relevant terms like "kinetic energy" and "momentum" have been included by this candidate, they are used in an almost colloquial way. Rigorous physics analysis is missing. The momentum conservation equation is written down, but the velocities are not precisely enough defined. A marker cannot be sure that this candidate has any understanding of the appropriate physics.

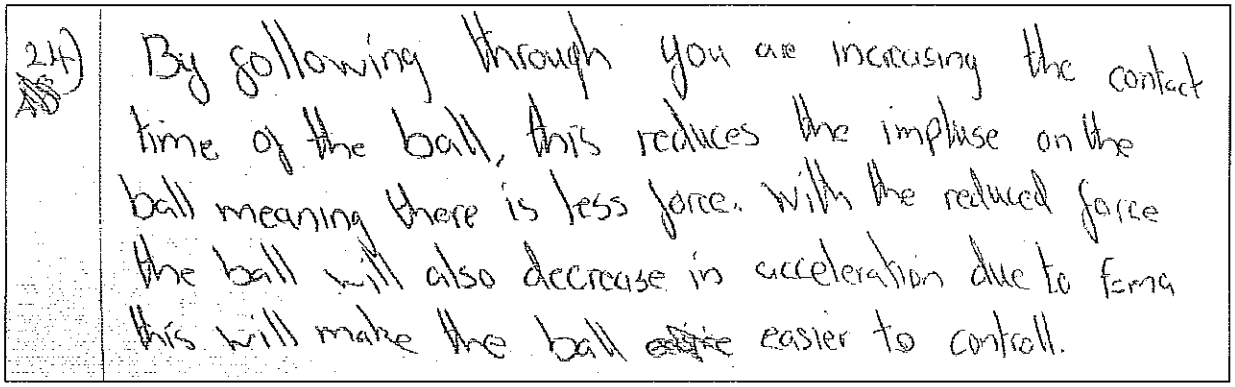
Candidate Answer 3:



Mark Awarded: 1

Comment:
This answer leaves the marker asking more questions such as "Why does the racquet have more potential energy?" and "Why does a longer contact time cause a greater speed?" However, there does seem to be limited understanding of relevant physics.

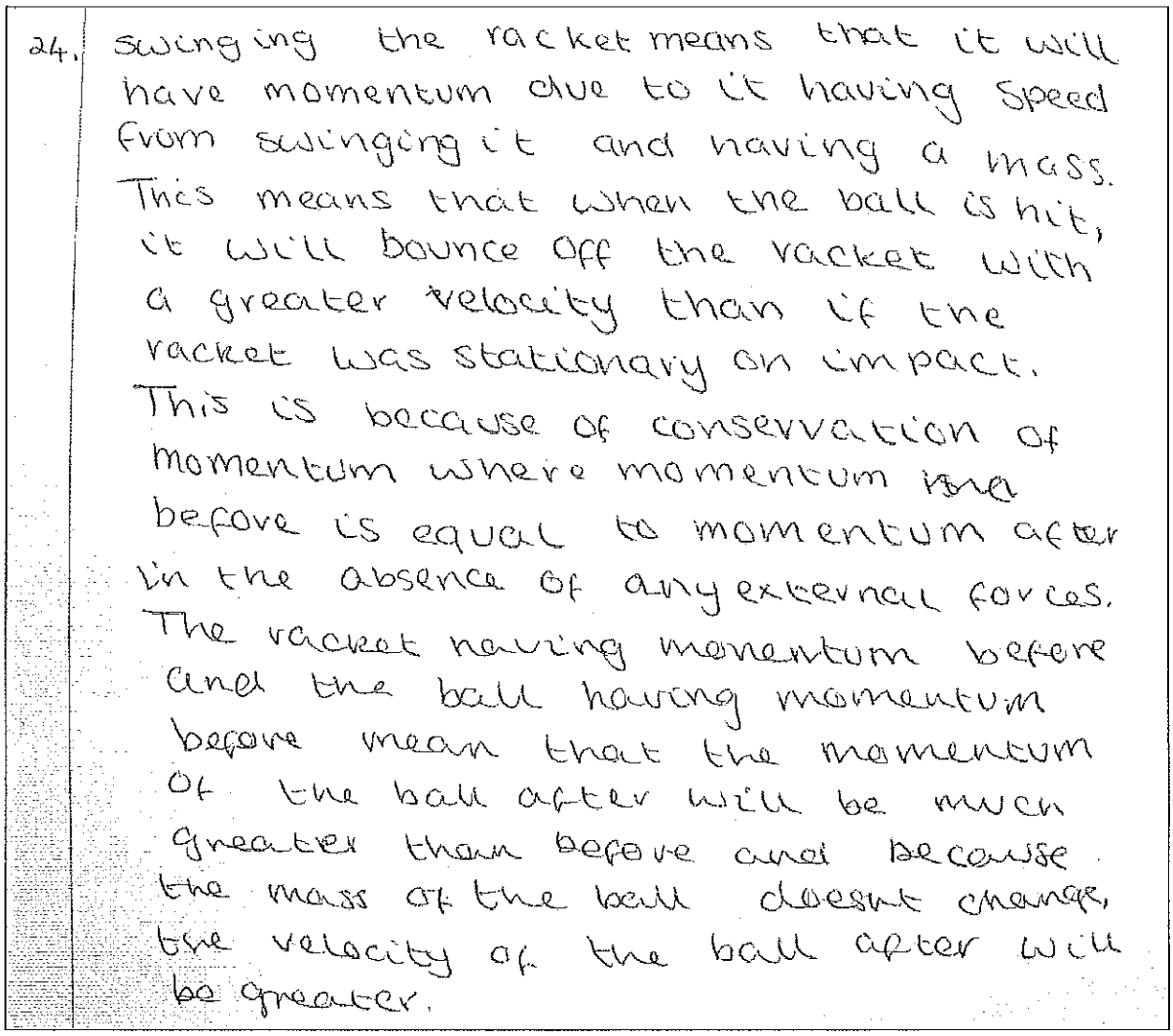
Candidate Answer 4:


24) By following through you are increasing the contact time of the ball, this reduces the impluse on the ball meaning there is less force. With the reduced force the ball will also decrease in acceleration due to f=ma this will make the ball ~~a~~ easier to controll.

Mark Awarded: 0

Comment:
This answer would lead to the conclusion that the ball would be slower. The candidate has mentioned relevant quantities and relationships but has made an incorrect link between increased contact time and impulse. He/She has taken the argument in the wrong direction. No real understanding is demonstrated.

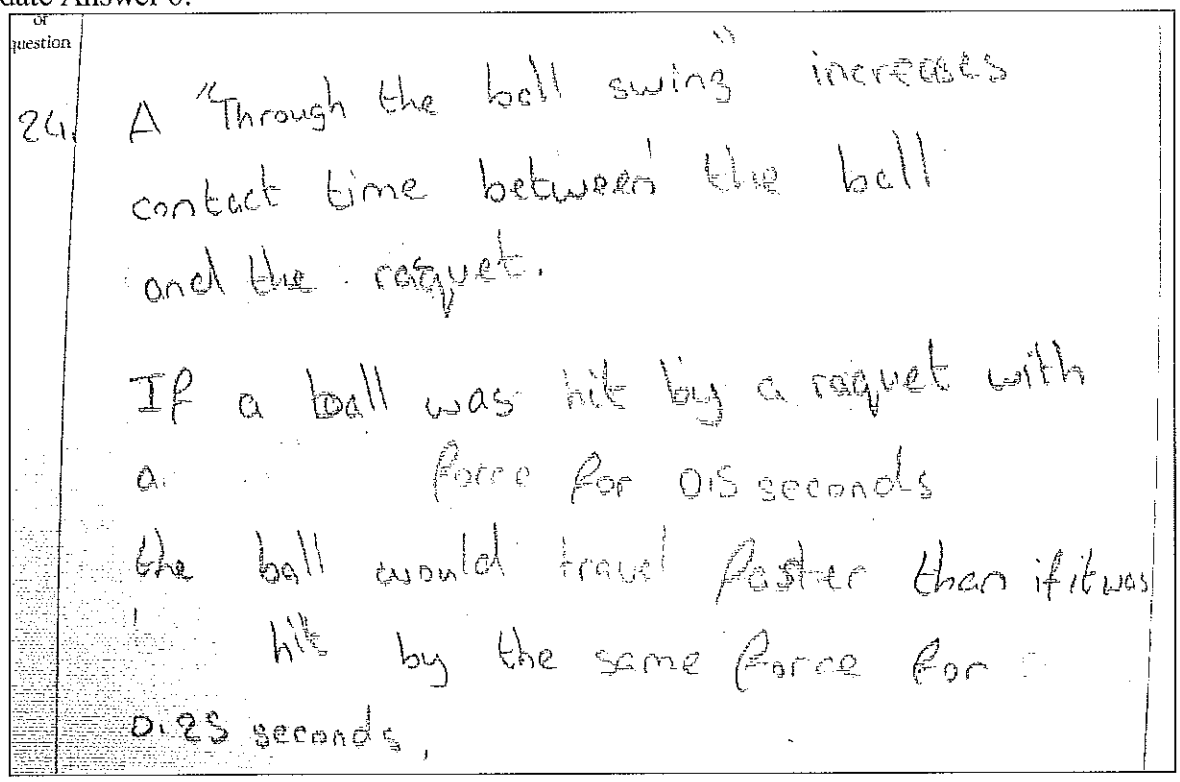
Candidate Answer 5:


24. Swinging the racket means that it will have momentum due to it having speed from swinging it and having a mass. This means that when the ball is hit, it will bounce off the racket with a greater velocity than if the racket was stationary on impact. This is because of conservation of momentum where momentum the before is equal to momentum after in the absence of any external forces. The racket having momentum before and the ball having momentum before mean that the momentum of the ball after will be much greater than before and because the mass of the ball doesn't change, the velocity of the ball after will be greater.

Mark Awarded: 2

Comment:
This answer is partially correct, but does not present a complete or rigorous argument. It shows more than limited understanding but is only just into the category of 'reasonable' understanding.

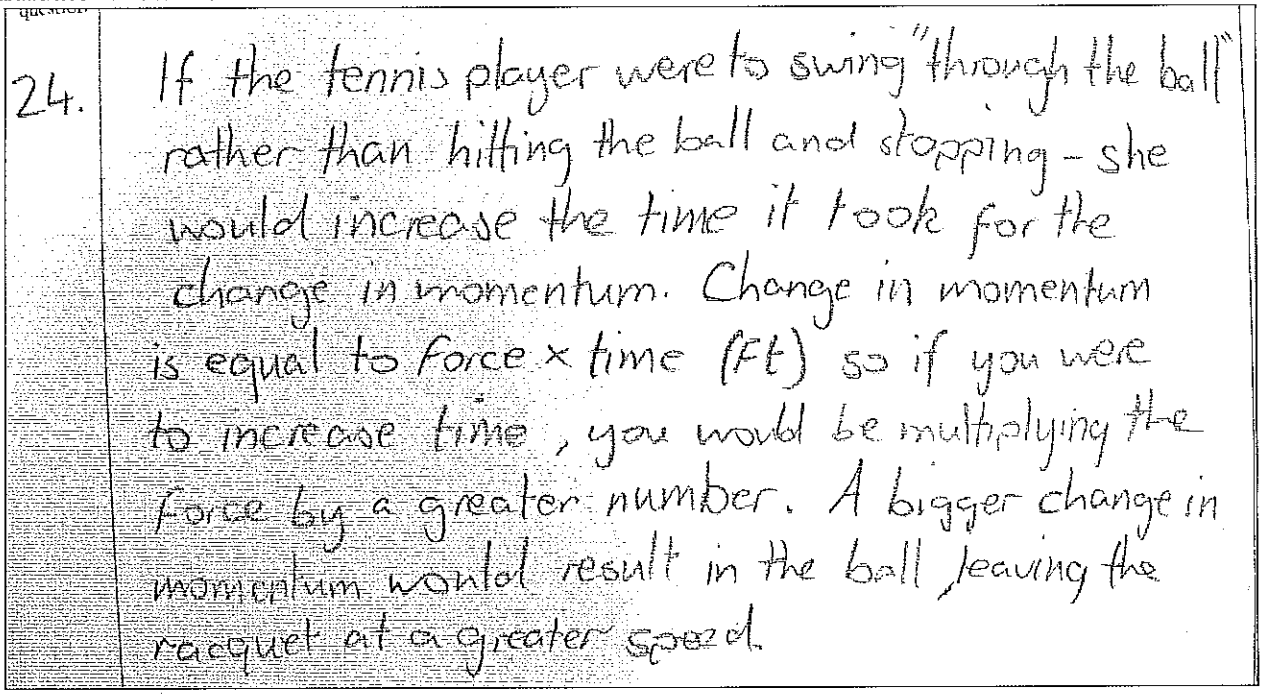
Candidate Answer 6:



Mark Awarded: 1

Comment:
This answer contains correct statements, but relevant quantities and relationships are not given or explained. In other words, little physics analysis is presented.

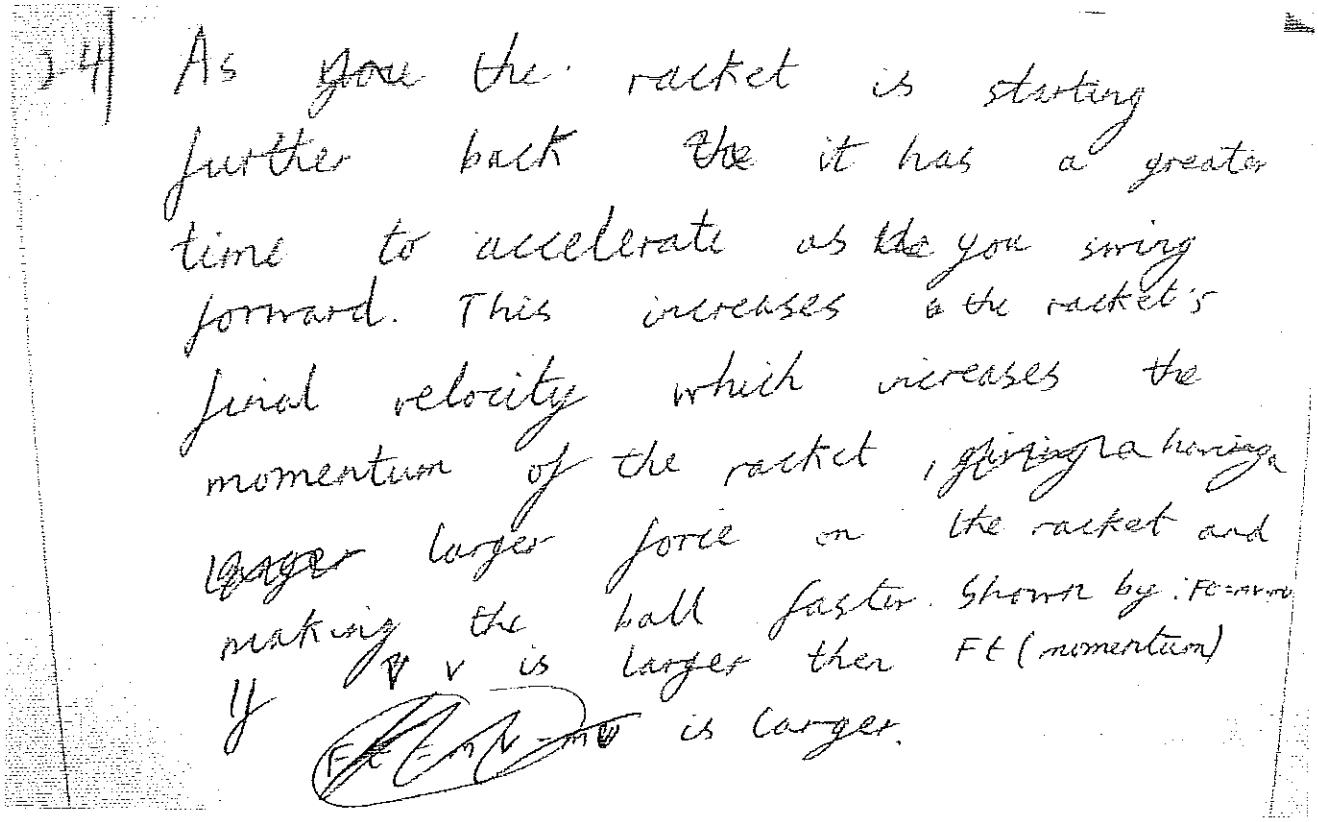
Candidate Answer 7:



Mark Awarded: 2

Comment:
This candidate is showing reasonable understanding. The candidate refers to "change in momentum" and equates it to '*Ft*'. However there is some vagueness about the analysis which leaves a marker wondering how complete the candidate's understanding of the interaction is.

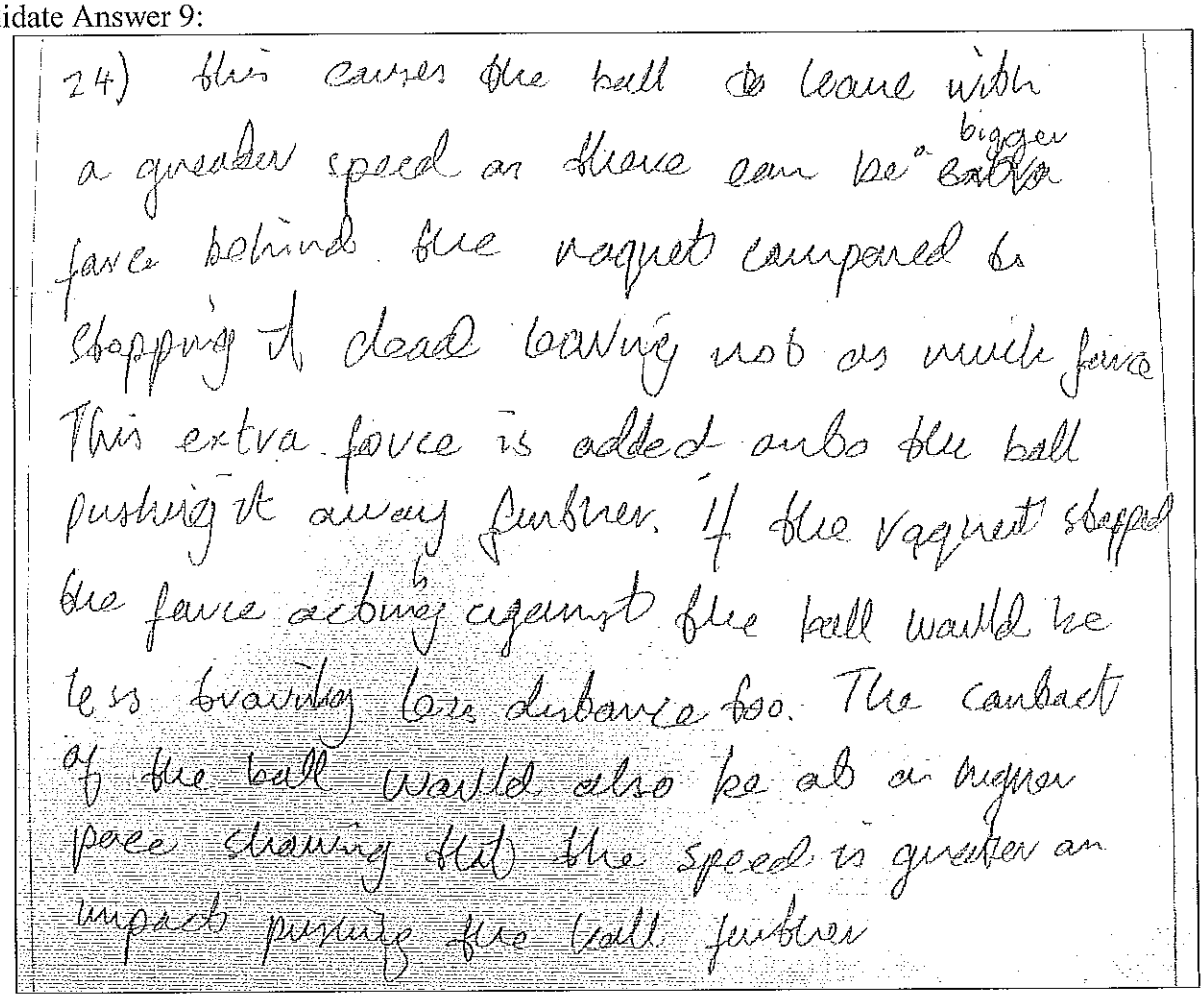
Candidate Answer 8:



Mark Awarded: 0

Comment:
Why is the racquet "starting further back"? Does the candidate think that the final velocity of the racquet is the 'v' in the formula?
There is no indication that the candidate understands the physics of what is happening.

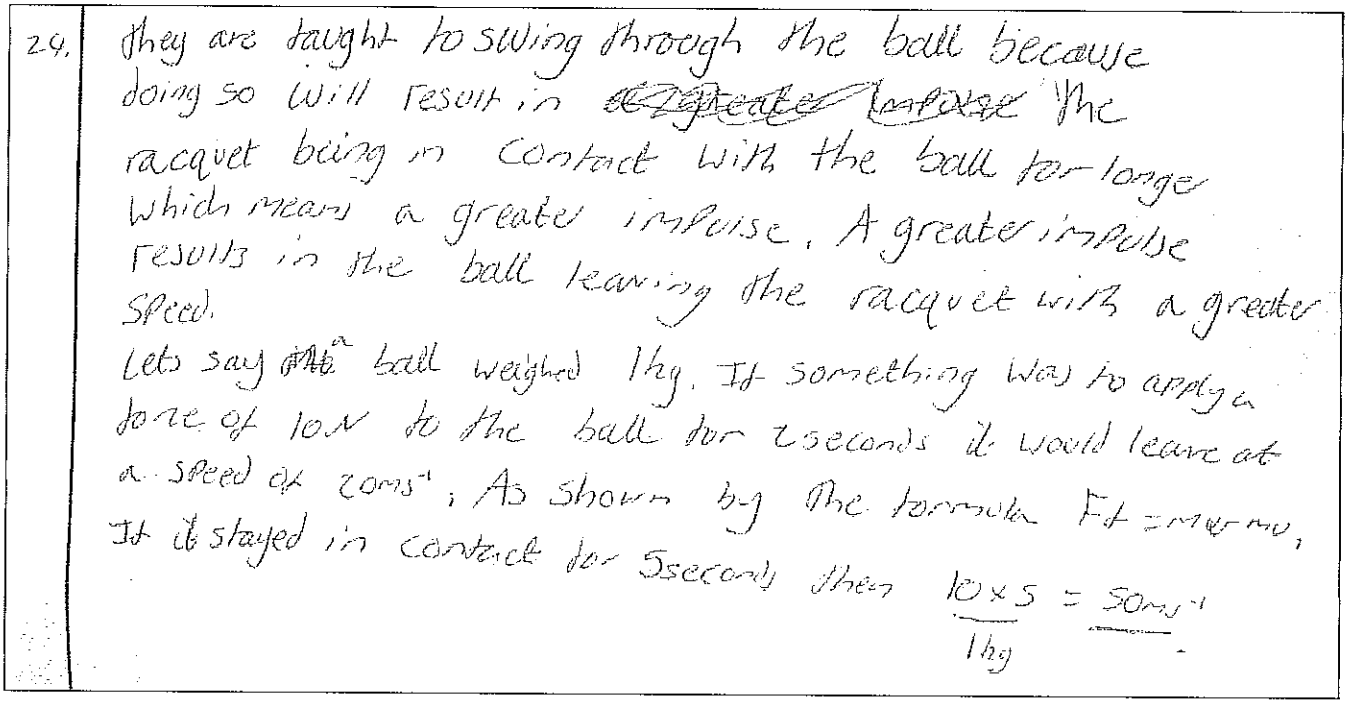
Candidate Answer 9:


24) this causes the ball to leave with a greater speed as there can be a bigger force behind the racquet compared to stopping it dead leaving not as much force This extra force is added onto the ball pushing it away further. If the racquet stopped the force acting against the ball would be less leaving for distance too. The contact of the ball would also be at a higher pace slowing it the speed is greater an impact pushing the ball further

Mark Awarded: 0

Comment:
There is no true physics analysis in this answer. "A bigger force behind the racquet", "This extra force is added onto the ball pushing it away further" and "The contact of the ball would also be at a higher [illegible]" are things that you might expect to be said by someone who has had no physics training. The use of correct terminology, at the level of Higher Physics, is missing.

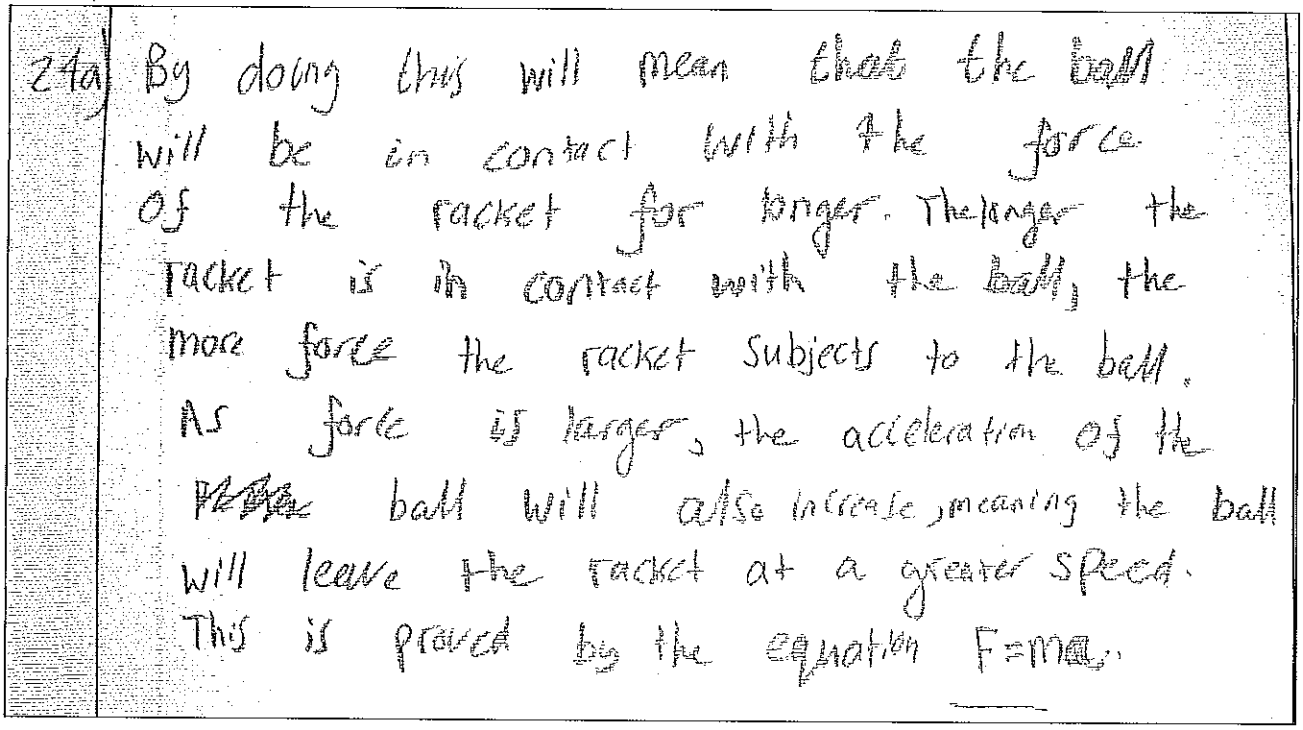
Candidate Answer 10:



Mark Awarded: 3

Comment:
The estimated values are poor. However, this question is probing the candidate's understanding of the underlying physics principles – these are presented clearly.

Candidate Answer 11:



Mark Awarded: 1

Comment:
This answer shows some limited understanding. The candidate does not seem to comprehend the difference between force and impulse.

Candidate Answer 12:

24. Using this technique would increase the speed of the ball as the momentum you have created by swinging your arm is carried on to the ball as the ball will be in contact with the racquet for longer.

Mark Awarded: 1

Comment:
This answer only demonstrates very limited understanding. The analysis is very incomplete but is not wrong or inconsistent.

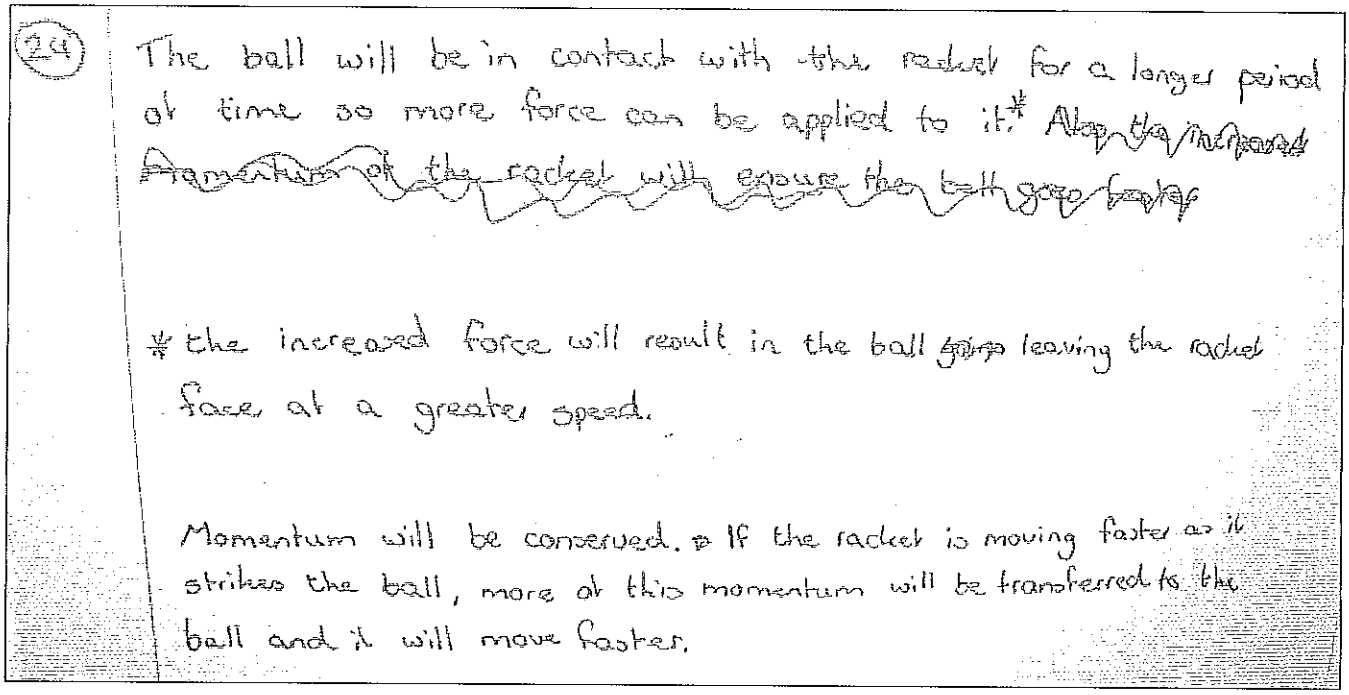
Candidate Answer 13:

24) As $E_w = Fxd$ So, if the ~~batt~~ racquet is swung through the ball and the force is exerted for longer distance then the work done increases and this gives a greater velocity as $v = \sqrt{\frac{2Fxd}{m}}$ So the greater the work done then the greater the velocity that the ball leaves the racquet.

Mark Awarded: 2

Comment:
This answer almost shows good understanding. Where does the relationship, in the fifth line, for 'v' come from? The candidate could have improved their answer by stating that they are assuming that all the work done on the ball by the racquet becomes kinetic energy of the ball.

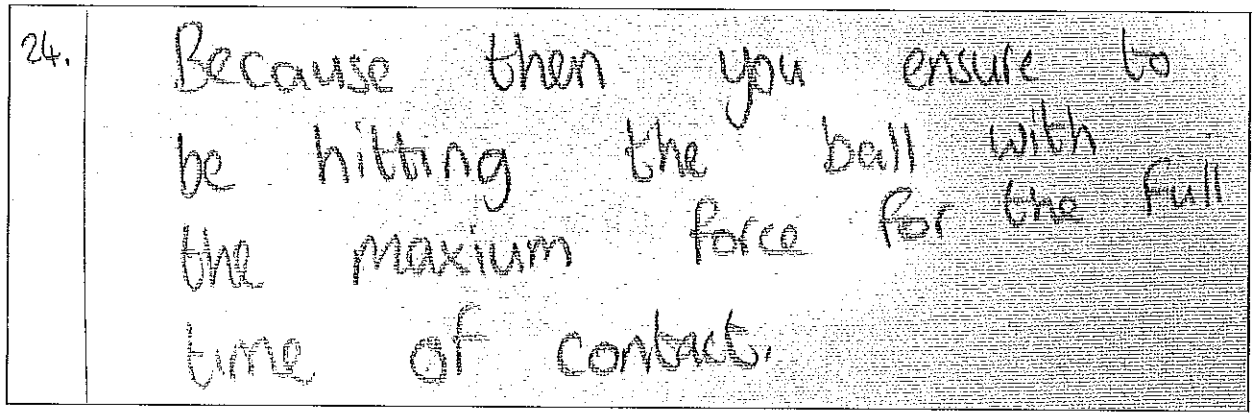
Candidate Answer 14:



Mark Awarded: 1

Comment:
This candidate does not define momentum or clarify its relationship with force and time. The candidate appears to think that an increase in contact time means an increased force (showing confusion between force and impulse?). However, it appears that there is a little understanding of relevant physics.

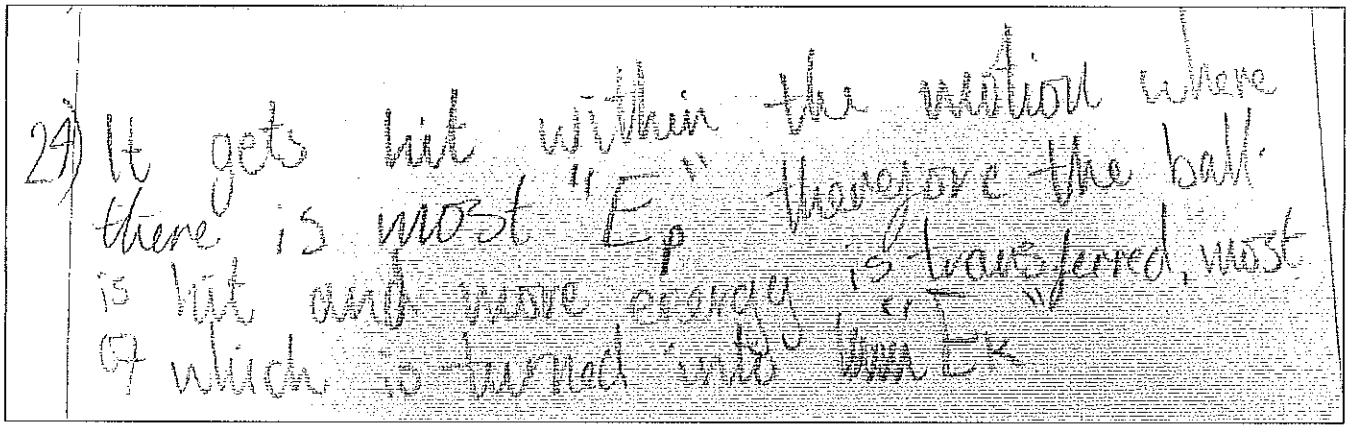
Candidate Answer 15:



Mark Awarded: 0

Comment:
Even allowing "maxium" to be "maximum", what does "maximum force" mean in this situation? What does "the full time of contact" mean in this situation? This answer does not show any understanding of the relevant physics.

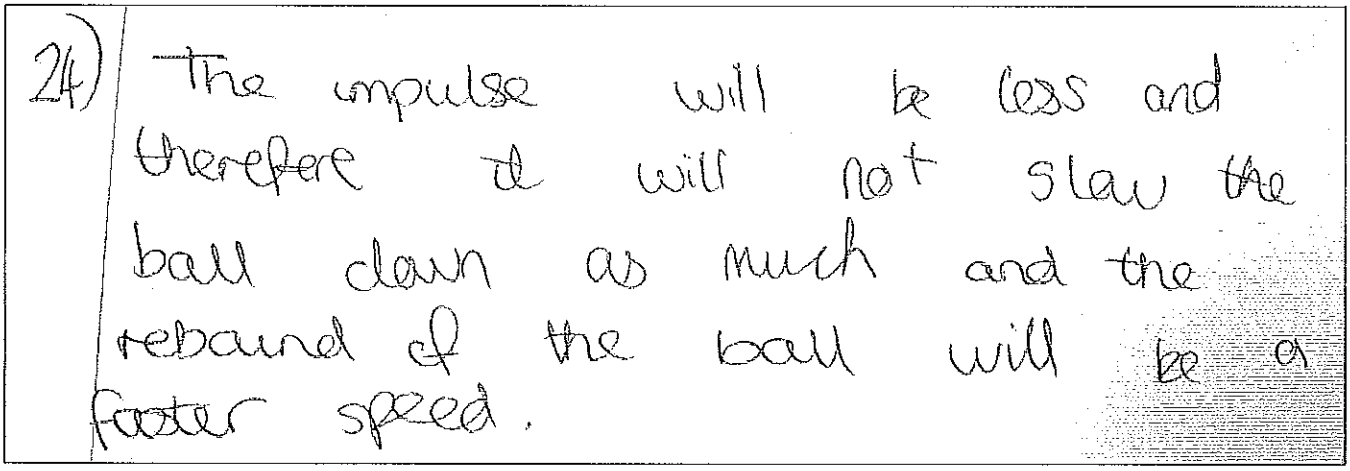
Candidate Answer 16:



Mark Awarded: 0

Comment:
What is meant by "It gets hit within the motion"? What is the relevance of potential energy? – is this referring to deformation of the racquet strings? Why is there more energy transferred?
This candidate has not demonstrated any correct understanding of what is happening.

Candidate Answer 17:



Mark Awarded: 0

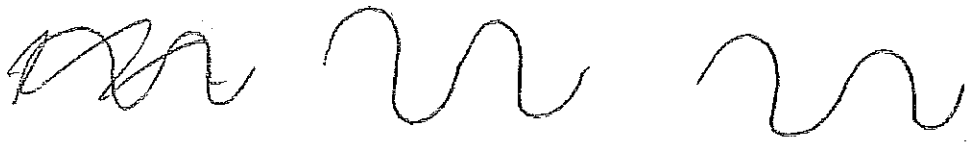
Comment:
There is no correct physics in this answer.

2012, question 28

One of the most important debates in scientific history asked the question: ***"Is light a wave or a particle?"*** Use your knowledge of physics to comment on our understanding of this issue.

Candidate Answer 1:

28) We understand that light acts like both a wave and a particle.



We have proved ~~shown~~ that it travels in small packets of waves as shown above, using the photoelectric effect.

Mark Awarded: 1

Comment:
This answer shows some correct understanding but does not give sufficient evidence for a marker to be convinced that the candidate's understanding is 'reasonable'.

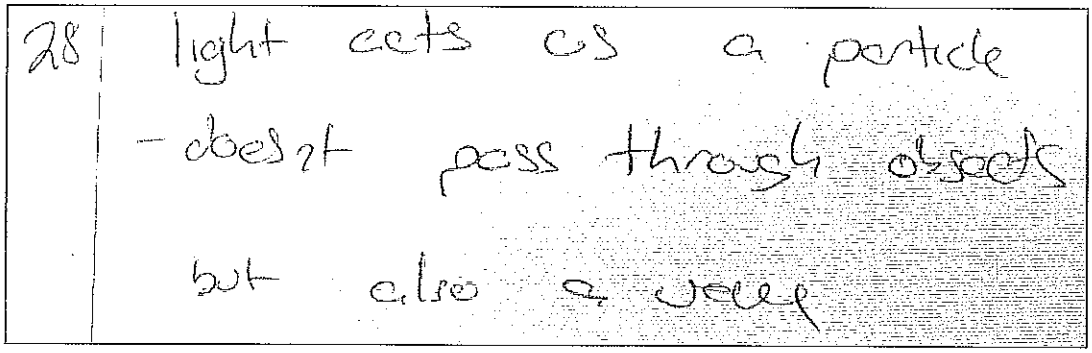
Candidate Answer 2:

28. The evidence for light being a wave is that it diffracts, as waves do.
Light also produces interference patterns, characteristic of waves.

Mark Awarded: 1

Comment:
This answer provides some correct discussion of the wave behaviour of light, but does not refer to its particle behaviour or the need for the duality theory. It demonstrates limited understanding.

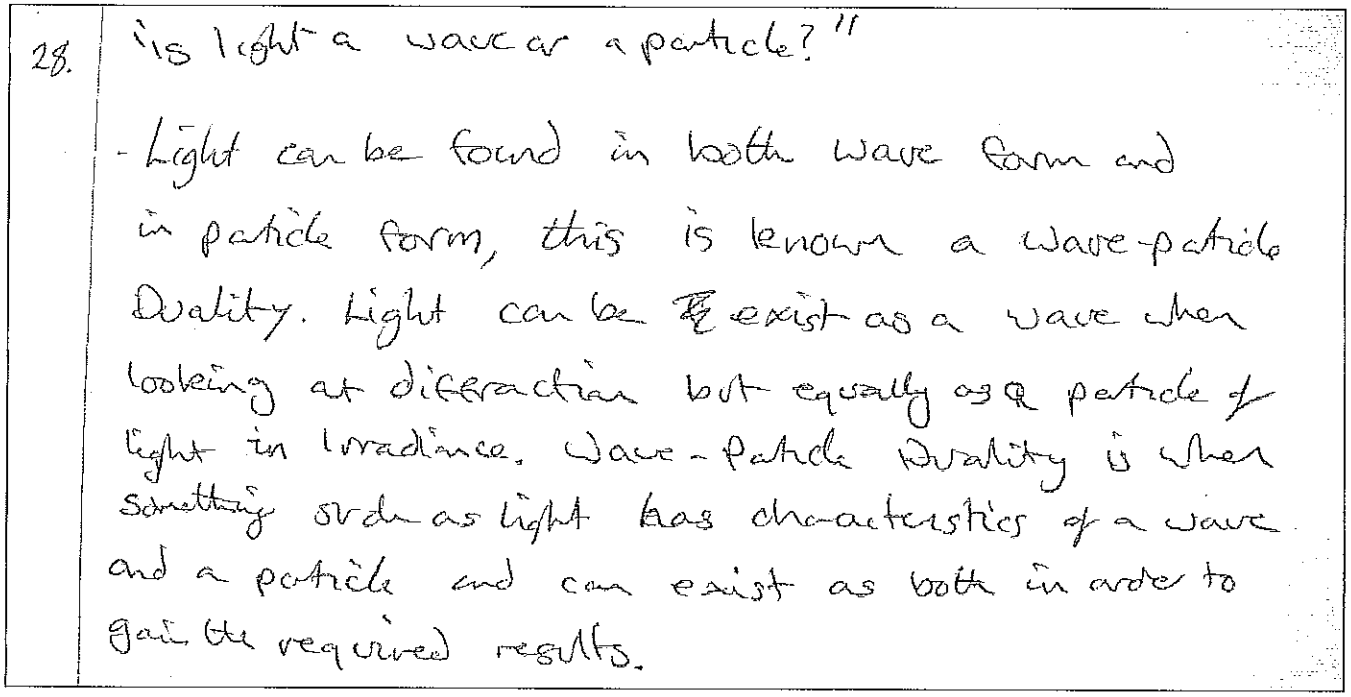
Candidate Answer 3:



Mark Awarded: 0

Comment:
A marker might initially think that this answer shows some limited understanding. However, this candidate wrongly states that light "doesn't pass through objects". This demonstrates that the candidate does not understand the behaviour of light.

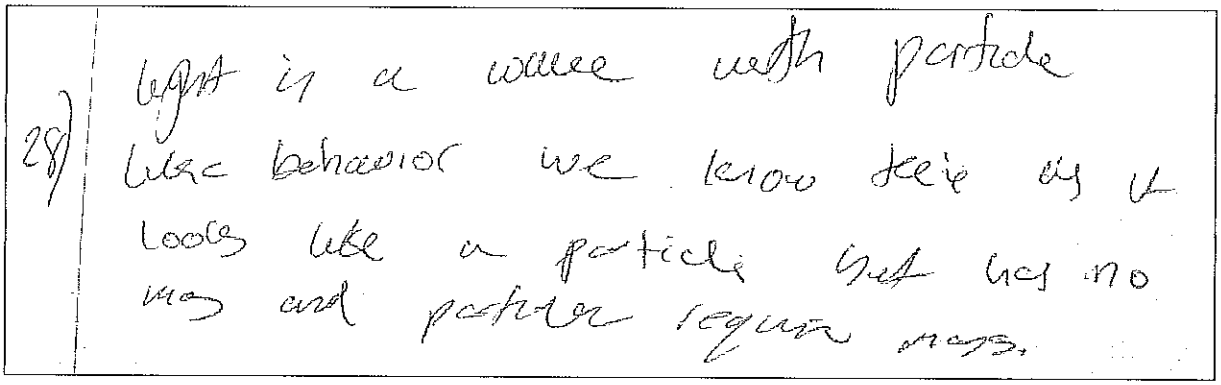
Candidate Answer 4:



Mark Awarded: 1

Comment:
This answer starts well as it correctly refers to the wave-particle duality and gives diffraction as proof of wave behaviour. However, "irradiance" does not necessarily indicate particle behaviour – this weakens the answer. The last sentence does not add anything to what the candidate has already written. This answer is at the 'top end' of showing limited understanding, but is not quite into the 'reasonable' range.

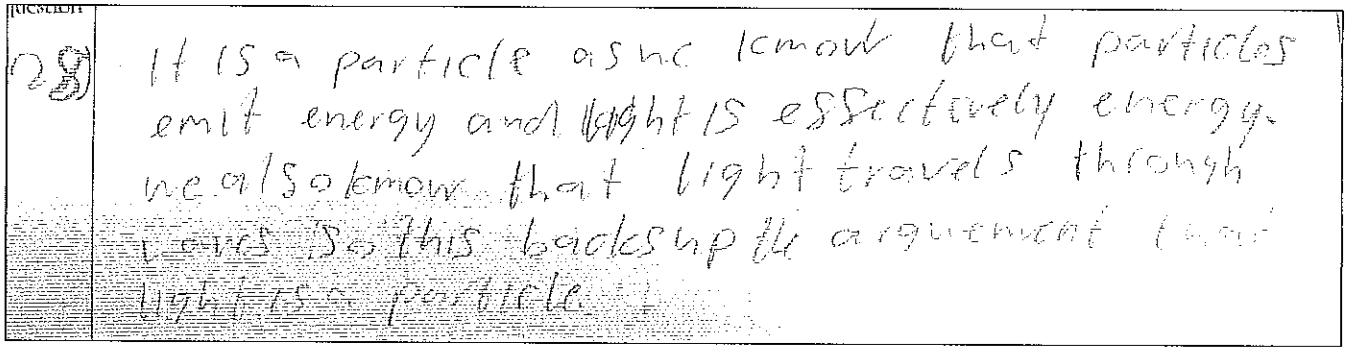
Candidate Answer 5:



Mark Awarded: 0

Comment:
The first eight words of this answer give a marker hope that marks can be awarded. However, the rest of the answer is poor. Taken as a whole, this response does not demonstrate understanding of the issue.

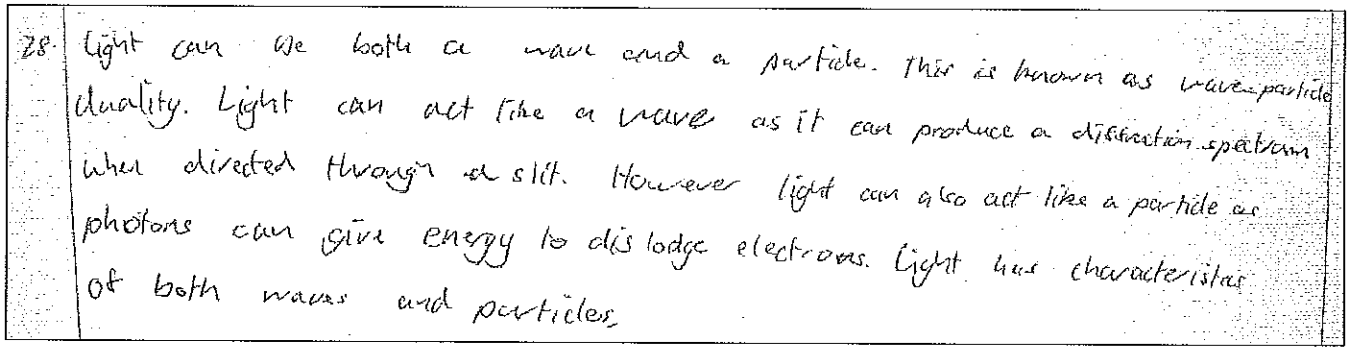
Candidate Answer 6:



Mark Awarded: 0

Comment:
This candidate has shown that he/she does not understand this issue. The last sentence (where the candidate states that "light travels through waves, so this backs up the argument that light is a particle") is particularly poor.

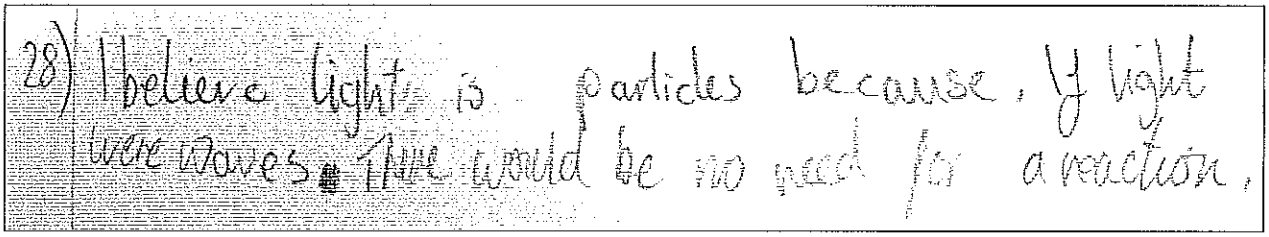
Candidate Answer 7:



Mark Awarded: 2

Comment:
This is almost a good answer, but it definitely shows reasonable understanding. The answer could have been made stronger by giving a bit more detail about the photoelectric effect and not just stating "light can also act like a particle as photons can give energy to dislodge electrons".

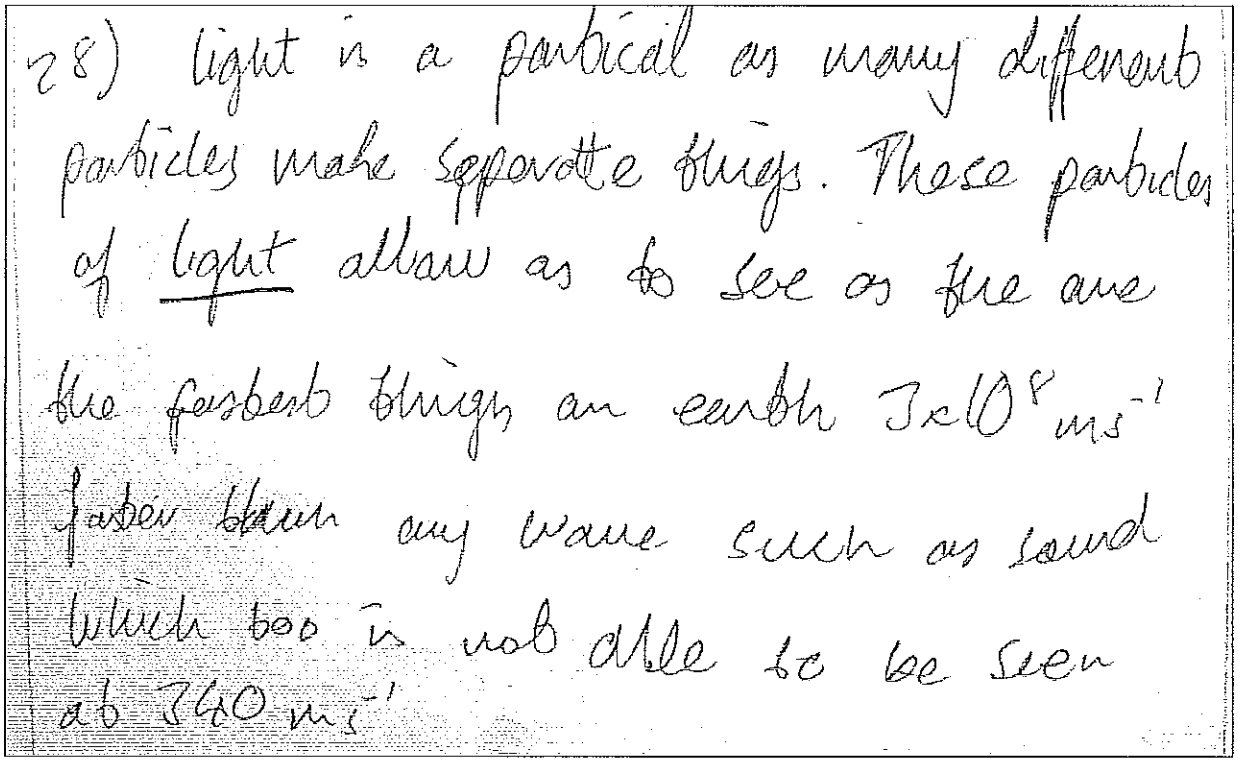
Candidate Answer 8:


28) I believe light is particles because, if light were waves there would be no need for a reaction,

Mark Awarded: 0

Comment:
This candidate response shows no understanding of the issue.

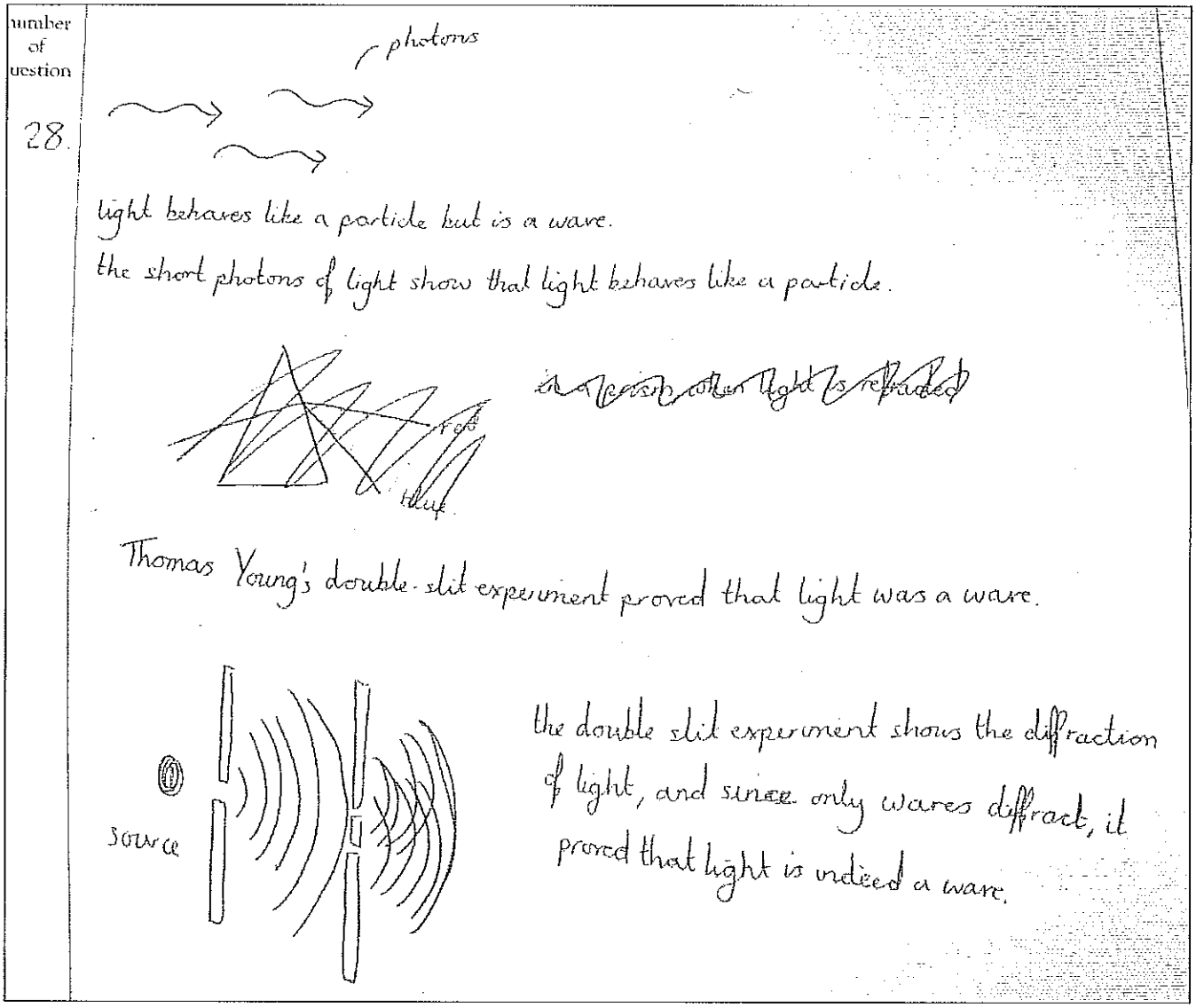
Candidate Answer 9:


28) Light is a partical as many different particles make seperate things. These particles of light allow us to see as the are the fastest things on earth $3 \times 10^8 ms^{-1}$ faster than any wave such as sound which too is not able to be seen at 340 ms^{-1}

Mark Awarded: 0

Comment:
This answer clearly demonstrates no understanding. Although correct facts are stated (like the speed of light and the speed of sound in air), the associated physics is either wrong or irrelevant.

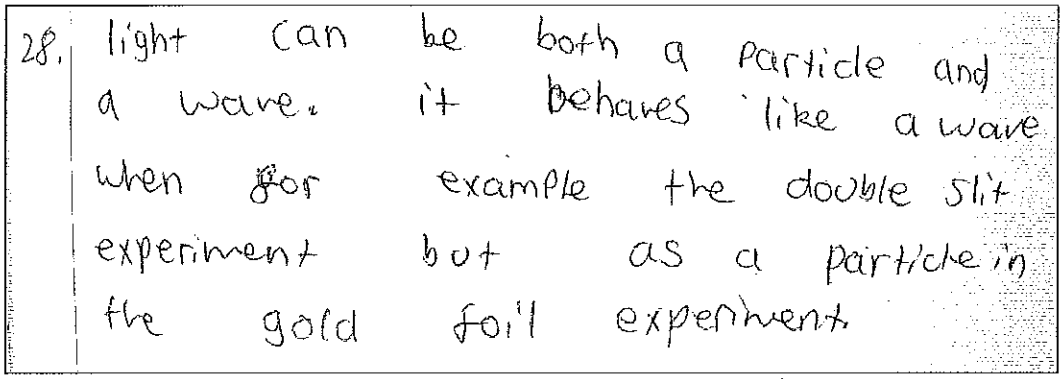
Candidate Answer 10:



Mark Awarded: 2

Comment:
There is sufficient correct physics in this answer to show 'reasonable' understanding. There are some weaknesses in the answer, such as stating "light behaves like a particle but is a wave". The diagram of Young's experiment is weak (e.g. irregular wavelength). The candidate could have taken the opportunity to refer to interference occurring in Young's experiment as further proof of wave behaviour.

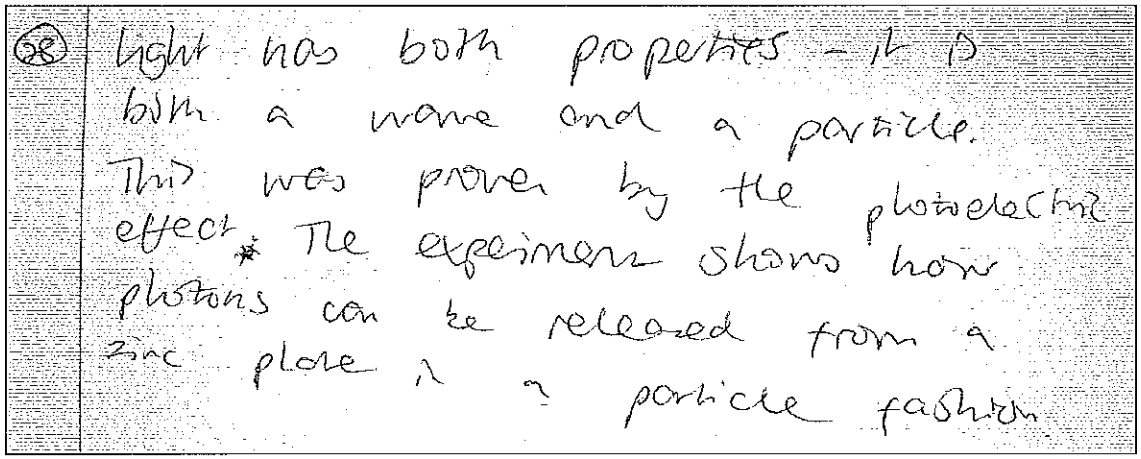
Candidate Answer 11:



Mark Awarded: 1

Comment:
This answer starts off well, but there is lack of detail in backing up the wave-particle duality model. For example, what is meant by the "double slit experiment"? Also, "the gold foil experiment" might be correctly referring to an electroscope used in demonstrating the photoelectric effect, but it also might be wrongly referring to Rutherford's experiment.

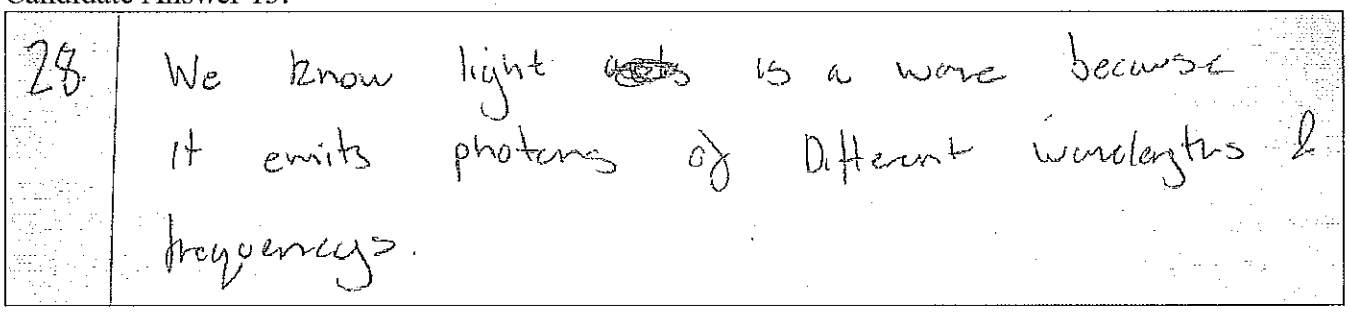
Candidate Answer 12:



Mark Awarded: 0

Comment:
Initially this answer shows promise. However, it goes on to imply that the photoelectric effect proves both properties. It then shows completely wrong physics by stating "photons can be released from a zinc plate". Taken as a whole, the answer shows no understanding.

Candidate Answer 13:



Mark Awarded: 0

Comment:
This answer only states that light is a wave and, even then, is weak by saying that "light … emits photons …". No understanding has been shown.

Candidate Answer 14:

28.

When a light source is shone through a grating, an ~~*~~ interference pattern caused by constructive and destructive interference between waves is obtained. This suggests light is a wave as there are maxima and minima produced.

On the other hand light ~~also exist~~ has also been proven to exist as individual particles called photons. In LEDs, due to the photovoltaic effect, ~~in~~ individual photons ~~are~~ can be released from an electron/hole pair.

Interestingly, if an individual photon is passed through a grating, an interference pattern is obtained which suggests light actually exists in wave packets called photons.

— a photon

Mark Awarded: 2

Comment:
This answer shows reasonable understanding of the dual nature of light. However, it is weak in the part which is attempting to describe the particle nature – it is not appropriate to refer to the photovoltaic effect in LEDs. If the candidate had correctly described the photoelectric effect, the answer could have demonstrated good understanding.

Candidate Answer 15:

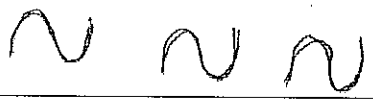
28a) light can be measured as [redacted] a particle.
If light can eject electrons at minimum frequency, this shows that light is a particle.
If you turn up the brightness, the frequency increases, however wavelength is unchanged
∴ a particle.

Mark Awarded: 0

Comment:
This answer shows no understanding of the dual nature of light. It repeatedly says that light is a particle.

Candidate Answer 16:

28) Light acts as a wave and a particle because it refracts through different substances - such as water or glass.
Light is made up of photons which are small separate particles in a wave form:

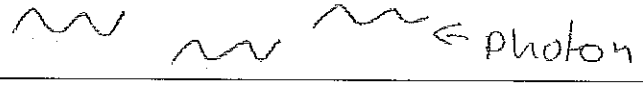


Mark Awarded: 1

Comment:
This answer shows limited understanding of the dual nature of light. However, there are no correct references to the evidence for either type of behaviour.

Candidate Answer 17:

28.) light is basically a mixture of both. The Youngs slit test showed that light was a wave but not a continuous one. It is split into segments of waves called photons. This gives it a particle and wave property.



Mark Awarded: 0

Comment:
Saying that light is a "mixture" of both is wrong. This candidate demonstrates too much confusion in their understanding for any marks to be awarded.

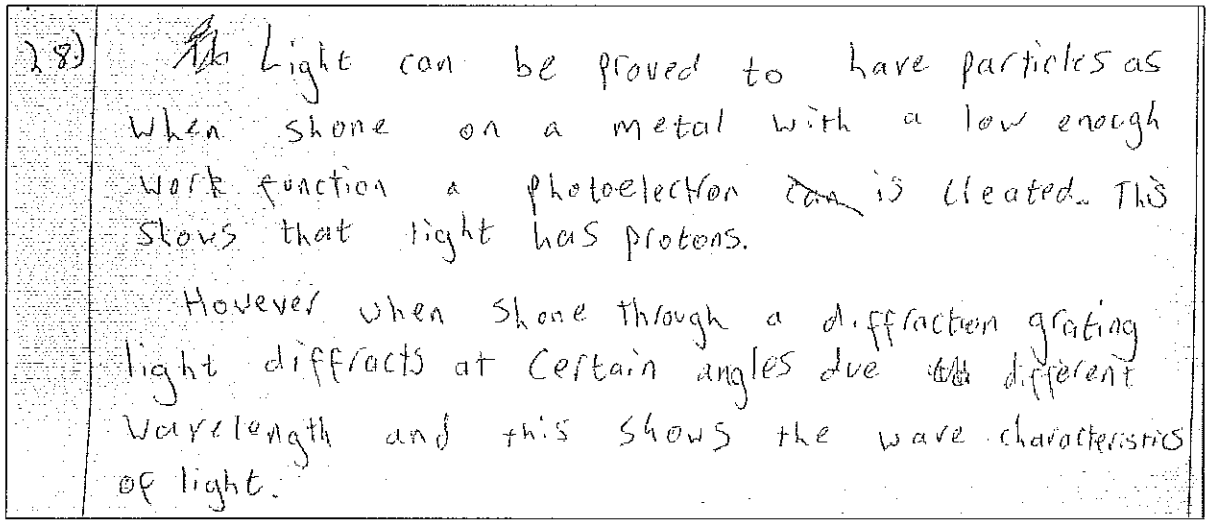
Candidate Answer 18:

28 Light is both like waves.
Light acts like a wave and a particle which is called a photon.

Mark Awarded: 1

Comment:
This short answer states enough to show limited understanding but is not detailed enough to demonstrate any greater depth of understanding.

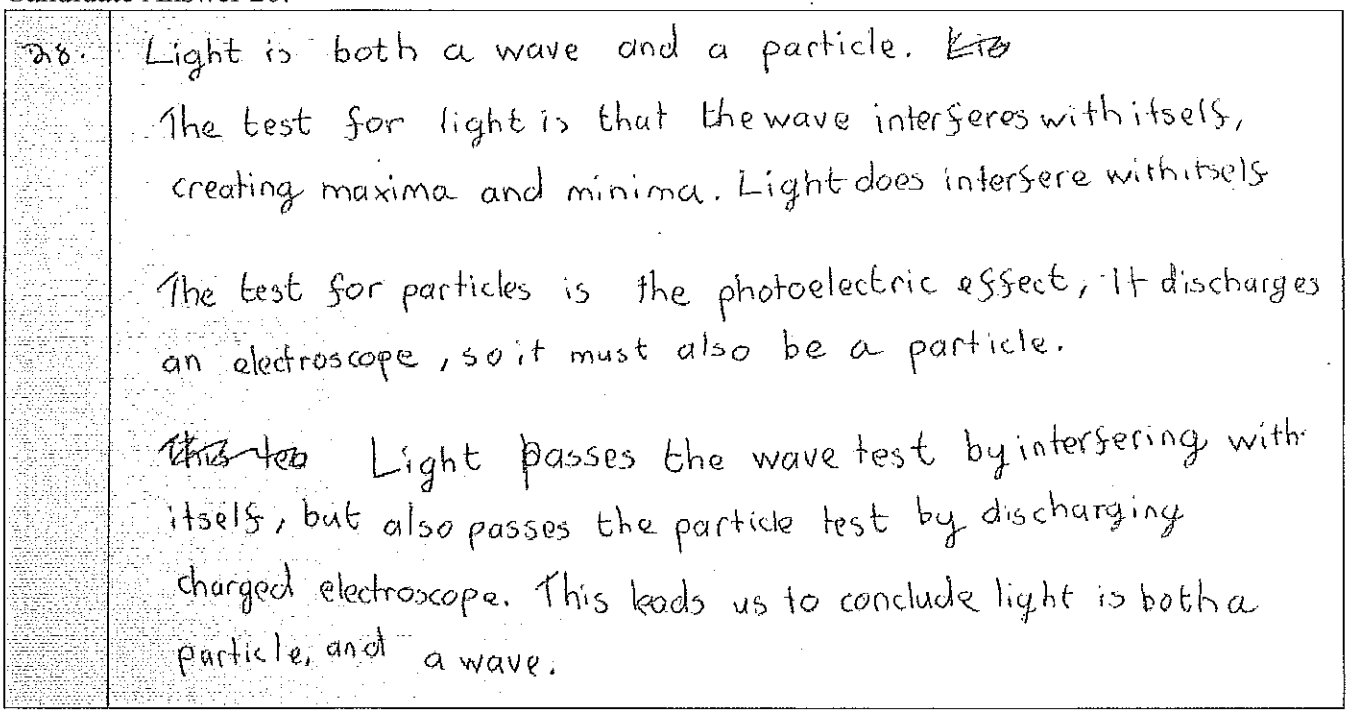
Candidate Answer 19:



Mark Awarded: 1

Comment:
This answer indicates that the candidate has some understanding of the dual nature of light and some knowledge that the photoelectric effect demonstrates its particle nature. However, the use of the word "protons" weakens the first part of the answer. In the second paragraph, it is wrong to say that "light diffracts at certain angles from a grating". In fact, all wavelengths diffract into (approximately) semicircular waves and the different colours of the spectrum are due to constructive interference for different wavelengths occurring at slightly different distances (and so angles) from the grating.

Candidate Answer 20:



Mark Awarded: 2

Comment:
This answer demonstrates reasonable understanding of the dual nature of light. The answer could be improved to 'good' by providing more details about experiments to show interference and the photoelectric effect.

Candidate Answer 21:

28.	Light is both a wave and a particle. We use Young's double slit experiment to show how light intergeres with itself to create maximum and minimum areas of light ∴ showing it acts as a wave.

Mark Awarded: 1

Comment:
This answer does state that light displays both wave and particle behaviour, but it only gives evidence for its wave nature. It is almost showing 'reasonable' understanding, but is a strong '1' rather than a '2'.

Candidate Answer 22:

of question	
28	Light can be both a wave and a particle. We know it can be a wave because it diffracts through a grating. We know it can be a particle because it releases energy when broken (e.g. light so we can see)

Mark Awarded: 1

Comment:
This candidate shows that they do know about the dual nature of light, but there is lack of detail about diffraction. The meaninglessness of the last sentence creates doubts about their knowledge and level of understanding.

Candidate Answer 23:

28.)
- Light can behave as both a wave and a particle.
- The photoelectric effect proves the particulate nature of light.
- Diffraction of light through a grating proves the wave nature of light.
- The nature of light can be best explained as being a wave-particle duality.

Mark Awarded: 3

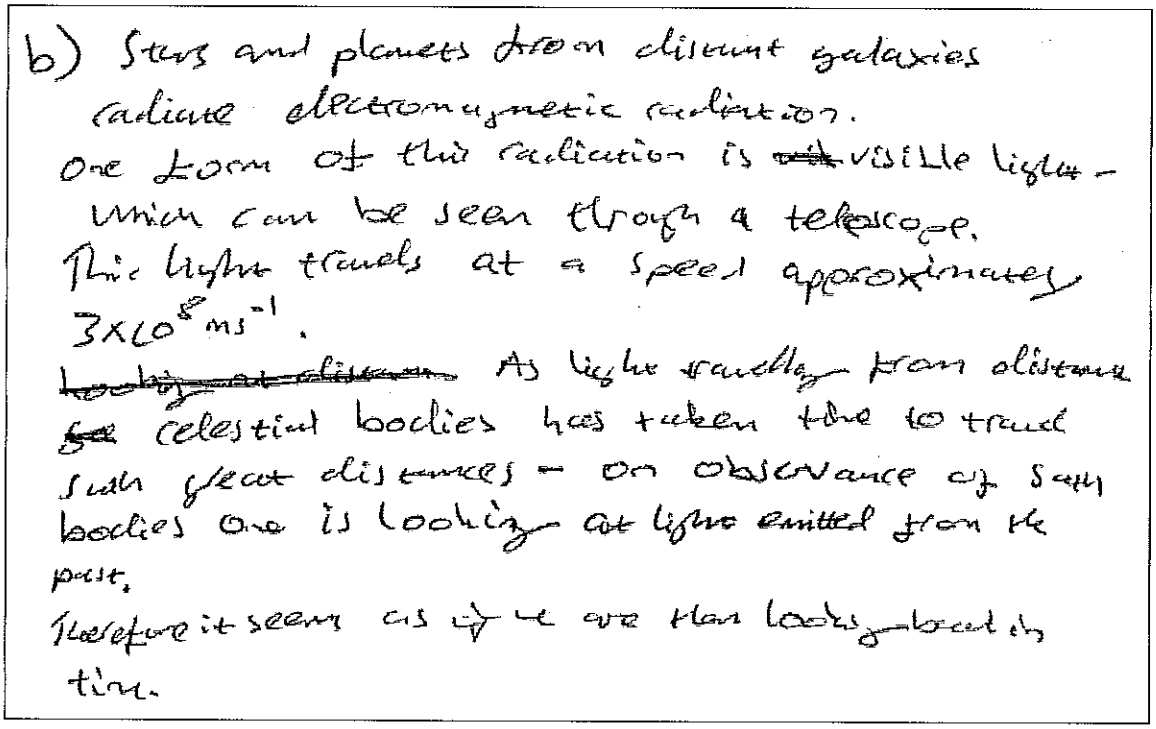
Comment:
This answer provides only just enough evidence of the candidate having a good understanding. It could have been made into a much more secure '3' by providing more information both about the photoelectric effect (e.g. a brief description of an experiment and/or what happens in the photoelectric effect) and about diffraction (e.g. what it means or what is observed in an experiment).

2013, question 25(b)

(*b*) During a television programme the presenter states, "*Looking through a telescope at the night sky is like looking back in time*".

Use physics principles to comment on this statement.

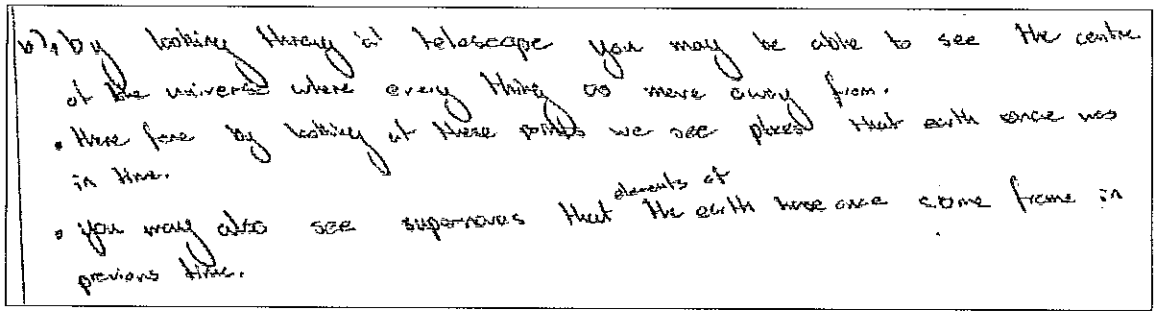
Candidate Answer 1:


b) Stars and planets from distant galaxies radiate electromagnetic radiation. One form of this radiation is ~~with~~ visible light - which can be seen through a telescope. This light travels at a speed approximately $3 \times 10^8 ms^{-1}$. ~~Looking at distant~~ As light travelling from distant ~~See~~ celestial bodies has taken time to travel such great distances - on observance of such bodies one is looking at light emitted from the past. Therefore it seems as if we are then looking back in time.

Mark awarded: 3

Comment:
We would normally consider that it is only stars, and not planets, which are significant radiators of electromagnetic radiation. However, this does not detract from this being a good answer. It is worth repeating that markers are not seeking full and perfect answers before awarding the full 3 marks.

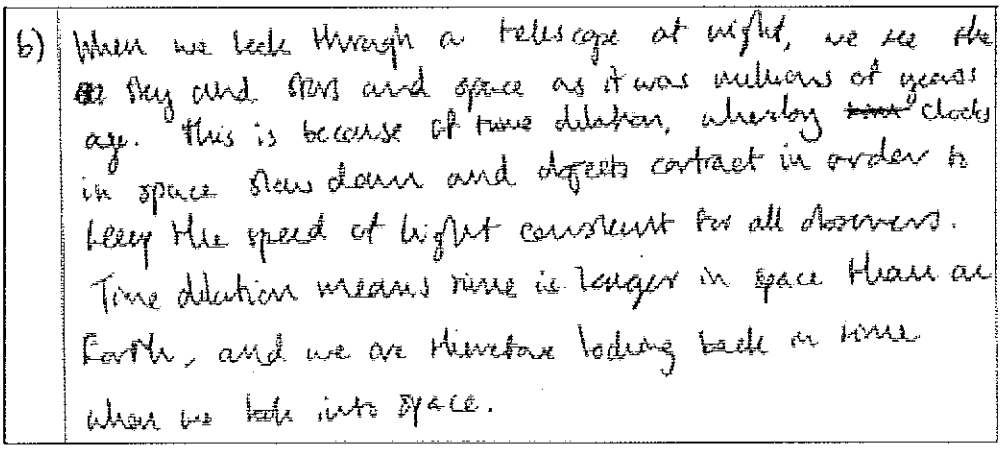
Candidate Answer 2:


b) By looking through a telescope you may be able to see the centre of the universe where every thing is move away from.
- How fore by looking at these points we see places that earth once was in time.
- you would also see supernovas that elements of the earth have once come from in previous time.

Mark awarded: 0

Comment:
There is not any evidence that this candidate has an understanding of the issue.

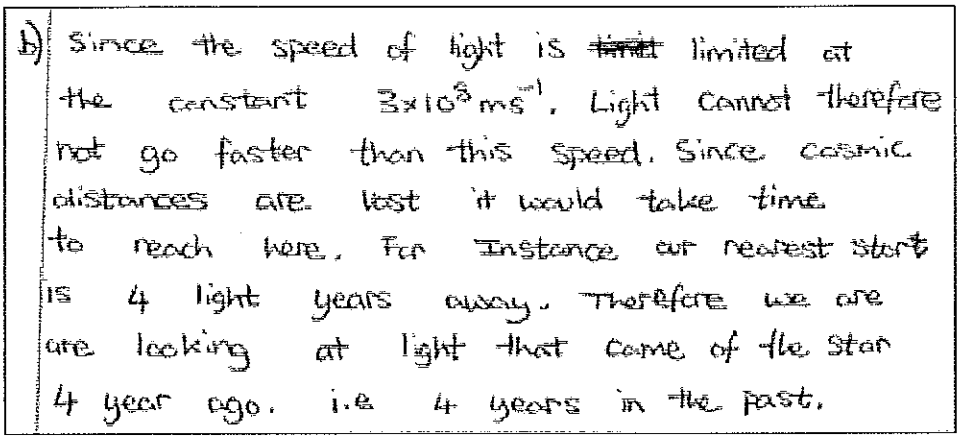
Candidate Answer 3:


b) When we look through a telescope at night, we see the sky and stars and space as it was millions of years ago. This is because of time dilation, whereby ~~time~~ clocks in space slow down and objects contract in order to keep the speed of light constant for all observers. Time dilation means time is longer in space than on Earth, and we are therefore looking back in time when we look into space.

Mark awarded: 0

Comment:
This is an example of a candidate showing that they have not understood that the relevant physics is light taking significant time to travel the vast distances across the universe. Instead, they have wrongly discussed time dilation which is to do with differing values of elapsed time for different frames of reference.

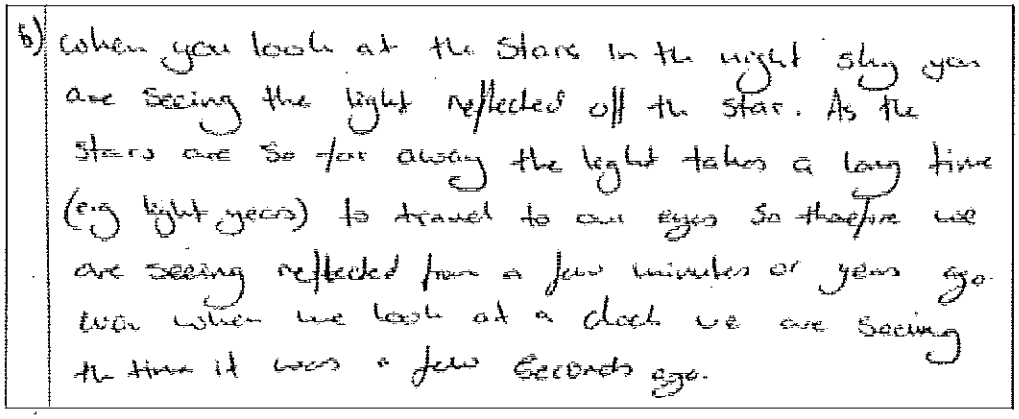
Candidate Answer 4:


b) Since the speed of light is ~~limit~~ limited at the constant $3 \times 10^8 ms^{-1}$. Light cannot therefore not go faster than this speed. Since cosmic distances are vast it would take time to reach here. For instance our nearest start is 4 light years away. Therefore we are are looking at light that come of the star 4 year ago. i.e 4 years in the past.

Mark awarded: 2

Comment:
This candidate has demonstrated a reasonable understanding of the appropriate physics. The 'double negative' in the second sentence has been ignored. The candidate has wrongly stated that our nearest star is 4 light years away. Our nearest star is the Sun, which is approximately 8·5 light minutes away. However, this error of fact does not weaken the answer very much. Making a reference to the relationship between distance, speed and time could have strengthened the answer.

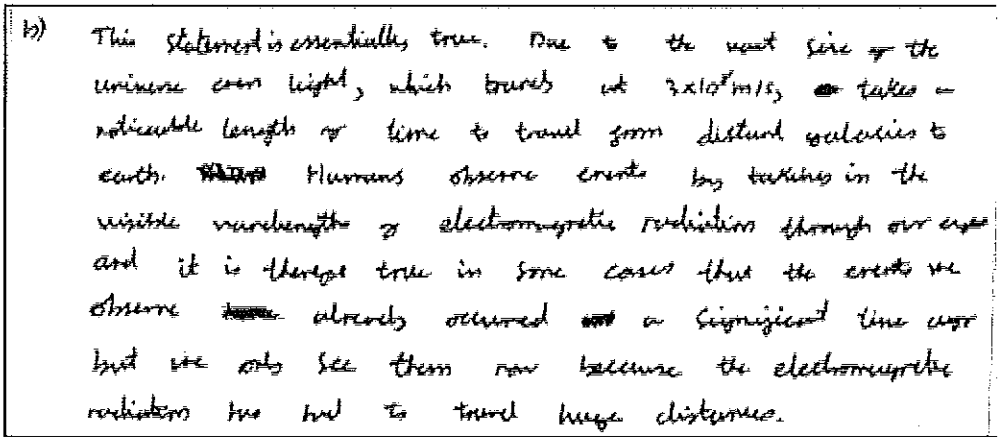
Candidate Answer 5:


b) When you look at the stars in the night sky you are seeing the light reflected off the star. As the stars are so far away the light takes a long time (e.g. light years) to travel to our eyes so therefore we are seeing reflected from a few minutes or years ago. Even when we look at a clock we are seeing the time it was a few seconds ago.

Mark awarded: 0

Comment:
There are a number of things wrong in this answer; light is radiated from stars, not reflected by them; a 'light year' is a distance, not a time; unless your clock is in a distant orbit, there are not "a few seconds" of delay! This candidate has not shown any real understanding of correct physics.

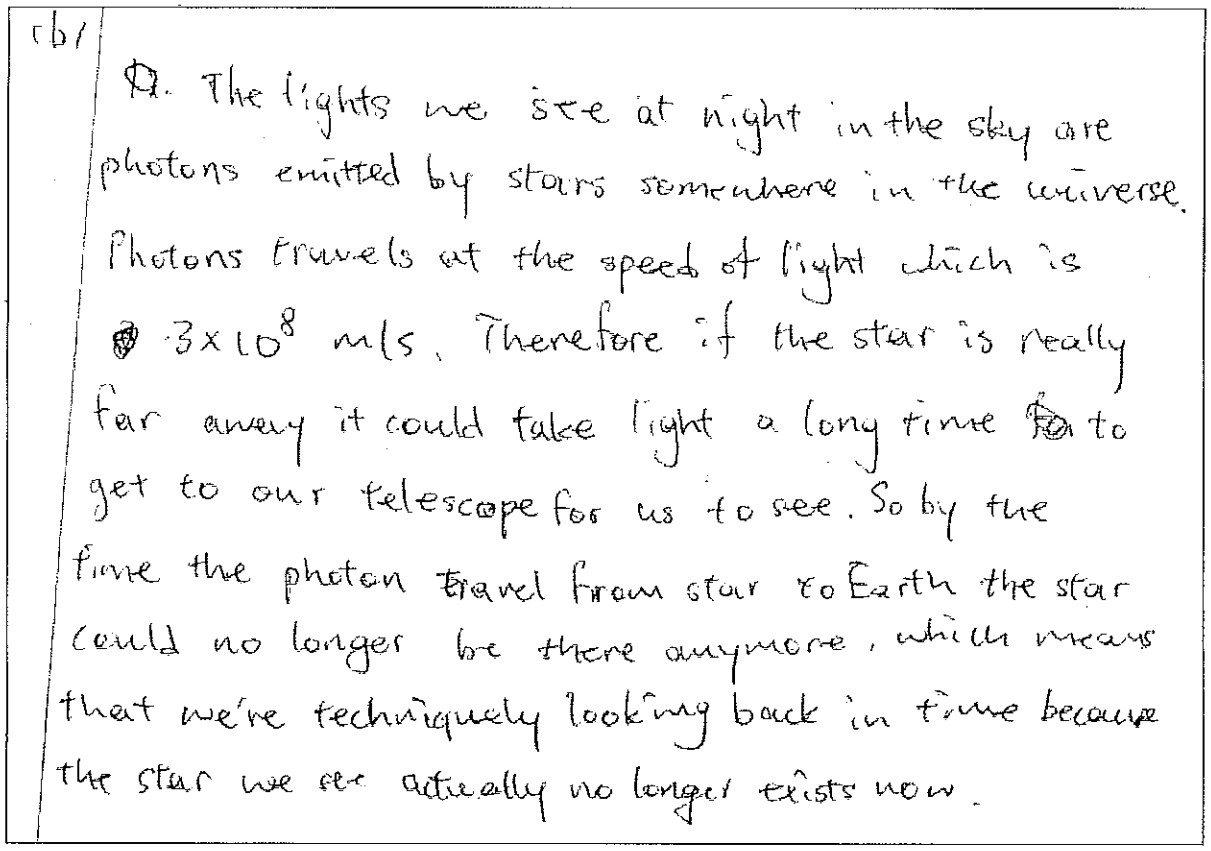
Candidate Answer 6:


b) This statement is essentially true. Due to the vast size of the universe even light, which travels at 3×10^8 m/s, takes a noticeable length of time to travel from distant galaxies to earth. Humans observe events by taking in the visible wavelengths of electromagnetic radiation through our eyes and it is therefore true in some cases that the events we observe already occurred a significant time ago but we only see them now because the electromagnetic radiation has had to travel huge distances.

Mark awarded: 3

Comment:
This candidate shows good understanding of the appropriate physics.

Candidate Answer 7:

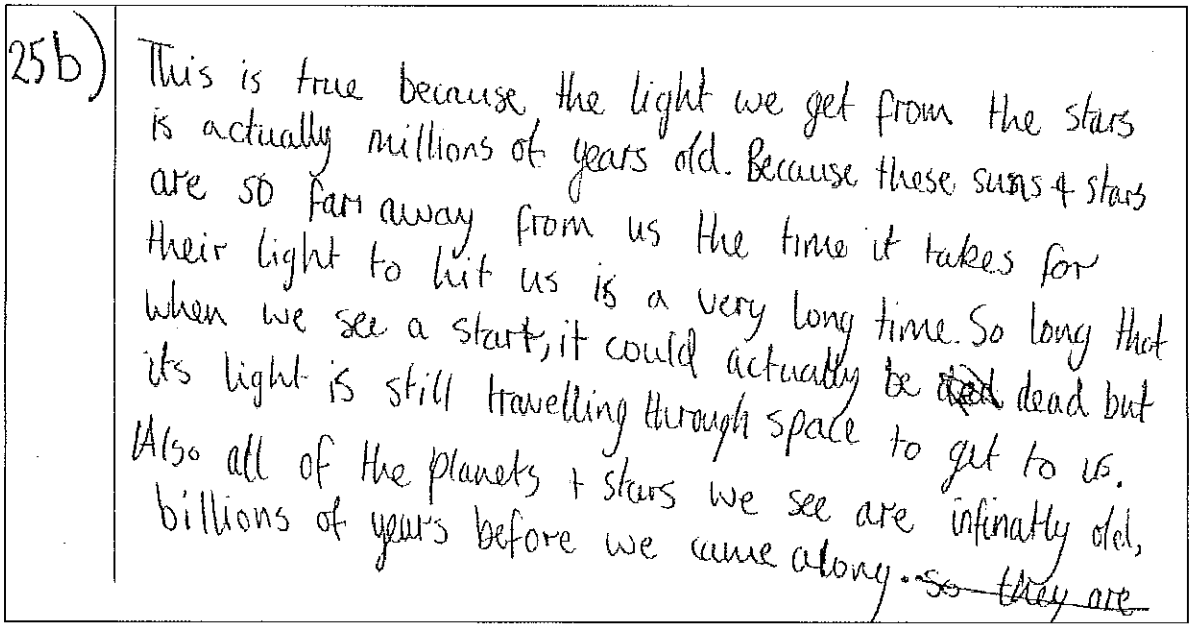

(b)

Q. The lights we see at night in the sky are photons emitted by stars somewhere in the universe. Photons travels at the speed of light which is 3×10^8 m/s. Therefore if the star is really far away it could take light a long time to get to our telescope for us to see. So by the time the photon travel from star to Earth the star could no longer be there anymore, which means that we're technicquely looking back in time because the star we see actually no longer exists now.

Mark Awarded: 3

Comment:
The candidate has demonstrated good understanding of relevant physics, making clear why we see the stars and why time is required for photons to travel to our eyes.

Candidate Answer 8:


25b) This is true because the light we get from the stars is actually millions of years old. Because these suns & stars are so far away from us the time it takes for their light to hit us is a very long time. So long that when we see a start, it could actually be dead but its light is still travelling through space to get to us. Also all of the planets & stars we see are infinatly old, billions of years before we came along. So they are

Mark Awarded: 1

Comment:
This candidate has shown some understanding of the issue by referring to the huge distances to the stars, but he/she has not developed how this links to the time light takes to travel to us from them.

Candidate Answer 9:

b) Because the stars are thousands (light year away that by the time the light reach our eyes it would been gone for ~~centuries~~ hundreds of years.

Mark Awarded: 0

Comment:
This answer does not discuss any of the relevant physics and is also internally inconsistent (i.e. if the stars are "thousands of light years away" then it should take thousands, not "hundreds", of years for the light to reach us).

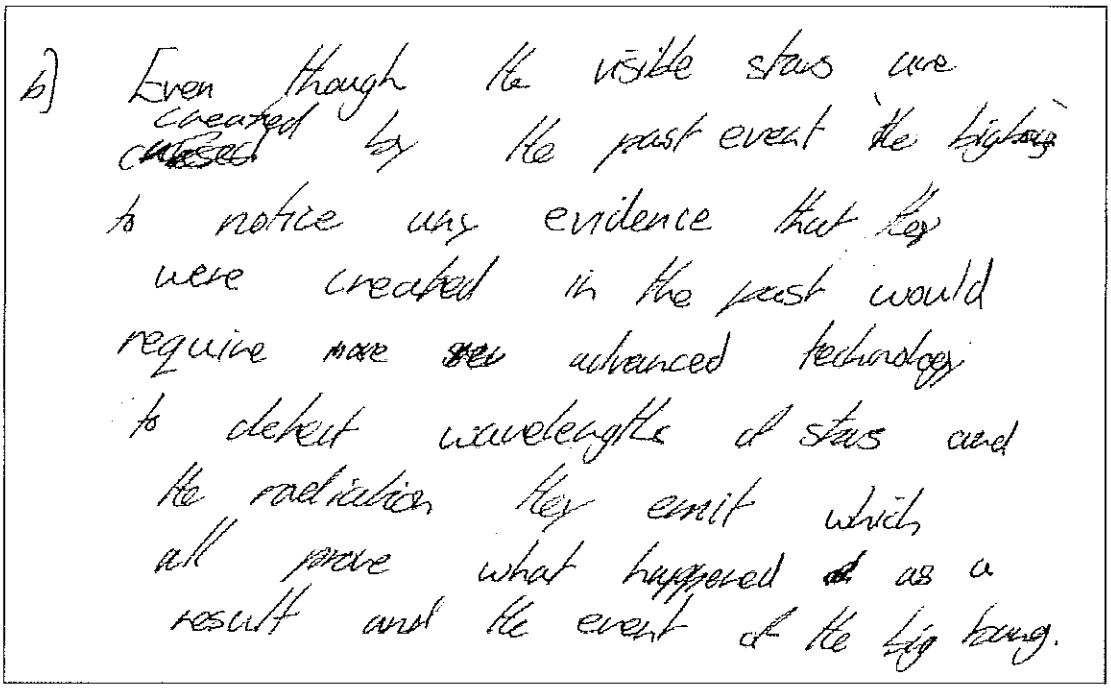
Candidate Answer 10:

b) This statement is correct because when you see ~~the~~ stars in the night sky, the light you are seeing has travelled a vast distance in order to reach and for you to see it. Since this light has travelled a vast distance, it is actually showing a different period of time (time in the past) compared to the period of time that is occuring on that planet now, as the distance is so vast light takes a long time to travel to earth, so when you see ~~the~~ stars through a telescope you are looking back in time.

Mark Awarded: 1

Comment:
Although there is reference to the "vast distance" to the stars, there is no explanation about why it takes light so long to travel. There is significant repetition in the answer – this makes it longer but not worth any more marks.

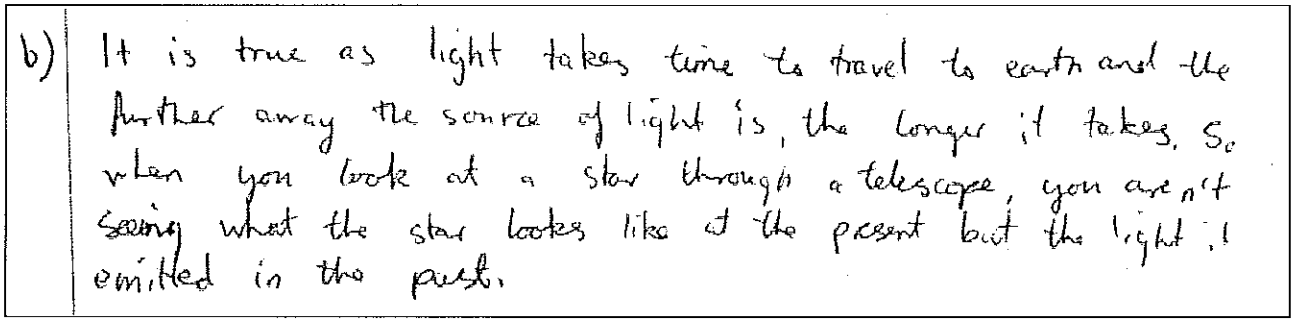
Candidate Answer 11:


b) Even though the visible stars are created by the past event the bigbang to notice any evidence that they were created in the past would require more advanced technology to detect wavelengths of stars and the radiation they emit which all prove what happened as a result and the event of the big bang.

Mark Awarded: 0

Comment:
The candidate refers to the 'Big Bang' as the basis of their explanation. This is not the correct physics for an answer to this question. This candidate has not shown that they have any understanding of the relevant physics.

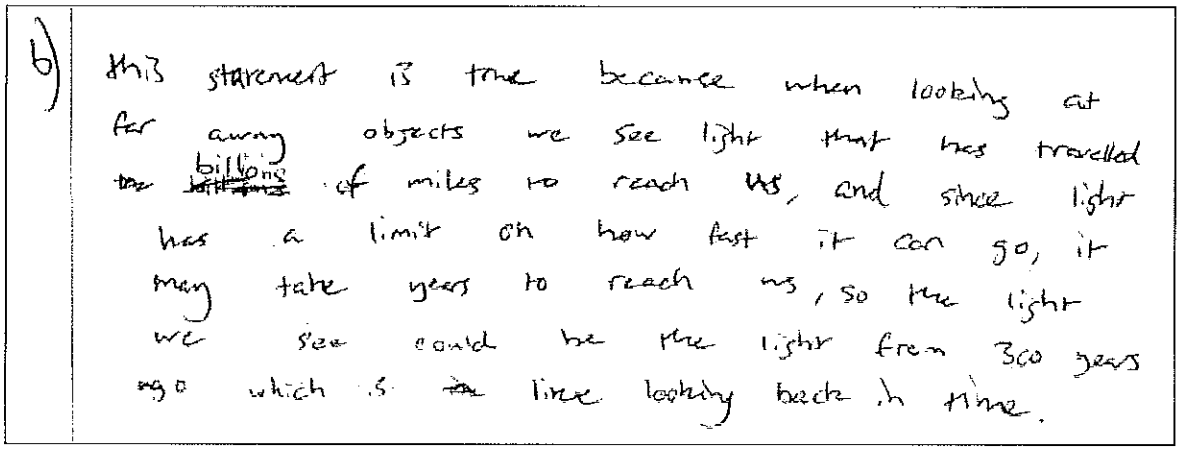
Candidate Answer 12:


b) It is true as light takes time to travel to earth and the further away the source of light is, the longer it takes. So when you look at a star through a telescope, you aren't seeing what the star looks like at the present but the light it emitted in the past.

Mark Awarded: 1

Comment:
This answer correctly states that "it takes light time to travel to earth" but there is no detail about why this is the case. Appropriate mention of the vast distances to stars, the speed of light and the relationship between distance, speed and time would have strengthened the answer considerably.

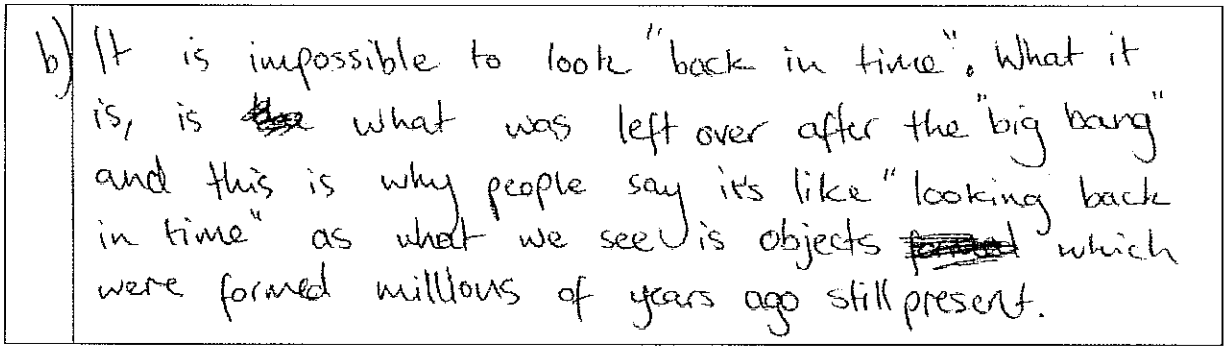
Candidate Answer 13:



Mark Awarded: 1

Comment:
This answer demonstrates limited understanding. The enormity of the distances to the stars has not been fully appreciated. The value of the speed of light could have been stated (and even an example of the time taken calculated). The 'example' of "300 years" indicates that the candidate does not fully appreciate the issue.

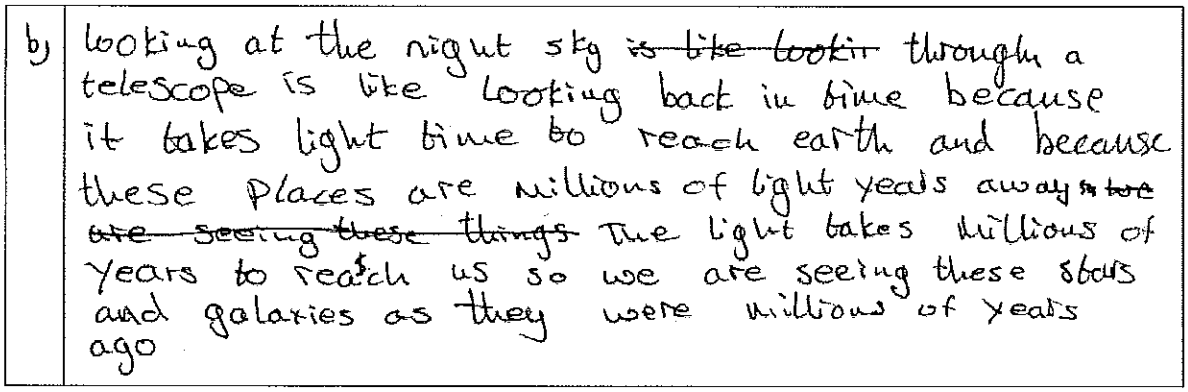
Candidate Answer 14:



Mark Awarded: 0

Comment:
This candidate has shown that she/he does not understand the appropriate physics.

Candidate Answer 15:



Mark Awarded: 1

Comment:
This answer shows a basic understanding of the issue but it really only keeps repeating that it takes light time to reach the Earth.

Candidate Answer 16:

b) Scientists believe before the big bang theory everything was dark. Dark matter is stuff we cannot see however it is what keeps the stars and galaxy together. Dark energy is responsible for the expansion of the universe.

Mark Awarded: 0

Comment:
There is nothing in this response which actually answers the question. The only conclusion a marker can come to is that the candidate has no understanding of the issue.

Candidate Answer 17:

b) What the presenter says is partly true, as looking at the night sky such as the stars is indeed like looking back in time as the stars are over a million years old, they are dead stars that once existed.

Mark Awarded: 0

Comment:
This candidate "partially" agrees with the presenter but provides no physics principles to explain why.

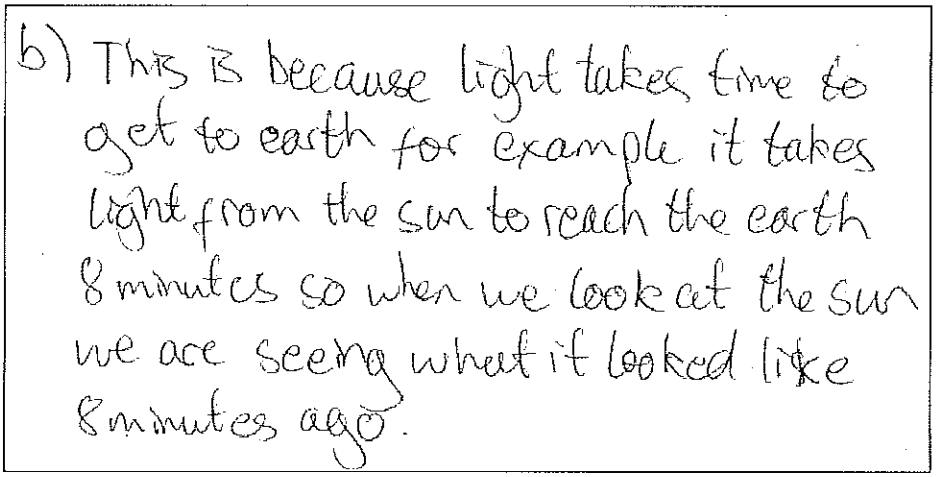
Candidate Answer 18:

b) The Universe is expanding as can be seen as it is being redshifted. This means the particles in space are moving away from the observers on Earth. As they can see everything moving away, they may feel like they are going back in time. As the universe expands the temperature begins to decrease.

Mark Awarded: 0

Comment:
This candidate's response shows that he/she has no understanding of the issue. None of the 'reasons' given are relevant.

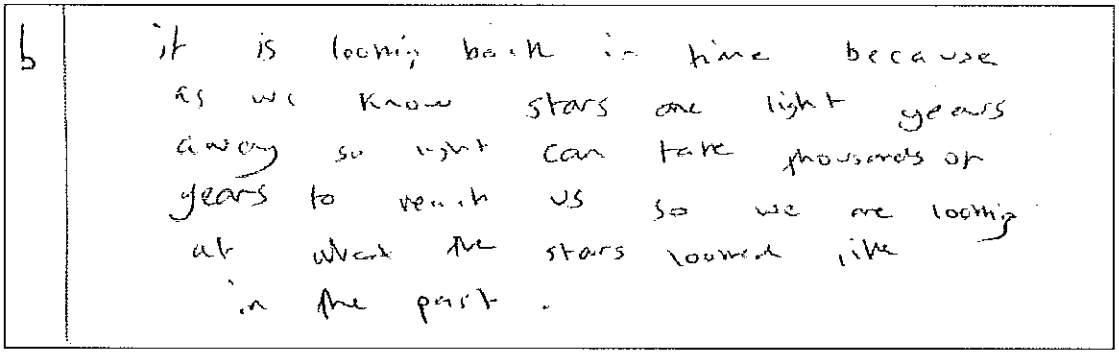
Candidate Answer 19:



Mark Awarded: 1

Comment:
This answer shows a minimal understanding of the issue but it lacks any explanation about why it takes time for light to travel to the Earth from the stars.

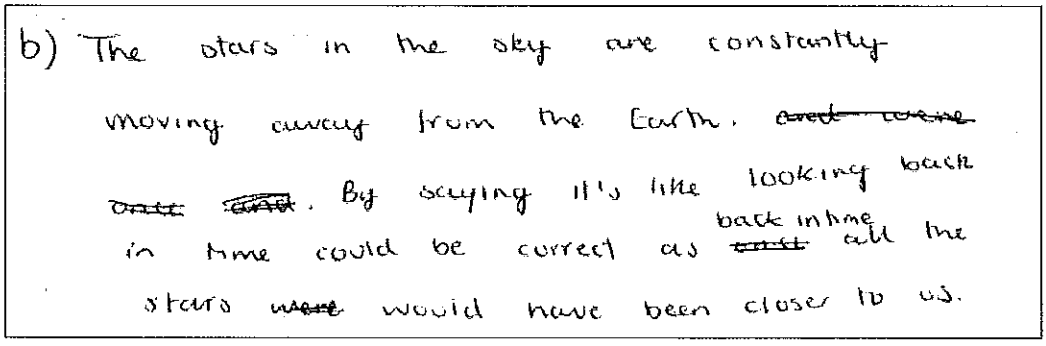
Candidate Answer 20:



Mark Awarded: 1

Comment:
This answer shows a minimal understanding of the issue but it lacks any explanation about why it takes time for light to travel to the Earth from the stars. It simply states that "we know stars are light years away".

Candidate Answer 21:



Mark Awarded: 0

Comment:
This answer makes it clear that the candidate does not understand the issue at all. He/She seems to think that the reason is the expansion of the Universe.

Candidate Answer 22:

b) The statement is true. This is because the light that is viewed in a telescope has travelled millions of miles to get to the telescope from the galaxy it has been emitted from. To travel such a distance takes a long time, so the light viewed in a telescope is light emitted hundreds of years before by the galaxy. So whilst looking into the telescope, the viewer is not looking at the present, but at the past.

Mark Awarded: 1

Comment:
A minimal level of understanding is shown by this answer. The candidate implies that light takes "hundreds of years" to travel "millions of miles" – this is, at best, weak physics.

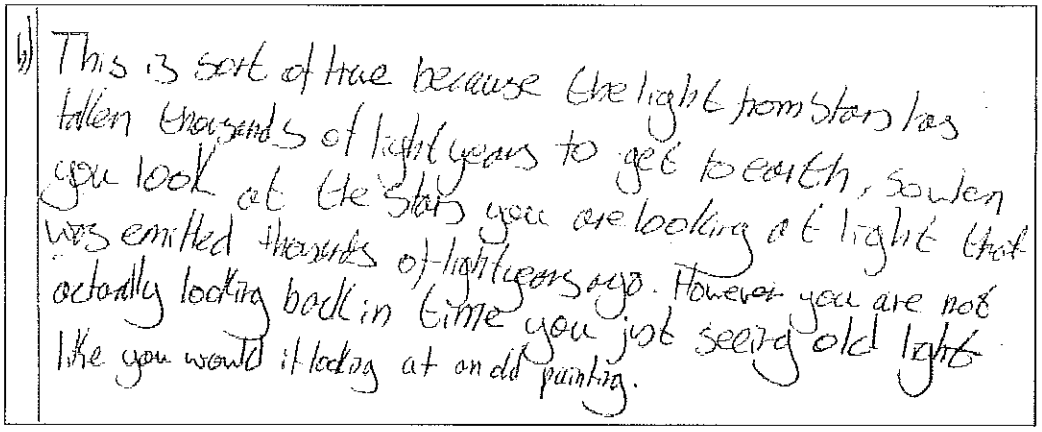
Candidate Answer 23:

b) this statement is accurate since all the ~~star~~ stars in the night sky are huge distances from earth, and since the speed of light is a constant 3×10^3 in a vacuum the light can take millions of years to get here. meaning what we are seeing is light that is very old, therefore we are looking at events that occured in the past.

Mark Awarded: 2

Comment:
There is an appreciation of the vastness of space. The speed of light is quoted (though the units are missing). Referring to "light that is very old" is not technically correct, although understandable at Higher. Overall, a reasonable level of understanding has been shown.

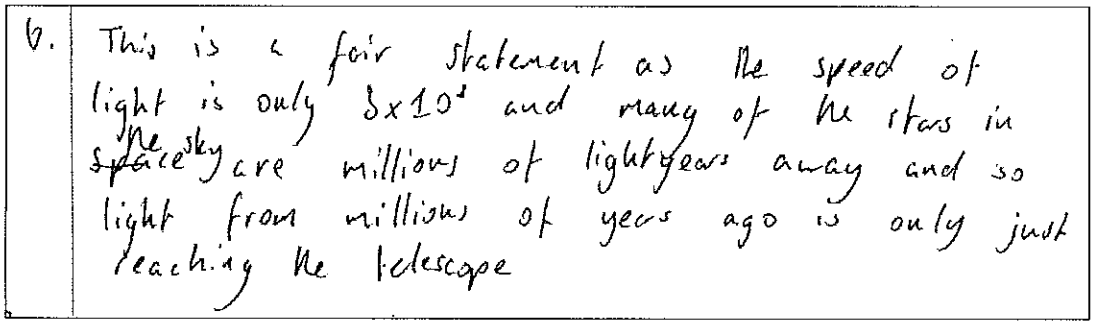
Candidate Answer 24:



Mark Awarded: 1

Comment:
This candidate's answer starts off being a bit tentative. She/He says the given statement is "sort of true". There is then a correct implication that light takes a long time to reach the Earth. The term 'light year' is a distance, but the candidate uses it as if it were a unit of time. The final reference to "seeing old light like you would if looking at an old painting" does not strengthen the marker's opinion about the candidate's level of understanding! Overall, there seems to be enough evidence that the candidate has a limited level of understanding of the correct physics.

Candidate Answer 25:



Mark Awarded: 1

Comment:
There is reference to the speed of light, though no units are given. There is appreciation of the vastness of space. It is stated that light has taken a long time to travel from the stars, but there is no real explanation.

Candidate Answer 26:

b) Since the Universe is so vast, it still takes time for light to travel, at $3 \times 10^8 ms^{-1}$ in a vacuum, from the furthest away stars. Therefore, the light being seen from stars and galaxies, actually left that source possibly millions of years ago. This means that basically, you are looking back in time as it left the star and has been travelling through space for an incredibly long period of time. As the speed of light is constant throughout the Universe, we know that the time taken for the light to travel to us is incredibly long period of time given the distance, tracking backwards from the moment the light is received.

Mark Awarded: 2

Comment:
This answer is a strong '2'. The second half of the answer tends to be repetitive rather than adding to what has already been said. Stating the relationship between distance, speed and time would have improved the explanation and made the answer a secure '3'.

Candidate Answer 27:

b) light takes time to travel distances, so anytime you look at anything that event has already taken place at the moment you see it. This effect is negligible at small distances, however it increases with increasing distance, meaning that the stars we see in the night sky can be are seen as they were millions of years back in time, so the presenter is correct.

Mark Awarded: 2

Comment:
A reasonable level of explanation has been demonstrated by this answer. The candidate possibly possesses a good level of understanding but he/she needs to give a stronger explanation to show that this is the case. For example, the candidate could have stated the speed of light and also quoted the relationship between distance, speed and time in order to justify the statement that "light takes time to travel distances".

Candidate Answer 28:

b) Time dialation is used to say that the faster you go and closer to the speed of light you go the slower time will go.

As you look through a telescope the light you see travelling at 'c' (3×10^8 ms^{-1}) means that you will see into a galaxy where time is so very slow.

If you reach the speed of light it would appear that time will have stopped.

This statement is partially correct since you would be looking into what we would consider the past because our clocks on earth are going at a normal speed.

Mark Awarded: 0

Comment:
This is another example of a candidate showing that they have not understood that the relevant physics is that light takes significant time to travel the vast distances across the universe. Instead, they have wrongly discussed time dilation which is to do with differing values of elapsed time for different frames of reference.

Candidate Answer 29:

b) It is like looking back in time because as it takes time for the light from stars, galaxies etc. to reach earth (to be observed through the telescope). The light observed on earth from e.g. a distant star has been created a long time before its observation. Therefore the light that the star created some time ago is only now being observed through the telescope.

Mark Awarded: 1

Comment:
There is nothing wrong stated in this answer. However, the answer is quite weak for several reasons. There is no obvious appreciation of the true vastness of space. There is no explanation about why it takes time for light to travel from the stars to the Earth. Giving the value of the speed of light and stating the relationship between distance, speed and time would have improved the explanation.

Candidate Answer 30:

b) This statement is reasonably accurate as what is seen through a telescope is light which had left distant stars a long time ago so what is being seen is what space was like a long time ago.

Mark Awarded: 1

Comment:
This answer merely states that the light entering the telescope "left stars a long time ago". The reasons for this being the case are not given.

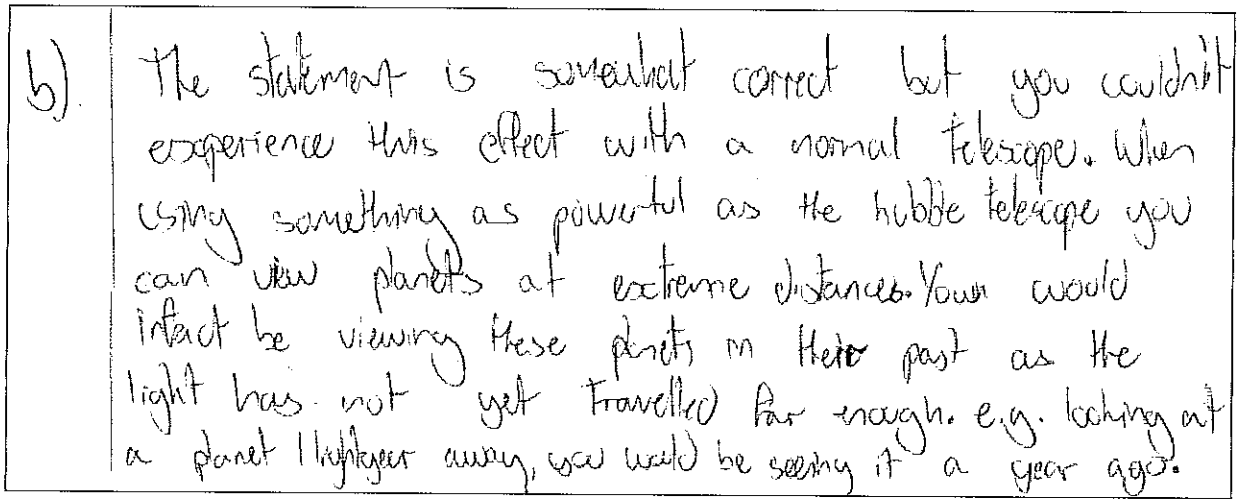
Candidate Answer 31:

(b) This statement makes sence as the light that you see hasn't reached earth yet so you could be looking at ~~stars~~ stars that don't actually exist at that time, that you look thrugh the telescope.

Mark Awarded: 0

Comment:
This candidate shows no understanding of the issue. Stating "the light that you see hasn't reached Earth yet" shows this lack of understanding.

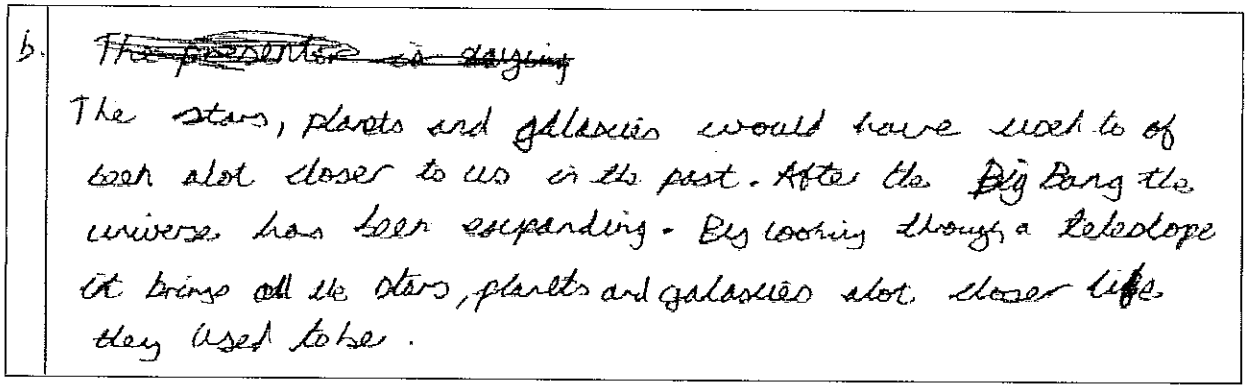
Candidate Answer 32:


b) The statement is somewhat correct but you couldn't experience this effect with a normal telescope. When using something as powerful as the hubble telescope you can view planets at extreme distances. Your would infact be viewing these planets in their past as the light has not yet travelled far enough. e.g. looking at a planet 1 lightyear away, you would be seeing it a year ago.

Mark Awarded: 0

Comment:
The statement that "you couldn't experience this effect with a normal telescope" is wrong. The answer should really refer to viewing stars, not planets. It is wrong to state that "the light has not yet travelled far enough" (otherwise we would not be seeing it). This answer has not demonstrated any understanding of the issue.

Candidate Answer 33:


b. ~~The presenter is saying~~

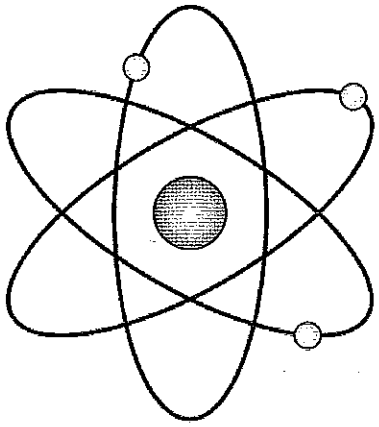
The stars, planets and galaxies would have used to of been alot closer to us in the past. After the ~~Big~~ Bang the universe has been expanding. By looking through a telescope it brings all the stars, planets and galaxies alot closer like they used to be.

Mark Awarded: 0

Comment:
This answer discusses the expansion of the universe, but this is not relevant. In the last sentence, the candidate seems to be stating that using a telescope reverses this expansion! No understanding of the issue has been shown.

2013, question 27

A science textbook contains the following diagram of an atom.



Use your knowledge of physics to comment on this diagram.

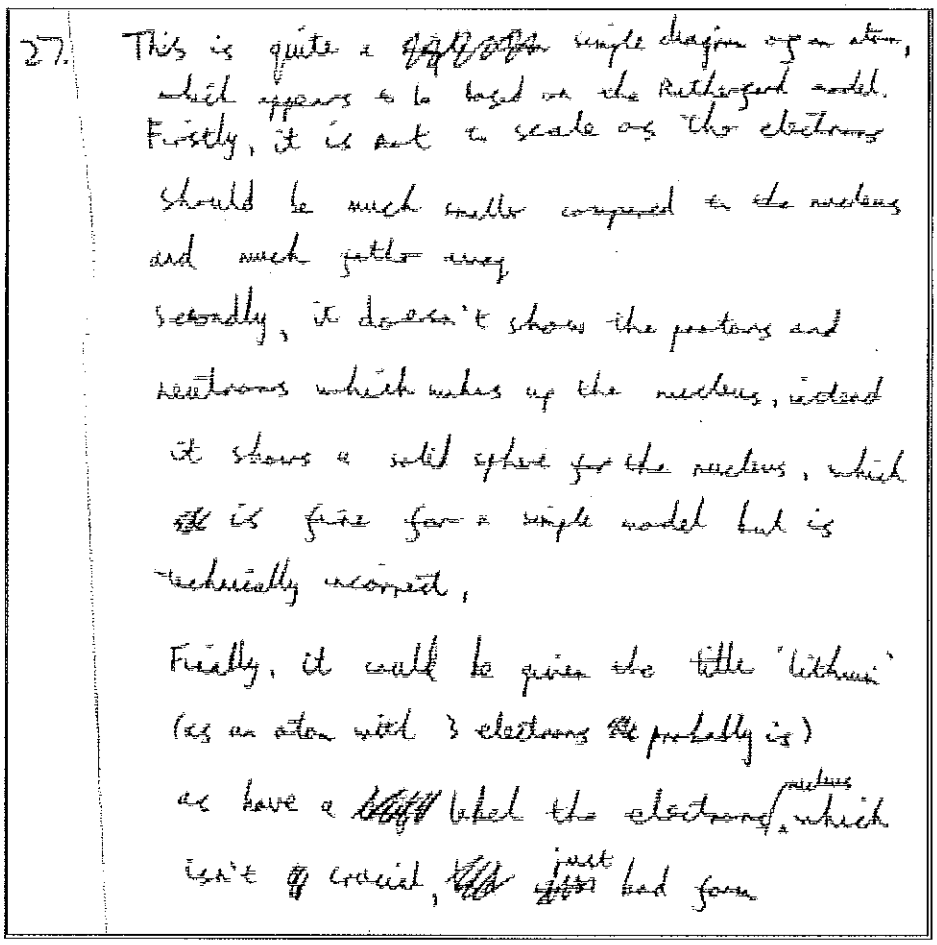
Candidate Answer 1:

27 The diagram shows a typical structure of an atom - there is a large centre and then a cloud of smaller objects on the outside. Although there are no labels it can be assumed that the centre is the nucleus and the outside objects are electrons. The diagram is clearly not a scale drawing as if it was the electrons would be many kilometres away. Aswell as that the diagram shows the nucleus as 1 uniform mass when inside is is obviously made of neutrons and protons.

Mark Awarded: 2

Comment:
This candidate has followed the instruction in the question to "comment on this diagram". He/She has discussed issues of labelling, scale and detail of structure. There may be some concerns about "*large centre*" and "*Many kilometres away*". This answer shows reasonable understanding.

Candidate Answer 2:



27. This is quite a simple diagram of an atom, which appears to be based on the Rutherford model. Firstly, it is not to scale as the electrons should be much smaller compared to the nucleus and much further away.

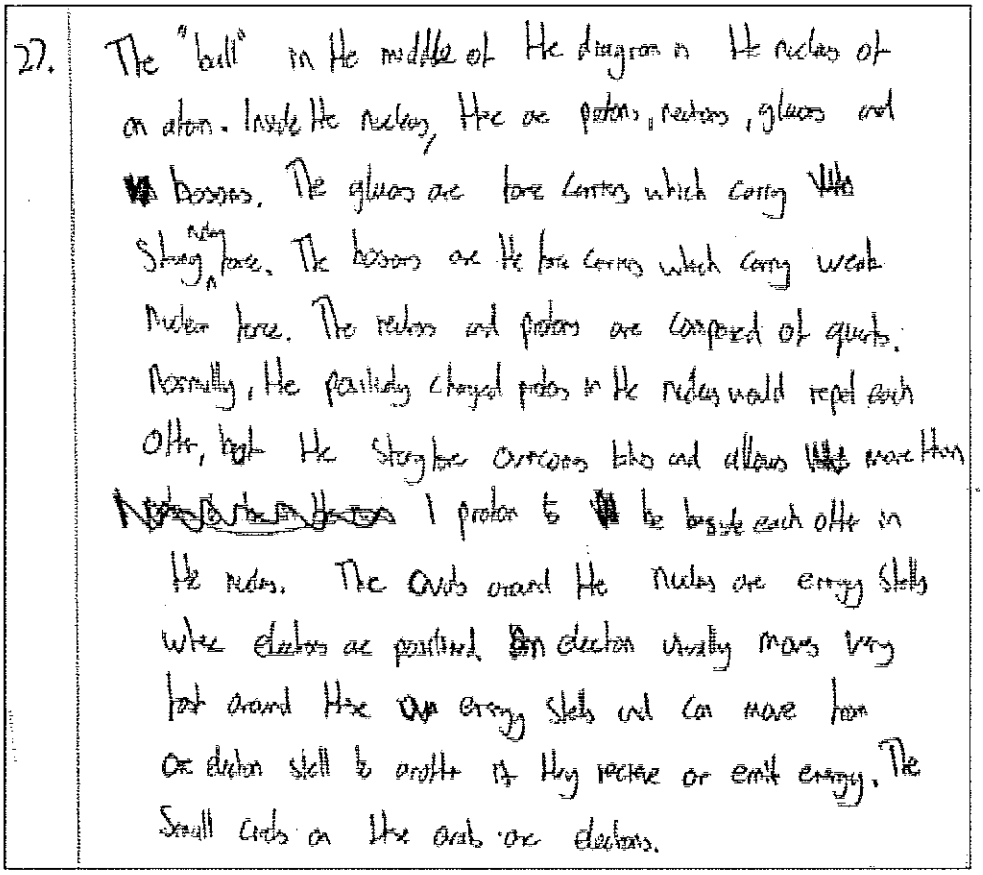
Secondly, it doesn't show the protons and neutrons which make up the nucleus, instead it shows a solid sphere for the nucleus, which is fine for a simple model but is technically incorrect.

Finally, it could be given the title 'Lithium' (as an atom with 3 electrons it probably is) as have a label the electrons/nucleus, which isn't of crucial, just bad form.

Mark Awarded: 3

Comment:
This candidate has followed the instruction in the question to "comment on this diagram". He/She has correctly discussed various relevant issues. This answer is in the 'range' of good understanding.

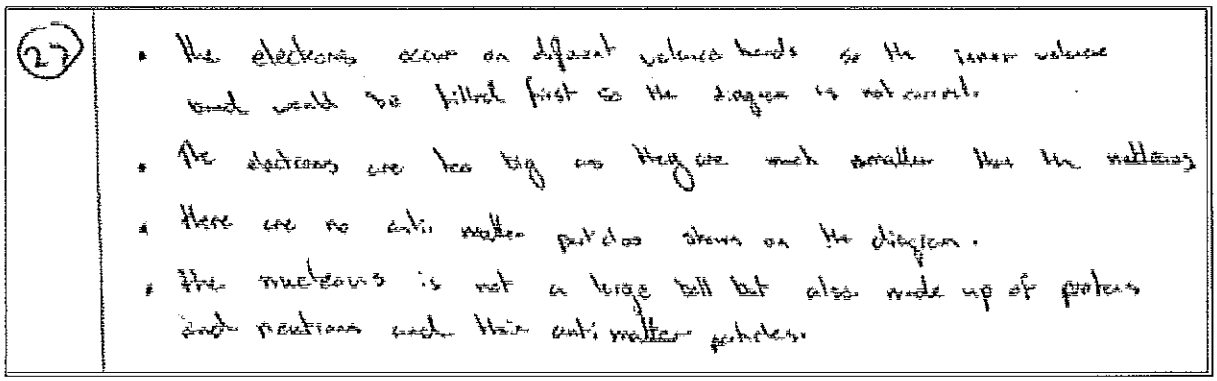
Candidate Answer 3:


27. The "ball" in the middle of the diagram is the nucleus of an atom. Inside the nucleus, there are protons, neutrons, gluons and bosons. The gluons are bare carriers which carry the strong force. The bosons are the bare carriers which carry weak nuclear force. The neutrons and protons are composed of quarks. Normally, the positively charged protons in the nucleus would repel each other, but the strong force overcomes this and allows the reaction [illegible] 1 proton to be beside each other in the nucleus. The rings around the nucleus are energy shells where electrons are positioned. An electron usually moves very fast around the energy shells and can move from one electron shell to another if they receive or emit energy. The small rings on the ends are electrons.

Mark Awarded: 2

Comment:
The majority of this answer is not directly commenting on the diagram as had been instructed. A large proportion is about the Standard Model. The candidate's discussion then returns to the diagram in the last three sentences. Some might argue that only limited understanding has been demonstrated but, overall, reasonable understanding has been shown.

Candidate Answer 4:

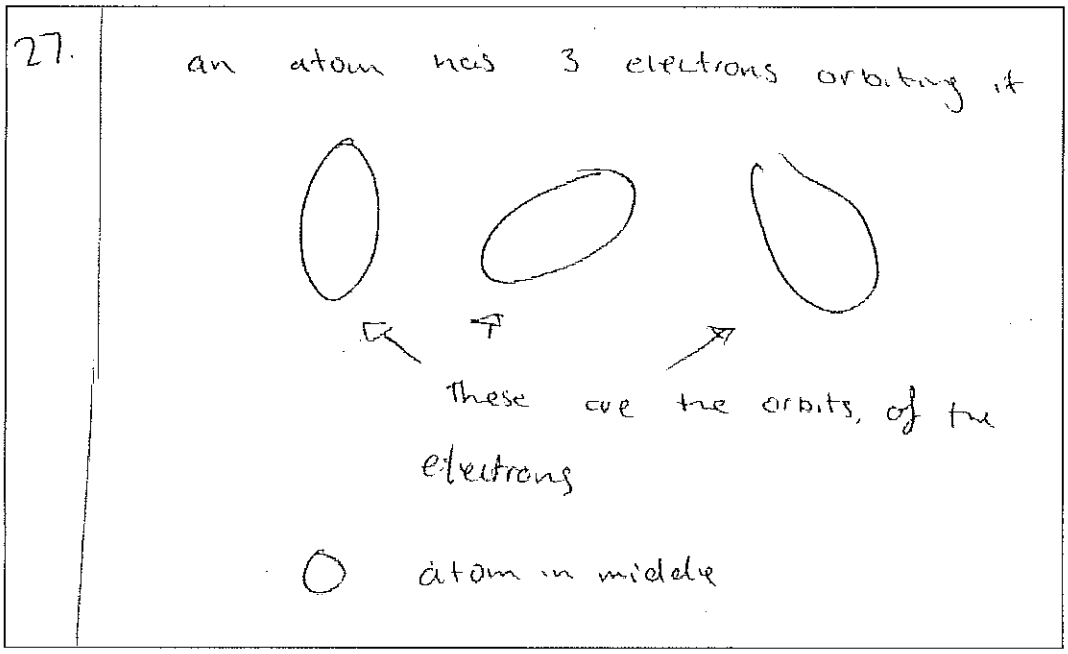

(27)

- the electrons occur on different valence bands so the inner valence band would be filled first so the diagram is not correct.
- the electrons are too big as they are much smaller than the nucleus
- there are no anti matter particles shown on the diagram.
- the nucleus is not a huge ball but also made up of protons and neutrons and their anti matter particles.

Mark Awarded: 0

Comment:
Although it is correct to say "the electrons are too big", this point could be stated by many students in the earlier years of secondary school. The answer contains major errors, e.g. the term "valence bands" is not relevant for an atom, the references to antimatter particles are inappropriate. This answer demonstrates no real understanding of the correct physics for this level of study.

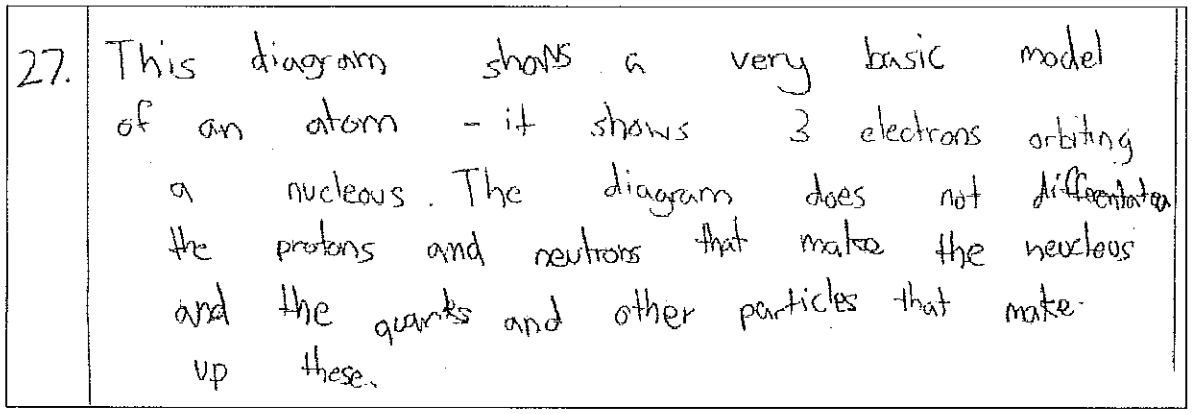
Candidate Answer 5:



Mark Awarded: 0

Comment:
Although the candidate has identified electrons and their orbits, she/he has also referred to the "atom" in the middle rather than the nucleus. This causes a marker to reconsider what was meant by the first sentence which states "an atom has three electrons orbiting it". Overall, no real understanding has been demonstrated.

Candidate Answer 6:



Mark Awarded: 1

Comment:
This candidate has shown some understanding of the structure of the atom – although the two different misspellings of "nucleus" are disappointing. This answer is at the upper end of limited understanding. The answer could have been improved by

- discussing the relative sizes of the particles representing the electrons and the nucleus
- discussing the particle sizes compared to the distance shown between them
- stating information about the charges carried by the different particles (i.e. further information about the lack of labelling)
- clarify what is meant by "protons and neutrons that *make* the nucleus"

However, it must be stressed that this is not meant to imply that there is a specific list of points that a candidate must make in order to gain the marks.

Candidate Answer 7:

27) The atom is made up of neutrons which have a ~~Neutron~~ neutrons (nut) charge and protons which have a positive charge and electrons which have negative charge. in the centre of an atom is the nucleus which contains protons + neutrons, therefore the nucleus has a overall positive charged but around about the atom in the outer layers are electrons which help keep the atom stable with negative charge. Electrons are always moving so this is why we have them in this pattern above.

Mark Awarded: 1

Comment:
The issue about the lack of labelling has been addressed. In the first sentence, there is a lack of clarity about the charge of the neutron. The electrons are said to be "around about the *atom*" rather than saying that they orbit the *nucleus*. The statement "… electrons which help keep the atom stable with negative charge" is, at best, unclear and might even imply misunderstanding.

Candidate Answer 8:

27) The center of an atom is called the nucleus, this contains both nutrons and protons. Electrons are the things that travell round the outside, they are in electron shells. The first electron shell holds 2 electrons and the 2nd and 3rd shells hold 8 electrons. for an atom to be stable it wants a full outer shell of electrons. If the number of Protons and electrons are equal then it is a neutral atom if they are not then it is an ion.

Mark Awarded: 1

Comment:
The issue about the lack of labelling has been addressed, although it is disappointing that, at Higher, a candidate cannot spell "neutron" correctly. Most of the rest of the answer does not discuss the diagram as had been instructed.

Candidate Answer 9:

27 The nucleaus is formed from Neutrons and Protons. The little circles on the outside is called electrons and is held togeter by the force from the Protons. since they are postively chargeed and electrons are negeetely chaged there is a lot of space between electrons and nucleus.

Mark Awarded: 1

Comment:
The candidate has addressed the issue about the lack of labelling, although the misspelling of "nucleus" is disappointing. There is a hint regarding the issue about the distance scale, but this has not been discussed in sufficient detail.

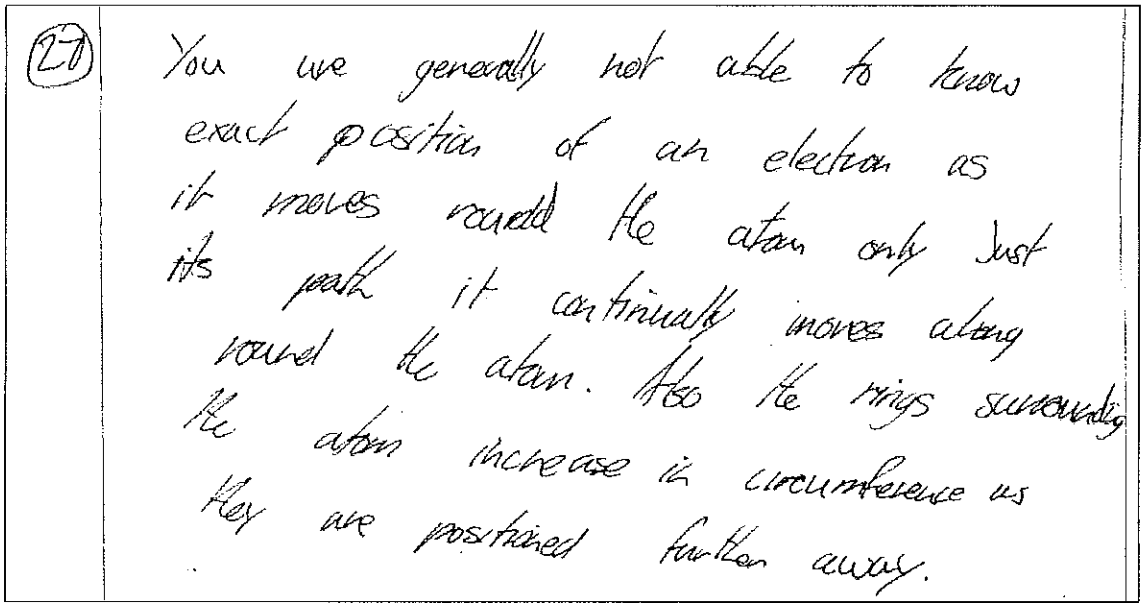
Candidate Answer 10:

(27) At the centre of the diagram lies a big round ball. This is called the nucleus and it contains neutrons and protons. These neutrons and protons contain Quarks which are held together by the strong nuclear force. The nucleus has an overall positive charge as protons have a positive charge and neutrons have no charge. The little balls orbiting around the nucleus are called electrons. Electrons have a much smaller mass than protons and neutrons and they have negative charges. The electrons orbit at different electron energy levels.

Mark Awarded: 1

Comment:
The issue regarding the lack of labelling has been addressed by this candidate. The major issues about the scale of the particle sizes and the distance between them have not been mentioned.

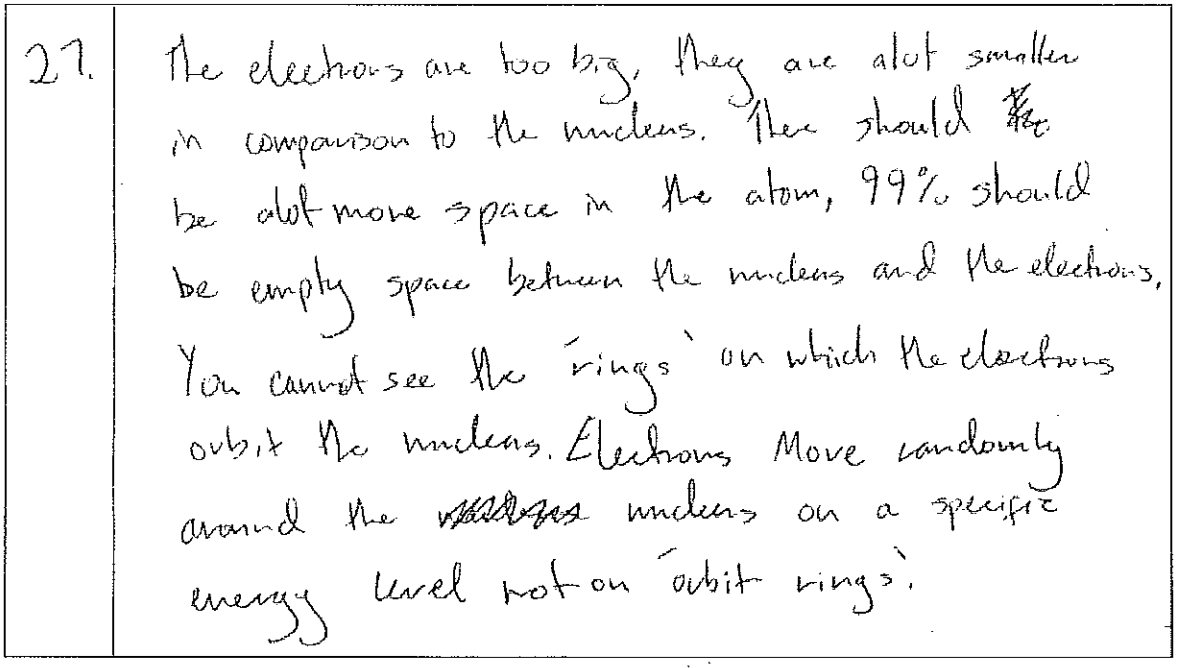
Candidate Answer 11:



Mark Awarded: 0

Comment:
This answer does not significantly discuss the *diagram* as had been instructed. It wrongly refers to an electron moving round the "atom" rather than the "nucleus" – electrons are part of the atom.

Candidate Answer 12:



Mark Awarded: 2

Comment:
Issues of scale have been addressed. Issues regarding the lack of labelling have been addressed by implication. Providing further detail about the charges on particles or making appropriate reference to protons and neutrons could have improved this answer to a '3'.

Candidate Answer 13:

27. The middle is the nucleus and is made up of protons which are positively charged and neutrons which have no charge. This section contains almost all of the mass of the atom and is very small.

The particles on the outside are electons, which are negatively charged and they move around at different energy levels (which are the black lines)

Mark Awarded: 1

Comment:
This answer mainly addresses the issue about the lack of labelling. The major issues about the scale of the particle sizes and the distance between them have not been mentioned.

Candidate Answer 14:

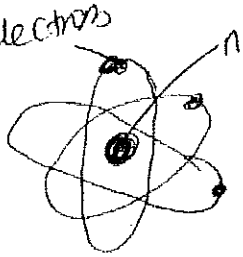
27. The first thing wrong with this diagram is that it shows the nucleus as a singular particle. where as it shoul show that it is made up from a number of protons and neutrons. the other thing that is wrong is that the electrons parts are all the same distanced away from the nucleus, where in fact the parts should be at different distances, I have

Mark Awarded: 1

Comment:
The lack of labelling of the diagram has been addressed implicitly in this answer. The major issues about the scale of the particle sizes and the distance between them have not been mentioned.

Candidate Answer 15:

27



atoms are mainly made up of 'empty' space with a concentrated mass of protons & neutrons in the very centre of the atom called the nucleus. The nucleus is positively charged. Strong (nuclear) forces hold the protons in the nucleus as it overcomes the repulsion fra between each proton in the nucleus protons have a charge of +1 whereas neutrons have a charge of 0 neutral. Electrons with a negligible mass (≈0) and a charge of −1 & spin around the nucleus which occupy specific energy bands. The overal charge of an atom is neutral.

Mark Awarded: 2

Comment:
The lack of labelling issue has been addressed. There is discussion of the charges on the different particles. There are references to scale factors by stating, "atoms are mainly made up of 'empty' space" and by discussing the masses of the nucleus and the electron. However, relative sizes and distances are not specifically discussed.

Candidate Answer 16:

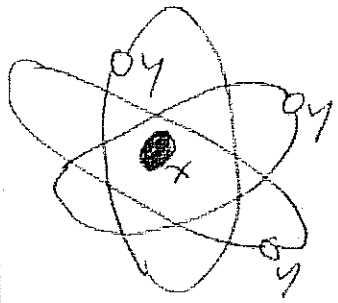
27.	In the centre there is a nucleus made up of neutrons and protons. A proton is made of fundamental particle called quarks and so is a neutron. A proton is made of two 'up' quarks and a 'down quark'. ~~Another~~ And has the charge +1. A neutron is made of two 'down' quarks and an 'up' quark and has no charge. The particle orbiting it are electrons and are have the charge -1 and are fundamental particles in the category of Leptons. In order for it to be stable there must be the same amount of protons as electrons.

Mark Awarded: 1

Comment:
The first sentence is fine – it is commenting on the diagram as instructed. In the second last sentence there is also a correct reference to electrons orbiting the nucleus. However, the majority of this answer only provides information about the Standard Model and does not discuss issues about the diagram.

Candidate Answer 17:

(27)



This model does give a general idea of how an atom is made up with a nucleus in the centre (x) and electrons orbiting it (y)

However the nucleus is misleading as it shows it to be one thing, however it is actually made up of several protons and neutrons

Also it's scale is completely wrong. 99% of the atom is actually space and if the nucleus was that size the the electrons would not be able to be seen with the naked eye and would be miles away from the nucleus.

On top of this, there are no lines for the electrons orbits in real life.

However it does represent the idea of the atom sucessfully.

Mark Awarded: 3

Comment:
This answer addresses the issues about labelling and scale quite well. It provides sufficient evidence for a marker to believe that this candidate has good understanding.

Candidate Answer 18:

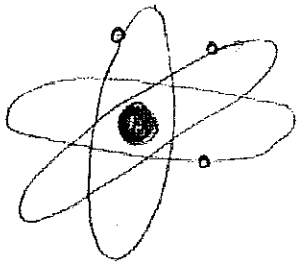
27. Protons and neutrons are found in the nucleus of the atom. This was proved in Rutherfords experiment as most of the alpha particles fired at the sheet of gold foil went through meaning most of the atom was empty space. Rutherford concluded that the mass of the atom must be concentrated in the centre. A few of the positive alpha particles were deflected meaning the nucleus must be positively charged. This meant that negatively charged electrons must exist outside the nucleus to give the atom an overall neutral charge.

Mark Awarded: 0

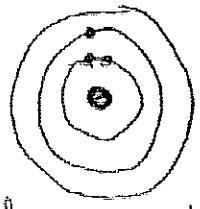
Comment:
This candidate response mainly discusses Rutherford's experiment and conclusions from it. There is actually no reference made to the diagram and so it is not answering the question.

Candidate Answer 19:

27.



This diagram represents Rutherford's model and shows that an atom has a nucleus that contains protons and neutrons and around the nucleus are electrons orbiting in a circular path. This particular atom contains 3 electrons. However, it has been shown that the nucleus does contain protons and neutrons but a better diagram as such, is this:

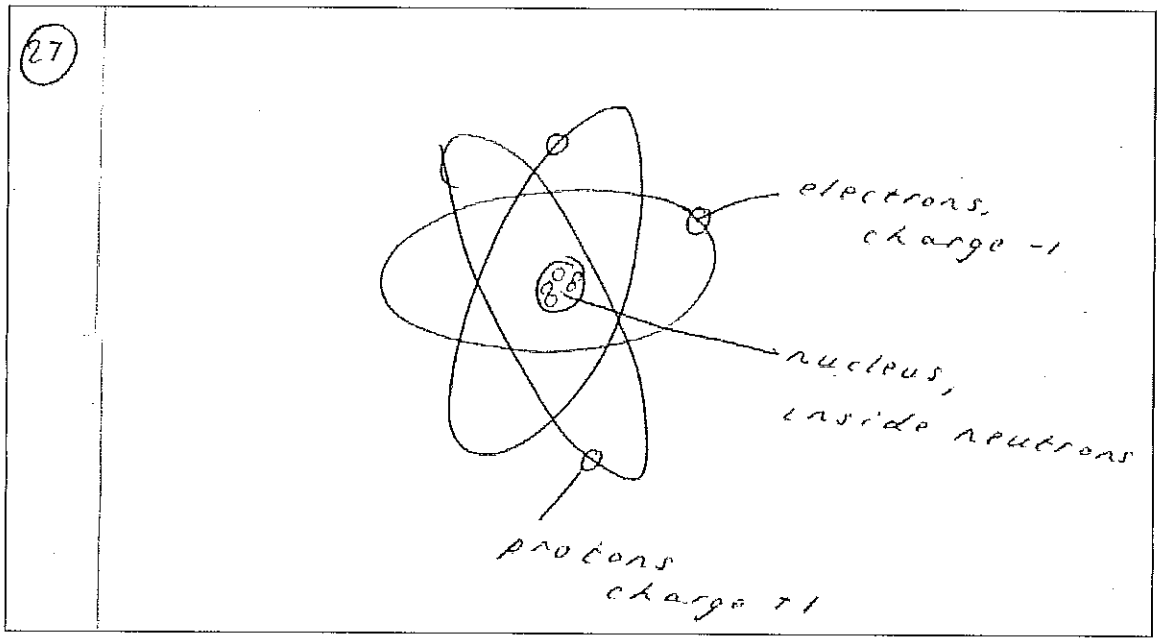


This diagram also shows the nucleus but also the energy electron shells of an atom. This diagram shows that it is very unstable as it needs a full octet to be stable.

Mark Awarded: 2

Comment:
This answer starts well but becomes weaker at the end. Labelling issues have been addressed. There is elaboration about electron orbits/energy levels. However, the reference to "unstable" is not appropriate – does the candidate think this atom is radioactive?

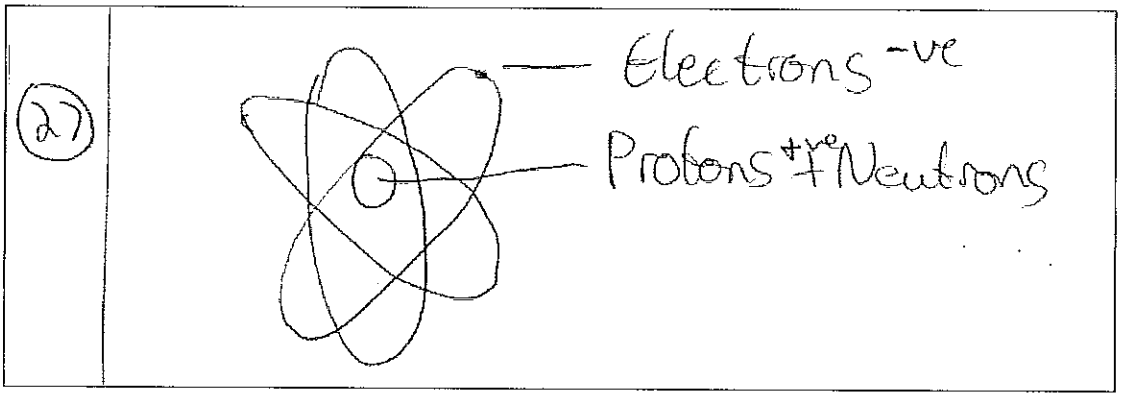
Candidate Answer 20:



Mark Awarded: 0

Comment:
Initially it appears that the lack of labelling has been addressed. However, this candidate has stated that one of the orbiting particles is a proton.

Candidate Answer 21:



Mark Awarded: 1

Comment:
This is a minimal answer to address the lack of labelling issue.

Candidate Answer 22:

27 This model of the atom is fairly representive however in reality the electrons in reality are much further away from the nucleus so much so that they have to put it in form like the model. also the nucleus would be like a cluster of balls rather than one ball.

Mark Awarded: 1

Comment:
The labelling issue has not been sufficiently addressed. There is a reference to one of the scaling issues, but it is not discussed in detail or particularly clearly.

Candidate Answer 23:

27. It is correct in that the nucleus containing protons and neutrons is situated in the centre with electrons orbiting around it. Although the scale of the diagram is not correct. If the nucleus were to be that big the electrons would be orbiting around at a much large diameter and also the size of the electrom would be a huge amount smaller.

Mark Awarded: 2

Comment:
Labelling and scaling issues have been identified and discussed, but not in sufficient detail for a '3' to be awarded.

Candidate Answer 24:

27. The diagram is accurate as it shows the nucleus of the atom surrounded by electrons. However, in reality the dark lines around the nucleus would not exist, they are there to show the path of the electrons as they orbit the nucleus.

Mark Awarded: 1

Comment:
There is the minimum amount of information in this answer regarding labelling of the diagram for a '1' to be awarded.

Candidate Answer 25:

27) This is a diagram of Lithium because it has 3 electrons. So it must also have 3 protons in the nucleus and some neutrons varying depending on isotopes.

As there is 3 protons and probably 2->4 neutrons in the nucleus it should not look like a single spherical particle because it is made up 5-7 small particles.

The electrons also inhabit energy levels, they do not orbit the nucleus randomly. Electrons always look to inhabit the lowest energy level

Mark Awarded: 2

Comment:
This answer contains enough information for a marker to believe the candidate has more than limited understanding, but not enough to be sure of good understanding.

Candidate Answer 26:

27. The drawings layout is correct in that the electrons are orbiting the nucleus, but it is missing both protons and neutrons. There must be an equal amount of protons and electrons.

Mark Awarded: 1

Comment:
This answer provides the minimum amount of information regarding labelling of the diagram for a '1' to be awarded.

Candidate Answer 27:

27.
- The atom is made up of mostly space, proven by Ernest Rutherford's experiment when he shot particles through a thin sheet of gold.
- The nucleus of the atom is made up of protons and neutrons which in turn are made from quarks; the fundamental particles of the universe.
- Quarks ~~are made from~~ consist of ~~Up, Down, Charm,~~ Up, Down, Strange, Charm, Top and Bottom which build up the protons and neutrons of the nucleus and are bound together using the strong and weak nuclear force.
- Rutherford's experiment proved that the atom was made up of mostly space as most of the particles passed through untouched, some were deflected and a few bounced back altogether.

Mark Awarded: 1

Comment:
Much of this answer is a discussion of Rutherford's experiment and the Standard Model. However, it can be argued there is enough in the first two bullet points (which could be referring to the diagram) about the names of particles for limited understanding to be shown.

Candidate Answer 28:

27. This diagram is correct as it has a central nucleus with orbiting electrons. However, its scale is impossible, as the electrons are far too large for the size of the nucleus. Also, they are much too close, as they would be a considerable distance further from the nucleus at that size. Also, only one orbital level is shown, implying that it is the first one, but this level can only hold two electrons, not three. The nucleus is also far too smooth, as it cannot be just one proton as it has 3 orbiting electrons.

Mark Awarded: 2

Comment:
Labelling and scaling issues have been identified and discussed, but not in sufficient detail for a '3' to be awarded.

Candidate Answer 29:

27. This is a very simplistic model. First of all the nucleus should be split up into both protons and neutrons and not just be pictured as one large ball. There should be three protons to counteract the charges of the three orbiting electrons. Furthermore, there are not only three particles there are also W bosons which are not pictured in the diagram. In addition, the electrons are clearly not to scale as in reality electrons are miniscule in comparison with the nucleus, they would not orbit so close, too, a true electron orbit radius would be much further out from the nucleus than what is pictured.

Mark Awarded: 2

Comment:
Labelling and scaling issues have been identified and discussed, but more detail could have been given. There are weaknesses in some statements, e.g. "to *counteract* the charges of …", "there are not only three particles there are also bosons …"

Candidate Answer 30:

27.

- The large round ball in the centre of the diagram represents the nucleus of the atom - where the protons and neutrons are held together in a small dense formation by the strong force.
- The three small balls represent electrons, tiny very small negatively charged leptons which orbit the positively charged nucleus.
- The diagram is misleading by the fact that the nucleus is shown as a solid ball, and does not indicate that it is made up of smaller particles (protons and neutrons), which in themselves are made up of even smaller particles - quarks.
- In addition, the scale is vastly wrong. The electrons are far too large compared to the nucleus and the distance between the electrons and the nucleus is much smaller than in reality.

Mark Awarded: 3

Comment:
The main issues have been identified and discussed in sufficient detail to show 'good' understanding.

Candidate Answer 31:

27 The electrons in this diagram are disproportionately large in comparison to the nucleus. Also ~~the~~ as the orbit of the electrons should be far further from the nucleus (most of an atom is empty space)

Mark Awarded: 1

Comment:
The scaling issues have been identified – more discussion on this would have been preferred.

Candidate Answer 32:

27. The dots flying around on ovals around the centre are electrons and the ovals are there to represent their path. The central dot is the nucleus which contains the protons and neutrons, however the ~~these~~ these two particles are not distinctly shown in this diagram, they are shown as one dot.

Mark Awarded: 1

Comment:
Only the issue about the lack of labelling has been addressed.

Candidate Answer 33:

27. If there are 3 electron orbiting the nucleus there must be ~~the~~ 3 protons inside the nucleus in order to keep the atom neutral. This is because electrons have a charge of -1 and protons have a charge of +1. The electrons occupy the outer shells of the atom.

Mark Awarded: 1

Comment:
The labelling issue has only been partially addressed – it is disappointing that a Higher candidate cannot spell "nucleus" correctly. There is some reference to the charges on particles. Protons have been discussed, but there is no mention of neutrons. There is no mention of scaling issues.