Higher Particles

Past Paper Answers

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Higher Particles Answers

Nuclear Reactions

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7. C 8. D 9. D 10. A 11. E 12. D

13. D 14. C 15. E 16. D 17. A 18. B

19. C

|  |  |  |
| --- | --- | --- |
| 20ai) | *x* = 222 *y* = 86 | (1) (1) |
| 20aii) | Lost mass is converted into energy. | (1) |
| 20aiii) | total mass before = 3.75428 x 10-25 (kg) total mass after = 3.75419 x 10-25 (kg)  lost mass = 9 x 10-30 (kg)  E = mc2 E = 9 x 10-30 x (3 x 108)2 E = 8.1 x 10-13 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |
| 20b) | Ek = ½mv2 Ek = ½ x 6.64832 x 10-27 x (1.5 x 107)2 Ek = 7.47936 x 10-13 J  Ew = QV Ew = 3.2 x 10-19 x 25 x 103 Ew = 8 x 10-15 J  Final Ek = 7.56 x 10-13 J | (1) both eq. (1) both sub. (1) initial Ek and Ew ans. (1) final ans. |
| 21ai) | Induced as a neutron is added. | (1) (1) |
| 21aii) | total mass before = 3.9842 x 10-25 (kg) total mass after = 3.9825 x 10-25 (kg)  lost mass = 1.7 x 10-28 (kg)  E = mc2 E = 1.7 x 10-28 x (3 x 108)2 E = 1.53 x 10-11 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |
| 21b) | P = E/t 900 x 106 = E/20 E = 1.8 x 1010 J  No. of reactions = Total energy/energy of one reaction No. of reactions = 1.8 x 1010/1.53 x 10-11 No. of reactions = 1.18 x 1021 (reactions) | (1) (1) (1)  (1) |
| 22a) | alpha | (1) |
| 22b) | total mass before = 398.626 x 10-27 (kg) total mass after = 398.615 x 10-27 (kg)  lost mass = 1.1 x 10-29 (kg)  E = mc2 E = 1.1 x 10-29 x (3 x 108)2 E = 9.9 x 10-13 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |
| 23ai) | The number of protons in the nucleus is 92. | (1) |
| 23aii) | The number of protons and neutrons in the nucleus is 235. | (1) |
| 23b) | total mass before = 391.848 x 10-27 (kg) total mass after = 391.476 x 10-27 (kg)  lost mass = 3.72 x 10-28 (kg)  E = mc2 E = 3.72 x 10-28 x (3 x 108)2 E = 3.35 x 10-11 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |
| 24a) | ***r*** = 95  ***s*** = 7 | (1)  (1) |
| 24b) | Lost mass is converted into energy. | (1) |
| 24c) | total mass before = 391.848 x 10-27 (kg) total mass after = 391.478 x 10-27 (kg)  lost mass = 3.7 x 10-28 (kg)  E = mc2 E = 3.7 x 10-28 x (3 x 108)2 E = 3.33 x 10-11 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |
| 25a) | (241 - 95 =) 146 | (1) |
| 25bi) | ***s*** = 237  ***r*** = 93 | (1) for both |
| 25bii) | ***T*** = Neptunium (*or* Np) | (1) |
| 25c) | V = IR 5 = I x 16 I = 0.3125 A  lost volts = Ir lost volts = 0.3125 x 2 lost volts = 0.625 V  V across resistor = 9 - 5 - 0.625 V across resistor = 3.375 V  *Or another method to reach the same final answer* | (1) both eq. (1) both sub. (1) I and lost volts ans.    (1) final ans. |
| 26ai) | (Nuclear) fusion  *"fussion" gets 0 marks. Fission and fusion* ***must*** *be accurately spelt.* | (1) |
| 26aii) | total mass before = 8.347 x 10-27 (kg) total mass after = 8.317 x 10-27 (kg)  lost mass = 3 x 10-29 (kg)  E = mc2 E = 3 x 10-29 x (3 x 108)2 E = 2.7 x 10-12 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |
| 26bi) | E2 - E1 = hf -1.360 x 10-19 - (-5.424 x 10-19) = 6.63 x 10-34 x f f = 6.129... x 1014 (Hz)  v = fλ 3 x 108 = 6.129... x 1014 x λ λ = 4.89 x 10-7 m  *Must put energies in the correct way. Getting a negative frequency and scoring out the negative is not okay.* | (1) both eq. (1), (1) sub. (1) final ans. |
| 26bii) | Blue  *or*  Blue-green | (1) |
| 27ai) | **X** = Lithium (*or* Li) | (1) |
| 27aii) | E = mc2 2.97 x 10-12 = m x (3 x 108)2 m = 3.3 x 10-29 kg  **X** + 3.342 x 10-27 = (2 x 6.642 x 10-27) + 1.675 x 10-27 + 3.3 x 10-29 **X** = 1.165 x 10-26 kg | (1) (1) (1)  (1) |
|  |  |  |
| 28a) | Lost mass is converted into energy. | (1) |
| 28bi) | **X** = Scandium (*or* Sc) | (1) |
| 28bii) | the (anti)neutrino | (1) |
| 29a) | Lost mass is converted into heat. | (1) |
| 29b) | total mass before = 8.3519 x 10-27 (kg) total mass after = 8.3214 x 10-27 (kg)  lost mass = 3.05 x 10-29 (kg)  E = mc2 E = 3.05 x 10-29 x (3 x 108)2 E = 2.745 x 10-12 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |

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| 29c) | Plasma would cool down if it came too close to the sides (and reaction would stop).  *or*  Plasma would melt the sides of the reactor.  *or*  High temperature plasma could damage/destroy the container. | (1) |
| 29d) | Up the page | (1) |
| 30a) | Two small nuclei combine (*or* fuse *or* join) to form a larger nucleus.  *Must be the terms nuclei/nucleus* ***not*** *atoms. It's nuclear fusion.* | (1) |
| 30bi) | Lost mass is converted into energy. | (1) |
| 30bii) | total mass before = 8.352 x 10-27 (kg) total mass after = 8.319 x 10-27 (kg)  lost mass = 3.3 x 10-29 (kg)  E = mc2 E = 3.3 x 10-29 x (3 x 108)2 E = 2.97 x 10-12 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |
| 31a) | (Nuclear) fusion  *"fussion" gets 0 marks. Fission and fusion* ***must*** *be accurately spelt.* | (1) |
| 31b) | total mass before = 6.6872 x 10-27 (kg) total mass after = 6.6831 x 10-27 (kg)  lost mass = 4.1 x 10-30 (kg)  E = mc2 E = 4.1 x 10-30 x (3 x 108)2 E = 3.69 x 10-13 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |
|  | No. of reaction = Total energy/energy of one reaction No. of reactions = 4.1 x 1026/3.69 x 10-13 No. of reactions = 1.11 x 1039 (reactions) | (1) (1) |

Particle Accelerators (MC done)

1. E 2. D 3. E 4. D 5. B 6. C

7. E 8. D 9. A 10. C 11. A 12. D

|  |  |  |
| --- | --- | --- |
| 13a) | 200 kJ of work done per coulomb of charge moving between P and Q | (1) |
| 13b) | Protons have a positive charge so are attracted to the negative tube/plate.  *or*  Protons have a positive charge and experience a force in an electric field.  *Must identify the type of charge the proton has.* | (1) |
| 13ci) | Ew = QV Ew = 1.6 x 10-19 x 200 x 103 Ew = 3.2 x 10-14 J  *Your answers for energy should never be negative in Higher Physics.* | (1) (1) (1) |
| 13cii) | Ek = ½mv2 3.2 x 10-14 = ½ x 1.673 x 10-27 x v2 v = 6.19 x 106 ms-1 | (1) (1) (1) |
| 13d) | No effect as the charge and voltage are constant  (so the work done is constant (Ew = QV), and as the mass of the proton is constant then the speed must also be constant (Ek = ½mv2)). | (1) (1) |
| 14a) | Ek = ½mv2 Ek = ½ x 6.64 x 10-27 x (2.6 x 106)2 Ek = 2.24... x 10-14 J  Work done = Energy gained Work done = 3.05 x 10-14 - 2.24... x 10-14 Work done = 8.1 x 10-15 J  *“Show” question means you’ve already been given the answer – no mark for this part. Your final answer must be shown and rounded so that it is the number that the question asked for. No marks if not done.* | (1) (1)  (1) |
| 14b) | Ew = QV 8.1 x 10-15 = 3.2 x 10-19 V V = 25300 V | (1) (1) (1) |
| 14c) | Less than as the voltage is constant but an electron has less charge (1.6 x 10-19 C) meaning the work done is less (Ew = QV). | (1)  (1) |

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| 15ai) | Ew = QV Ew = 1.6 x 10-19 x 1.22 x 103 Ew = 1.95 x 10-16 J  *“Show” question means you’ve already been given the answer – no mark for this part. Answer must be exactly the same as value given for “show” questions. No mark if left as 1.952 x 10-16 J.* | (1) (1) |
| 15aii) | Ek = ½mv2 1.95 x 10-16 = ½ x 2.18 x 10-25 x v2 v = 4.23 x 104 ms-1 | (1) (1) (1) |
| 15b) | Ft = mv - mu 0.07 x 60 = 750 x v - 750 x 0 v = 0.0056 ms-1  (Change in speed = 0.0056 - 0 = 0.0056 ms-1) | (1) (1) (1) |
| 15c) | The Xenon ion engine as the change in momentum (*or* impulse) is greater (due to their larger mass) meaning the force must be greater.  *Could prove by doing an example calculation to justify your statement.* | (1)  (1) |
| 16ai) | Ew = QV Ew = 1.6 x 10-19 x 55 x 103 Ew = 8.8 x 10-15 J  *“Show” question means you’ve already been given the answer – no mark for this part.* | (1) (1) |
| 16aii) | Ek = ½mv2 8.8 x 10-15 = ½ x 1.673 x 10-27 x v2 v = 3.24 x 106 ms-1 | (1) (1) (1) |
| 16b) | Into the page. | (1) |
| 16c) | a.c. voltage needs to change direction to change the direction of the force on the proton.  The proton needs to be changed direction to keep moving across the gap (left to right then right to left etc.) | (1)  (1) |
| 17a) | Ew = QV Ew = 1.6 x 10-19 x 2 x 103 Ew = 3.2 x 10-16 J  *The work done is the kinetic energy gained by the electron.* | (1) (1) (1) |
| 17b) | Q = It Q = 8 x 10-3 x 60 Q = 0.48 C  No. of electrons = total charge/charge of one electron No. of electrons = 0.48/1.6 x 10-19 No. of electrons = 3 x 1018 (electrons) | (1) (1) (1)  (1) |
| 17c) | *Electric field lines always shown going away from positive charge/voltage.* | (1) |
| 18ai) | Ew = QV Ew = 1.6 x 10-19 x 2.5 x 103 Ew = 4 x 10-16 J |  |
| 18aii) | So the electron (or particle) always experiences a force in the same direction.  *or*  So the electron (*or* particle) accelerates in the same direction.  *or*  To ensure the direction of the electric field is correct when the electron (*or* particle) passes between gaps.  *Must make some implication of "same direction".* | (1) |
| 18bi) | Out of the page. |  |
| 18bii) | Magnetic fields are in opposite direction (as electron forced opposite way).  Magnetic field in S is stronger than R (as electron is forced/deviated more in S). | (1)  (1) |
| 18c) | Ek = ½mv2 4.16 x 10-17 = ½ x 9.11 x 10-31 x v2 v = 9.56 x 106 ms-1 | (1) (1) (1) |
| 19ai) | Ew = QV Ew = 1.6 x 10-19 x 1.6 x 103 Ew = 2.6 x 10-16 J  *“Show” question means you’ve already been given the answer – no mark for this part. Answer must be exactly the same as value given for “show” questions. No mark if left as 2.56 x 10-16 J.* |  |
| 19aii) | Ek = ½mv2 2.6 x 10-16 = ½ x 9.11 x 10-31 x v2 v = 2.39 x 107 ms-1 | (1) (1) (1) |
| 19b) | Screen will be brighter (*or* increase in glow).  Electrons will gain more energy (*or* move faster).  *or*  Increase in number of electrons per second.  *Acceptable:*  *Circle of brightness on fluorescent screen is reduced. Greater force of attraction on the electrons due to the cross.*  *or*  *Cross on screen is sharper. Greater force of attraction on the electrons due to the cross.* | (1)  (1)  *or*  (1)  *(1) (1)*  *(1) (1)* |
| 20. | \**Show teacher if possible\**  *Answer could include correct information on a comparison of the ball being like charged particles in a real particle accelerator, or the motor accelerating the ball being like the electric fields that accelerate charged particles, or the track changing the direction of the ball where magnetic fields change the direction of charged particles. It could also include equations such as Ew = QV and Ek = ½mv2. Also, the collision with the block may break the ball apart if going fast enough in the same way that certain charged particles like hadrons and be broken apart into quarks, which are fundamental particles and cannot be broken down further.* | (3) |

The Photoelectric Effect

1. B 2. D 3. A 4. A 5. A 6. E

7. D 8. A 9. A 10. D 11. B 12. C

13. C 14. E

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| 15ai) | Photoelectric emission is when electrons are ejected from a metal surface when exposed to electromagnetic radiation. | (1) |
| 15aii) | The threshold frequency. | (1) |
| 15aiii) | More photons are incident on the metal surface (per second) so more electrons are ejected from it per second. | (1) (1) |
| 15bi) | E = hf E = 6.63 x 10-34 x 9 x 1014 E = 5.97 x 10-19 J | (1) (1) (1) |
| 15bii) | No. of photons = total energy/energy of one photon No. of photons = 40.5 x 10-6/5.97 x 10-19 No. of photons = 6.78 x 1013 (photons) | (1) (1) |
| 16a) | The threshold frequency. | (1) |
| 16bi) | Eo = hfo Eo = 6.63 x 10-34 x 3.33 x 1014 E­o = 2.21 x 10-19 J | (1) (1) |
| 16bii) | Ek = hf - hfo Ek = 6.63 x 10-34 x 5.66 x 1014 - 6.63 x 10-34 x 3.33 x 1014 Ek = 1.54 x 10-19 J | (1) (1) (1) |
| 16biii) | Ew­ = QV Ew = 1.6 x 10-19 x 2 x 104 Ew = 3.2 x 10-15 J | (1) (1) (1) |
| 17a) | Intensity  0  Current | (1) |
| 17bi) | The work function is the minimum energy required to eject electrons from a metal. | (1) |
| 17bii) | v = fλ 3 x 108 = f x 400 x 10-9 f = 7.5 x 1014 Hz  Ek = hf - hfo Ek = 6.63 x 10-34 x 7.5 x 1014 - 3.11 x 10-19 Ek = 1.86 x 10-19 J | (1) both eq. (1), (1) sub. (1) final ans. |
| 18a) | v = fλ 3 x 108 = f x 605 x 10-9 f = 4.95... x 1014 Hz  Eo = hfo Eo = 6.63 x 10-34 x 495... x 1014 Eo = 3.29 x 10-19 J | (1) both eq. (1), (1) sub. |
| 18bi) | Ek = hf - hfo Ek = 5.12 x 10-19 - 3.29 x 10-19 Ek = 1.83 x 10-19 J | (1) |
| 18bii) | The reading will decrease as less irradiance means less photons incident on the metal (per second) so less electrons ejected per second. | (1)  (1) |
| 19a) | 0  energy (*or* E)  frequency (*or* f) | (1) |
| 19b) | Ek = hf - hfo 6 x 10-20 = 6.63 x 10-34 x 6.1 x 1014 - hfo (work function) work function = 3.44 x 10-19 J  *Or another method to reach the same final answer* | (1) (1) (1) |
| 19c) | As each photon still has the same amount of energy (as it still has the same frequency (E = hf)). | (1) |
| 20ai) | Ek = hf - hfo Ek = 5.23 x 10-19 - 2.56 x 10-19 Ek = 2.67 x 10-19 J  *Or another method to reach the same final answer* | (1) |
| 20aii) | Ek = ½mv2 2.67 x 10-19 = ½ x 9.11 x 10-31 x v2 v = 7.66 x 105 ms-1 | (1) (1) (1) |
| 20b) | No effect as the energy of each photon is still the same (as the frequency is still the same (E = hf)). | (1) (1) |
| 21ai) | v = fλ 3 x 108 = f x 525 x 10-9 f = 5.71... x 1014 Hz  E = hf E = 6.63 x 10-34 x 5.71... x 1014 E = 3.79 x 10-19 J  *“Show” question means you’ve already been given the answer – no mark for this part. Your final answer must be shown and rounded so that it is the number that the question asked for. No marks if not done.* | (1) both eq. (1), (1) sub. |
| 21aii) | Ek = hf - hfo Ek = 3.79 x 10-19 - 2.24 x 10-19 Ek = 1.55 x 10-19 J | (1) |
| 21bi) | Photons with a frequency below fo do not have the energy required to eject electrons.  *Your answer must be in terms of photon energy.* | (1) |
| 21bii) | Eo = hfo 2.24 x 10-19 = 6.63 x 10-34 x f­o­ fo = 3.38 x 1014 Hz | (1) (1) (1) |
| 22ai) | Ek = hf - hfo Ek = 6.63 x 10-34 x 6.74 x 1014 - 3.78 x 10-19 Ek = 6.89 x 10-20 J | (1) (1) (1) |
| 22aii) | Ek = ½mv2 6.89 x 10-20 = ½ x 9.11 x 10-31 x v2 v = 3.89 x 105 ms-1 | (1) (1) (1) |
| 22b) | No effect as the energy of each photon is still the same (and the work function of the metal is still the same, so the kinetic energy of each photoelectron is unchanged therefore the maximum velocity of each photoelectron is unchanged) | (1) (1) |
| 23a) | Frequency of the UV/photons/light is not high enough.  *or*  Frequency of the UV/photons/light is less than the threshold.  *or*  Energy of the photons (*not UV or light*) is not high enough.  *or*  Energy of the photons is less than work function.  *or*  May not be a "clean plate". | (1) |
| 23bi) | 6.94 x 10-19 J of energy is the minimum energy required for electrons to be ejected. | 1 |
| 23bii) | No effect as the energy of each photon is unchanged. | (1) (1) |
| 23c) | *same gradient  lower starting frequency If your line starts at the origin (zero) then no marks.* | (1) (1) |
| 23d) | Each photon contains a discrete amount of energy  *or*  Each photon ejects one electron. | (1) |

The Standard Model

1. B 2. C 3. B 4. E 5. C 6. D

7. A 8. D 9. D 10. E 11. A 12. E

13. B 14. A

|  |  |  |
| --- | --- | --- |
| 15ai) | Number at **X** much larger than number at **Y**.  *Need to indicate significantly more at* ***X****.* | (1) |
| 15aii) | Small nucleus compared to size of the atom.  *or*  Most of an atom is empty space.  *or*  Mass of the atom is concentrated in the nucleus.  *or*  Nucleus has a positive charge.  *or*  Atoms have a nucleus. | (1) *any one* |
| 15bi) | Induced because a neutron is added.  *No attempt to justify means 0 marks, even if you said induced. “****must*** *justify your answer”.* | (1) (1) |
| 15bii) | **r** = 55  **s** = 95 | (1)  (1) |
| 15biii) | ***T*** = Rubidium (*or* Rb) | (1) |
| 15biv) | total mass before = 391.894 x 10-27 (kg) total mass after = 391.554 x 10-27 (kg)  lost mass = 3.4 x 10-28 (kg)  E = mc2 E = 3.4 x 10-28 x (3 x 108)2 E = 3.06 x 10-11 J  *An arithmetic error when calculating lost mass can be carried forward, i.e. you still get the last three marks if you calculate lost mass wrong. If your masses are rounded then you only get one mark for the equation. Only round your final answers! Not your working!* | (1)  (1) (1) (1) |
| 16a) | They cannot be broken down (into something smaller). | (1) |
| 16b) | -1/3 (*negative one third* ) | (1) |
| 16c) | 1 up quark and 2 down quarks | (1) |
| 16di) | Down the page | (1) |
| 16dii) | They have no charge so won't be affected by electric/magnetic fields. | (1) (1) |
| 17ai) | Meson as mesons are made of a quark-antiquark pair. | (1) (1) |
| 17aii) | +1/3 (*positive two thirds* ) | (1) |
| 17aiii) | An anti-up and a down quark. | (1) |
| 17aiv) | t' = 5.96 x 10-8 s  *If both "c" values changed to 3 x 108 ms-1 then this is fine for substitution too.* | (1)  (1) sub.  (1) |
| 17bi) | electric field | (1) |
| 17bii) | magnetic field | (1) |
| 18a) | The photon | (1) |
| 18bi) | Energy of 126 GeV = 126 x 109 x 1.6 x 10-19 Energy = 2 x 10-8 J  E = mc2 2 x 10-8 = m x (3 x 108)2 m = 2.2 x 10-25 kg | (1)  (1) (1) |
| 18bii) | 2.2 x 10-25/1.673 x 10-27 = 132  Higgs boson is 2 orders of magnitude bigger.  *If not shown working but still correct answer then still two marks given.* | (1)  (1) |
| 19a) | They are made up of smaller particles (*or* quarks). | (1) |
| 19bi) | Baryons are hadrons made of 3 quarks.  Mesons/some hadrons are made of a quark-anitquark pair so are not baryons. | (1)  (1) |
| 19bii) | -1/3 (*negative one third* ) | (1) |
| 19ci) | strong nuclear force | (1) |
| 19cii) | The gluon | (1) |
| 19d) | t' = 3.4 x 10-10 s  *If both "c" values changed to 3 x 108 ms-1 then this is fine for substitution too.* | (1)  (1)  (1) |
| 20ai) | They cannot be broken down (into something smaller). | (1) |
| 20aii) | Fermions |  |
| 20b) | + *e + e - e + e - e*  +1*e* **or**1*e* **or** *e* | (1)  (1) |
| 20ci) | Meson |  |
| 20cii) | t' = 1.93 x 10-20 s  *If both "c" values changed to 3 x 108 ms-1 then this is fine for substitution too.* |  |
| 20di) | Energy of 4450 MeV = 4450 x 106 x 1.6 x 10-19 Energy = 7.12 x 10-10 J  *Fine if you've not given the units as the question asked for it "in joules".* | (1) ans. |
| 20dii) | E = mc2 7.12 x 10-10 = m x (3 x108)2 m = 7.91 x 10-27 kg | (1) (1) (1) |