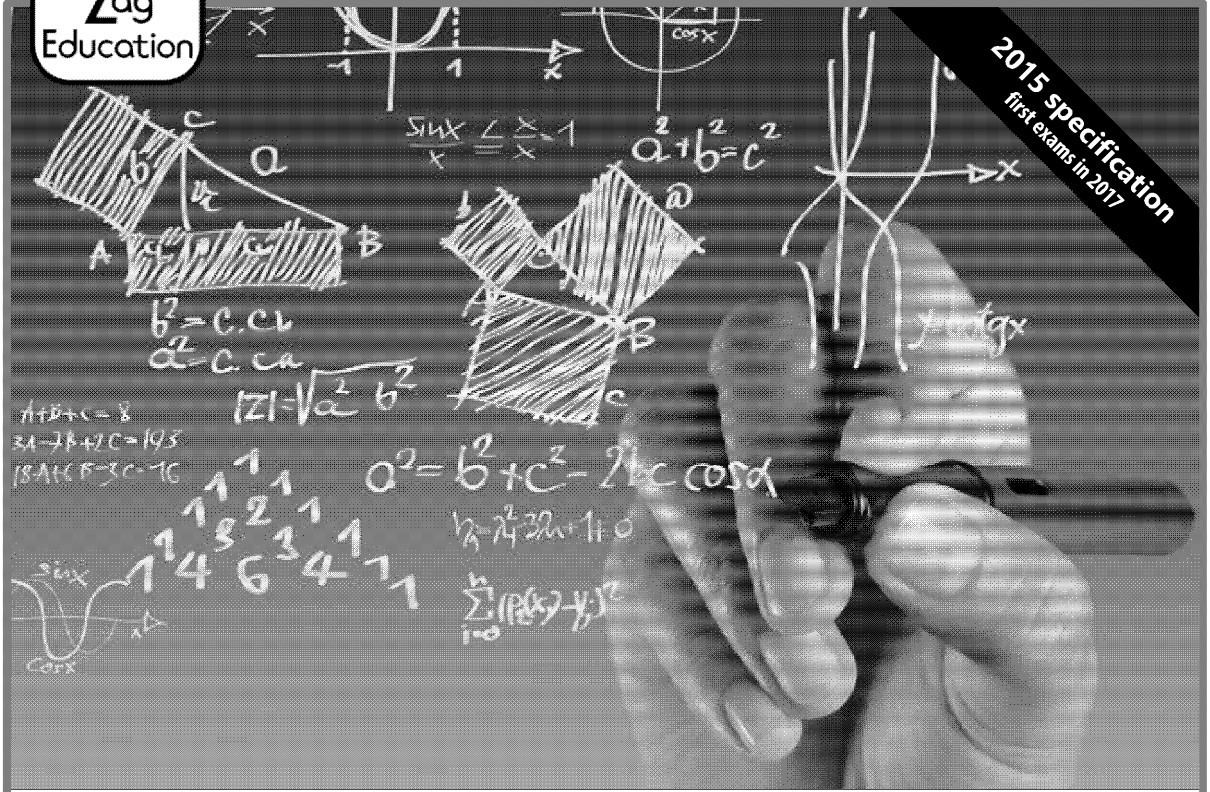
Physics A Level | AQA | 7408



Topic Tests for A Level AQA Physics

Sections 6–8

2nd Edition, 8th November 2018

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Contents

Teacher's Introduction

These topic tests have been designed to help you and your students assess their knowledge of a topic after you have taught each part of **A Level AQA Physics Section 6: Further mechanics and thermal physics**, **Section 7: Fields and their consequences**, and **Section 8: Nuclear physics**.

Each topic test closely follows the content of the specification and includes:

- **Factual questions**: Some simpler factual questions are included to ensure that all the content and basics are covered, and to allow weaker learners access to some marks.
- **Short-answer questions**: These are not in exam style, and the purpose of these is to test different elements, knowledge and skills from the specification in a variety of styles.
- **Exam-style questions**: Where appropriate, topics may contain one or more exam-style questions, to prepare students for what they might meet in the exam, and to test exam skills.

Mathematical and practical skills are also covered in these Topic Tests.

The questions are provided in write-on and non-write-on format to for ease of use, and mark allocations and answers are provided to help with marking. A range of question styles has been used to expose students to different question types and to give variety.

Tests have been designed to take approximately 25–60 minutes and most contain on average between 30 and 40 marks, though please note that this has not been possible where topics require more detailed knowledge and assessment. Please note that some topics have been combined, as show in the table:

Topic Number	Number of Marks
3.6.1.1	36
3.6.1.2/3.6.1.3/3.6.1.4	47
3.6.2.1	21
3.6.2.2	20
3.6.2.3	31
3.7.2	37
3.7.3	38
3.7.4	40
3.7.5	31
3.7.5.4/3.7.5.5/3.7.5.6	37
3.8.1.1/3.8.1.2/3.8.1.3	50
3.8.1.4/3.8.1.5	47
3.8.1.6/3.8.1.7/3.8.1.8	46

The topic tests are suitable for a classroom assessment, revision aid or homework task and are, therefore, suitable for use immediately after a topic is completed in class or at the end of teaching the course.

Students are able to see the number of marks awarded for each question, allowing them to gauge the level of detail they will require for the answers, as in exam conditions. Full answers with marks are included at the end of the resource. Additionally it makes the resource a suitable tool for students to use independently.

It is recommended that students have access to a calculator to complete the questions.

Students may also need a sheet containing Physics data and formulae, which can be found on the exam board website.

I hope you find these tests useful during your teaching.

June 2016

Second edition, November 2018
Improvements and corrections have been made to this resource, including rewording questions for greater clarity and context, corrections to answers, improving quality of graphs and reformatting units throughout.

Topic Test 1: Circular motion (3.6.1.1)

1. A moving Ferris wheel is an example of circular motion. The compartments o
from its centre and travel at a speed of 1.4 m s^{-1}.

   a) Calculate the period of the rotation of a compartment.
   b) Calculate the frequency of the compartment.
   c) Calculate the angular velocity of the compartment.
   d) Calculate the angular distance the compartment travels through in 50 se
      - In radians.
      - In degrees

2. Using your knowledge of Physics, describe the conditions required for an obj
circular path during its motion.

3. State the equation for centripetal force

4. Sketch a force diagram of a body travelling in a circular path and include the
velocity.

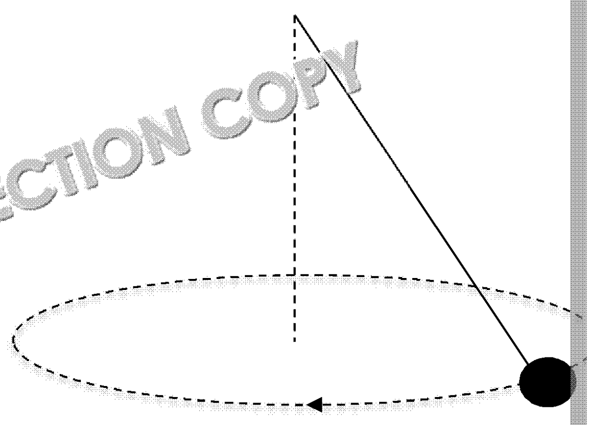
5. During [illegible]rm a group of friends travel to a theme park for a day. One of th
they ride that day has a large loop at the end of its run.

   The radius of the loop is 19 m and the speed of the cart at the top of the loop
   capacity roller-coaster and passengers weigh 1.4×10^{3} kg.

   a) Sketch the force diagram of the cart at the top and the bottom of the lo
   b) State the source(s) of centripetal force acting on the cart at the bottom
   c) State the source(s) of centripetal force acting on the cart at the top of th
   d) Calculate the normal force acting on the cart at the top of the loop.

6. As a hammer throw competitor rotates to swing the hammer round his body, circular path.

An average hammer weighs around 7.2 kg and maps out a circular path with competitor's body. At full extension the hammer travels at a speed of 22 m s



a) Sketch a force diagram of the hammer as it is being swung.
b) Calculate the centripetal acceleration of the hammer.
c) State an alternative equation for determining centripetal acceleration to your answer to b).
d) Calculate the centripetal force.
e) Calculate the tension in the chain.

7. When you are in a car and your car makes a right or left turn, you will experie force exerted on you.

The car is only mapping out part of a circle but the laws of circular motion sti

a) State the source of centripetal force on the car in this situation.

An example is a car making a right turn at a set of traffic lights. The 7×10^3 kg velocity [illegible]7 rad s^{-1} and maps out a circular path with radius 11 m.

b) Calculate the frictional force of the tyres as the car makes the turn.
c) Explain how the frictional force would need to alter if the car had taken a cyclist on its inside but moved with the same angular speed.

During a later part of the car's journey it travels over the top of a hill. The hil 8.9 m.

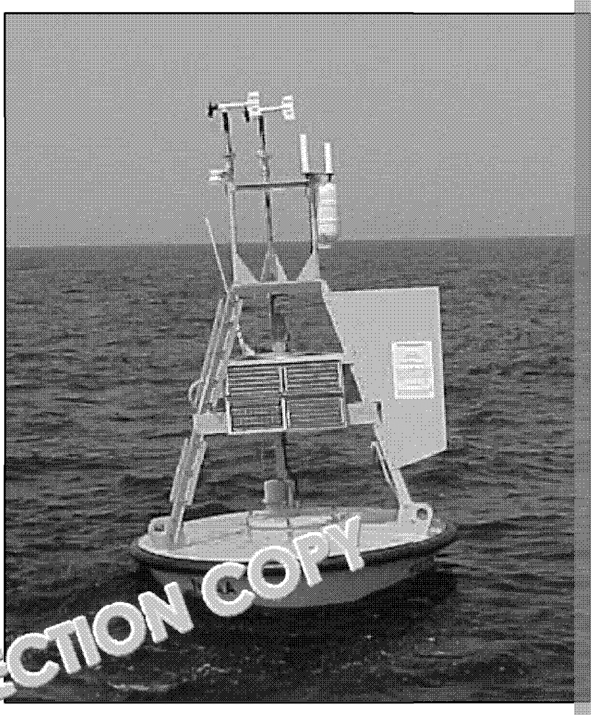
d) State whether the source of the centripetal force will be the same as you
e) Determine the maximum speed the car can travel over the top of the hil contact with the road.

Topic Test 2: Simple harmonic motion and oscillati
(3.6.1.2/3.6.1.3/3.6.1.4)

1. Explain what is meant by an object having simple harmonic motion.

2. If a clock pendulum is oscillating at a frequency of 1.7 Hz and is displaced a di equilibrium position, calculate its acceleration at th distance.

3. A buoy at sea will oscillate un . It oscillates with an average freque amplitude of the bu on is 0.5 m.



   a) Sk graph of displacement against time for an object displaying sim
   b) Calculate the displacement of the object 0.8 seconds into its motion.
   c) Sketch a graph for the buoy's velocity and acceleration with respect to ti
   d) Calculate the velocity of the buoy after 0.8 seconds.
   e) Explain at which point in the buoy's motion it will have maximum veloci
   f) Calculate the maximum velocity of the buoy.

4. A group of physicists are using a pendulum to assess the properties of simple use a pendulum and a clamp stand and have a metre stick, stop clock, set of

   a) Describe an experiment that could be carried out with the apparatus to SHM of the pendulum.
   b) Sketch a force diagram of the pendulum.
   c) Resolve the forces to show that:

$$= -g\sin\theta$$

   d) Using the condition for e the equation for the period of the p

$$T = 2\pi\sqrt{\frac{L}{g}}$$

The phy s release the pendulum from a maximum displacement of 0.2 m oscillates with an angular velocity of 1.2 rad s^{-1}.

   e) Calculate the maximum acceleration of the pendulum.

5. A Christmas tree decoration is made up of a bauble on the end of a spring. As setting up the Christmas tree the bauble is pulled downwards by 0.4 m.

The spring is not acted upon by any other force and is allowed to oscillate na bauble is 0.02 kg and it has a period of 54 s.

a) Using the condition for SHM, derive the equation for the period of any m
b) Calculate the spring constant of the spring.
c) Explain what would happen to the period of an oscillation if a spring wit constant was used.
d) Sketch the energy–displacement graph for KE and PE, explaining their re during the spring's
e) Calculate the KE of the spring when it is displaced by 0.1 m.

In reality the spring will not oscillate continuously and it will eventually come
f) Explain what is meant by the term 'damping' and suggest its source in th
g) Sketch a displacement–time graph of this lightly damped mass–spring sy

6. Explain the differences between free and forced oscillations.

7. Define the term 'periodic force'.

8. A young child is being pushed on a swing by the child's parent. The parent pu swing. The child reaches maximum height every time.

a) Explain what must be happening for this to occur.

It takes the child 4 seconds to make one complete swing.

b) Calculate the natural frequency of the swing system.

The parent stops pushing the child on the swing and the child is then allowed

c) Explain the effect on the child's swing amplitude.
d) State what will happen to the sharpness of the resonance curve on an ar graph once damping is in effect.

Topic Test 3: Thermal energy transfer (3.6.2.1)

1. State the two temperature scales and explain their differences.

2. Explain what is meant by the term internal energy.

3. A group of physicists are carrying out research testing a new heating system experiment in a lab they model the system with an electric heater placed in a

   The physicists used a mass of [illegible] of water with specific heat capacity 4.18 heater is connected to a power supply.

   a) In terms of the first law of thermodynamics, explain what will happen to the water when the electric heater is turned on.
   b) Calculate the amount of energy required to raise the temperature of the
   c) If more water was added to the basin but the same amount of energy w effect on the final temperature the water could reach.

   From the experiment the physicists calculate the specific heat capacity of wa

   d) Suggests two reasons why the measurement that the physicists calculate the true value.
   e) For your answer to d) suggest methods whereby the physicists could red increase the accuracy of their measurement value.
   f) Calculate the power supplied per second when the temperature of the w 21 °C to 48 °C over 150 seconds.
   g) Calculate the current suppled to the electric heater over this time if 12 V

4. Water being brought to the boil in a kettle is an example of a change of state changes state into steam. The specific latent heat of vaporisation of water is hold on average 0.8 kg of water.

   a) State the type of energy required to vaporise the water in a kettle.
   b) Explain how your answer to a) vaporises the water.
   c) Calculate the energy required to vaporise the water.
   d) If the example had been discussing ice melting into water, would more e required to for this change of state compared to your answer to c)?
   e) Comment on the internal energy, and the KE and PE of the substance as moment a solid changes into a liquid.

Topic Test 4: Ideal gases (3.6.2.2)

1. Explain the term absolute zero.

2. Define Avogadro's constant.

3. Calculate the number of moles in 1.2 kg of helium if its molar mass is 0.004 k

4. Calculate the number of molecules in 1.2 kg of helium.

5. Explain the difference between molar mass and molecular mass.

6. A medical research group are carrying out a range of tests on the properties

   Hospitals use containers filled with gases such as oxygen, nitrous oxide and n uses and need to know about their properties in order to store and use them

   The group initially use nitrous oxide, and are evaluating the relationship betw volume it occupies inside a container when its temperature is fixed.

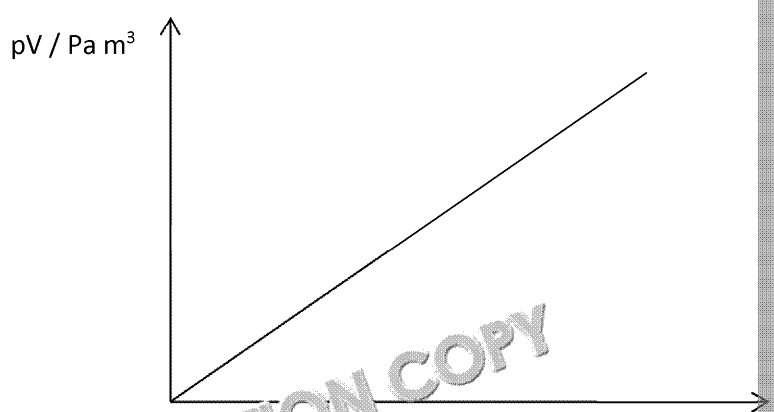
   The group measure the initial volume of the container to be 0.8 m^3 and the i

   a) State the law that the research group are investigating with this experim of pressure against volume you'd expect them to achieve.
   b) Calculate the work done on the gas if the group decrease the volume to
   c) Explain the experimental method the group would use if they wanted to relationship between the gas's temperature and volume at constant pre
   d) Sketch the graph of the relationship.

   The temperature is then allowed to fluctuate and is no longer constant. It wa of 292 K.

   e) Calculate the temperature of the gas after the volume has been altered to 11[illegible] kPa

7. An experiment was carried out on a gas modelled to be an ideal gas. The gas was at a temperature of 321 K. A rough sketch of the results observed is dem the product of pressure and volume against temperature.



   The gradient of the graph was determined to be 607 Pa m^3 K^{-1}.

   a) Explain how you would determine the number of moles in the gas from t
   b) Use the gradient of the graph to calculate the pressure of the gas used i
   c) The same experiment is carried out again and this time the group know t present in amount of gas they are using.

   The temperature, pressure and volume are 276 K, 112.8 kPa and 2.3 m^3 resp Use the measurements of the ideal gas to prove Boltzmann's constant.

Topic Test 5: Molecular kinetic theory model (3.6.

1. The explanation of Brownian motion helped develop our understanding of h

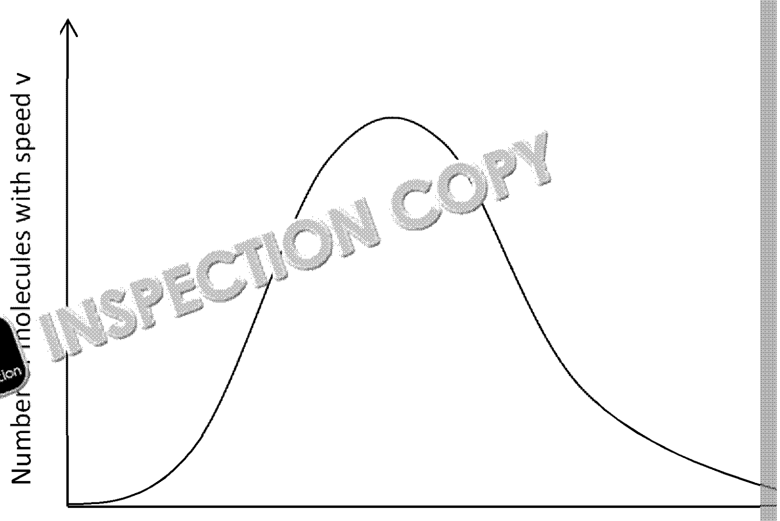
   Explain how Brownian motion was used as proof for the existence of atoms.

2. A diving group are carrying out tests on some new diving equipment. The mo the oxygen canisters to aid breathing under water.

   a) Explain, in terms of the molecular model, what the diver would notice if remained constant during the dive, but the gas in the canister increased
   b) Explain, in terms of the molecular model, what would happen if the volu to expand inside the canister as the temperature increased, but the pressu constant throughout the dive.
   c) Explain, in terms of the molecular model, what would happen to the pre the diver used the same number of molecules of gas but in a smaller co

3. a) Explain what is meant when the gas laws are referred to as having an e
   b) Can the same be said for the kinetic model? Give a reason for you answ

4. Molecules in any gas have a continuous range of speeds. A graph indicating t speeds is modelled below:



   a) State the equation for root mean square speed that relates the number individual speeds.
   b) Sketch how the distribution would alter if the temperature of the gas in

5. State the five main assumptions about gas molecules.

6. Consider one molecule of mass m inside a rectangular box.

   a) Using the laws of mechanics derive the equation for pressure of the mo
   b) Derive the equation for the total pressure.
   c) For an ideal gas, explain what is meant by the internal energy.
   d) Calculate the kinetic energy of a carbon dioxide molecule if its root mea and its molar mass is 0.044 kg mol^{-1}.
   e) Determine the temperature of the gas.

Topic Test 6: Gravitational fields (3.7.2)

1. State what is meant by a force field.

2. Define a gravitational field.

3. Define gravitational potential of a field.

4. Explain where in a gravitational field the gravitational potential is zero.

5. Explain how gravitational potential difference differs from gravitational pote

6. Every mass produces its own gravitational field and therefore exerts a gravita around it. Explain why on Earth we only feel the effects of Earth's gravitatio of the objects around us.

7. In a gravitational field, explain what the field lines represent.

8. Sketch the field lines for Earth's gravitational field and state the type of field.

9. Explain why Earth's gravitational field is taken to be uniform at a small dista

10. A 3.4×10^3 kg hot-air balloon, once in flight above an alien planet, experienc 2.94×10^4 N.
    Calculate the gravitational field strength experienced by the hot-air balloon.

11. The gravitational force between two objects is given by $F = \frac{Gm_1m_2}{r^2}$, where t $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}.
    a) Use this to estimate the force due to gravity between you and your hou separated by 1 km. An average student weighs around 65 kg and an ave
    b) Explain the effect on the force due to gravity between you and your ho further 4 km away.

12. Subatomic particles are also attracted to each other by the force of gravity a gravitational fields.
    a) Use the equation for gravitational force between two objects to derive t field strength $g = \frac{GM}{r^2}$.
    b) Calculate the gravitational field strength created by an electron, approxi the electron. ($m_e = 9.1 \times 10^{-31}$ kg)

13. Communication satellites, essential for televisions, mobile networks and Inte the front of rockets at an orbit radius of approximately 40 000 km above Ear
    The rockets and satellite have a combined mass of $\times 10^4$ kg. The potentia surface and 40 000 km above the surface is 4×10^{7} J kg^{-1}.
    ($G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}, mass of Earth $= 5.98 \times 10^{24}$ kg, radius of Earth = 6.
    a) Calculate the work done, against Earth's gravitational field, to launch th
    b) Describe what is meant by an equipotential surface.
    c) On orbit, if the satellite was moved along an equipotential surface t what would be the work done against gravity in this case?

The speed of an object in a circular orbit is given by $v = \sqrt{\frac{GM}{r}}$.

d) Use this to estimate the satellite's speed once in orbit around Earth.
e) Hence calculate the orbital period of the satellite.
f) Explain the effect on the orbital period of the satellite if its radius of orbi

Some artificial satellites are launched into geosynchronous orbit.

g) Explain what is meant by geosynchronous orbit.

In reality, when determining orbits of planets around other planets, we cann
as circular. When the Moon orbits Earth, the Moon will be closer to Earth at p
compared to others.

h) Explain at which point in the Moon's orbit it will have the greatest kineti

14. A number of countries are investing a significant amount of money in their sp
forefront of space travel. Russia, China and the USA are planning missions to
research and expand knowledge of space exploration.

Each of the countries' space programmes needs to establish basic knowledge
fields before missions can begin.

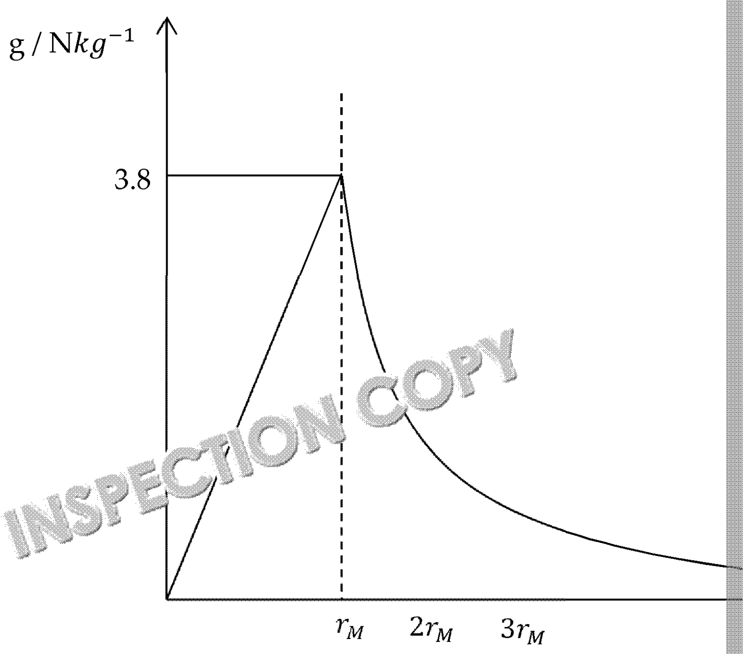
a) Sketch the graph of gravitational potential against distance from the cen
field of the Moon.
b) State how you could determine the gravitational field strength of the Mo
c) Calculate the gravitational potential on the surface of the Moon.
(m_{moon} = 7.35 × 10^{22} kg; r_{moon} = 1.74 × 10^{6} m)

Various projects involving missions to Mars have also taken centre stage.

To ensure they build the equipment and rockets that can provide enough ene
field, graphs of gravitational field strength against distance from Mars' centre
(m_m = [illegible] × [illegible] kg, $r_m = 3.39 \times 10^6$ m)

d) Calculate the escape velocity of the rocket leaving the surface of Mars.

A plot of gravitational field strength against distance from the centre of Mars



Note: the radius of Mars is 3390 km.

e) Determine the gravitational potential difference between Mars' centre a

Topic Test 7: Electric fields (3.7.3)

1. Newton's law of gravitation is given by the equation $F = \frac{Gm_1m_2}{r^2}$. Write dow force equation for electric fields in a vacuum.

2. Comment on a similarity and a difference between the two laws.

3. a) Use Coulomb's law to estimate the electrostatic force between two prot nucleus, if they are approximately [illegible] m apart. ($e = 1.60 \times 10^{-19}$ C, ε_0 =

   The gravitational [illegible] between two protons in an atomic nucleus is $F = 1.8$

   b) Ex[illegible]ow the gravitational force between protons compares to your a

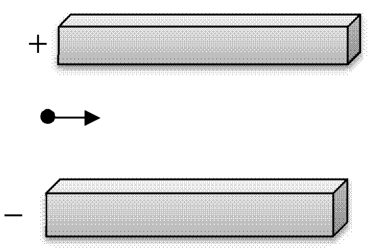
4. Define electric field strength.

5. State what electric field lines represent.

6. Sketch the electric field lines for the following:
   - An electric field between two parallel plates
   - An electron (point charge)
   - A positively charged sphere
   - A proton and an electron in proximity to each other

7. All charged particles produce an electric field around themselves. An electron therefore produces its own electric field.
   a) State the equation for electric field strength in a radial field.
   b) State what the term ε_0 represe[illegible]
   c) Calculate the electric field strength of the electron felt at 1.3×10^{-3} m f
   d) Calculate the electric potential of the field at this distance.

8. A capa[illegible]n be constructed from two oppositely charged parallel plates. V be used to tune radios by selecting particular wave frequencies. The plates cr strength, $E = 3.1\times10^{10}\ NC^{-1}$.



   a) Calculate the force an electron would experience inside the electric field

   The potential difference between the [illegible]s altered in order for the tuning results. The positively charge[illegible] now +15 V and the negatively charged between the plates [illegible] = 2.4 mm.

   b) D[illegible]e equation $E = \frac{V}{d}$ from knowledge that the force exerted on a p ele[illegible] field is $F = QE$.
   c) Calculate the force exerted on the electron between the new plates.
   d) Sketch the trajectory of the electron as it enters the field between the pl

   e) Explain the difference in the trajectory if the charged particle had been a

9. a) Explain the difference between absolute electric potential and electric p

b) Calculate the electrical potential difference when an electron is moved f from an electric field source.
($e = 1.60 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1})

c) Hence calculate the work done to move the electron.

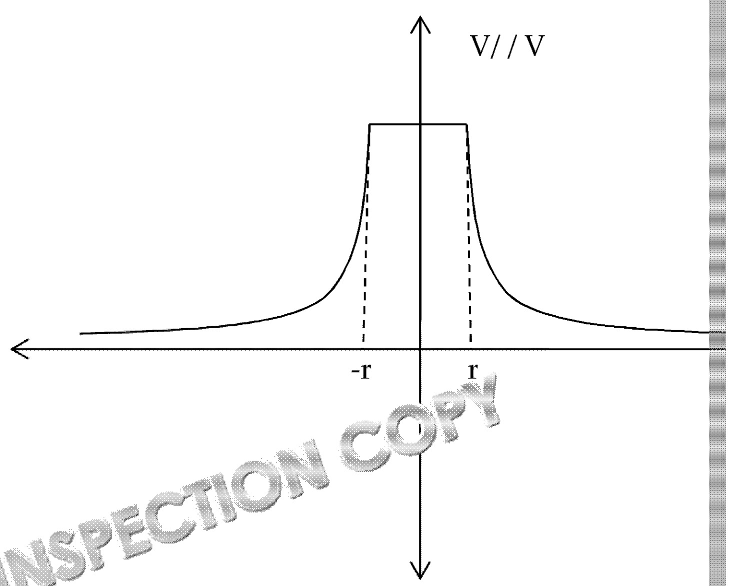
d) Sketch the graphs of E and V against the distance from the centre of a p

e) How can the size of the electric field be found in ... graph of electric po

10. A university research group is carrying ... investigatory tests on the effects c on the population and their ... ...gs.

A hollow sphere ... can be a comparable model to the metal exterio charge... what happens to a car's exterior when hit by lightning.

The res... group plot the potential of the sphere against the distance fro



a) Explain why the electric field strength inside the sphere, and consequen

b) Sketch a graph of the electric field strength.

c) Suggest why it would be appropriate to refer to the inside of the sphere

d) Determine the work done to move a charge inside the charged sphere.

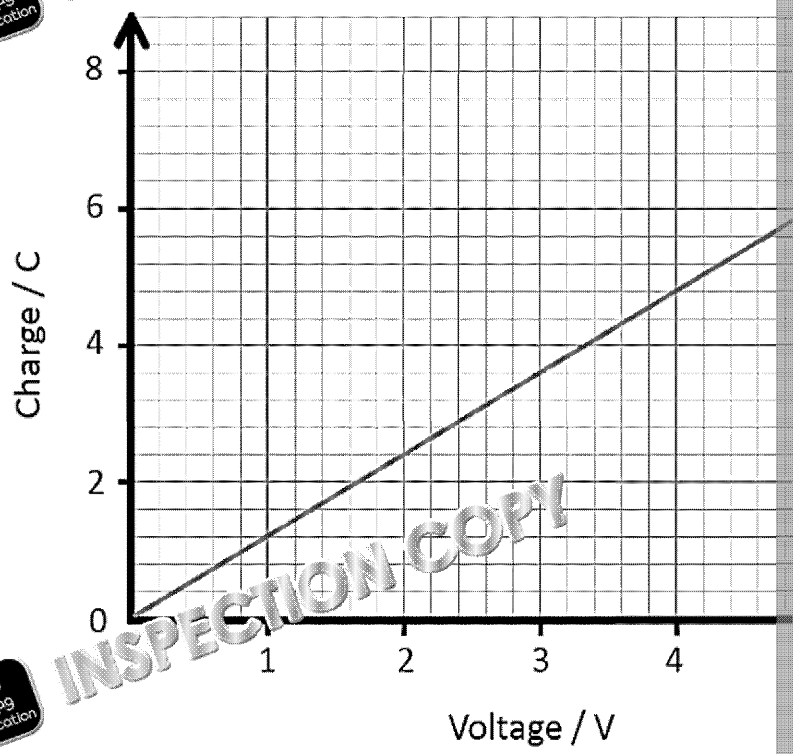
Topic Test 8: Capacitance (3.7.4)

1. Calculate the capacitance of a capacitor that stores a charge of 6 C and has a

2. State what is meant by a dielectric material.

3. Sketch the graphs of a capacitor charging and discharging for:
   - Charge against time
   - Current against time

4. The graph shows charge stored against voltage for a particular capacitor.



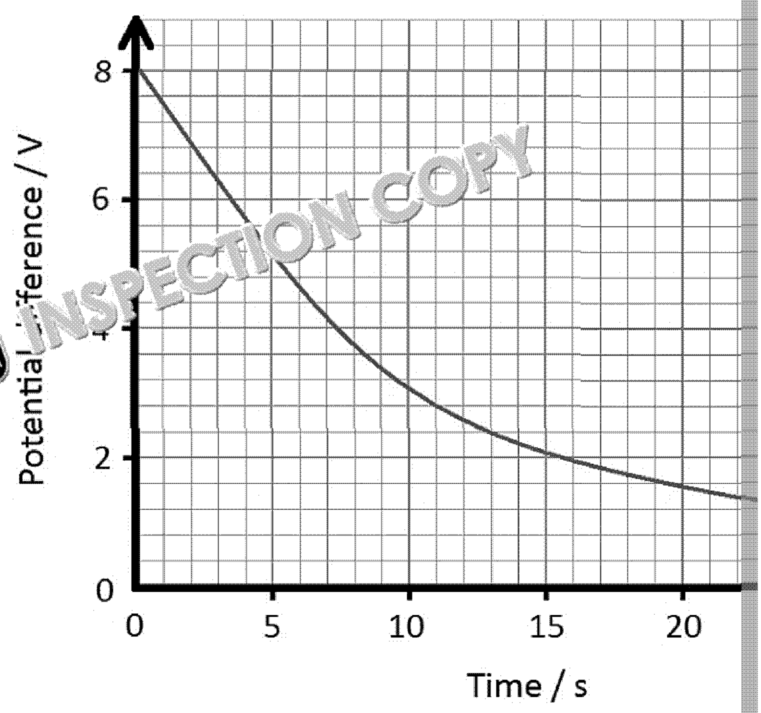
   a) Using the graph, calculate the capacitance of this capacitor.
   b) With reference to the graph, explain why the energy stored by a capacit using the formula $E = ½ QV$.
   c) Hence calculate the energy stored by this capacitor when the voltage ac
   d) Calculate the energy stored by the 50 μF capacitor, if the charge stored v

5. A Year 13 Physics class are investigating the properties of dielectric substance capacitors that consist of two plates of area 155 cm^2. Note that ε_o = 8.85 × 1

   For one of the experiments the pupils use a glass sheet of thickness 1.22 × 10 between the plates.

   a) Design a circuit that could determine the relative permittivity of glass.
   b) Explain the effect on the capacitor when the glass sheet is placed in betw
   c) Explain how the students could use the experimental set-up in your answ the relative permittivity of the glass (ε_r).
   d) Calculate the relative permittivity of the dielectric if the students measu dielectric present to be 2 A and without to be 9.4 A.
   e) Calculate the capacitance of the capacitor when the dielectric is present
   f) Explain the effect on the capacitance if the pupils used a thicker polythen
   g) Explain what would happen to the energy stored on the capacitor plates if

6. A capacitor is discharged through a resistor. A graph of the p.d. of the capacit
a data logger – the results are shown below.



a) Calculate the capacitor's capacitance if it can store 10.4 J of energy.
b) State what is meant by a time constant.
c) Use the graph to calculate the time constant of the capacitor.
d) Hence calculate the value of the resistor.
e) Determine how much charge was initially stored in the capacitor.
f) Calculate the amount of time it takes for the charge in the capacitor to f
g) Indicate how you would have determined your answer to f) if the capaci
rather than discharging.

Topic Test 9: Magnetic fields (3.7.5)

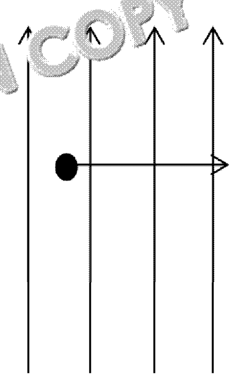
1. Explain what happens to a current–carrying wire when placed in a magnetic f
   - Perpendicular to the field.
   - Parallel to the field.

2. Use Fleming's left-hand rule to determine the direction in which the wire mo
   A: A wire is placed in a magnetic field B that is acting into the page, and th
   travelling from left to right.
   B: A wire is placed in a magnetic field B that is acting out of the page, and
   travelling from left to right.
   C: A wire is placed in a magnetic field B that is acting from bottom to top,
   travelling from top to bottom.

3. Give the definition for the unit of magnetic flux density.

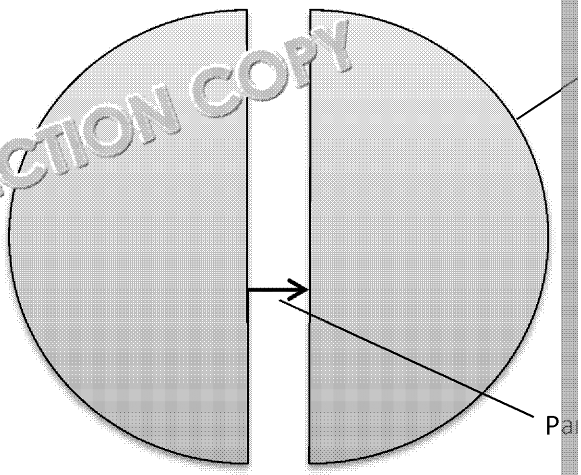
4. A Year 13 Physics class are carrying out an experiment with a top pan balance
   a wire varies with flux density, current and length of wire.
   a) Explain how the class can determine how the force on the wire varies wi
   b) State the equation for the force on a wire that is perpendicular to the m
   c) Calculate the length of the wire the class use if a current of 5.4 A flowed
   experienced a force of 0.2 N when perpendicular to a field of strength 2.
   d) Explain how the force would alter if magnetic flux density was increased

5. An electron is travelling perpendicular to a magnetic field.



   a) State the direction of the force felt by the moving electron.
   b) Explain how the direction would alter if the particle moving through the
   a proton.

6. Radiotherapy is a medical treatment used for various types of cancer. It uses the tumour cells in the body. The NHS uses particle accelerators such as cyclo beam's direction and focus the radiation beam on the particular point in the treatment.



a) Determine the direction of the magnetic flux if the electron is to continu cyclotron.
b) Sketch the completed path of the electron.
c) Explain how the path obtains its shape.
d) Calculate the size of the force if the electron reaches a maximum speed the field strength is 6.2×10^{-5} T.
e) Hence calculate the maximum radius of the electron's path.

7. A plane is flying in a horizontal path through Earth's atmosphere at an averag Earth's vertical magnetic field at this point is 8.5×10^{-6} T. If the wingspan of t calculate the total magnetic flux cut by the wings of the plane in one minute.

8. Search coils are used in fitted contact lenses to track the movement of the ey magnetic fields, whose properties can be used to indicate how an eye is rotat

The flux density of the field is 3.4×10^{-3} T, and the search coil has 147 turns

a) Explain how you could set up a search coil and an oscilloscope to investi magnetic flux linkage when the angle between a coil and the magnetic fi
b) Calculate the flux when the angle made between the coil and the field is
c) Calculate the maximum flux linkage.

Topic Test 10: Coils, currents and transformers (3.

1. State Faraday's law.

2. State the equation of Faraday's law.

3. State Lenz's law.

4. Calculate the magnitude of the induced emf of a coil, with 470 turns, perpen
   field with magnetic flux that changes by 2.45×10^{-3} T m^2 over 0.7 seconds.

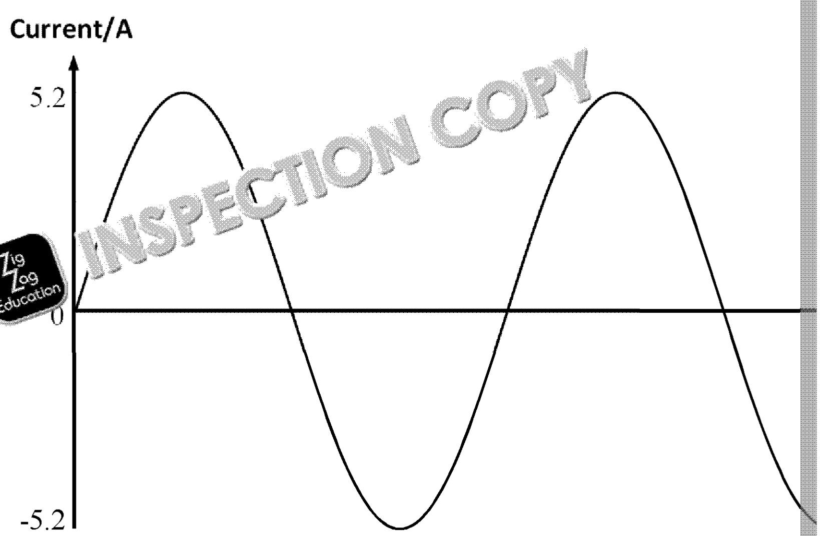
5. A coil is placed in a uniform magnetic field with a magnetic flux density of 31
   125,29 and a cross-sectional area of 0.09 m^2, and rotates in the field a
   3.4 rad s^{-1}.

   a) Calculate the induced emf in the coil after 1.2 seconds of rotation.
   b) State how your answer to a) would differ if the coil had 100 more turns.

6. State what is meant by an alternating current.

7. a) Indicate how you could observe an alternating p.d.
   b) Using your set-up from a), explain how you could observe a higher peak v

8. A graph plot of an oscilloscope reading of current against time is sketched be



   a) Calculate the frequency of the wave.
   b) Determine the values of I_0 and I_{rms}.

9. The electric heaters used in a local school are supplied with an alternating cu
   The maximum power that can be supplied to the heaters is 100 W.

   a) State what is meant by the root mean square value.
   b) Calculate the peak current value.
   c) Calculate the root mean square value of the alternating current.
   d) With calculation, indicate what the mean power supply will be to the
   e) Hence calculate the root mean square value for the alternating p.d.

10. Engineers are working on repairs in the National Grid system that supplies ou to repair particular sections of the system so as to increase the efficiency at w homes. Transformers are used frequently within the system. The primary coil

a) Explain why the engineers step up the voltage from 22 000 V to 39 000 V the power lines.

b) Calculate the number of turns required in the secondary coil of the step- the voltage step-up.

c) What would be the effect on the number of turns in the second coil if th a greater increase in the step-up voltage in the secondary coil?

d) Calculate the current necessary to deliver a transmission of 1.2 MW thro

e) Calculate the power lost through heating the cables if the resistance of t system is 6 Ω.

f) Hence calculate the efficiency of the transformer.

The engineers noticed that eddy currents were a huge source of energy loss i were causing the significantly low efficiency of the transformer.

g) Suggest a way to reduce the presence of eddy currents to increase the e transformer system.

h) State two other sources of energy loss that the engineers could have mis the efficiency of the transformer system.

i) Explain how one of these sources of energy loss could be reduced.

Topic Test 11: 3.8.1 (1–3): Radioactivity A

1. a) Describe how the Rutherford scattering experiment was conducted.
   b) How did the observations prove the nuclear model of the atom?

2. a) List the three types of ionising radiation.
   b) The radiation emitted by a sample passes through paper but not alumini
   What kind of radiation is it emitting? Explain how you can tell.

3. The radiation from a gamma source has an intensity of 0.12 W m^{-2} at a distar
   intensity at 0.30 m?

4. State and explain two ways to reduce your exposure to ionising radiation wher

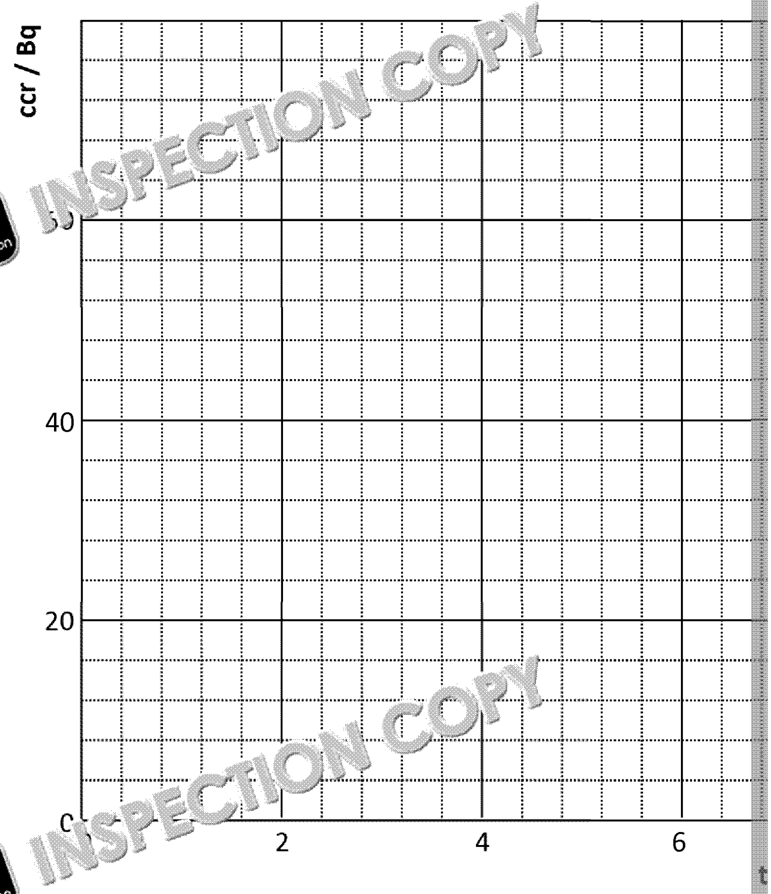
5. a) What is background radiation?
   b) Give two examples of sources of background radiation.

6. In an experiment the following results were obtained. Background was 2 Bq.

   a) Calculate the corrected count rates.

time / s	0	2	4
count rate / Bq	62	40	26
ccr / Bq			

   b) Plot a graph of corrected count rate against time.



   c) What is the half-life of this sample?

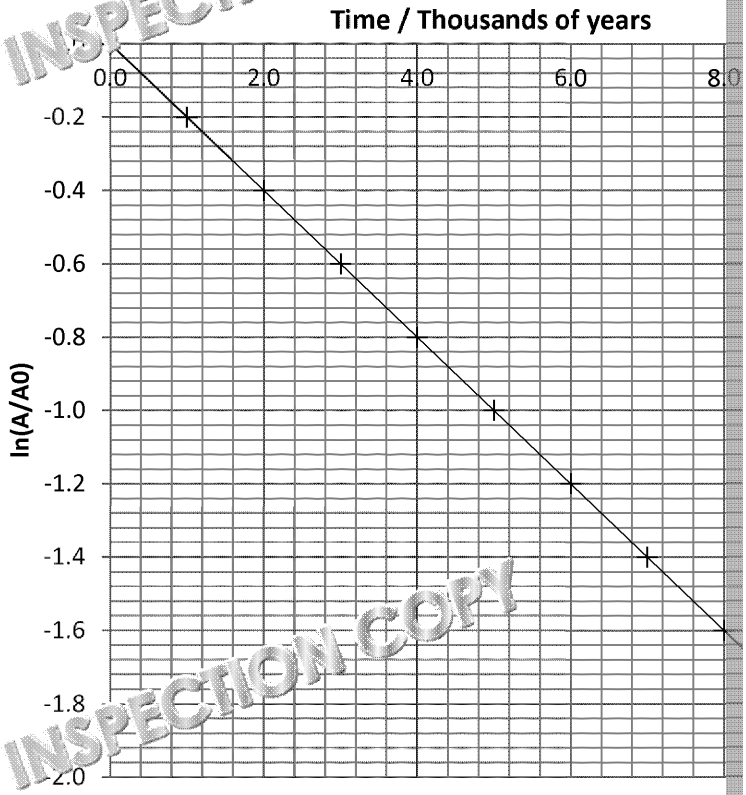
7. a) Describe how radio-carbon dating works.
   b) In a sample of carbon-14, 150 nuclei decay in 3 s. The decay constant is
   How many active nuclei are there?

8. a) What does it mean to say that radioactivity is a random process?
b) What does the decay constant represent?

A sample of a radioactive isotope contains 2.34×10^{24} unstable nuclei at the
decay constant of $0.0214\ s^{-1}$.

c) What is the activity at the start of the experiment?
d) How many unstable nuclei would you expect to find after 1 minute?
e) What is the half-life of this isotope?

9. a) What is the half-life of this isotope?



b) Why would it be difficult to dispose of it safely?

10. a) A pure sample of technetium-99 has a mass of 0.788 g. How many activ
The relative atomic mass of technetium-99 is 98.9.
b) Technetium-99 has a half-life of 6.01 hours. At what time would there b
technetium-99 remaining in the sample?

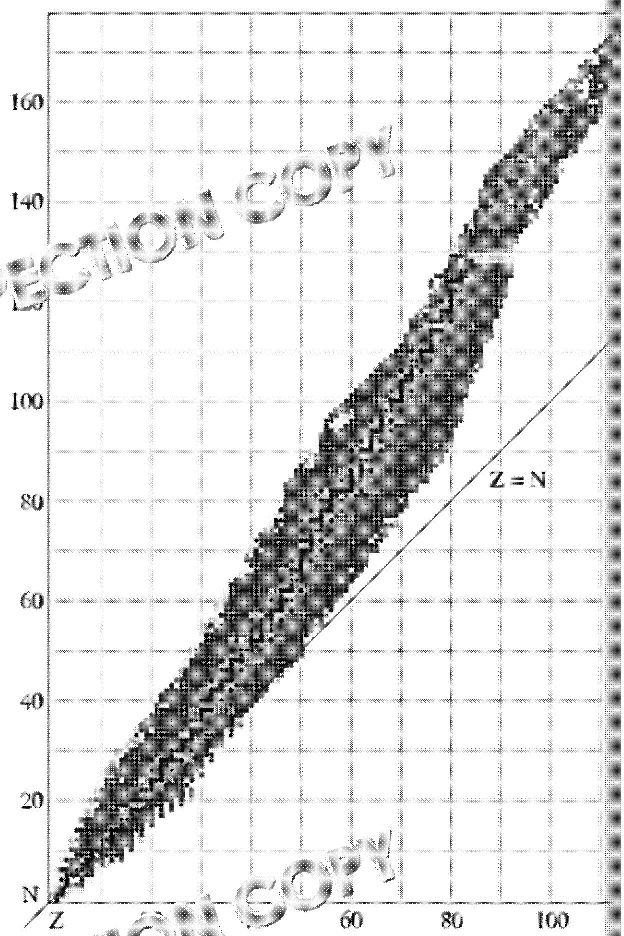
11. Describe how a beta source could be used to measure the thickness of a shee

12. Describe an experiment to prove that gamma radiation obeys the inverse squ
Mention any graph you would plot as part of the test.

13. Discuss the risks and benefits of using radiation in medicine.

Topic Test 12: 3.8.1(4–5): Radioactivity B

1.



a) Explain which ki[illegible] radiation will be emitted by a nucleus with 60
b) Wh[illegible] $^{46}_{56}$Ba emit?
c) In[illegible] on the diagram the regions where fission and fusion would rele

2. Complete the following decays:

a)

$$^{12}_{6}\mathrm{C} \rightarrow\, ^{12}_{7}\mathrm{N} + ?$$

b)

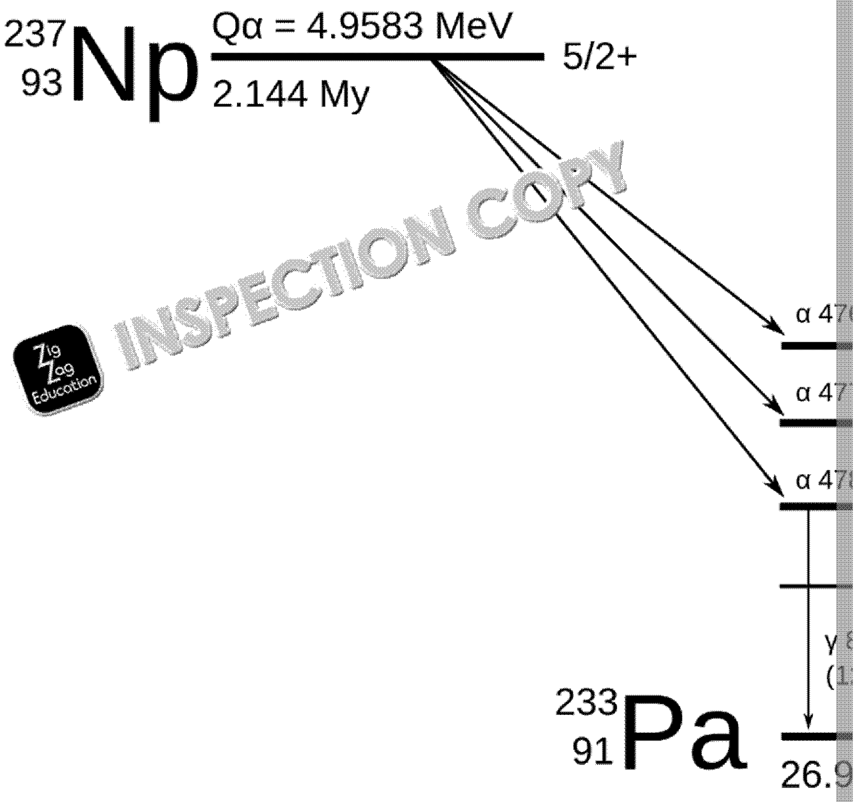
$$^{238}_{92}\mathrm{U} \rightarrow\, ^{?}_{?}\mathrm{Th} + \,^{4}_{2}\alpha$$

c)

$$^{26}_{13}\mathrm{Al} + ? \;\rightarrow\; ^{26}_{12}\mathrm{Mg} + ?$$

3. a) How is gamma radiation produced?

b) Describe what can happen when Np-237 decays.



c) Technetium-99m is a metastable isotope. What does this mean?
d) Describe a use of technetium-99m.

4. Discuss the relative hazards of exposure to alpha, beta and gamma radiation.

5. a) Which of these is a typical nuclear radius? Circle the correct answer.

10^{-20} m	**10^{-15} m**	**10^{-10} m**

b) What affects the size of a nucleus?
c) Describe how the radius of nuclei is now measured using electrons.

d) The following data was collected about nuclei.

A	2	5	10
R / 10^{-15} m	1.6	2.1	2.7

i) Plot a suitable graph to determine the relationship between relativ
nuclear radius.

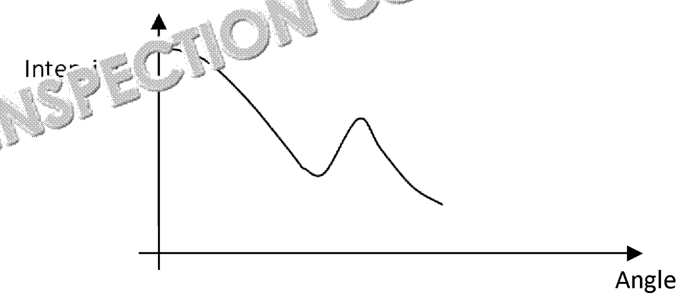
ii) Determine the constant of proportionality.

e) What does this relationship show about the density of nuclei?
f) Calculate the radius of a copper-64 nucleus if a hydrogen nucleus has a r

6. Calculate the density of an iodine-127 nucleus, which has a radius of 6.3 fm.

7. a) Calculate the kinetic energy of an alpha particle travelling at 15,000 km s
   b) Estimate its closest approach to a nucleus of gold (Z = 79).

8. State what would change about this graph of intensity against angle for elect
the nucleus were replaced by a larger one.



Topic Test 13: 3.8.1 (6–8): Nuclear energy

1. a) 1.65×10^{-27} kg of the mass of a proton comes from the binding energy b
   Calculate this binding energy.
   b) A nucleus contains 200 nucleons. What is the energy equivalent (in MeV
   Neglect binding energy.
   c) Einstein's formula for mass–energy equivalence only applies to nuclear i
   Circle the correct answer, and explain your answer.

TRUE	FALSE

2. a) Use data below to calculate the mass defect for:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{91}_{36}Kr + ^{142}_{56}Ba + 3^{1}_{0}n$$

particle	$^{235}_{92}U$	$^{91}_{36}Kr$	$^{14}_{5}$
mass	235.04392u	90.92345u	141.

   b) How much energy is released in this event?
   c) Use the data below to calculate the mass defect and energy released wh
   deuterium to make helium-3:

particle	$^{1}_{1}H$	$^{2}_{1}D$
mass	1.00794u	2.01410u

3. a) Sketch a graph of binding energy per nucleon vs mass number. State the
   peak lies.
   b) Explain why fission of heavy nuclei and fusion of light nuclei releases ene

4. a) Define the following terms.
   i) Chain reaction
   ii) Critical mass
   b) How can a material be induced to fission.

5. a) State a suitable material for each of these components of a fission reac

   i) Moderator:
   ii) Control rod:
   iii) Coolant:
   iv) Fuel:

   b) What does a moderator do?
   c) What do the control rods do?
   d) What does the coolant do?

6. a) Why are reactors surrounded by thick concrete?
   b) What safety measure is in place for a complete loss of power?
   c) Describe the three main types of radioactive waste.
   d) Give two examples of how radioactive waste is produced.
   e) How is radioactive waste handled?
   f) What is done with radioactive waste?

7. Discuss why some people are in favour of the development of nuclear power a

8. State and explain two safety measures in place in a nuclear reactor.

Answers

Section 6: Further mechanics and thermal physics

3.6.1.1 Circular motion

1. a) $v=\frac{2\pi r}{T}$ ✓

   $T=\frac{2\pi r}{v}=\frac{2\times\pi\times 20}{1.4}=89.8$ s ✓

   b) $f=\frac{1}{T}$ ✓

   $f=\frac{1}{89.8}=0.01$ Hz ✓

   c) $\omega=2$[illegible] ✓

   ω [illegible] $01=0.07$ rads^{-1} ✓

   OR

   $\omega=\frac{v}{r}$ ✓

   $\omega=\frac{1.4}{20}=0.07$ rads^{-1} ✓

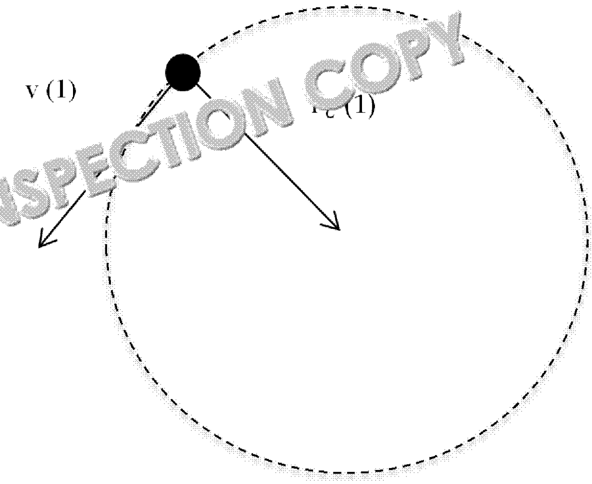
   d) $\theta=\frac{2\pi t}{T}$

   $\theta=\frac{2\pi\times 50}{89.8}=3.5$ rad (1) ; $\theta=3.5\times\frac{360}{2\pi}=200.5°$ ✓

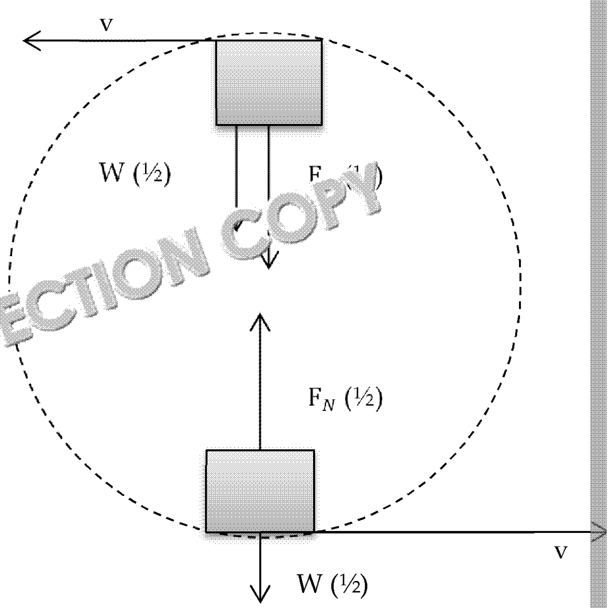
2. A body will remain in a circular path during its motion if a constant net force is appli motion (centripetal force) towards the centre of motion. ✓

3. $F=\frac{mv^2}{r}$ ✓ OR $F=m\omega^2 r$ ✓

4.



5. a)



b) $F_C = F_{net} = \text{Normal force} - \text{weight}$ ✓

c) $F_C = F_{net} = \text{Normal force} + \text{weight}$ ✓

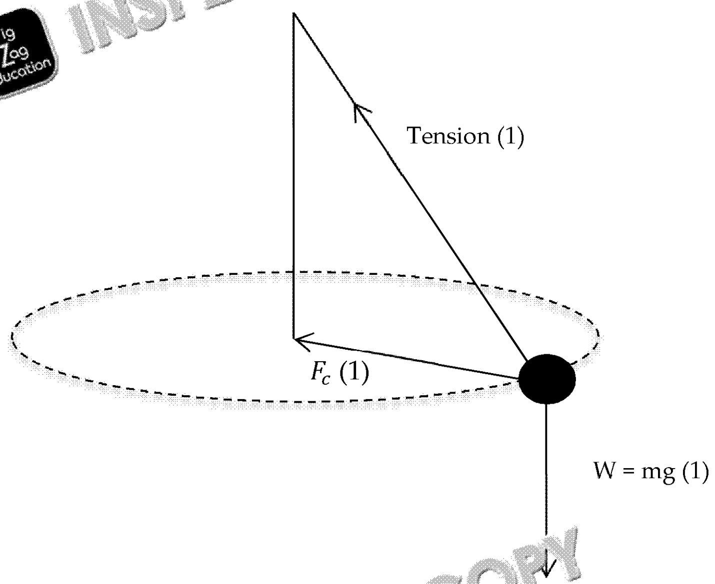
d) $W + F_N = \frac{mv^2}{r}$

$F_N = \frac{mv^2}{r} - W$ ✓

$F_N = \frac{1.4 \times 10^3 \times (26)^2}{19} - (1.4 \times 10^3 \times 9.81)$ ✓

$F_N = 4.98 \times 10^4 - (1.37 \times 10^4) = 3$[illegible]$\times 10^4$ N ✓

6. a)



b) $a = \frac{v^2}{r}$ ✓

$a = \frac{(22)^2}{1.1}$

$a = 440\ ms^{-2}$ ✓

c) a = [illegible]

d) $F_C = F_{net} = F_{horizotnal} = ma$ ✓

$F_C = 7.2 \times 440 = 3168$ N ✓

e) $F_{tension} = \sqrt{{F_{horizontal}}^2 + {F_{vertical}}^2}$

$F_{tension} = \sqrt{{F_c}^2 + {F_w}^2}$ ✓

$F_{tension} = \sqrt{(3168)^2 + (7.2 \times 9.81)^2}$

$F_{tension} = 3168.8$ N ✓

7. a) The frictional force between the tyres and the road surface.

b) $F_f = F_C = m\omega^2 r$ ✓

$F_f = (7 \times 10^3) \times (0.07)^2 \times 11 = 377.3$ N ✓

c) A wider turn would result [illegible] circular path radius and therefore the fric[illegible] be greater to ens[illegible] remains in its circular path round the bend. ✓

d) N[illegible]ent[illegible]petal force will be $F_C = W - N$ ✓

e) N = 0 in this situation

$mg = \frac{m{v_{max}}^2}{r}$ ✓

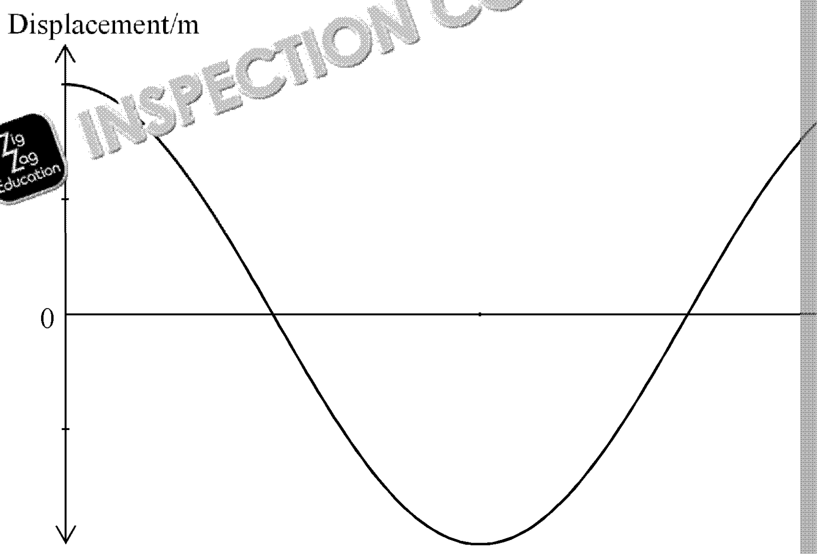
$v_{max} = \sqrt{gr} = \sqrt{9.81 \times 8.9} = 9.34\ ms^{-1}$ ✓

3.6.1.2 Simple harmonic motion

1. An object exhibits simple harmonic motion if its acceleration (restoring force) is direc opposite direction, to its displacement from rest (equilibrium position). ✓

2. $a = -(2\pi f)^2 x$ or $a = -(\omega)^2 x$ ✓
   $a = -(2\pi \times 1.7)^2 \times 0.3 = -34.2\ \text{ms}^{-2}$ ✓

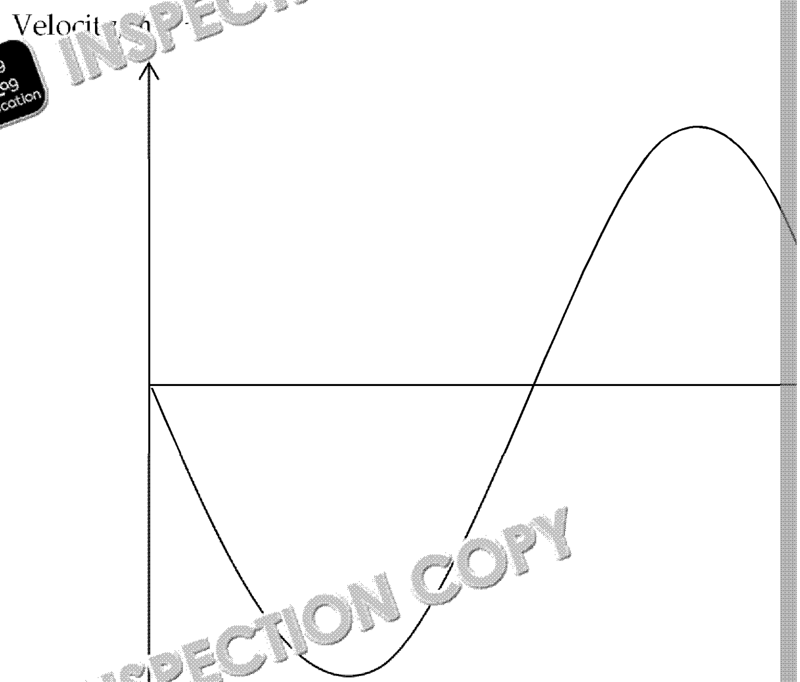
3. a) (1) mark for correct sketch.



Note: full marks are given to sketches that also demonstrate a repeated wave.

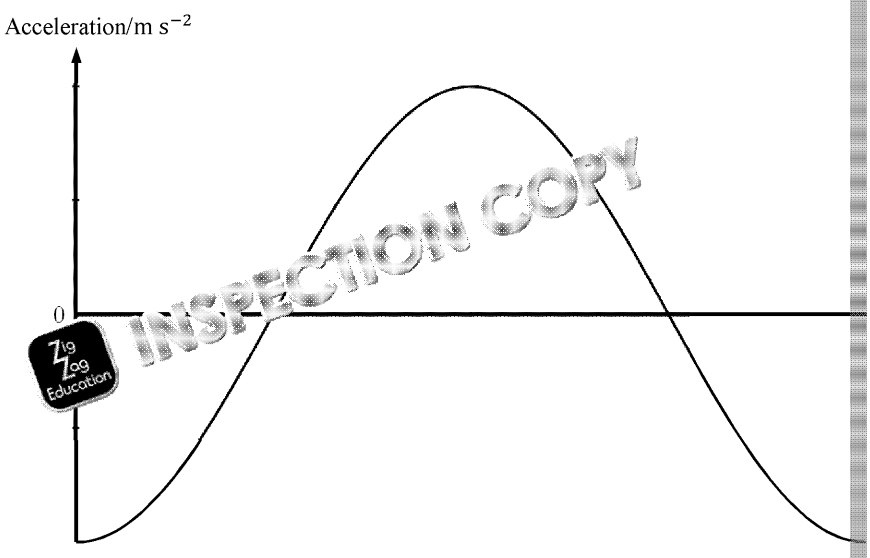
b) $x = A\cos\omega t$ ✓
   $x = 0.5\cos(2\pi \times 0.1 \times 0.8) = 0.4$ m ✓

c) (1) mark for correct sketch



Nc marks are given to sketches that also demonstrate a repeated wave.

(1) Mark for correct sketch



Note: full marks are given to sketches that also demonstrate a repeated wave.

d) $x = A\cos\omega t$ ✓

$v = \pm\omega\sqrt{A^2 - x^2} = \pm\omega\sqrt{A^2 - (A\cos(\omega t))^2}$

$v = \pm 2\pi \times 0.1 \times \sqrt{(0.5^2 - (0.5\cos(2\pi \times 0.1 \times 0.8))^2)} = 0.15 \text{ m s}^{-1}$ ✓

e) When x = 0 ✓

OR

When the object trave[illegible] [illegible]ck t[illegible] [illegible]ugh its rest (equilibrium) position. ✓

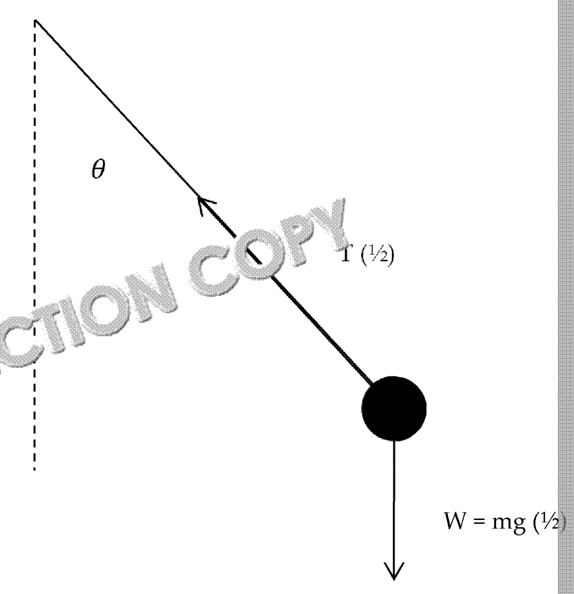
f) v [illegible] ✓

v [illegible]$0.1 \times 0.5 = 0.31 \text{ m s}^{-1}$ ✓

3.6.1.3 Simple harmonic systems

4. a)
- Measure mass of pendulum with a digital balance and length of pendulum from clamp stand. ✓
- Extend the pendulum from its rest position and measure the angle with a pendulum and allow it to swing naturally. ✓
- Use a stop clock to measure the time it takes to make n swing and divide from this the group can observe its different SHM properties such as displ amplitude, frequency and energy. ✓

b)



c) $F_{net}(\text{restoring}) = -mg\sin\theta$ ✓
$ma = -mg\sin\theta$
$a = -g\sin\theta$ ✓

d) $a = -\omega^2 x = -g\sin\theta$ ✓
By the small angle approximation, $sin\theta = \frac{x}{L}$
$a = -\omega^2 x = -g\frac{x}{L}$ ✓
$\omega^2 = \frac{g}{L}$
$T = \frac{2\pi}{\omega}$ ✓
$T = 2\pi\sqrt{\frac{l}{g}}$ ✓

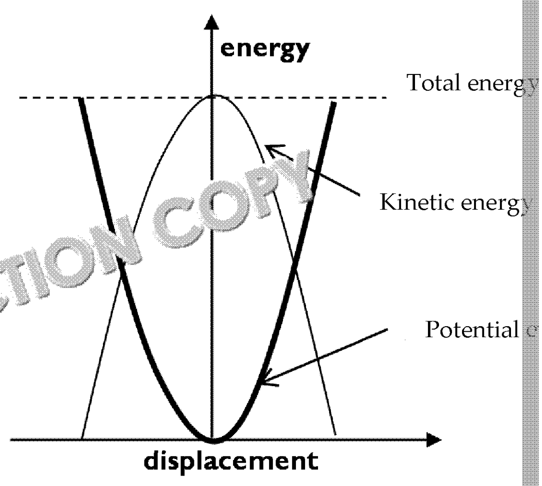
e) Maximum accele[illegible] at x = 0
$a =$ [illegible] ✓
a [illegible] $\times 0.2 = 0.29\ ms^{-2}$ ✓

5. a) $a = -\omega^2 x$
$F_{net}(\text{restoring}) = ma = -kx$ ✓
$-\omega^2 x = \frac{-kx}{m}$
$\omega^2 = \frac{k}{m}$ ✓
$T = \frac{2\pi}{\omega}$
$T = 2\pi\sqrt{\frac{m}{k}}$ ✓

b) $T = 2\pi\sqrt{\frac{m}{k}}$
$k = \frac{4\pi^2 m}{T^2} = \frac{4\pi^2 \times 0.02}{(54)^2} = 2.7 \times 10^{-4}$ N m^{-1} ✓

c) If k was greater, then T would be l[illegible]

d) (1) mark for correct sketch.

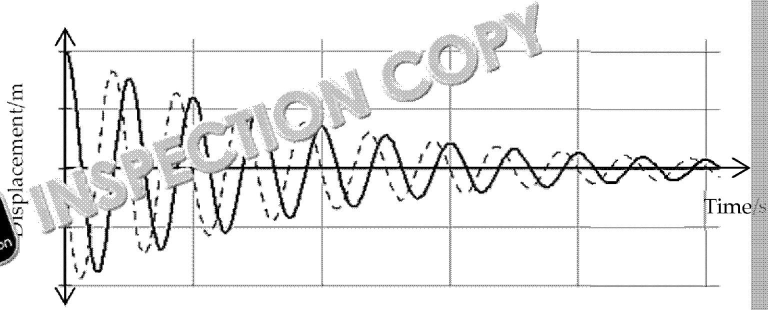


As the potential energy decreases, the kinetic energy increases and vice versa. and the total potential energy due to the motion of the system is always equal energy in the system. ✓

e) Kinetic energy $= \frac{1}{2}mv^2 = \frac{1}{2} \times m \times \omega^2(A^2 - x^2)$ ✓
Kinetic energy $= \frac{1}{2} \times 0.02 \times \left(\frac{2\pi}{54}\right)^2 \times (0.4^2 - 0.1^2) = 2.03 \times 10^{-5}$ J

f) *Damping* refers to the dissipative forces present in the system reducing the tot amplitude is zero. The source of damping in this case will be the resistive force

g)



3.6.1.4 Forced oscillations

6. A free oscillation has no driving force when displaced from its equilibrium position a oscillate with its natural frequency ✓whereas a forced vibration is caused by a drivi with a frequency equal to the frequency of the driving force. ✓

7. Periodic force is a force applied at regular intervals. ✓

8. a) Since the swing is oscillating at maximum amplitude, then the phase differenc displacement is π. ✓ The frequency of the pushing fo[illegible] the same as the nat

b) At resonance the natural fre[illegible] = [illegible] applied frequency:
$f = \frac{1}{4} = 0.25$ Hz ✓

c) Th[illegible] system will no longer be at resonance as the resistive forces in the sy Th[illegible]gy within the system begins to be removed and the achieved amplitud amplitude. ✓

d) The sharpness of the resonance curve will decrease. ✓

3.6.2.1 Thermal energy transfer

1. Absolute and Celsius scales ✓ The absolute scale is defined in terms of absolute zero whereas the Celsius scales is defined in terms of ice point and steam point. ✓

2. The sum of randomly distributed kinetic energies and potential energies of the partic

3. a) When the electric heater is turned on, heat is added to the water and the first l that there will be an increase in the internal energy of the water (**first law**: the c of the object = the total energy transfer due to work done on the system.)

   b) $Q = mc\Delta\theta$ ✓
   $Q = 1.7 \times (4.18 \times 10^3) \times (27 - 21) = 4.26 \times 10^4$ J ✓

   c) If there was an increase in mass but the same energy supplied then the final ter be able to reach during heating would be less than 27 °C as the change in temp

   d) $c = \frac{IVt}{m\Delta\theta}$
   Full marks (2) for identification of any two of the following answers:
   - Heat loss (inaccurate change in temperature measurement)
   - Systematic error in voltage meter readings (inaccurate value for energy)
   - Systematic error in current meter readings (inaccurate value for energy)
   - Systemic error in scale reading (inaccurate value for mass)

   e) Give full marks (2) for any two of the following:
   - Insulate the basin to reduce the amount of heat loss to it. ✓
   - Insulate the entire experimental system to reduce the amount of heat loss
   - Use reference values to calibrate the metre readings to reduce the system
   - Repeat the experiment. ✓

   f) $P = \frac{mc\Delta\theta}{t}$ ✓
   $P = \frac{1.7 \times (4.5 \times 10^3) \ldots}{\ldots} = 1.38 \times 10^3$ W ✓

   g) $I = \ldots$
   $I = \frac{1.38 \times 10^3}{12} = 115$ A ✓

4. a) Latent heat of vaporisation ✓

   b) When the water is heated its molecules gain kinetic energy and gain sufficient e that keep them in contact with one another to create bubbles of vapour in the w

   c) $Q = ml$ ✓
   $Q = 0.8 \times 2264.76 = 1811.8$ J ✓

   d) Less energy is required to change a substance from a solid to a liquid compared

   e) During a change of state the internal energy of the substance changes due to th ensemble but not the kinetic energy as they remain constant. ✓

3.6.2.2 Ideal gases

1. Temperature where particles have lowest possible energy ✓

2. The number of atoms in 12 g of carbon-12
   OR
   6.02×10^{23} molecules in one mole of a substance ✓

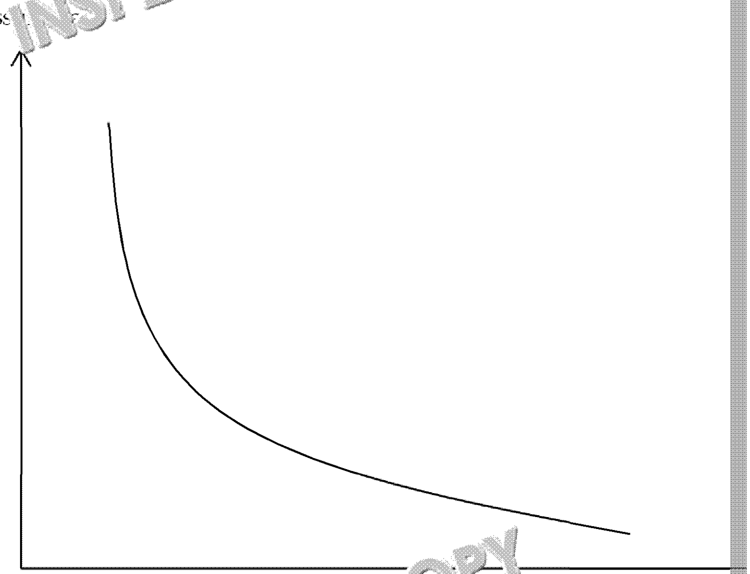
3. $n = \frac{M_s}{M}$ ✓

$n = \frac{1.2}{0.004} = 300 \text{ moles}$ ✓

4. $N = nN_A = 300 \times (6.023 \times 10^{23}) = 1.81 \times 10^{26}$ molecules ✓

5. Molar mass refers to the mass of 1 mole of the substance whereas molecular mass r
the substance. ✓

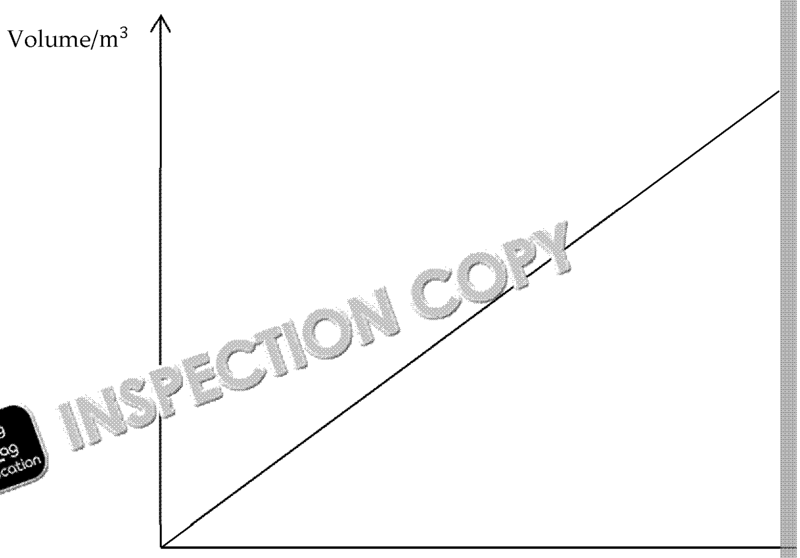
6. a) Boyle's law ✓
Correct sketch of graph ✓



b) work done $= P\Delta V$ ✓
work done $= 120$ [illegible] $-0.8) = -1.2 \times 10^4$ J ✓

c) The temperature of the gas would be measured by a thermometer, and a press
pre[illegible] and ensure it remains constant throughout the experiment. The maxi
the container would have to be measured by a micrometer to obtain the volum
The temperature can be varied to different and regular intervals and a note of t
can be taken at each interval to identify the relationship. ✓

d) Correct sketch of graph ✓



e) Since $Nk = constant$

Then can deduce that $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ ✓

$T_2 = \frac{P_2V_2T_1}{P_1V_1} = \frac{(110 \times 10^3) \times 0.9 \times 292}{(120 \times 10^3 \times 0.8)} = 301.1$ K ✓

7. a) Compare $pV = nRT$ with $y = mx + c$
Gradient $(m) = nR$ and therefore could determine the number of moles from t
constant R. ✓

b) $pV = nRT$ ✓
Gradient $(m) = nR = 607$ Pa m³ K⁻¹
$p = \frac{607 \times 321}{1.3} = 1.5 \times 10^5$ Pa ✓

c) $pV = NkT$ ✓
$k = \frac{pV}{NT} = \frac{(112.8 \times 10^3) \times 2.3}{(5 \times 10^{25}) \times 276} = 1.88 \times 10^{-23}$ J K⁻¹ ✓

3.6.2.3 Molecular kinetic theory model

1. Brownian motion refers to the random motion of visible particles. ✓
The random motion can be explained by collisions with smaller invisible particles (at
existence of atoms. ✓

2. a) If the temperature increases the kinetic energy of the molecules increases and t
Since the volume is kept constant the number of collisions per second increases
on the canister wall. Due to $\frac{F}{A}$ the pressure will in turn increase. ✓

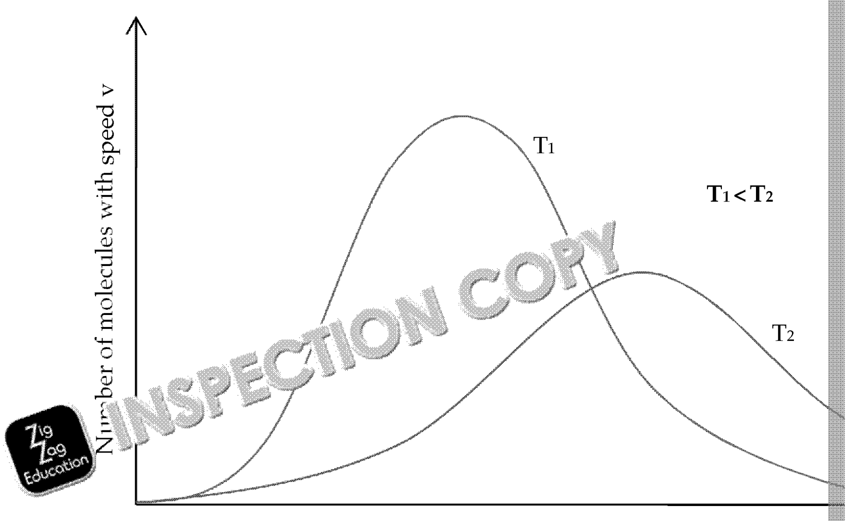
b) If the temperature increases the kinetic energy of the molecules increases and t
The number of collisions per second will increase creating a greater force exert
resulting in the volume increasing. ✓

c) If a smaller volume was used then the number of molecules colliding with a give
and therefore creating an increased in pressure inside the canister. ✓

3. a) It means they have been concluded from experimental findings and observatio

b) No, the kinetic theory model has not be concluded from experimental findings
based on theory. ✓

4. a) $c_{rms} = \left(\frac{{c_1}^2 + {c_2}^2 + \ldots + {c_N}^2}{N}\right)^{½}$ ✓

b) 

5.
- No interactions between molecules. ✓
- Molecules move with random motion. ✓
- The volume of each molecule of gas is negligible compared to the volume of th
- All collisions between molecules are elastic. ✓
- The duration of each collision is significantly less than the time between each c

6. a) The speed of the molecule is made up of its perpendicular components:

$c_1{}^2 = u_1{}^2 + v_1{}^2 + w_1{}^2$ ✓

The time between collisions:

$t = \frac{\text{the total distance to the opposite face and back}}{\text{x} - \text{component of velocity}} = \frac{2l_x}{u_1}$ ✓

Using Newton's second law:

$\text{F on molecule} = \frac{\Delta p}{t}$

$\text{F on molecule} = \frac{-2mu_1}{2l_x/u_1} = \frac{-mu_1{}^2}{l_x}$

Due to Newton's third law the force of impact on the wall F_1 is equal and oppos

$F_1 = \frac{mu_1{}^2}{l_x}$ ✓

Then $P = \frac{F}{A}$

$p_1 = \frac{+mu_1{}^2}{l_x l_y l_z} = \frac{+mu_1{}^2}{V}$ ✓

b) If there are N molecules in the box then the total pressure will be the sum of th

$p = p_1 + p_2 + p_3 + \ldots + p_N$

$p = \frac{mu_1{}^2}{V} + \frac{mu_2{}^2}{V} + \ldots \frac{mu_N{}^2}{V}$ ✓

$p = \frac{m}{V}(u_1{}^2 + u_2{}^2 + u_3{}^2 + \ldots + u_N{}^2)$

The since $\bar{u}^2 = \frac{u_1{}^2 + u_2{}^2 + u_3{}^2 + \ldots + u_N{}^2}{N}$, we can say

$p = \frac{Nm\bar{u}^2}{V}$ ✓

One of the assumptions is that the motion of molecules is random and therefor direction of motion.

The equation for pressure of one molecule on the surface can be derived equall th... components and, therefore, these possible velocities must also be taken in

$p = \frac{Nm\bar{u}^2}{V} + \frac{Nm\bar{v}^2}{V} + \frac{Nm\bar{w}^2}{V}$ ✓

$p = \frac{Nm}{V}(\bar{u}^2 + \bar{v}^2 + \bar{w}^2)$

$p = \frac{Nm}{3V} c_{rms}{}^2$ ✓

c) The internal energy is only due to the kinetic energy of the molecules of gas. ✓

d) The mass of carbon dioxide molecule = $\frac{0.044}{6.02 \times 10^{23}} = 7.3 \times 10^{-26}$ kg ✓
$E_k = ½mc_{rms}^2$ ✓
$E_k = ½ \times (7.3 \times 10^{-26}) \times 284^2 = 2.9 \times 10^{-21}$ J ✓

e) $E_k = ½mc_{rms}^2 = \frac{3}{2}kT$ ✓
$T = \frac{2E_K}{3k} = \frac{2 \times (2.9 \times 10^{-21})}{3 \times 1.38 \times 10^{-23}} = 140$ K ✓

Section 7: Fields and their consequences

3.7.2 Gravitational fields

1. A region in which a body will experience a non-contact force. ✓

2. The force produced around a mass that exerts a non-contact force on other mas
3. The work done per unit mass, by gravity to move an object from infinity to a point i

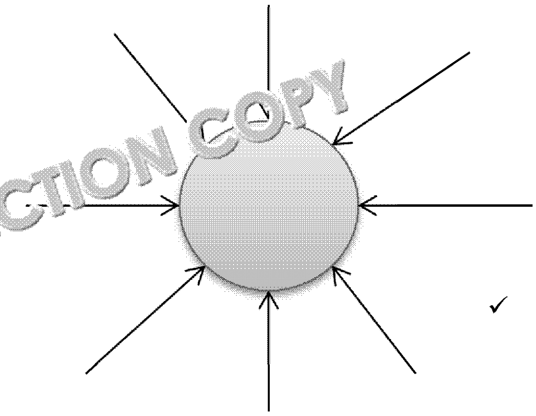
4. The gravitational potential is zero at infinity. ✓

5. Gravitational potential is the gravitational energy that a unit mass has a particular po negative whereas the gravitational potential difference is the difference between the between two points and can be negative or positive. ✓

6. Earth's mass is significantly greater than the mass of objects on Earth; therefore, Ear significantly greater and so is the force it exerts. The force exerted by other objects is

7. The direction and strength of the force felt by a mass in a gravitational field.

8. Radial field. ✓



9. For small distances, significantly less than the radius of Earth, the change in gravitati is negligible compared to distances far out into space and, therefore, the field can be

10. $g = \frac{F}{m}$ ✓
$g = \frac{2.94 \times 10^4}{3.4 \times 10^3} = 8.65$ N kg^{-1} ✓

11. a) $F = \frac{(6.67 \times 10^{-11}) \times (65) \times (3 \times 10^4)}{(4 \times 10^3)^2}$ ✓
$F = 8.13 \times 10^{-12}$ N ✓

b) Since $F = \frac{GMm}{r^2}$, if the distance was doubled then the force of attraction would be

12. a) $F = \frac{GMm}{r^2}$ and $F = mg$
$mg = \frac{GMm}{r^2}$
$g = \frac{GM}{r^2}$ ✓

b) $g = \frac{(6.67 \times 10^{-11}) \times (9.1 \times 10^{-31})}{(1.1 \times 10^{-15})^2}$
$g = 5.01 \times 10^{-11}$ Nkg^{-1} ✓

13. a) $\Delta W = \Delta V m$ ✓
$W = 4 \times 10^7 \times 1.2 \times 10^4 = 4.8 \times 10^{11}$ J ✓

b) A surface of constant potential. ✓

c) If V is constant, then $\Delta V = 0$ and therefore there will be zero work done. ✓

d) $r = r_E + r_{orbit}$
$v = \sqrt{\frac{(6.67 \times 10^{-11}) \times (5.98 \times 10^{24})}{(6.37 \times 10^6 + 4 \times 10^7)}} = 2.93 \times 10^3\ ms^{-1}$ ✓

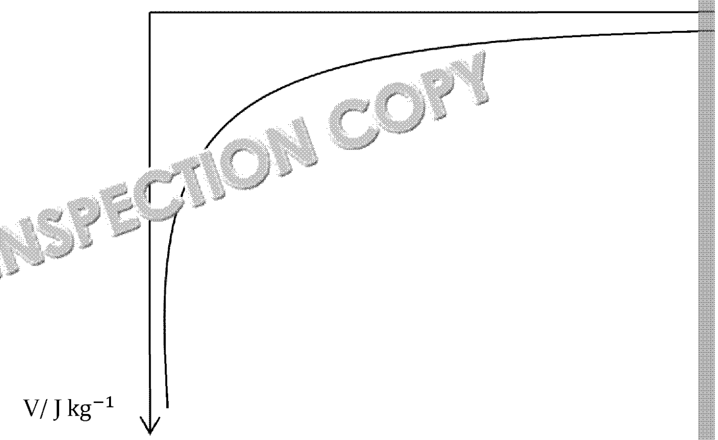
e) $T = \frac{d}{t} = \frac{2\pi r}{v}$ ✓
$T = \frac{2\pi(6.37 \times 10^6 + 4 \times 10^7)}{(2.93 \times 10^3)} = 9.94 \times 10^4$ s ✓

f) If the radius of the orbit doubled then since $T^2 \propto r^3$ the period would also incr

g) Orbit which moves round Earth at the same speed as Earth's rotation / stays ab point on Earth's surface. ✓

h) KE+PE is conserved, so KE is highest where PE is lowest and therefore KE will be is closest to Earth (r is the smallest $V = -\frac{GM}{r}$). ✓

14. a) (½) for correct label axes. (½) for correct curve shape.



b) Gravitational field strength (g) = gradient of the graph. ✓

c) $V = -\frac{GM}{r}$ ✓
$V = -\frac{(6.67 \times 10^{-11} \times 7.35 \times 10^{22})}{(1.74 \times 10^6)} = -2.82 \times 10^6$ J kg^{-1} ✓

d) $\Delta W = m\Delta V = \frac{GMm}{r}$ (work done to move an object from Mars' surface to infinit
To escape Mars the rocket's KE > ΔW ($\frac{1}{2}mv^2 > \frac{GMm}{r}$) ✓
Therefore the minimum velocity required will be:
$v_e = \sqrt{\frac{2GM}{r}} = \sqrt{\frac{2 \times (6.67 \times 10^{-11}) \times (6.39 \times 10^{23})}{(3.39 \times 10^6)}} = 5.01 \times 10^3$ m s^{-1} ✓

e) $g = -\frac{\Delta V}{\Delta r}$; therefore, ΔV = distance under g–r graph. ✓
$\Delta V = ½ \times 3.39 \times 10^6 \times 3.8 = 6.44 \times 10^6$ J kg^{-1} ✓

3.7.3 Electric fields

1. $F = \frac{1}{4\pi\epsilon_o}\frac{Q_1 Q_2}{r^2}$ ✓

2. Similarities (give full marks (1) for any one of the following):
   - Both obey an inverse square law ✓
   - Field strength is force per unit of the property that governs the force (mass and
   - Both 'contactless' forces ✓

   Differences (give full marks (1) for any one of the [illegible]:
   - Gravitational field affects all objects – [illegible] only affects charged objects
   - All masses attract each oth[illegible] charges can attract or repel ✓
   - It is possible to shie[illegible] from an electric field but not a gravitational fiel

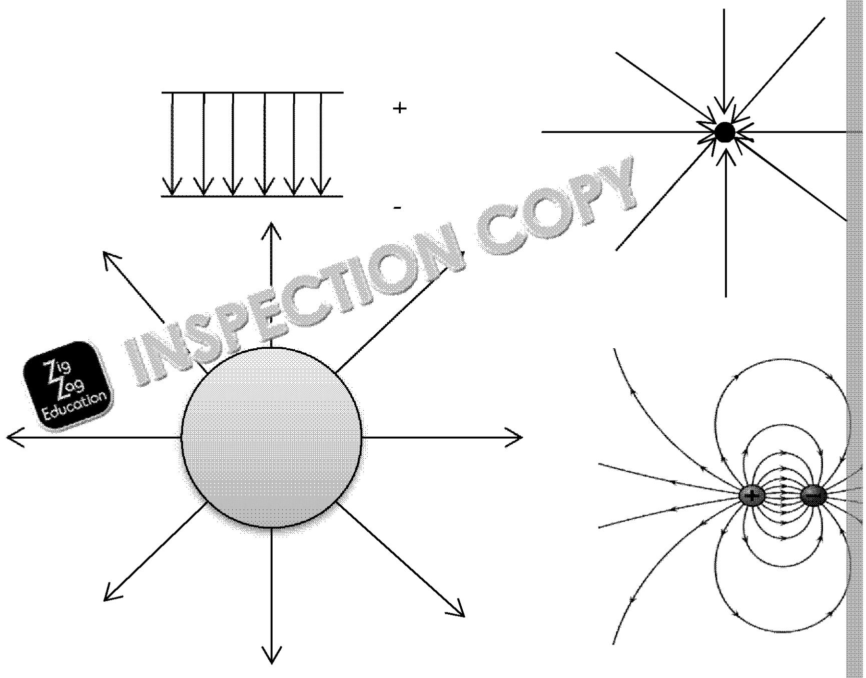
3. a) $F =$ [illegible] $\times (10^{-15})^2$ ✓ $= 230\ \text{N}$ ✓

   b) Th[illegible]ostatic force between protons is significantly greater than the gravita
   them and therefore in comparison the gravitational force is negligible ✓ OR in
   electrostatic force is the dominant force in the interaction of protons. ✓

4. The force exerted per unit positive charge at that point. ✓

5. Show direction and strength of force felt by a positive charge at that point. ✓

6. 1 mark for each correct diagram.



7. a) $E = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}$ ✓

   b) Permittivity of free space. ✓

   c) $E = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}$

   $E =$ [illegible] $= -8.5 \times 10^{-4}\ \text{NC}^{-1}$ ✓

   d) $V = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r}$; therefore can multiple your answer to c) by r.

   $V = 1.1 \times 10^{-6}\ \text{V}$ ✓

8. a) $E = \frac{F}{Q}$ ✓

$F = (3.1 \times 10^{10}) \times (1.6 \times 10^{-19}) = 4.96 \times 10^{-9}$ N ✓

b) $F = QE$

$W = F \times d = QEd$ ✓

$V = \frac{W}{Q}\ (by\ definition)$ ✓

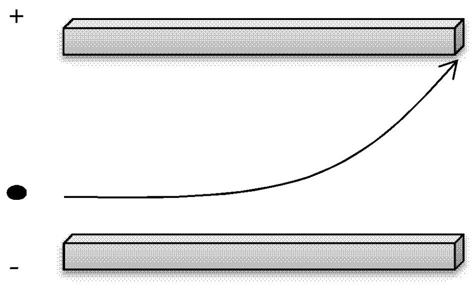
$V = \frac{QEd}{Q} = Ed$

$E = \frac{V}{d}$ ✓

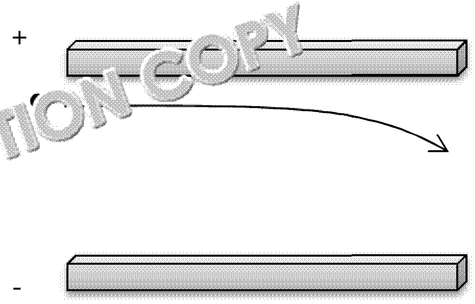
c) $\frac{F}{Q} = \frac{V}{d}$ ✓

$F = \frac{VQ}{d} = \frac{(15 - [illegible])([illegible] \times 10^{-19})}{([illegible] \times 10^{-3})} = 2 \times 10^{-15}$ N ✓

d)



e) The trajectory curve would have bent towards the negatively charged plate an
a larger mass. ✓
OR



9. a) Electric potential difference is the difference between the electric potential bet
and, unlike electric potential, can be negative or positive ✓.

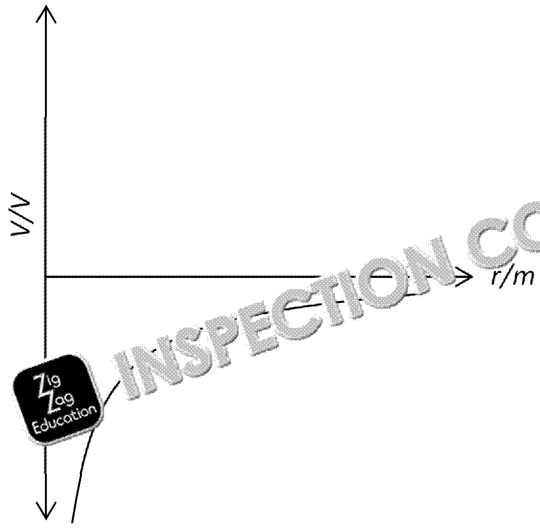
b) $\Delta V = V_2 - V_1$ ✓

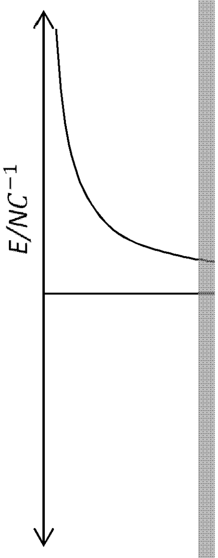
$\Delta V = \frac{1}{4\pi\varepsilon_o}\frac{(-1.6 \times 10^{-19})}{(10^{-9})} - \frac{1}{4\pi\varepsilon_o}\frac{(-1.6 \times 10^{-19})}{(10^{-13})} = -1.44 \times 10^{4}$ V ✓

c) $\Delta W = Q\Delta V$ ✓

$\Delta W = (-1.6 \times 10^{-19} \times 1.44 \times 10^{4}) = -2.3 \times 10^{-15}$

d) (1) for each correct graph.

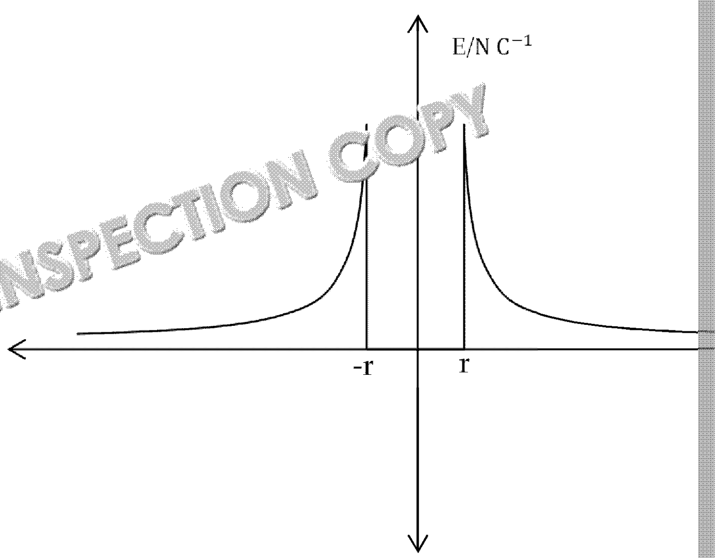




e) The gradient. ✓

10. a) Since V is constant inside the hollow sphere ($\Delta V = 0$) and E = $\frac{\Delta V}{\Delta r}$ then E = 0. ✓

b) (1) mark for correct graph. (Note the slope of the curve must be steeper than t



c) The electric potential is constant inside the hollow sphere and, therefore, satisf equipotential surface. ✓

d) Since V is constant ($\Delta V = 0$) then no work is done since $\Delta W = Q\Delta V$ ✓

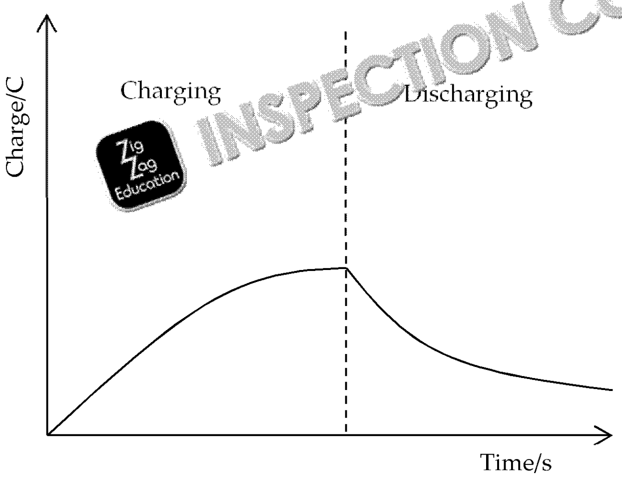
3.7.4 Capacitance

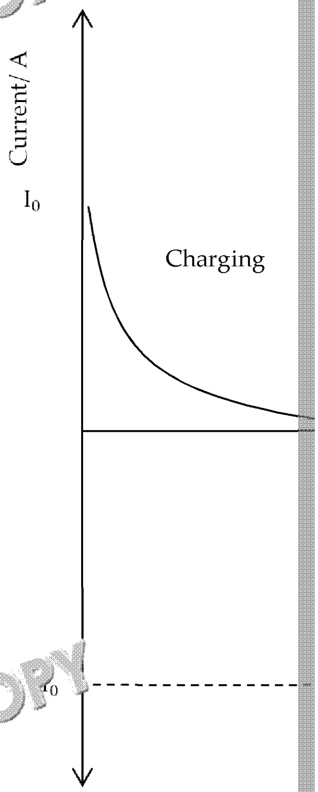
1. $C = \frac{Q}{V}$ ✓

   $C = \frac{6}{8} = 0.75$ F ✓

2. An insulating material that can be electrically polarised. ✓

3. 1 mark for each correct graph.





4. a) Co[illegible]g [illegible] with $y = mx + c$

   Gr[illegible]m) = C ✓

   $C = \frac{[illegible]}{5} = 1.2\ F$ ✓

   b) Energy stored = Area under the Q–V graph. ✓

   E = ½ base × height = ½QV. ✓

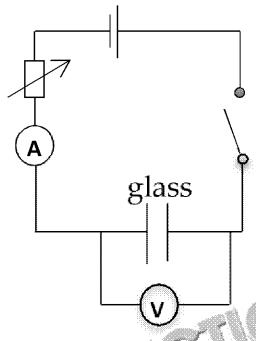
   c) E = ½QV = 0.5 × 4.8 × 4 ✓

   E = 9.6 J ✓

   d) E = ½$\frac{Q^2}{c}$ ✓

   E = 0.5 × $\frac{(11.5)^2}{50 \times 10^{-6}} = 1.3 \times 10^6$ J ✓

5. a)



b) Th... be an increase in charge (and, therefore, capacitance) stored on the p... sid... e dielectric attracting more electrons to the negatively charged plate a... dielectric repelling more electrons from the positively charged plate, leaving an... charges. ✓

c)
- The switch is used to charge and discharge the capacitor through the micr...
- The student can record the reading on the ammeter when the glass sheet... sheet is not present (I_0) ✓
- Since charge and current are directly proportional ($Q = It$) and the equati... permittivity is $\varepsilon_r = \frac{Q}{Q_0}$, then can determine relative permittivity by $\varepsilon_r = \frac{I}{I_0}$.

d) $\varepsilon_r = \frac{I}{I_0}$ ✓ $= \frac{9.4}{2} = 4.7$ ✓

e) $C = \frac{A\varepsilon_0\varepsilon_R}{d}$ ✓

$C = \frac{155 \times 10^{-4} \times 4.7 \times 8.85 \times 10^{-12}}{1.22 \times 10^{-3}} = 5.28 \times 10^{-10}$ ✓

f) If the thickness of the sheet was increased (therefore the distance between the... the capacitance would decrease. ✓
OR
An... demonstrated by numerical calculation. ✓

g)
- When the glass sheet is present the polar dielectric molecules orientate th... charged end of the material is facing the negative plate. ✓
- When the glass sheet is removed the polar molecules are not orientated w... electric field decreases, and so does the energy stored. ✓

6. a) $E = \frac{1}{2}CV^2; C = \frac{2E}{V^2}$ ✓

$C = \frac{2 \times 10.4}{64} = 0.325$ F ✓

b) Is the time for p.d./current to fall to 1/e of the initial p.d./current. ✓

c) Time constant: time for p.d. to fall to 1/e of initial p.d. ✓

$\frac{8}{e} = 2.94$ ✓

From graph: time constant = approx... s (10.5 s) ✓

d) Time constant ...

R $= \frac{\text{time constant}}{C} = \frac{10.5}{0.325} = 32.3\ \Omega$ ✓

e) $C = \frac{Q}{V}; Q = CV$ ✓

Q = 0.325 × 8 = 2.6 C ✓

f) $Q = Q_0 e^{-t/RC}$; $\frac{-t}{RC} = \ln(\frac{Q}{Q_0})$; $t = -RC \ln(\frac{Q}{Q_0})$ ✓
$t = -10.5 \ln(0.5)$ ✓
$t = 7.28$ s ✓

g) The equation for a charging capacitor:
$$Q = Q_0(1 - e^{-t/RC})$$
$$ln\left(\frac{Q}{Q_0}\right) = ln1 + \left(\frac{t}{RC}\right)$$
$$\frac{t}{RC} = ln\left(\frac{Q}{Q_0}\right) - ln1$$
Since ln1 = 0 we can say that
$$t = RC\left(ln\left(\frac{Q}{Q_0}\right)\right)$$

3.7.5 Magnetic fields

1. • A force acts on the wire, perpendicular to both current and magnetic field direc
   • The force is zero. ✓

2. A: Upwards direction ✓
   B: Downwards direction ✓
   C: No movement ✓

3. A tesla (magnetic flux density unit) is a Newton per amp metre. ✓

4. a) • Magnet is placed on a top pan balance, and when current flows through a a force is exerted on the magnet. ✓
   • Students can take a reading from the top pan balance when current is flow the force exerted on the ... ✓

   b) $F = BIL$ ✓

   c) L

   $L = \frac{0.2}{2.4 \times 10^{-3} \times 5.4} = 15.4$ m ✓

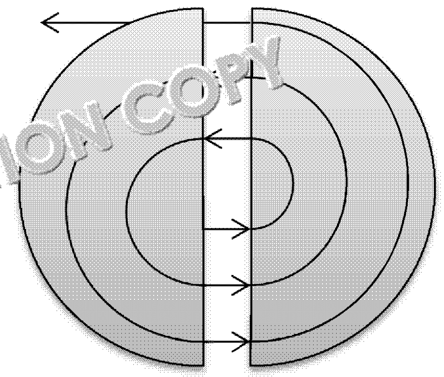
   d) The force would also increase. ✓

5. a) Into the page. ✓

   b) Proton holds a positive charge therefore the force direction would alter to be o

6. a) Out of the page. ✓

   b)



✓

c) A force is exerted on the electron by the magnetic field, which is directed inwards t hand rule and, therefore, acts as a centripetal force constantly pulling the electron i Since a centripetal force is present the electron accelerates during each turn increas but travels in a straight line with constant speed in between the semicircular plates

d) $F = BQv$ ✓
$F = 6.2 \times 10^{-5} \times 1.6 \times 10^{-19} \times 8.7 \times 10^{6} = 8.6 \times 10^{-17}$ N ✓

e) $\frac{mv^2}{r} = BQv$ ✓
$r = \frac{mv^2}{BQv}$
$r = \frac{\ldots 10^{-}\ldots \times 10^{6})^2}{8.6 \times 10^{-17}} = 0.8$ m ✓

7. Area A = 70 m × 120 ms^{-1} × 60 s = 504 000 m^2 ✓
Φ = BA = 8.5 × 10^{-6} × 504 000 ✓
Φ = 4.28 T m^2 ✓

8. a)
- Place search coil in a uniform magnetic field, facing perpendicular to magr the oscilloscope ✓
- Take an initial reading and then rotate the search coil through 360°, takin set angle increments and plot a graph of the magnetic flux linkage against dependency. ✓

b) $N\emptyset = BANcos\theta$ ✓
$N\emptyset = 3.4 \times 10^{-3} \times \pi \times (1.7 \times 10^{-2})^2 \times cos32 \times 147 = 3.85 \times 10^{-4}$ Wb ✓

c) $N\emptyset = BANcos\theta$; maximum occurs when θ = 0 ✓
$N\emptyset = 3.4 \times 10^{-3} \times \pi \times (1.7 \ldots 147 = 4.54 \times 10^{-4}$ Wb. ✓

3.7.5.4 Electromagnetic induction

1. The emf induced is equal to the rate of change of magnetic flux linkage ✓

2. $\varepsilon = \frac{N\Delta\emptyset}{\Delta t}$ ✓

3. An induced emf gives rise to a current whose magnetic field opposes the original cha

4. $\varepsilon = \frac{N\Delta\emptyset}{\Delta t}$ ✓
$\varepsilon = \frac{470 \times (2.45 \times 10^{-3})}{0.7} = 1.65$ V ✓

5. a) $\varepsilon = BAN\omega sin\omega t$ ✓
$\varepsilon = (31 \times 10^{-3} \times 0.09 \times 125290 \times 3.4sin3.4 \times 1.2) =$ -958.7 V ✓

b) If the number of turns increased then the induced emf would increase proporti

3.7.5.5 Alternating current

6. A current which ... changes its direction. ✓

7. a) Co... signal generator to an oscilloscope to display a waveform of the alternati

b) Increase the number of volts per division on the oscilloscope, so a larger amplit

8. a) $f = \frac{1}{T} = \frac{1}{0.75} = 1.33$ Hz. ✓

b) $I_0 = 5.2$ A ✓
$I_{rms} = \frac{5.2}{\sqrt{2}} = 2.7$ A ✓

9. a) The value of direct current that would give the same heating effect as the alter

b) $P_{max} = {I_0}^2 R$ ✓
$I_0 = \sqrt{\frac{P_{max}}{R}} = \sqrt{\frac{100}{3.4}} = 5.42$

c) I_{r} ... I_0
$I_{rms} = \frac{1}{\sqrt{2}} \times 5.42 = 3.83$ A ✓

d) Mean power = half of maximum power; therefore, mean power = 50 W ✓

e) $P_{mean} = I_{rms} V_{rms}$
$V_{rms} = \frac{50}{3.83} = 13.1$ V ✓

3.7.5.6 The operation of a transformer

10. a) By increasing the voltage the engineers will increase the efficiency in the transm
If voltage is increased, the amount of current needed to deliver the required po
from the heating effect of current in the cables is reduced. ✓

b) $\frac{V_P}{V_S} = \frac{N_P}{N_S}$ ✓
$N_S = \frac{V_S}{V_P} \times N_P = \frac{39\ 000}{22\ 000} \times 2625 = 465$ ... turns

c) If V_S was greater th... would need to be greater. ✓

d) $I_s = \frac{P_s(deliv...)}{V_S}$
$I_S = \frac{...0^6}{...\times 10^3} = 30.8$ A ✓

e) $P = I^2 R$ ✓
$P = (30.8)^2 \times 625 = 5.93 \times 10^5$ W ✓

f) $efficiency\ of\ a\ transformer = \frac{I_S V_S}{I_P V_P} \times 100\ \% = \frac{P_S}{P_P} \times 100\ \%$ ✓
$P_p(supplied) = P_s(delivered) + P_{lost} = 1.2 \times 10^6 + 5.93 \times 10^5 = 1.79 \times 1$
$efficiency\ of\ a\ transformer = \frac{P_S}{P_P} \times 100\ \% = \frac{1.2 \times 10^6}{1.79 \times 10^6} \times 100\ \% = 67\ \%$

g) Eddy currents induced in the core: reduced by laminating the core using thin la
restricts eddy currents. ✓

h) Full marks (2) for identification of any two of the following:
- Heating of coils by current ✓
- Magnetic losses in the core ✓
- Energy needed for magnetisation/demagnetisation of the core ✓

i) Give ... mark for any one of the following answers:
- ...ing of coils by current: reduced by using thicker or lower resistivity of ... therefore current.
- Magnetic losses in the core: reduced by improving core design to bring the together.
- Energy needed for magnetisation/demagnetisation of the core: reduced b material so the core is magnetised/demagnetised more quickly.

Section 8: Nuclear physics

3.8.1 (1–3): Radioactivity A

1. a) Alpha particles fired at (gold) foil ✓
   Detector to find out where they went after hitting foil ✓

   b) Mostly straight through ✓ Meant atoms were mostly empty space ✓
   A few bounced (almost) straight back ✓ so there is a small, dense and positively

2. a) Alpha beta gamma [in any order]

   b) Beta ✓
   Alpha can't penetrate [illegible] and gamma can penetrate aluminium ✓

3. 0.12 × 0.1[illegible] I × [illegible]
   I = 0.01[illegible] m⁻²

4. Increase distance (from source) – radiation more spread out
   Reduce time (of exposure) – less radiation emitted
   Wear protective clothing – shielded from some radiation
   [*1 mark* for any two ways, *1 mark* for two correct explanations]

5. a) Radiation that is always present / not from the sample / from substances in the

   b) [Any two for *1 mark* each]
   Medical uses, cosmic rays, fallout, food, gases in the air, rocks, building materia

6. a) 60 38 24 15 9

   b) Smooth curve of best fit ✓ Points correct ✓

   c) 3 (s)

7. a) **Any three from:**
   Living things maintain a constant ratio of C_{14}:C_{12} (through respiration) ✓
   When they die the amount of [illegible] starts to fall ✓
   The ratio (of C_{14}:C_{12}) in the sample is measured ✓
   The (known) half-life is used to calculate how long it took to fall to that ratio ✓

   b) $\frac{dI}{dt}$ [illegible]
   $N = -\frac{1}{\lambda}\frac{dN}{dt} = -\frac{1}{4.71\times10^{-11}} \times \frac{-150}{3}$
   $N = 1.06 \times 10^{12}$ ✓

8. a) Impossible to predict when a particular nucleus will decay

   b) Probability a particular nucleus will decay in the next second

   c) $A = \lambda N = 2.34 \times 10^{24} \times 0.0214$ ✓ $= 5.0 \times 10^{22}$ ✓ Bq

   d) $N = N_0 e^{-\lambda t} = 2.34 \times 10^{24} \times e^{-0.0214 \times 60}$ ✓ $= 6.5 \times 10^{23}$ ✓

   e) $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda} = {ln2}/{0.0214}$ ✓ = 32 ✓s

9. a) λ = 0.2 / thousand years OR 0.0002 /yr OR 6[illegible] × 10[illegible] s ✓
   $T_{1/2} = \frac{\ln 2}{\lambda}$
   $T_{½}$ = 3500 ✓ years

   b) Maintains high radioactivity for long time

10. a) $N = \frac{m}{m_{mol}} = \frac{0.788 \times 10^{-3} \times 6.02 \times 10^{23}}{0.0989}$ ✓ $= 4.80 \times 10^{21}$ ✓

    b) $2.00 \times 10^{-3} \times 6.02 \times 10^{23}$ ✓ $= 1.20 \times 10^{21}$ ✓
    i.e. 2 half-lives ✓ = 12.0 ✓ hrs

11. Measure count rate on other side of paper to source ✓
Compare to calibration curve ✓

12. **Any three of the following:**
Measure count rate at different ranges ✓
Safety measure (e.g. minimise exposure time or minimise proximity) ✓
Plot count rate vs 1/distance^2 ✓ Should be a straight line ✓

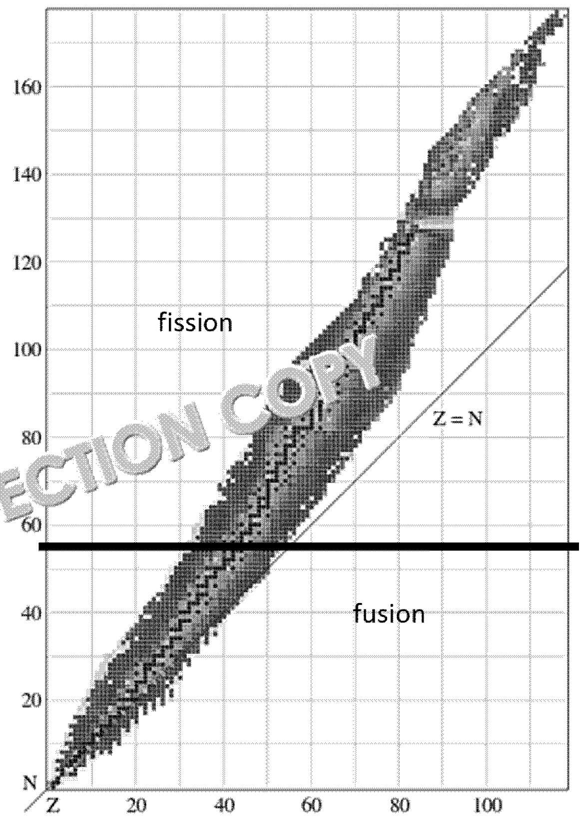
13. **Risks**: Causes cancer ✓ Damages healthy cells ✓
Benefits: Diagnosis ✓ Treatment (without surgery) ✓

3.8.1 (4–5): Radioactivity 3

1. a) Beta [illegible] ✓
To[illegible] protons / Not enough neutrons ✓

b) N = 90 ✓
Beta minus ✓

c)



2. a) ${}^{12}_{6}C \rightarrow {}^{12}_{7}N + {}^{0}_{-1}\beta + \bar{\nu_e}$
[*1 mark* for beta, *1 mark* for neutrino]

b) ${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$
[*1 mark* for each number on Th]

c) ${}^{26}_{13}Al + {}^{0}_{-1}e \rightarrow {}^{26}_{12}Mg + \nu_e$
[*1 mark* for e regardless of sign, *1 mark* for showing sign i.e. ${}^{0}_{-1}e$ or e$^-$, *1 mark* for r

3. a) Nucle[illegible] losing energy ✓ following an α or β ✓decay

b) An[illegible] from:
Emits alpha particle ✓ with three possible energies ✓
One of them then emits a gamma ✓ with two possible energies ✓

c) After emitting a particle it is left in a high-energy state ✓ but doesn't rearrange imme

d) Medical tracer ✓ inject into bloodstream and see where it goes ✓

4. Alpha can't penetrate skin but most damaging if inside body ✓
Gamma most penetrating but each particle least likely to cause damage ✓
(Beta in the middle)

5. a) 10^{-15} m

b) Number of nucle...

c) (L... he ...fraction ✓ and measure angle of interference fringe(s) ✓

d) **Graph:**
R^3 vs A OR R vs $A^{1/3}$ plotted ✓
Points correct ✓
Straight line of best fit including through origin ✓
Constant:
1.3×10^{-15} ✓ m

e) Same for all nuclei / constant

f) $64^{1/3} \times 1.3 \times 10^{-15}$ ✓ = 5.2×10^{-15} ✓m

6. m = 127u = $127 \times 1.66 \times 10^{-27} = 2.108 \times 10^{-25}$ ✓ kg
$V = \frac{4}{3}\pi(6.3 \times 10^{-15})^3$ = 1.047×10^{-42} ✓ m^3
$\rho = \frac{m}{V}$ = 2.01×10^{17} ✓ kg m^{-3} ✓

7. a) v = 15 000 000 ms^{-1} ✓
m = $4 \times 1.67 \times 10^{-27}$ ... 6.7×10^{-27} kg
KE = ½ × 6.7 ... 15 000 000^2
= ...

b) $KE_{st...}$ = $EPE_{closest}$ ✓
$7.5 \times 10^{-13} = \frac{2e \times 79e}{4\pi\varepsilon_0 R}$ ✓
R = 4.8×10^{-14} ✓ m

8. First minimum would be at a smaller angle

3.8.1 (6–8): Nuclear energy

1. a) $E = \Delta mc^2 = 1.65 \times 10^{-27} \times (3.00 \times 10^8)^2 = 1.5 \times 10^{-10}$ (J)

   b) 200 × 931.5 MeV ✓ = 1.9×10^5 ✓ MeV

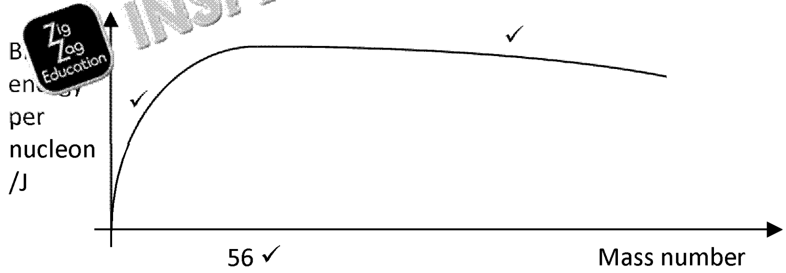
   c) False – all energy changes involve a change in mass, but this is not noticeable o

2. a) Δm = (235.04392 + 1.00860 – 90.92345 – 141.91645 – 3 × 1.00866)u ✓ = 0.186

   b) $E = \Delta mc^2$ = 0.18664 × 1.66 × 10^{-27} × (3 × 10⁸)² = 2.79 × 10^{-11} ✓ J

   c) Δm = (1.00794 + 2.01410 – 3.01 …)u ✓ = 0.00601u ✓ = 9.98 × 10^{-30} kg ✓
   $E = \Delta mc^2$ = 9.98 × … × (3.00 × 10^8)² = 8.98 × 10^{-13} J ✓

3. a)



   b) Products have more binding energy per nucleon

4. a) i) Chain reaction: one (fission) event causes another ✓
   ii) Critical mass: density above which spontaneous fission leads to a chain re

   b) Bombard ✓ with neutrons ✓ (while at critical mass)

5. a) i) Moderator: graphite/carbon / water ✓ ½
   ii) Control rod: boron ✓ ½
   iii) Coolant: carbon dioxide / water ✓ ½
   iv) Fuel: U-235 ✓ ½

   b) Slows down neutrons … increase chance of causing fission ✓

   c) Ab… neutrons … to prevent causing fission ✓

   d) Tak… heat away from the moderator

6. a) To protect from outside damage ✓ to stop radiation entering the environment

   b) Control rods held by electromagnets ✓ drop in if power cut ✓

   c) Spent fuel rods ✓
   Other reactor components ✓
   Things used to handle fuel rods ✓

   d) Spent fuel ✓
   Materials exposed to (neutron) radiation ✓

   e) Remote handling (e.g. robotic arms) ✓
   Allowed to 'cool off' in water tank ✓

   f) Reprocessed ✓ stored ✓

7. **In favour of:** No CO_2 emission / no SO_2 emission / efficient / other sensible answer ✓
   Against: (Perceived) risk … hazardous waste / other sensible answer ✓

8. **Any two from:**
   - Con… rods held by electromagnets ✓ so fall into reactor in event of power cut
   - Turbines can be reversed ✓ so can pump coolant into reactor if pumps fail ✓
   - Reactor encased in concrete shell / thick steel ✓ to protect from attack / natural
   - Remote handling devices used ✓ so operators not exposed to high levels of radi
   - Other sensible precaution ✓ Explanation of that precaution ✓