SPECIMEN MATERIAL

A-level
PHYSICS
(7408/2)

Paper 2

Specimen 2014 | Morning | Time allowed: 2 hours

Materials
For this paper you must have:
- a pencil
- a ruler
- a calculator
- a data and formulae booklet.

Instructions
- Answer **all** questions.
- Show all your working.

Information
- The maximum mark for this paper is 85.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname

Forename(s)

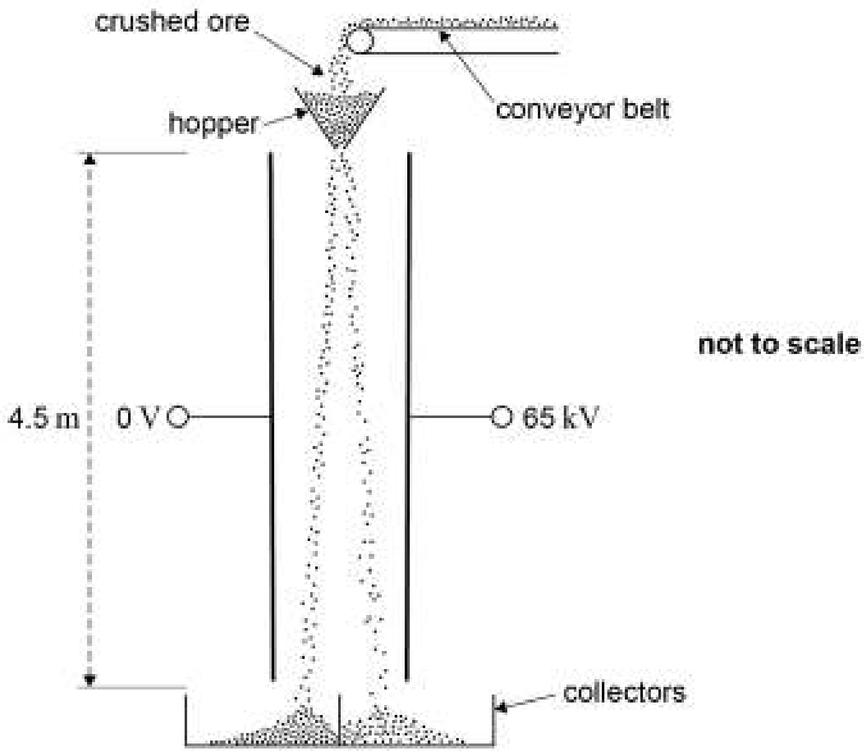
Candidate signature ________________________

Section A

Answer **all** questions in this section.

0 1 **Figure 1** shows a system that separates two minerals from the ore containing them using an electric field.

Figure 1



The crushed particles of the two different minerals gain opposite charges due to friction as they travel along the conveyor belt and through the hopper. When they leave the hopper they fall 4.5 metres between two parallel plates that are separated by 0.35 m.

0 1 . 1 Assume that a particle has zero velocity when it leaves the hopper and enters the region between the plates.

Calculate the time taken for this particle to fall between the plates.

[2 marks]

time taken = ____________ s

0 1 . 2 A potential difference (pd) of 65 kV is applied between the plates.

Show that when a particle of specific charge $1.2 \times 10^{-6}\ \mathrm{C\ kg^{-1}}$ is between the plates its horizontal acceleration is about $0.2\ \mathrm{m\ s^{-2}}$.

[3 marks]

0 1 . 3 Calculate the total horizontal deflection of the particle that occurs when falling between the plates.

[1 mark]

horizontal deflection = ______________ m

0 1 . 4 Explain why the time to fall vertically between the plates is independent of the mass of a particle.

[2 marks]

0 1 . 5 State and explain **two** reasons, why the horizontal acceleration of a particle is different for each particle.

[4 marks]

Turn to page 6 for the next question

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

0 2 **Figure 2** shows a capacitor of capacitance 370 pF. It consists of two parallel metal plates of area 250 cm^2. A sheet of polythene that has a relative permittivity 2.3 completely fills the gap between the plates.

Figure 2

not to scale

0 2 . 1 Calculate the thickness of the polythene sheet.

[2 marks]

thickness = ______________ m

0 2 . 2 The capacitor is charged so that there is a potential difference of 35 V between the plates. The charge on the capacitor is then 13 nC and the energy stored is 0.23 μJ.

The supply is now disconnected and the polythene sheet is pulled out from between the plates without discharging or altering the separation of the plates.

Show that the potential difference between the plates increases to about 80 V.

[2 marks]

0 2 . 3 Calculate the energy that is now stored by the capacitor.

[2 marks]

energy stored = ____________ μJ

0 2 . 4 Explain why there is an increase in the energy stored by the capacitor when the polythene sheet is pulled out from between the plates.

[2 marks]

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Turn over for the next question

0 3 . 1 State **two** assumptions made about the **motion** of the molecules in a gas in the derivation of the kinetic theory of gases equation.

[2 marks]

0 3 . 2 Use the kinetic theory of gases to explain why the pressure inside a football increases when the temperature of the air inside it rises. Assume that the volume of the ball remains constant.

[3 marks]

0 3 . 3 The ‘laws of football’ require the ball to have a circumference between 680 mm and 700 mm. The pressure of the air in the ball is required to be between 0.60×10^5 Pa and 1.10×10^5 Pa above atmospheric pressure.

A ball is inflated when the atmospheric pressure is 1.00×10^5 Pa and the temperature is 17 °C. When inflated the mass of air inside the ball is 11.4 g and the circumference of the ball is 690 mm.

Assume that air behaves as an ideal gas and that the thickness of the material used for the ball is negligible.

Deduce if the inflated ball satisfies the law of football about the pressure.

molar mass of air = 29 g mol^{-1}

[6 marks]

Turn over for the next question

0 4 An ancient sealed flask contains a liquid, assumed to be water. An archaeologist asks a scientist to determine the volume of liquid in the flask without opening the flask. The scientist decides to use a radioactive isotope of sodium ($^{24}_{11}\mathrm{Na}$) that decays with a half-life of 14.8 h.

0 4 . 1 She first mixes a compound that contains 3.0×10^{-10} g of sodium-24 with 1500 cm^3 of water. She then injects 15 cm^3 of the solution into the flask through the seal.
Show that initially about 7.5×10^{10} atoms of sodium-24 are injected into the flask.

[1 mark]

0 4 . 2 Show that the initial activity of the solution that is injected into the flask is about 1×10^{6} Bq.

[3 marks]

activity = ______________ Bq

0 4 . 3 She waits for 3.5 h to allow the injected solution to mix thoroughly with the liquid in the flask. She then extracts 15 cm^3 of the liquid from the flask and measures its activity which is found to be 3600 Bq.

Calculate the total activity of the sodium-24 in the flask after 3.5 h and hence determine the volume of liquid in the flask.

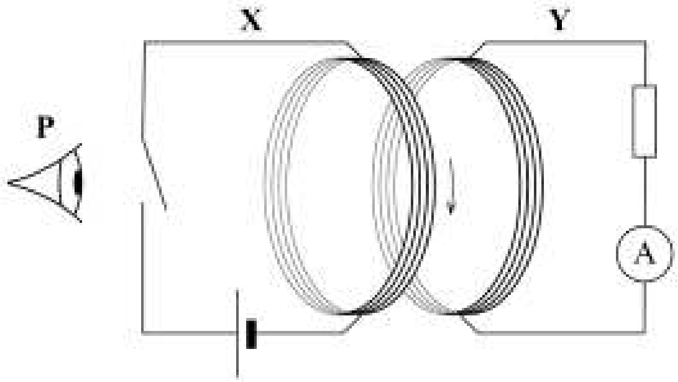
[3 marks]

0 4 . 4 The archaeologist obtained an estimate of the volume knowing that similar empty flasks have an average mass of 1.5 kg and that mass of the flask and liquid was 5.2 kg. Compare the estimate that the archaeologist could obtain from these masses with the volume calculated in part 4.3 and account for any difference.

[2 marks]

0 5 **Figure 3** shows an arrangement for investigating electromagnetic induction.

Figure 3



When the switch is closed there is a current in the coil in circuit **X**. The current is in a clockwise direction as viewed from position **P**.

Circuit **Y** is viewed from position **P**.

0 5 . 1 Explain how Lenz's law predicts the direction of the induced current when the switch is opened and again when it is closed.

[4 marks]

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An 'Earth inductor' consists of a 500 turn coil. **Figure 4** and **Figure 5** shows it set up to measure the horizontal component of the Earth's magnetic field. When the coil is rotated an induced emf is produced.

Figure 4

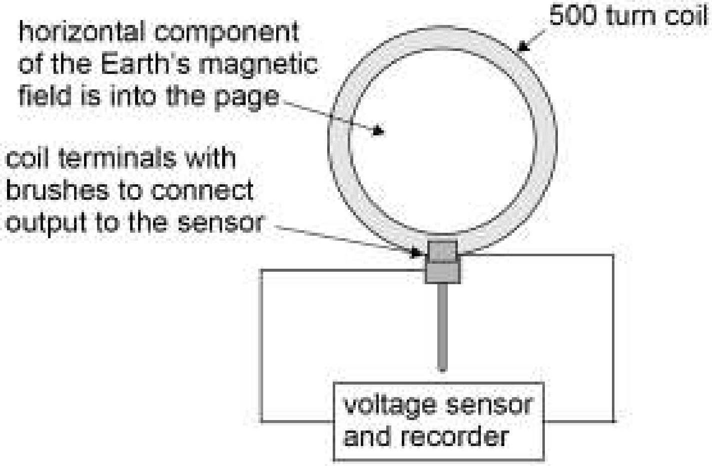
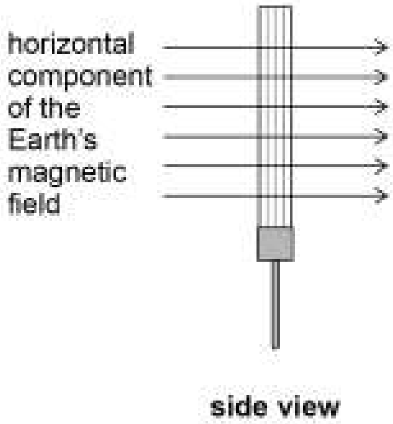
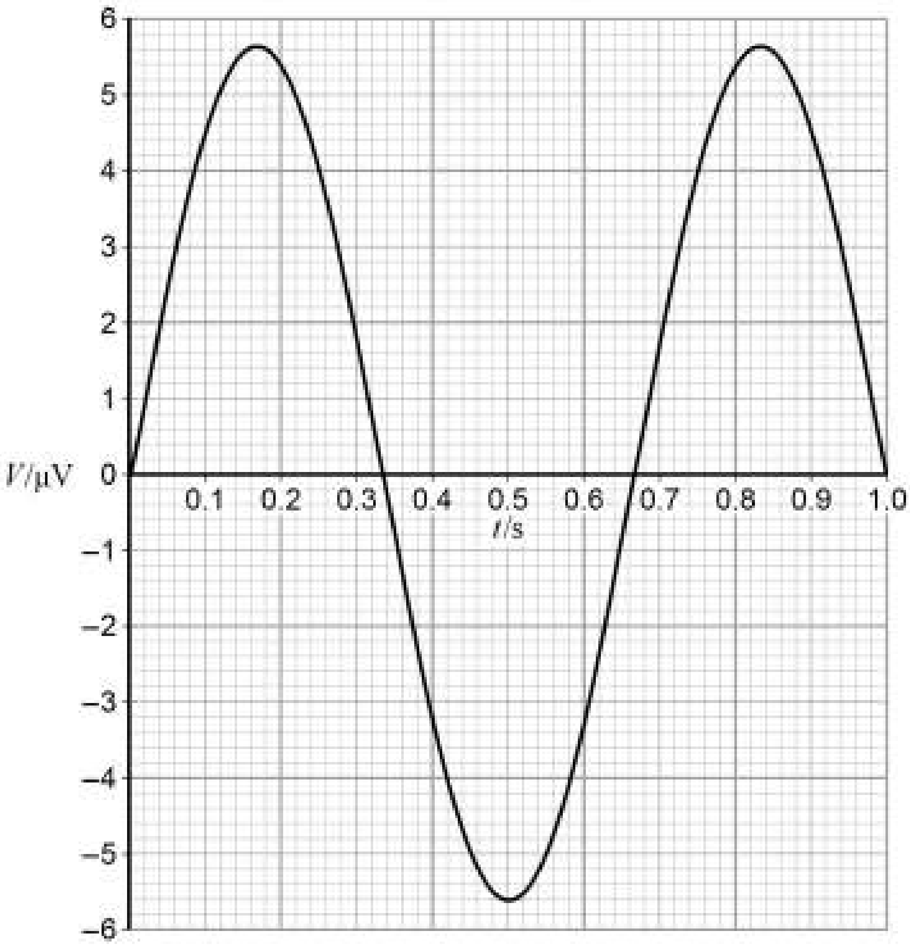


Figure 5



The mean diameter of the turns on the coil is 35 cm. **Figure 6** shows the output recorded for the variation of potential difference V with time t when the coil is rotated at 1.5 revolutions per second.

Figure 6



0 5 . 2 Determine the flux density, B_{H}, of the horizontal component of the Earth's magnetic field.

[3 marks]

horizontal component of flux density = ______________ T

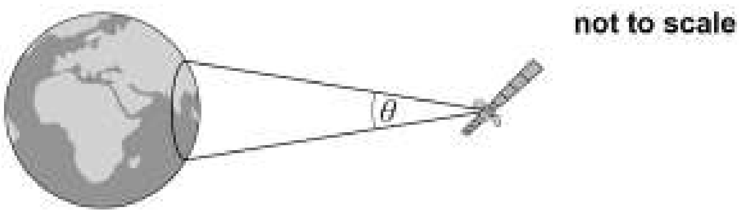
0 6 **Read the following passage and answer the questions that follow**

Satellites used for telecommunications are usually in geostationary orbits. Using suitable dishes to transmit the signals, communication over most of the Earth's surface is possible at all times using only 3 satellites.

Satellites used for meteorological observations and observations of the Earth's surface are usually in low Earth orbits. Polar orbits, in which the satellite passes over the North and South Poles of the Earth, are often used.

One such satellite orbits at a height of about 12 000 km above the Earth's surface circling the Earth at an angular speed of $2.5 \times 10^{-4}\ \mathrm{rad\ s^{-1}}$. The microwave signals from the satellite are transmitted using a dish and can only be received within a limited area, as shown in **Figure 7.**

Figure 7



The signal of wavelength λ is transmitted in a cone of angular width θ, in radian, given by

$$\theta = \frac{\lambda}{d}$$

where d is the diameter of the dish.

The satellite transmits a signal at a frequency of 1100 MHz using a 1.7 m diameter dish. As this satellite orbits the Earth, the area over which a signal can be received moves. There is a maximum time for which a signal can be picked up by a receiving station on Earth.

0 6 . 1 Describe **two** essential features of the orbit needed for the satellite to appear geostationary.

[2 marks]

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0 6 . 2 Calculate the time taken, in s, for the satellite mentioned in line 7 in the passage to complete one orbit around the Earth.

[1 mark]

time taken = ______________ s

0 6 . 3 Show that at a distance of 12 000 km from the satellite the beam has a width of 1900 km.

[3 marks]

0 6 . 4 The satellite is in a polar orbit and passes directly over a stationary receiver at the South Pole.

Show that the receiver can remain in contact with the satellite for no more than about 20 minutes each orbit.

radius of the Earth = 6400 km

[3 marks]

maximum time = ______________________________ minute

0 6 . 5 The same satellite is moved into a higher orbit.

Discuss, with reasons, how this affects the signal strength and contact time for the receiver at the South Pole.

[4 marks]

END OF SECTION A

Section B

Each of Questions **7** to **31** is followed by four responses, **A**, **B**, **C**, and **D**. For each question select the best response.

Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

0 7 Which of the following gives a correct unit for $\left(\frac{g^2}{G}\right)$?

[1 mark]

A N

B $\mathrm{N\,kg^{-1}}$

C N m

D $\mathrm{N\,m^{-2}}$

0 8 A planet has a radius half the Earth's radius and a mass a quarter of the Earth's mass. What is the approximate gravitational field strength on the surface of the planet?

[1 mark]

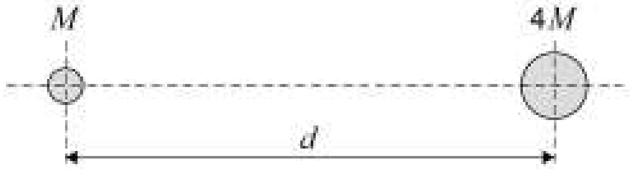
A $1.6\ \mathrm{N\,kg^{-1}}$

B $5.0\ \mathrm{N\,kg^{-1}}$

C $10\ \mathrm{N\,kg^{-1}}$

D $20\ \mathrm{N\,kg^{-1}}$

0 9 Two stars of mass M and $4M$ are at a distance d between their centres.



The resultant gravitational field strength is zero along the line between their centres at a distance y from the centre of the star of mass M.

What is the value of the ratio $\frac{y}{d}$?

[1 mark]

A $\frac{1}{2}$ ⬭

B $\frac{1}{3}$ ⬭

C $\frac{2}{3}$ ⬭

D $\frac{3}{4}$ ⬭

1 0 Which of the following statements about Newton's law of gravitation is correct?

Newton's gravitational law explains

[1 mark]

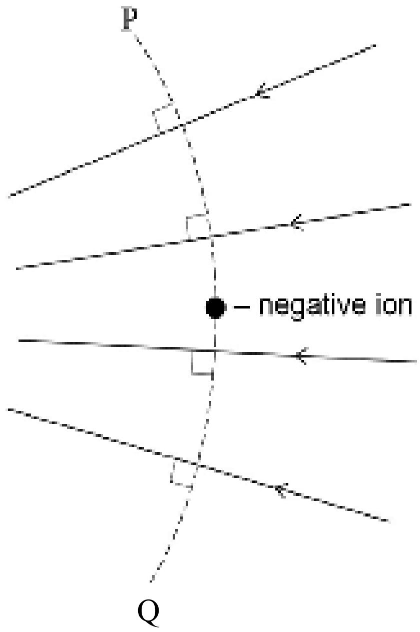
A the origin of gravitational forces. ⬭

B why a falling satellite burns up when it enters the Earth's atmosphere. ⬭

C why projectiles maintain a uniform horizontal speed. ⬭

D how various factors affect the gravitational force between two particles. ⬭

1 1 The diagram shows a small negative charge at a point in an electric field, which is represented by the arrowed field lines.



Which of the following statements, about what happens when the charge is displaced, is correct?

[1 mark]

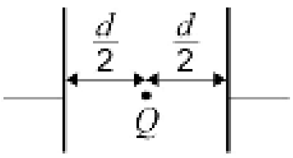
When the negative charge is displaced

A	to the left the magnitude of the electric force on it decreases.	⬭
B	to the right its potential energy increases.	⬭
C	along the line PQ towards Q its potential energy decreases.	⬭
D	along the line PQ towards P the magnitude of the electric force on it is unchanged.	⬭

Turn over for the next question

1 2 Two parallel metal plates are separated by a distance d and have a potential difference V across them. Which expression gives the magnitude of the electrostatic force acting on a charge Q placed midway between the plates?

[1 mark]



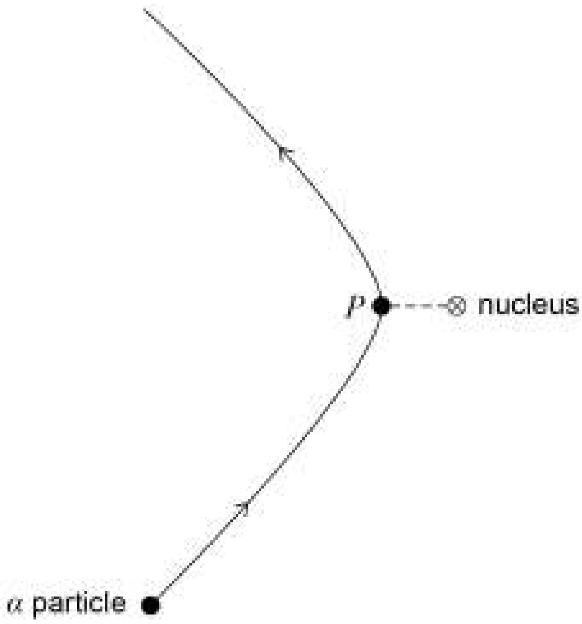
A $\frac{2VQ}{d}$

B $\frac{VQ}{d}$

C $\frac{VQ}{2d}$

D $\frac{Qd}{V}$

1 3 The diagram shows the path of an α particle deflected by the nucleus of an atom. Point P on the path is the point of closest approach of the α particle to the nucleus.



Which of the following statements about the α particle on this path is correct?

[1 mark]

A Its acceleration is zero at P.

B Its kinetic energy is greatest at P.

C Its potential energy is least at P.

D Its speed is least at P.

1 4 The electric potential at a distance r from a positive point charge is 45 V. The potential increases to 50 V when the distance from the point charge decreases by 1.5 m. What is the value of r?

[1 mark]

A 1.3 m ☐
B 1.5 m ☐
C 7.9 m ☐
D 15 m ☐

1 5 The diagram shows two particles at distance d apart. One particle has charge $+Q$ and the other $-2Q$. The two particles exert an electrostatic force of attraction, F, on each other. Each particle is then given an additional charge $+Q$ and their separation is increased to distance $2d$.

Which of the following gives the force that now acts between the two particles?

[1 mark]

A an attractive force of $\frac{F}{4}$ ☐

B a repulsive force of $\frac{F}{4}$ ☐

C an attractive force of $\frac{F}{2}$ ☐

D a repulsive force of $\frac{F}{2}$ ☐

1 6 Which of the following statements about a parallel plate capacitor is **incorrect**?

[1 mark]

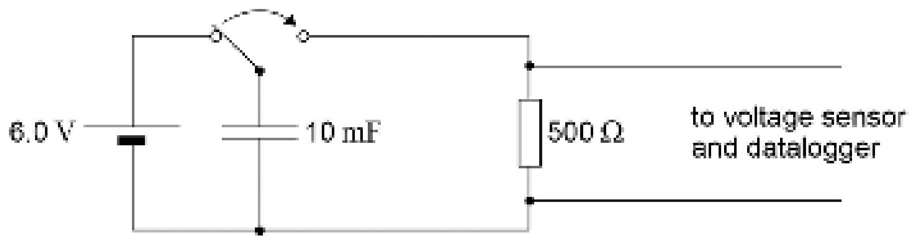
A The capacitance of the capacitor is the amount of charge stored by the capacitor when the pd across the plates is 1 V. ☐

B A uniform electric field exists between the plates of the capacitor. ☐

C The charge stored on the capacitor is inversely proportional to the pd across the plates. ☐

D The energy stored when the capacitor is fully charged is proportional to the square of the pd across the plates. ☐

1 7 A voltage sensor and a datalogger are used to record the discharge of a 10 mF capacitor in series with a 500 Ω resistor from an initial pd of 6.0 V. The datalogger is capable of recording 1000 readings in 10 s.

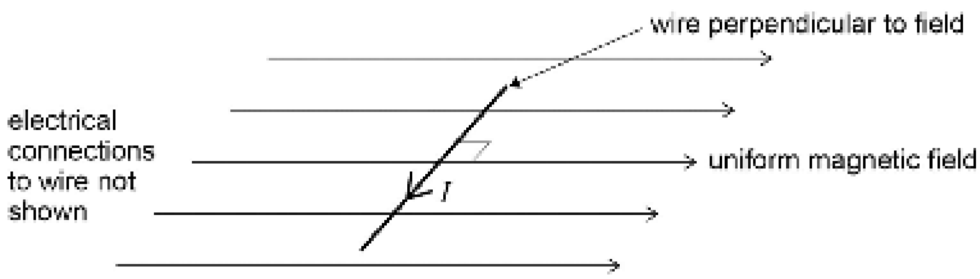


After a time equal to the time constant of the discharge circuit, which one of the rows gives the pd and the number of readings made?

[1 mark]

	Potential difference / V	Number of readings	
A	2.2	50	⬭
B	3.8	50	⬭
C	3.8	500	⬭
D	2.2	500	⬭

1 8 A horizontal straight wire of length 0.30 m carries a current of 2.0 A perpendicular to a horizontal uniform magnetic field of flux density 5.0×10^{-2} T. The wire 'floats' in equilibrium in the field.



What is the mass of the wire?

[1 mark]

A 8.0×10^{-4} kg ⬭
B 3.1×10^{-3} kg ⬭
C 3.0×10^{-2} kg ⬭
D 8.2×10^{-1} kg ⬭

1 9 Charged particles, each of mass m and charge Q, travel at a constant speed in a circle of radius r in a uniform magnetic field of flux density B.
Which expression gives the frequency of rotation of a particle in the beam?

[1 mark]

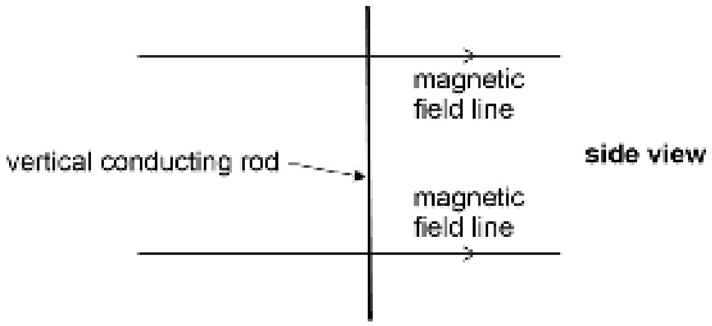
A $\dfrac{BQ}{2\pi m}$ ◯

B $\dfrac{BQ}{m}$ ◯

C $\dfrac{BQ}{\pi m}$ ◯

D $\dfrac{2\pi BQ}{m}$ ◯

2 0 A vertical conducting rod of length l is moved at a constant velocity v through a uniform horizontal magnetic field of flux density B.



Which of the rows gives a correct expression for the induced emf between the ends of the rod for the stated direction of the motion of the rod?

[1 mark]

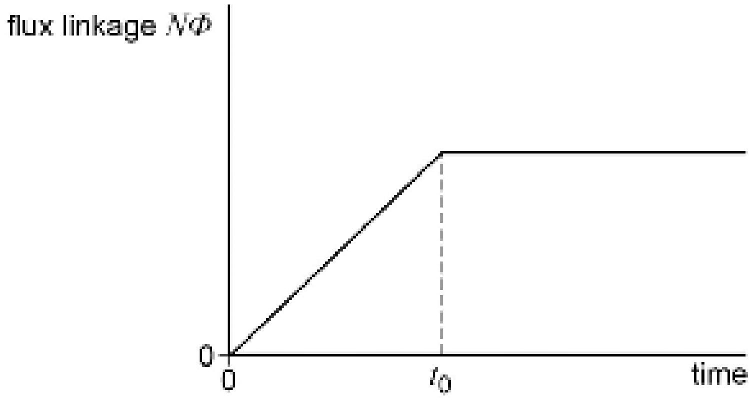
	Direction of motion	Induced emf	
A	Vertical	$\dfrac{B}{lv}$	◯
B	Horizontal at right angles to the field	Blv	◯
C	Vertical	Blv	◯
D	Horizontal at right angles to the field	$\dfrac{B}{lv}$	◯

2 1 A simple pendulum and a mass-spring system have the same oscillation frequency f at the surface of the Earth. The pendulum and the mass-spring system are taken down a mine where the acceleration due to gravity is less than at the surface. What is the change in the frequency of the simple pendulum and the change in the frequency of the mass-spring system?

[1 mark]

	simple pendulum	**mass-spring**	
A	f increases	f decreases	⬭
B	f decreases	f decreases	⬭
C	f increases	f stays unchanged	⬭
D	f decreases	f stays unchanged	⬭

2 2 The graph shows how the flux linkage, $N\Phi$, through a coil changes when the coil is moved into a magnetic field.



The emf induced in the coil

[1 mark]

A decreases then becomes zero after time t_0. ⬭

B increases then becomes constant after time t_0. ⬭

C is constant then becomes zero after time t_0. ⬭

D is zero then increases after time t_0. ⬭

2 3 A liquid flows continuously through a chamber that contains an electric heater. When the steady state is reached, the liquid leaving the chamber is at a higher temperature than the liquid entering the chamber. The difference in temperature is Δt.

Which of the following will increase Δt with no other change?

[1 mark]

A Increasing the volume flow rate of the liquid

B Changing the liquid to one with a lower specific heat capacity

C Using a heating element with a higher resistance

D Changing the liquid to one that has a higher density

Turn over for the next question

2 4 The temperature of a hot liquid in a container falls at a rate of 2 K per minute just before it begins to solidify. The temperature then remains steady for 20 minutes by which time all the liquid has all solidified.

What is the quantity $\frac{\text{Specific heat capacity of the liquid}}{\text{Specific latent heat of fusion}}$?

[1 mark]

A $\frac{1}{40}\ \mathrm{K}^{-1}$

B $\frac{1}{10}\ \mathrm{K}^{-1}$

C $10\ \mathrm{K}^{-1}$

D $40\ \mathrm{K}^{-1}$

2 5 A fixed mass of gas occupies a volume V. The temperature of the gas increases so that the root mean square velocity of the gas molecules is doubled.
What will the new volume be if the pressure remains constant?

[1 mark]

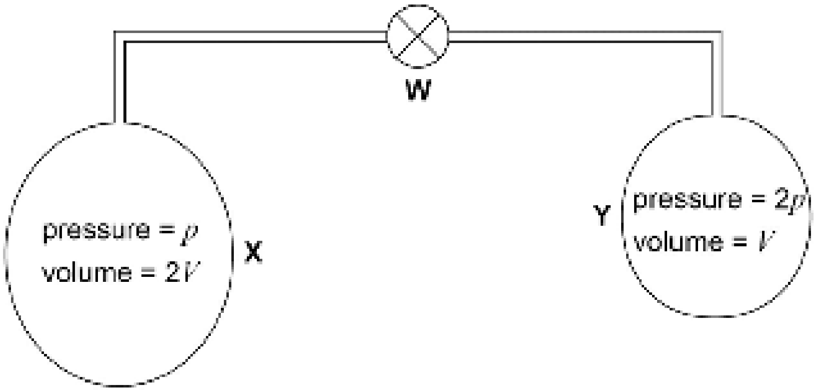
A $\frac{V}{2}$

B $\frac{V}{\sqrt{2}}$

C $2V$

D $4V$

2 6 $\mathbf{X}$ and $\mathbf{Y}$ are two gas bottles that are connected by a tube that has negligible volume compared with the volume of each bottle.



Initially the valve $\mathbf{W}$ is closed.
$\mathbf{X}$ has a volume $2V$ and contains hydrogen at a pressure of p.
$\mathbf{Y}$ has a volume V and contains hydrogen at a pressure of $2p$.
$\mathbf{X}$ and $\mathbf{Y}$ are both initially at the same temperature.

$\mathbf{W}$ is now opened. Assuming that there is no change in temperature, what is the new gas pressure?

[1 mark]

A $\frac{2}{3}p$ ☐

B $\frac{5}{3}p$ ☐

C $\frac{4}{3}p$ ☐

D $\frac{3}{2}p$ ☐

2 7 A radioactive nucleus emits a β^- particle then an α particle and finally another β^- particle. The final nuclide is

[1 mark]

A an isotope of the original element ☐

B the same element with a different proton number ☐

C a new element of higher proton number ☐

D a new element of lower nucleon number ☐

2 8 Which of the following best describes the decay constant for a radioisotope?

[1 mark]

A The reciprocal of the half-life of the radioisotope.

B The rate of decay of the radioisotope.

C The constant of proportionality which links half-life to the rate of decay of nuclei.

D The constant of proportionality which links rate of decay to the number of undecayed nuclei.

2 9 Which of the following is equal to $\frac{\text{radius of a nucleus of } {}^{125}_{51}\text{Sb}}{\text{radius of a nucleus of } {}^{64}_{30}\text{Zn}}$?

[1 mark]

A 1.19

B 1.25

C 1.33

D 1.40

3 0 After 64 days the activity of a radioactive nuclide has fallen to one sixteenth of its original value. The half-life of the radioactive nuclide is

[1 mark]

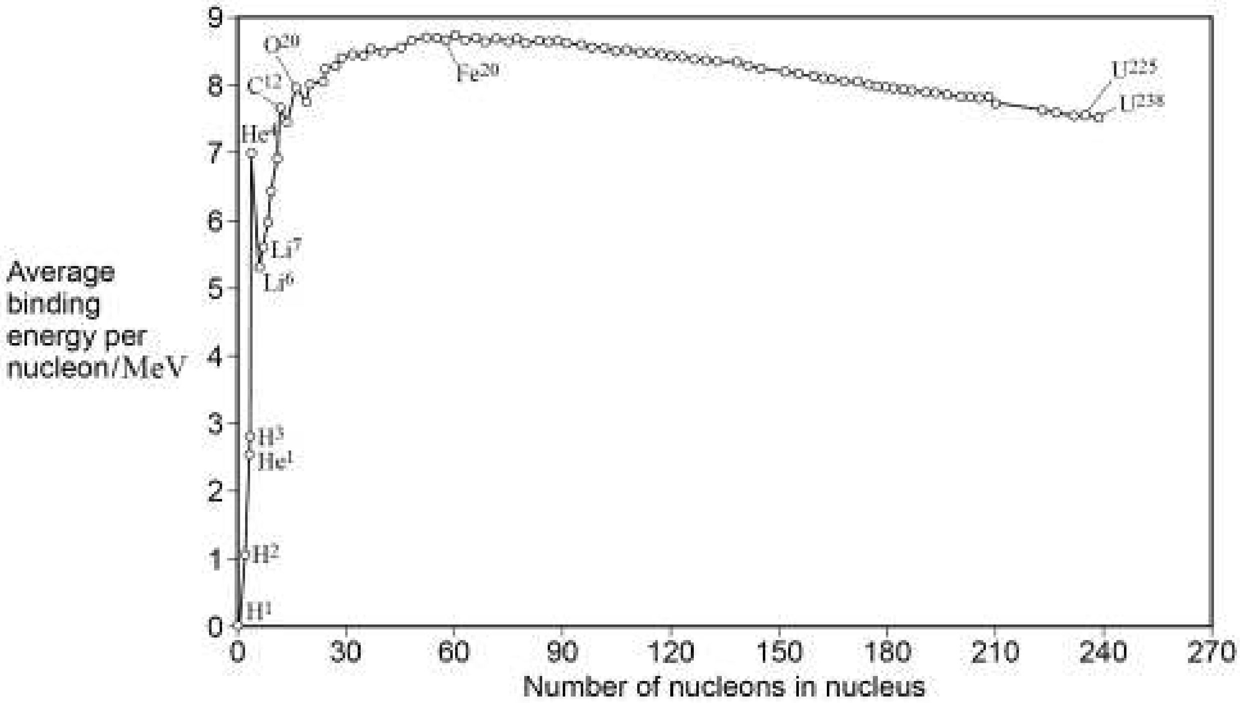
A 2 days.

B 4 days.

C 8 days.

D 16 days.

3 1 The graph shows how the binding energy per nucleon varies with the nucleon number for stable nuclei.



What is the approximate total binding energy for a nucleus of $^{184}_{74}W$?

[1 mark]

A 1.28 pJ

B 94.7 pJ

C 103 pJ

D 230 pJ

END OF QUESTIONS

There are no questions printed on this page.