



## SECTION A

You should spend a maximum of 20 minutes on this section.

Answer all the questions.

- 1 To find the density  $\rho$  of a metal wire, a student makes the following measurements:

length  $l = 100 \pm 1$  mm

diameter  $d = 2.50 \pm 0.05$  mm

mass  $m = 4.00 \pm 0.02$  g

The equation  $\rho = \frac{4m}{\pi d^2 l}$  is used to calculate the density of the metal.

What is the percentage uncertainty in the answer?

- A  $\pm 2.5\%$
- B  $\pm 3.5\%$
- C  $\pm 4.5\%$
- D  $\pm 5.5\%$

Your answer

[1]

- 2 A copper wire is connected across a cell. The conduction electrons within the copper wire move.

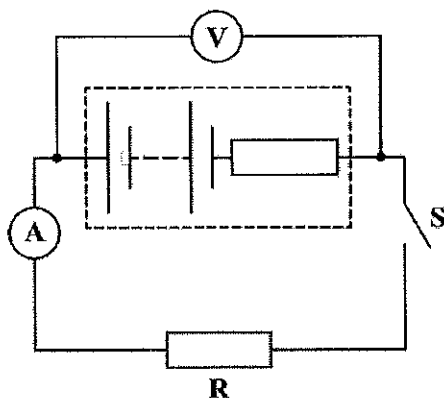
Which statement is correct about these electrons?

- A They drift towards the negative end of the cell.
- B They have random speeds because of collisions with other electrons.
- C They travel through the wire at the speed of light.
- D They collide with vibrating copper ions.

Your answer

[1]

- 3 A resistor **R**, an ammeter and a switch are connected in series to a battery.



The switch **S** is open. The voltmeter reading is 9.0 V and the ammeter reading is zero. With **S** closed, the voltmeter reading is 6.0 V and ammeter reading is 2.0 A.

What is the internal resistance of the battery?

- A 1.5  $\Omega$
- B 3.0  $\Omega$
- C 4.5  $\Omega$
- D 6.0  $\Omega$

Your answer

[1]

- 4 Which of the following statements is/are true about photons?

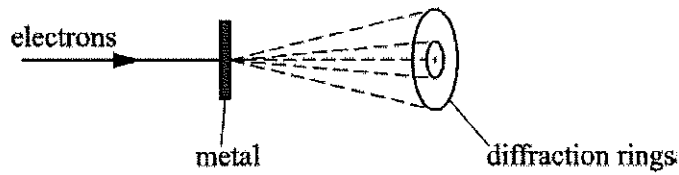
- 1 All photons travel at the same speed in a vacuum.
- 2 Photons have no charge.
- 3 The energy of a photon depends only on its frequency.

- A 1, 2 and 3
- B Only 2 and 3
- C Only 1 and 2
- D Only 2

Your answer

[1]

- 5 Electrons travelling through a thin layer of polycrystalline metal are diffracted.



Which statement is correct about these electrons?

- A The electrons travel as photons through the metal.
- B The electrons have a wavelength of about  $10^{-10}$  m.
- C The electrons are diffracted by holes in the metal.
- D The electrons repel each other to produce the diffraction.

Your answer

[1]

- 6 A sodium lamp is rated at 40 W. About 12% of the power is emitted as yellow light of wavelength  $5.9 \times 10^{-7}$  m.

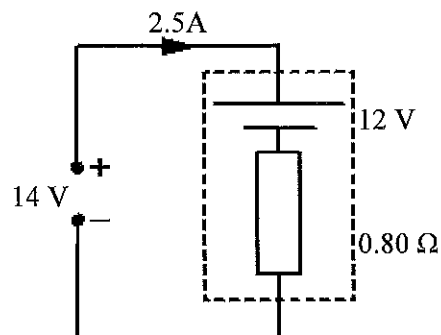
How many photons of yellow light are emitted per second from this lamp?

- A  $1.4 \times 10^{19} \text{ s}^{-1}$
- B  $1.2 \times 10^{20} \text{ s}^{-1}$
- C  $3.6 \times 10^{27} \text{ s}^{-1}$
- D  $1.0 \times 10^{40} \text{ s}^{-1}$

Your answer

[1]

- 7 A 14 V d.c. supply is used to charge a 12 V car battery of internal resistance  $0.80 \Omega$  for 6.0 hours. The current in the circuit is 2.5 A.



How much electrical energy is provided by the charging supply?

- A 13 kJ
- B 110 kJ
- C 650 kJ
- D 760 kJ

Your answer

[1]

- 8 The electric potential is  $-1.2 \times 10^{-4} \text{ J C}^{-1}$  at a point  $1.2 \times 10^{-5} \text{ m}$  from an isolated electron. An  $\alpha$ -particle  ${}^4_2\text{He}$  passes through this point.

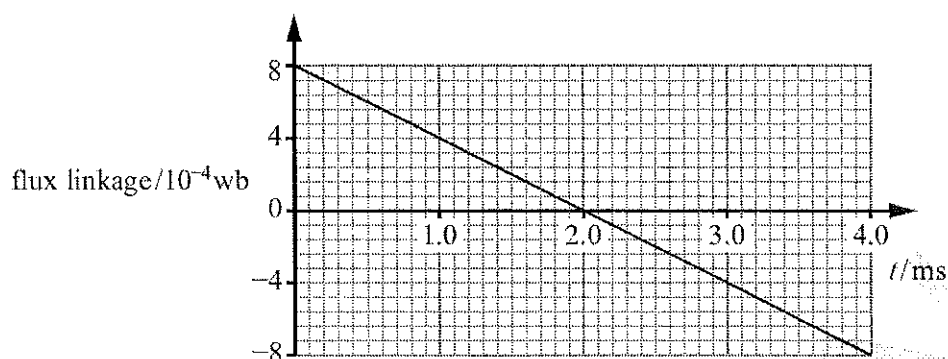
What is the magnitude of the electric potential at the mid-point between the  $\alpha$ -particle and the electron at this instant?

- A  $-7.2 \times 10^{-4} \text{ J C}^{-1}$
- B  $+2.4 \times 10^{-4} \text{ J C}^{-1}$
- C  $+4.8 \times 10^{-4} \text{ J C}^{-1}$
- D  $+7.2 \times 10^{-4} \text{ J C}^{-1}$

Your answer

[1]

- 9 A coil with three turns of wire is used in an experiment.  
The graph shows the variation of magnetic flux linkage with time  $t$  for this coil.



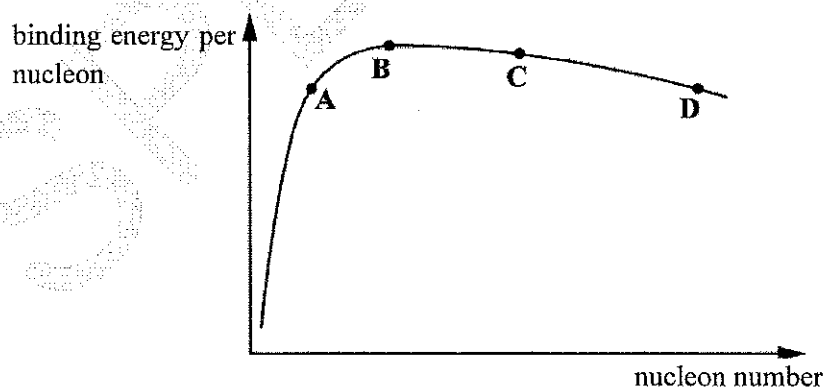
What is the e.m.f. induced across the ends of the coil?

- A 0 V  
B 0.20 V  
C 0.40 V  
D 1.2 V

Your answer

[1]

- 10 A graph of binding energy per nucleon against nucleon number is shown below.



Which nucleus, A, B, C, or D, shown on the graph has the largest magnitude of binding energy?

Your answer

[1]

- 11 A radiographer in a hospital directs a parallel beam of X-rays at the leg bone of a patient. The attenuation (absorption) coefficient of bone is  $0.7 \text{ cm}^{-1}$ .

The answers below are given to one significant figure.

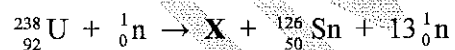
What is the percentage intensity of X-rays transmitted through bone of thickness 0.7 cm?

- A 0 %
- B 40 %
- C 50 %
- D 60 %

Your answer

[1]

- 12 When a nucleus of uranium-238 absorbs a neutron, one combination of fission products can be tin-126 and a nucleus of element X. 13 neutrons are also emitted.



How many neutrons are there in the nucleus of element X?

- A 30
- B 42
- C 58
- D 100

Your answer

[1]

- 13 The potential difference across the cathode and the anode of an X-ray tube is  $V$ . The minimum wavelength of the X-ray photons emitted from the tube is  $\lambda_0$ .

Which of the following statements is/are correct?

- 1  $\lambda_0$  is halved when  $V$  is doubled.
  - 2  $\lambda_0$  is unchanged when the temperature of the cathode is increased.
  - 3  $\lambda_0$  is independent of the cathode material.
- A 1, 2 and 3  
 B Only 2 and 3  
 C Only 1 and 2  
 D Only 2

Your answer

[1]

- 14 Two leptons are emitted when a down quark decays into an up quark.

Which of the following is correct about this decay?

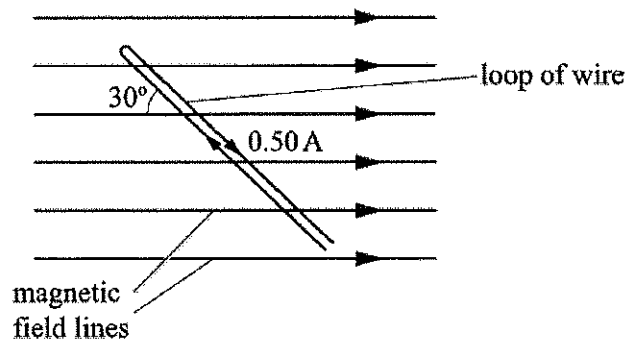
	force responsible for the decay	leptons emitted
A	strong nuclear	positron and antineutrino
B	weak nuclear	positron and neutrino
C	strong nuclear	electron and neutrino
D	weak nuclear	electron and antineutrino

Your answer

[1]



- 15 A rigid loop of insulated wire is placed in a uniform magnetic field of flux density 80 mT. The current in this loop is 0.50 A and the angle between the wire and the direction of the magnetic field is  $30^\circ$ .



What is the magnitude of the force experienced by a 1.0 cm section of the loop?

- A 0 N
- B  $2.0 \times 10^{-4}$  N
- C  $3.5 \times 10^{-4}$  N
- D  $4.0 \times 10^{-4}$  N

Your answer

[1]

## SECTION A

You should spend a maximum of 25 minutes on this section.

Answer **all** the questions.

- 1 The table below shows the measurements recorded by a student for a solid metal sphere. The absolute uncertainties in the mass of the sphere and in its radius are also shown.

mass	$100 \pm 6$ g
radius	$1.60 \pm 0.08$ cm

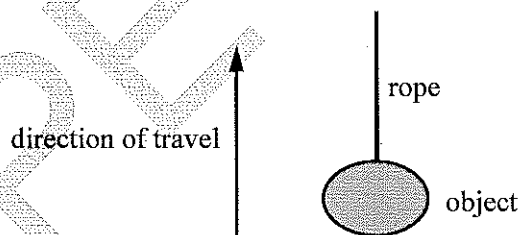
What is the percentage uncertainty in the density of the sphere?

- A 1%  
 B 11%  
 C 16%  
 D 21%

Your answer

[1]

- 2 An object of mass 7.0 kg is pulled vertically upwards by a rope. The acceleration of the object is  $2.0 \text{ m s}^{-2}$ .



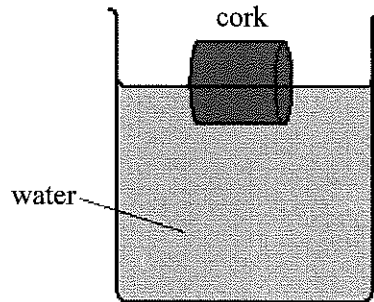
What is the tension in the rope?

- A 14 N  
 B 55 N  
 C 69 N  
 D 83 N

Your answer

[1]

- 3 A bottle cork floats on water. It is partially submerged in the water.



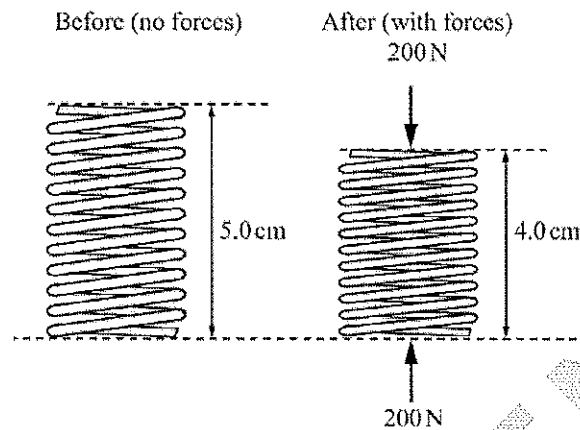
Which of the following statements is/are true?

- 1 The net force acting on the cork is equal to the weight of the water displaced.
- 2 The weight of the cork is equal to the upthrust on the cork.
- 3 The upthrust on the cork is equal to the mass of the water displaced.
- A 1, 2 and 3
- B Only 2 and 3
- C Only 3
- D Only 2

Your answer

[1]

- 4 A compression spring is being tested in an engineering laboratory. The diagram shows the spring before and after the forces are applied to its opposite ends.



The initial length of the spring is 5.0 cm and during the application of the forces its length is 4.0 cm.

What is the force constant of this spring?

- A  $4.0 \times 10^3 \text{ N m}^{-1}$
- B  $5.0 \times 10^3 \text{ N m}^{-1}$
- C  $2.0 \times 10^4 \text{ N m}^{-1}$
- D  $4.0 \times 10^4 \text{ N m}^{-1}$

Your answer

[1]

- 5 A balloon is travelling vertically downwards at a constant acceleration. The upthrust on the balloon is  $U$ , its weight is  $W$  and it experiences air resistance  $F$ .

Which statement is correct?

- A  $F + W > U$
- B  $W + U > F$
- C  $F > W + U$
- D  $W > U + F$

Your answer

[1]

- 6 A brick of mass  $m$  has sides of lengths  $a$ ,  $b$  and  $c$ , where  $a < b < c$ . The brick is placed on a horizontal table such that the pressure it exerts on the table is a maximum.

What is the maximum pressure  $p$  acting on the table?

- A  $p = \frac{mg}{ab}$   
B  $p = \frac{mg}{ac}$   
C  $p = \frac{mg}{bc}$   
D  $p = \frac{mg}{abc}$

Your answer

[1]

- 7 Two balls **X** and **Y** are dropped from a very tall building. Both balls reach terminal velocity before hitting the ground. The balls have the same diameter. The mass of **X** is greater than the mass of **Y**.

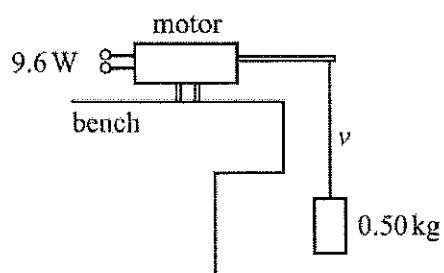
Which statement is correct?

- A The balls hit the ground at the same time.  
B The terminal velocity of **Y** is greater than that of **X**.  
C The initial acceleration of both balls is the same.  
D The balls have the same kinetic energy just before hitting the ground.

Your answer

[1]

- 8 A small electric motor is 20% efficient. Its input power is 9.6 W when it is lifting a mass of 0.50 kg at a steady speed  $v$ .



What is the value of  $v$ ?

- A  $0.39 \text{ m s}^{-1}$   
 B  $2.0 \text{ m s}^{-1}$   
 C  $2.8 \text{ m s}^{-1}$   
 D  $3.8 \text{ m s}^{-1}$

Your answer

[1]

- 9 A car accelerates uniformly from rest along a level road. The effects of air resistance on the car are negligible. The car travels 12 m in the second second of its journey.

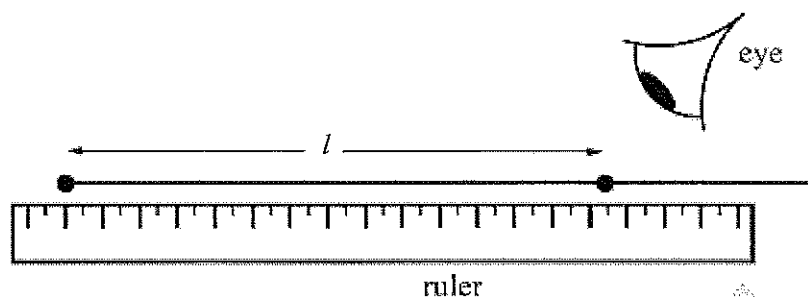
How far does it travel in the fourth second?

- A 28 m  
 B 35 m  
 C 48 m  
 D 64 m

Your answer

[1]

- 10 A metre rule is being used to measure the length  $l$  of a section of wire. The end of the ruler is displaced from the start of the wire.



What is the nature of the errors associated with the length measurement?

- A There are random errors but no systematic errors.
- B There are systematic errors but no random errors.
- C There are both systematic and random errors.
- D There is no overall error because the random and systematic errors cancel out.

Your answer

[1]

- 11 Which of the following statements is/are true about photons?

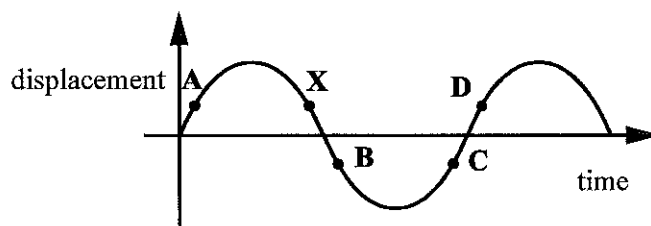
- 1 The speed of a photon changes at the boundary between air and glass.
- 2 Photons are electrically neutral.
- 3 The energy of a photon depends only on its wavelength.

- A 1, 2 and 3 are correct
- B Only 1 and 2 are correct
- C Only 2 and 3 are correct
- D Only 1 is correct

Your answer

[1]

- 12 The diagram below shows the displacement-time graph of a particle as a progressive wave travels through a medium.

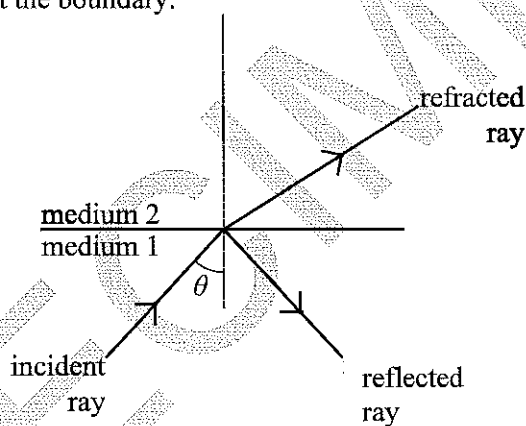


Which point A, B, C, or D has a phase difference of  $180^\circ$  with reference to point X?

Your answer

[1]

- 13 A ray of monochromatic light is incident at a boundary between medium 1 and medium 2. The ray is both refracted and reflected at the boundary.



Which of the following statements is/are true?

- 1 The refracted light and incident light have the same wavelength.
- 2 The speed of light in medium 2 is greater than the speed of light in medium 1.
- 3 The angle  $\theta$  is the critical angle.

- A 1, 2 and 3  
 B Only 1 and 2  
 C Only 1  
 D Only 2

Your answer

[1]



- 14 A resistor is connected across a power supply.

Which statement is correct about the conduction electrons in this resistor?

- A They travel at the speed of light between collisions with ions.
- B They make random collisions with vibrating electrons.
- C They travel at their mean drift velocity between collisions.
- D They drift towards the positive end of the power supply.

Your answer

[1]

- 15 A filament lamp is described as being 120 V, 60 W. The lamp is connected to a supply so that it lights normally.

Which statement is correct?

- A The charge passing through the filament in one second is 2.0 coulomb.
- B The lamp transfers 60 joule for each coulomb passing through the filament.
- C The lamp transfers 120 joule in 2.0 second.
- D The supply provides 60 joule to the lamp when the current is 2.0 ampere.

Your answer

[1]

- 16 A battery of e.m.f. of 8.0 V and internal resistance 2.5  $\Omega$  is connected to an external resistor. The current in the resistor is 350 mA.

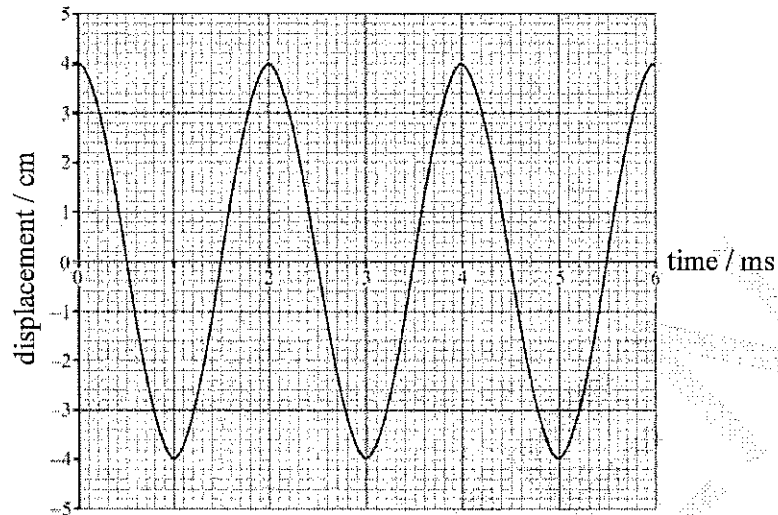
What is the power dissipated in the external resistor?

- A 1.9 W
- B 2.5 W
- C 2.8 W
- D 3.1 W

Your answer

[1]

- 17 The diagram below shows the displacement-time graph of an air particle as a sound wave passes.



The speed of the sound wave is  $340 \text{ m s}^{-1}$ .

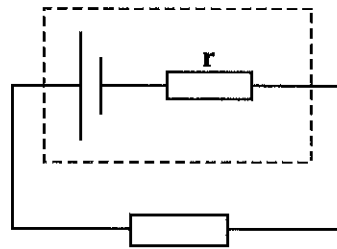
What is the wavelength of the sound wave?

- A 0.68 m
- B 1.7 m
- C 170 m
- D 680 m

Your answer

[1]

- 18 The diagram below shows a cell with an internal resistance connected to an external resistor.



Which of the following will increase the terminal p.d?

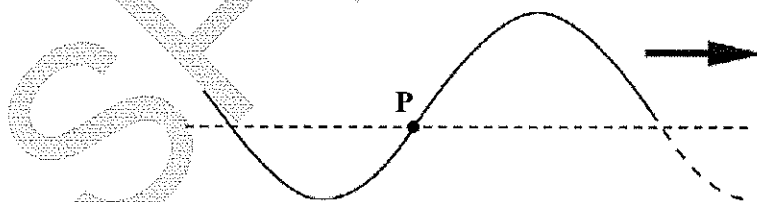
- 1 Increasing the e.m.f. of the cell.
- 2 Increasing the value of the external resistance.
- 3 Increasing the value of the internal resistance.

- A 1, 2 and 3  
 B Only 1 and 2  
 C Only 2 and 3  
 D Only 1

Your answer

[1]

- 19 The figure shows part of a transverse progressive wave which is travelling to the right along a string. The horizontal dotted line shows the position of the string when there is no wave present. In which direction is the string at the point P moving at the instant shown?

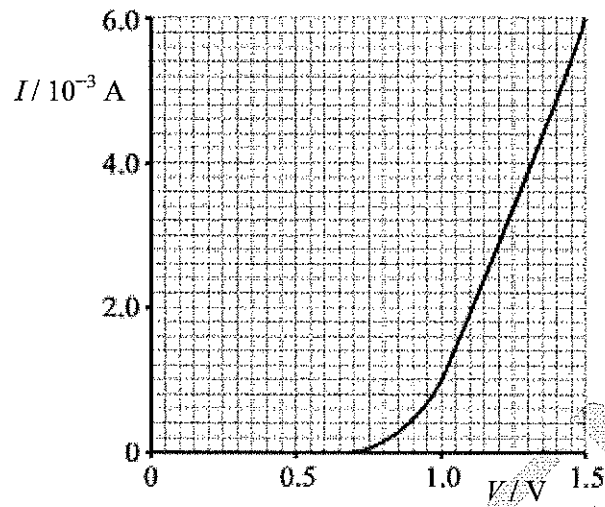


- A upwards  
 B downwards  
 C to the right  
 D it is at rest

Your answer

[1]

20 The graph shows the  $I$ - $V$  characteristic of a semiconductor diode.



Which statement about the resistance of the diode can be deduced from the characteristic?

- A It is zero between 0 V and 0.70 V.
- B It is constant between 1.0 V and 1.5 V.
- C It is  $0.4 \Omega$  at 1.2 V.
- D It decreases between 0.70 V and 1.0 V.

Your answer

[1]

## SECTION A

You should spend a maximum of 20 minutes on this section.

Answer all the questions.

- 1 A length  $x$  is  $50 \text{ mm} \pm 2 \text{ mm}$ . Length  $y$  is  $100 \text{ mm} \pm 6 \text{ mm}$ . The length  $z$  is given by  $z = y - x$ .

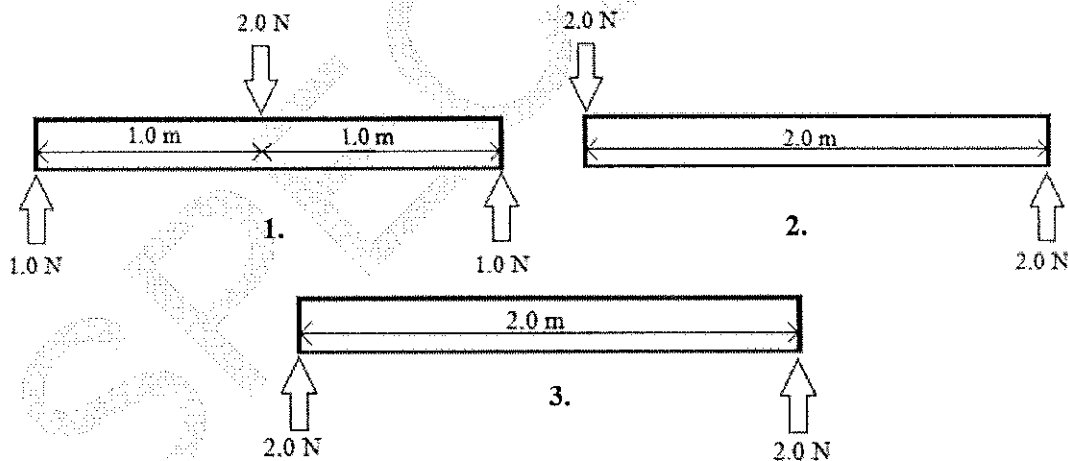
What is the best estimate of the uncertainty in  $z$ ?

- A  $\pm 1 \text{ mm}$   
 B  $\pm 4 \text{ mm}$   
 C  $\pm 5 \text{ mm}$   
 D  $\pm 8 \text{ mm}$

Your answer

[1]

- 2 A 2.0 m rigid rod with negligible weight is subject to forces in three different ways as shown in diagrams 1-3 below.



For the rod to be in equilibrium which of the diagrams above is/are correct?

- A 1, 2 and 3  
 B Only 1 and 2  
 C Only 2 and 3  
 D Only 1

Your answer

[1]

- 3 The p.d. across a resistor is 12 V. The power dissipated is 6.0 W.

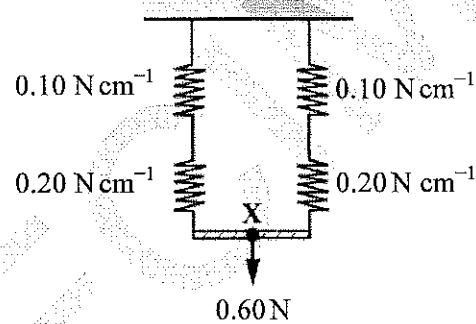
Which statement is correct?

- A The charge passing through the resistor in one second is 2.0 coulomb.  
 B The resistor transfers 6.0 joule for each coulomb passing through the resistor.  
 C The resistor transfers 12 joule in 2.0 second.  
 D The resistor dissipates 6.0 joule when the current is 2.0 ampere.

Your answer

[1]

- 4 A spring with force constant  $0.10 \text{ N cm}^{-1}$  is placed in series with one of  $0.20 \text{ N cm}^{-1}$ . These are then placed in parallel with an identical set of springs as shown. A force of 0.60 N is applied.



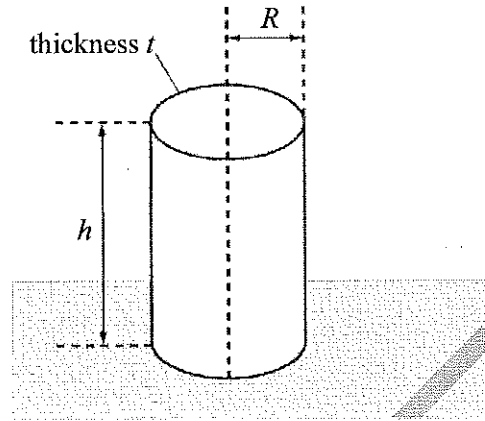
What distance does the point X move down when the 0.60 N force is applied?

- A 2.0 cm  
 B 3.0 cm  
 C 4.5 cm  
 D 9.0 cm

Your answer

[1]

- 5 A group of civil engineers are assessing whether or not to use solid concrete pillars or hollow metal tubes to support a building. One such metal tube is shown below. The tube is placed on a horizontal surface. The tube is made of metal of thickness  $t$ . The tube has height  $h$  and a mean internal radius  $R$ . The radius  $R \gg$  thickness  $t$ .



A heavy metal block of mass  $m$  is placed on top of the tube.

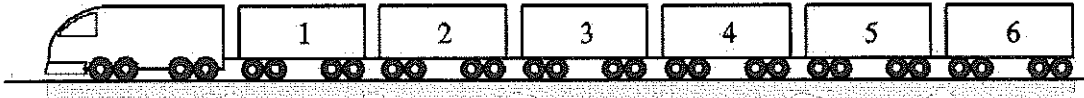
What is the approximate pressure  $p$  acting on the tube?

- A  $p = \frac{mg}{2\pi Rt}$   
 B  $p = \frac{mg}{\pi R^2}$   
 C  $p = \frac{mg}{\pi R^2 h}$   
 D  $p = \frac{mg}{\pi R^2 t}$

Your answer

[1]

- 6 A train consisting of six trucks each of mass  $6.0 \times 10^4 \text{ kg}$  is pulled at a constant speed by a locomotive of mass  $24 \times 10^4 \text{ kg}$  along a straight horizontal track. The horizontal force resisting the motion of each truck is  $4000 \text{ N}$ .



The coupling between trucks 2 and 3 snaps.

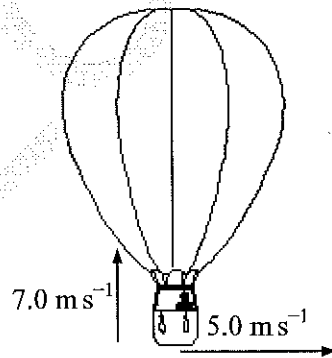
What is the initial acceleration of the locomotive?

- A  $0.022 \text{ m s}^{-2}$   
 B  $0.044 \text{ m s}^{-2}$   
 C  $0.067 \text{ m s}^{-2}$   
 D  $0.133 \text{ m s}^{-2}$

Your answer

[1]

- 7 When a sandbag is dropped from a balloon hovering  $1.3 \text{ m}$  above the ground, it hits the ground at  $5.0 \text{ m s}^{-1}$ .  
 On another occasion, the sandbag is released from the balloon which is rising at  $7.0 \text{ m s}^{-1}$  when  $1.3 \text{ m}$  above the ground. There is also a crosswind of  $5.0 \text{ m s}^{-1}$ .



At what speed does the sandbag hit the ground?

- A  $2.0 \text{ m s}^{-1}$   
 B  $5.4 \text{ m s}^{-1}$   
 C  $10 \text{ m s}^{-1}$   
 D  $13 \text{ m s}^{-1}$

Your answer

[1]



- 8 A piece of flat A4 paper is dropped and falls to the floor. The same piece of paper is then collapsed into a ball and dropped again.

Which of the following will change in the second situation?

- A the maximum magnitude of the air resistance
- B the weight of the paper
- C the time taken to reach terminal velocity
- D the initial acceleration when dropped

Your answer

[1]

- 9 A small amount of copper is heated in a container. The copper starts to melt.

Which statement about the melting of copper is correct?

- A Temperature is constant and the kinetic energy of the copper atoms increases.
- B Temperature increases and the potential energy of the copper atoms increases.
- C Temperature is constant and the potential energy of the copper atoms increases.
- D Temperature increases and the kinetic energy of the copper atoms increases.

Your answer

[1]

- 10 What is the correct unit for specific heat capacity?

- A  $\text{m}^2 \text{s}^{-2} \text{K}^{-1}$
- B  $\text{m} \text{s}^{-2} \text{K}^{-1}$
- C  $\text{m}^2 \text{s}^{-1} \text{K}^{-1}$
- D  $\text{m}^2 \text{s}^{-2} \text{K}$

Your answer

[1]

- 11 Betelgeuse is a star in the constellation of Orion which astronomers think could undergo a supernova explosion.

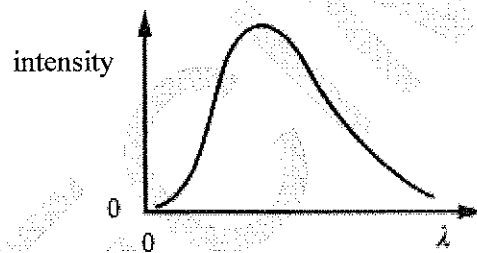
What could Betelgeuse evolve into following the supernova stage?

- A main sequence star
- B neutron star
- C planetary nebulae
- D red giant star

Your answer

[1]

- 12 Stars emit electromagnetic radiation. A graph of intensity against wavelength  $\lambda$  for a main sequence star is shown.



Which statement is correct as the main sequence star evolves into a red giant?

- A the peak wavelength does not change
- B the peak wavelength moves towards the origin
- C the peak wavelength moves to the left
- D the peak wavelength moves to the right

Your answer

[1]

13 When the light from a star is passed through a diffraction grating it forms a spectrum.

Which of the following statements is/are correct?

- 1 Light emitted from the surface of a star would form a continuous spectrum.
  - 2 Light received from the Sun has dark lines across its spectrum which correspond to the absorption of certain wavelengths by atoms in the Earth's atmosphere.
  - 3 A photon in an emission spectrum occurs when an electron moves from a low to a higher energy level within an atom.
- A 1, 2 and 3  
B Only 1 and 2  
C Only 2 and 3  
D Only 1

Your answer

[1]

14 A star has surface temperature  $3000^{\circ}\text{C}$  and luminosity  $L$ . Another star of identical size has a surface temperature of  $2500^{\circ}\text{C}$ .

What is the luminosity of this second star in terms of  $L$ ?

- A  $0.48L$   
B  $0.52L$   
C  $0.83L$   
D  $0.85L$

Your answer

[1]

- 15 Scientists are planning to launch a rocket from the surface of the Earth into an orbit at a distance of 18000 km above the centre of the Earth. The radius of the Earth is 6400 km and it has mass  $6.0 \times 10^{24}$  kg.

What is the minimum work done to move the 150kg mass of the rocket into this orbit?

- A  $-13 \times 10^5$  J  
B  $-6.0 \times 10^5$  J  
C  $+6.0 \times 10^5$  J  
D  $+13 \times 10^5$  J

Your answer

[1]

SPECIMEN