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Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Wednesday 17 January 2018 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
WPH05/01

You must have:
Ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 5 1 9 4 4 A 0 1 2 8

Pearson

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following statements about the absolute zero of temperature is correct?

☒ **A** It is the temperature of deep space.

☒ **B** It is the temperature at which water becomes ice.

☒ **C** It is the lowest temperature yet reached in a laboratory.

☒ **D** It is the temperature at which the internal energy of an ideal gas would be least.

(Total for Question 1 = 1 mark)

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2 A gas consists of a mixture of nitrogen and oxygen molecules. Oxygen molecules are more massive than nitrogen molecules.

Which of the following statements is correct?

☒ **A** On average all the molecules have the same speed.

☒ **B** On average all the molecules have the same kinetic energy.

☒ **C** On average a nitrogen molecule has more kinetic energy than an oxygen molecule.

☒ **D** On average the speed of the nitrogen molecules is less than the speed of the oxygen molecules.

(Total for Question 2 = 1 mark)

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3 A mass is hung from a spring and set into vertical oscillation of amplitude x_0. The total energy of oscillation is E_0.

Which of the following expressions gives the total energy of oscillation E when the amplitude has reduced to $\frac{1}{2}x_0$?

☒ **A** $E = 4E_0$

☒ **B** $E = 2E_0$

☒ **C** $E = \frac{1}{2}E_0$

☒ **D** $E = \frac{1}{4}E_0$

(Total for Question 3 = 1 mark)

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4 A brass ring and a gold ring are supplied with the same amount of thermal energy. The brass ring is half the mass of the gold ring, and the specific heat capacity of brass is 3 times that of gold.

Which of the following is the ratio $\frac{\text{temperature rise of brass ring}}{\text{temperature rise of gold ring}}$?

☒ **A** $\frac{1}{6}$

☒ **B** $\frac{2}{3}$

☒ **C** $\frac{3}{2}$

☒ **D** 6

(Total for Question 4 = 1 mark)

5 A technician is planning to use a radioactive source to check the calibration of a radiation counter. The source should have a large rate of decay.

Select the row in the table which would result in the largest rate of decay.

	Number of unstable nuclei in source	Half-life of source
☒ **A**	small	short
☒ **B**	small	long
☒ **C**	large	short
☒ **D**	large	long

(Total for Question 5 = 1 mark)

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6 The distances to two stars are being determined using trigonometric parallax.
The radiation flux from star P is greater than that from star Q, and the parallax angle for star P is greater than that of star Q.

Which of the following is a correct deduction about the stars?

☒ **A** Star P has a greater luminosity than star Q.

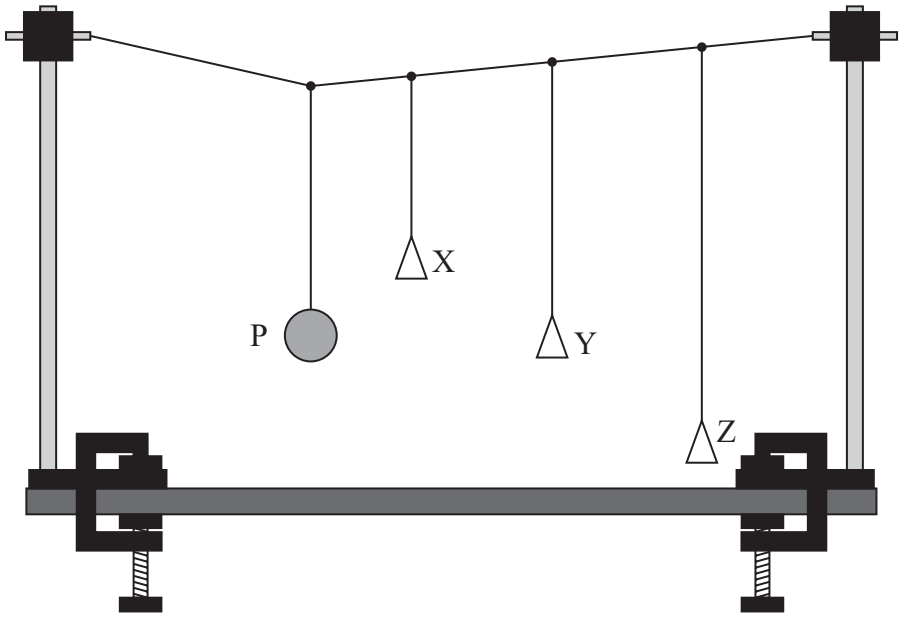
☒ **B** Star P has the same luminosity as star Q.

☒ **C** Star P is closer than star Q.

☒ **D** Star P is the same distance from the Earth as star Q.

(Total for Question 6 = 1 mark)

7 The diagram shows three light pendulums X, Y and Z being driven into oscillation by a heavy pendulum P. The time period of a pendulum increases with the pendulum length.



Which of the following statements is correct?

☒ **A** X has the largest amplitude.

☒ **B** Y has the largest amplitude.

☒ **C** Z has the largest amplitude.

☒ **D** X, Y and Z have the same amplitude.

(Total for Question 7 = 1 mark)

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8 Astrophysicists have determined a value for the age of the universe using

☒ **A** the cosmic background radiation.

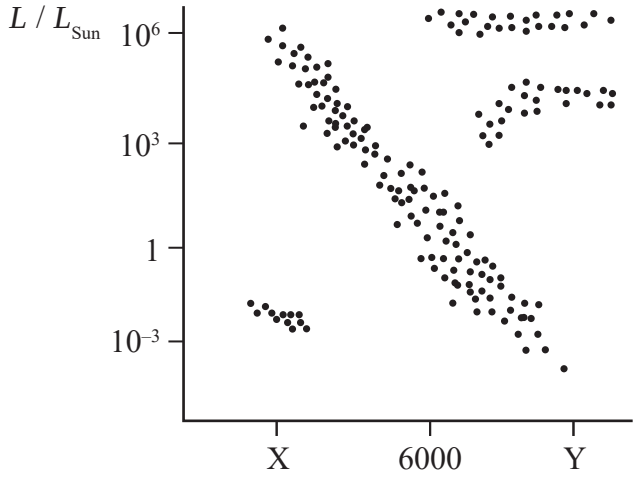
☒ **B** the gravitational constant.

☒ **C** a Hertzsprung-Russell diagram.

☒ **D** the Hubble constant.

(Total for Question 8 = 1 mark)

9 The temperature scale on the Hertzsprung-Russell diagram shown below is not complete.



Select the row in the table which gives possible values for X and Y.

	X / K	Y / K
☒ **A**	3000	9000
☒ **B**	3000	12 000
☒ **C**	9000	3000
☒ **D**	12 000	3000

(Total for Question 9 = 1 mark)

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10 Some buildings are designed to withstand earthquakes. The energy from the earthquake waves is dissipated by deforming some parts of the building.

For this to be effective, these parts of the building must be

☒ **A** able to undergo elastic deformation.

☒ **B** able to undergo plastic deformation.

☒ **C** stiff under compressive forces.

☒ **D** strong under compressive forces.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

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SECTION B

Answer ALL questions in the spaces provided.

11 A line in the hydrogen spectrum from a laboratory source has a wavelength of 486 nm. In the spectrum of light received from a distant galaxy this line appears at a wavelength of 507 nm.

Determine the velocity of the galaxy.

(3)

Velocity of galaxy = ...

(Total for Question 11 = 3 marks)

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12 While underwater a diver releases an air bubble of volume 6.50×10^{-8} m^3. At the point of release the pressure is 8.55×10^5 Pa and the temperature of the sea is 5.0 °C. The bubble rises to the surface where the temperature of the sea is 20.0 °C.

(a) As the bubble rises, the mass of air in the bubble remains constant.

Calculate the volume of the bubble as it reaches the surface of the sea. Assume the air behaves as an ideal gas.

(3)

atmospheric pressure = 1.02×10^5 Pa

Volume of bubble as it reaches the surface = ...

(b) Explain why the actual volume of the bubble as it reaches the surface would be less than the volume calculated.

(2)

(Total for Question 12 = 5 marks)

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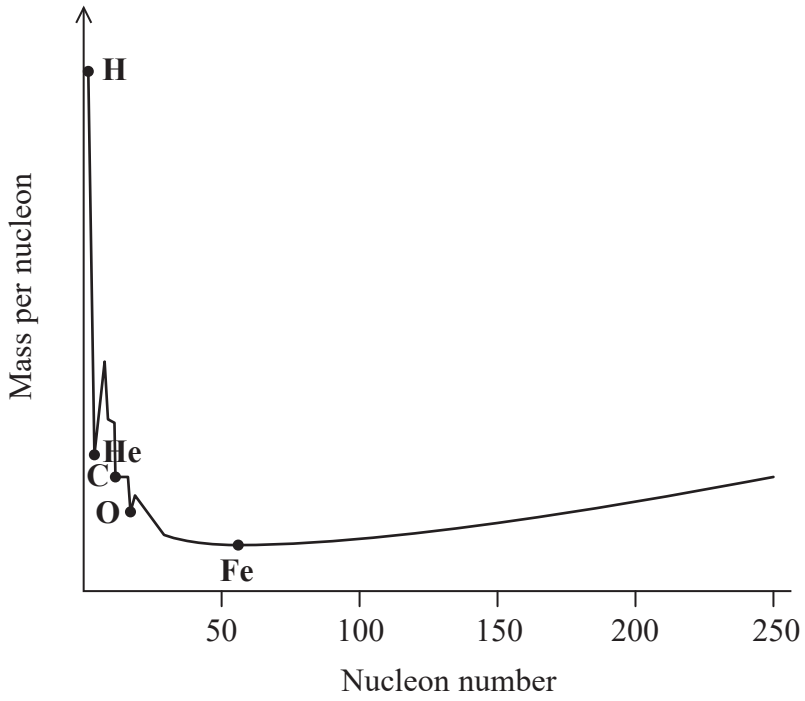
13 In an experimental nuclear fusion reactor, magnetic fields are used to confine a hot plasma. This is to sustain a controlled nuclear fusion reaction.

*(a) Explain why it is difficult to sustain a controlled nuclear fusion reaction.

(4)

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(b) The graph shows how the mass per nucleon varies for a range of nuclei.



(i) Explain, using the graph, how a fusion process is able to release energy.

(2)

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(ii) Explain, using the graph, a limitation to the elements suitable for fusion.

(2)

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(Total for Question 13 = 8 marks)

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14 Cepheid variable stars can be used as standard candles.

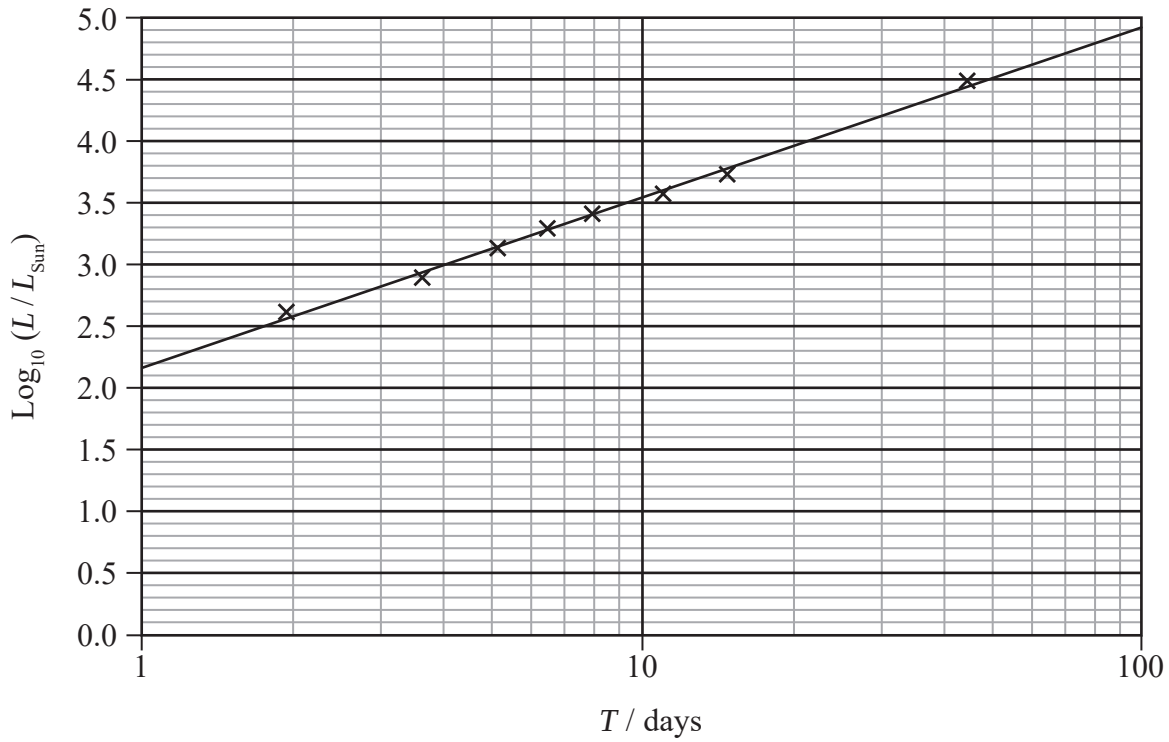
(a) State what is meant by a standard candle.

(1)

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(b) The graph shows how the luminosity L of one type of Cepheid variable star depends upon the period T of variation in its luminosity.



(i) A Cepheid variable star is identified in the Andromeda galaxy with a period of 3.0 days.

Use the graph to show that the luminosity of this star is about 2×10^{29} W.

(3)

$L_{Sun} = 3.85 \times 10^{26}$ W

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(ii) The radiation flux of the Cepheid star at the Earth is measured to be 3.36×10^{-17} W m^{-2}.

Calculate the distance to the Andromeda galaxy.

(2)

Distance to Andromeda galaxy = ...

*(c) Standard candles can only be used to determine distances to relatively close galaxies.

Outline the method used by astronomers to determine distances to more distant galaxies in our universe.

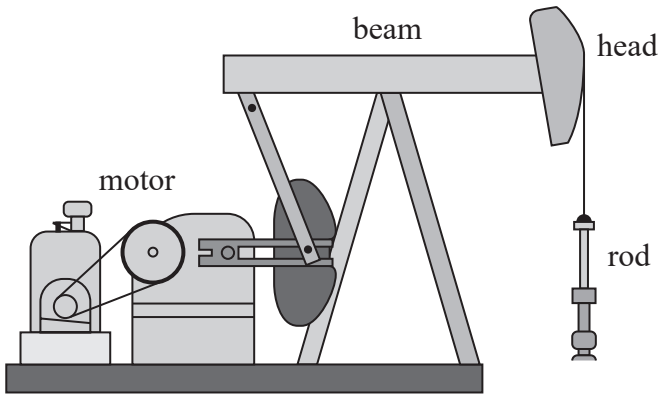
(4)

(Total for Question 14 = 10 marks)

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15 The photograph and diagram show a "nodding donkey" used to pump oil from the ground.





The motor raises and lowers one end of the beam, causing the head of the beam to move with simple harmonic motion. The head is attached to a metal rod that moves up and down, operating a pump deep in an oil well.

(a) State what is meant by simple harmonic motion.

(2)

(b) The motor takes 7.4 s for one complete cycle.

(i) Show that the angular velocity of the motor is about 0.8 rad s^{-1}.

(2)

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(ii) The head of the beam moves with an amplitude of 22 cm.

Calculate the maximum velocity of the head.

(2)

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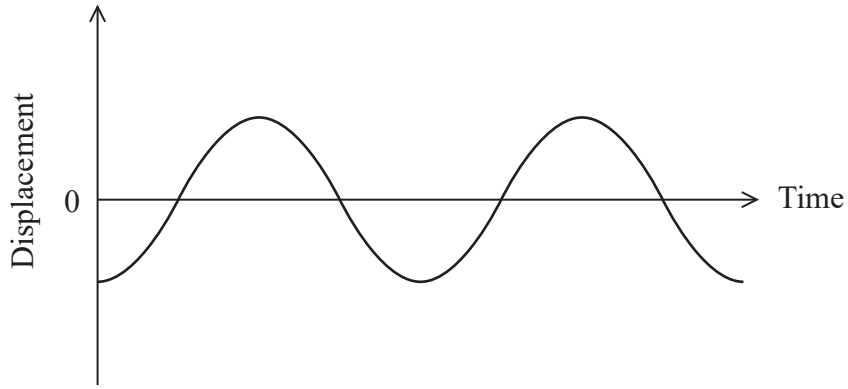
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Maximum velocity of head = ...

(iii) The graph shows how the displacement varies with time for two complete cycles.

Add a line to the graph to show the corresponding variation of velocity with time.

(2)



(Total for Question 15 = 8 marks)

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16 Sirius is a binary star system 8.1×10^{16} m from Earth. Sirius A is a main sequence star and the brightest star in the night sky. Sirius B is a white dwarf star.

(a) State what is meant by a main sequence star.

(1)

(b) Explain why it is appropriate for stars such as Sirius B to be called white dwarf stars.

(2)

(c) The two stars in the binary system were formed at roughly the same time.

Explain how we can deduce that Sirius B was initially much more massive than Sirius A.

(5)

(Total for Question 16 = 8 marks)

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17 Jupiter is the most massive planet in the solar system. In 2016 the spacecraft Juno completed a five-year mission to Jupiter. Juno is currently orbiting Jupiter with a period of 14 days.

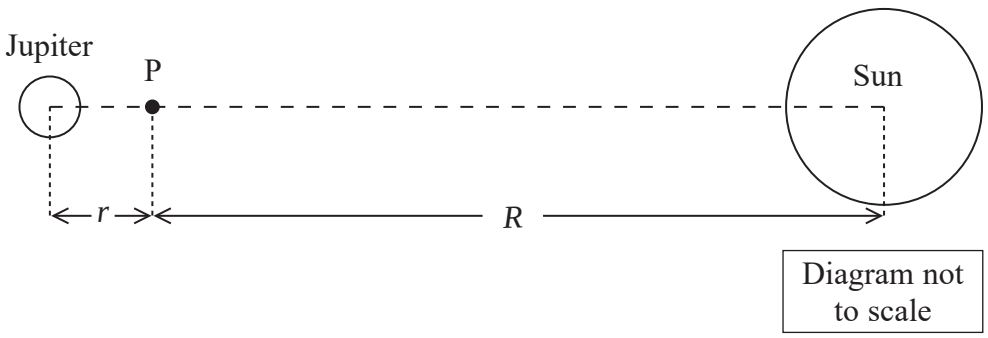
(a) Calculate the radius of Juno's orbit about Jupiter.

(3)

mass of Jupiter = 1.9×10^{27} kg
1 day = 86 400 s

Radius of orbit = ...

(b) The diagram shows Jupiter and the Sun. A point where the gravitational field strength of the Sun is equal and opposite to the gravitational field strength of Jupiter is labelled P.



The mass of the Sun is M_S. The mass of Jupiter is M_J. The gravitational constant is G.

(i) State expressions for the gravitational field strength of the Sun g_s at point P and the gravitational field strength of Jupiter g_J at point P.

(2)

g_s = ...

g_J = ...

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(ii) Show that the ratio $\frac{R}{r}$ is about 30.

(2)

$M_S = 2.0 \times 10^{30}$ kg

(iii) Hence calculate r.

The distance from the centre of Jupiter to the centre of the Sun is 7.8×10^8 km.

(2)

$r =$ .....

(c) One function of Juno is to monitor the temperature of Jupiter's atmosphere. At the top of the atmosphere the temperature can reach 725 °C.

Determine the type of electromagnetic radiation that the instruments in Juno must be sensitive to. Your answer should include a calculation.

(3)

(Total for Question 17 = 12 marks)

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18 Radon is a naturally occurring radioactive gas, mainly produced in areas rich in granite. In the open air radon causes no problems, but it can seep into buildings from the ground and reach dangerous concentrations.

(a) Radon-222 decays to polonium by emitting α-particles.

(i) Complete the nuclear equation for the decay of a radon-222 nucleus.

(2)

$$\text{.....}^{222}\text{Rn} \rightarrow \text{.....}_{84}\text{Po} + \text{.....}\alpha$$

(ii) Give two reasons why radon gas is particularly dangerous.

(2)

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(b) The total kinetic energy of the α-particle and the polonium nucleus is 5.59 MeV.

Calculate the mass difference in kg between a nucleus of radon-222 and its products in the decay.

(3)

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Mass difference = ... kg

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(c) In some homes the activity from the decaying radon can be as high as 1000 Bq for each cubic metre of air.

Radon-222 has a half-life of 3.30×10^5 s.

(i) Calculate the number of radon-222 nuclei in a cubic metre of air with an activity of 950 Bq.

(3)

Number of radon-222 nuclei = ...

(ii) It is recommended that radon levels should be reduced in homes where the average activity per cubic metre of air is greater than 200 Bq.

Calculate the time taken for the activity of radon in a sample to decrease from 950 Bq to 200 Bq.

(3)

Time taken for the activity to decrease = ...

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(iii) The risk to people increases as the concentration of radon gas in the home increases. However, about 90 per cent of deaths caused from exposure to radon gas occur in homes where the activity per cubic metre of air is less than 200 Bq.

Suggest why this is the case.

(1)

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(d) A sample of radon gas is placed in a sealed container and its initial activity is measured. A student calculates a value for the activity inside the container after a time equal to two half-lives. However, a measurement of the activity inside the container gives a value considerably higher than this.

Explain why the student's calculation does not agree with the measurement.

(2)

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(Total for Question 18 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$	
	$= 8.99 \times 10^9\ \text{N m}^2\ \text{C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \text{kg}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta r v$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i / \sin r = v_1 / v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

$$\% \text{ efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\% \text{ efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

Resistivity	$R = \rho l / A$
Current	$I = \Delta Q / \Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$

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Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0e^{-t/RC}$
In a magnetic field	$F = BIl \sin \theta$ $F = Bqv \sin \theta$ $r = p/BQ$
Faraday's and Lenz's laws	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

Unit 5

Energy and matter

Heating	$\Delta E = mc\Delta\theta$
Molecular kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Ideal gas equation	$pV = NkT$

Nuclear Physics

Radioactive decay	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{\frac{1}{2}}$
	$N = N_0 e^{-\lambda t}$

Mechanics

Simple harmonic motion	$a = -\omega^2 x$ $a = -A\omega^2 \cos \omega t$ $v = -A\omega \sin \omega t$ $x = A \cos \omega t$ $T = 1/f = 2\pi/\omega$
Gravitational force	$F = Gm_1m_2/r^2$

Observing the universe

Radiant energy flux	$F = L/4\pi d^2$
Stefan-Boltzmann law	$L = \sigma T^4 A$ $L = 4\pi r^2 \sigma T^4$
Wien's law	$\lambda_{max} T = 2.898 \times 10^{-3}$ m K
Redshift of electromagnetic radiation	$z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$
Cosmological expansion	$v = H_0 d$

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