Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number

Candidate Number

Physics

Advanced
Unit 5: Physics from Creation to Collapse

Tuesday 28 June 2016 – Morning
Time: 1 hour 35 minutes

Paper Reference
WPH05/01

You do not need any other materials.

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.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 4 6 6 5 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 A mass is hung from a spring and set into vertical oscillation.

The resultant force on the oscillating mass always acts

☒ **A** in the same direction as the velocity.

☒ **B** towards the equilibrium position.

☒ **C** vertically downwards.

☒ **D** vertically upwards.

(Total for Question 1 = 1 mark)

2 Radiation beam therapy can be used to kill cancerous cells in the body. One treatment for brain tumours directs many narrow beams of radiation from different directions onto the cancerous cells.

What would be the most suitable radiation to use?

☒ **A** alpha radiation because it is very ionising

☒ **B** alpha radiation because it is high energy

☒ **C** gamma radiation because it is very penetrating

☒ **D** gamma radiation because it has a very short wavelength

(Total for Question 2 = 1 mark)

3 Americium is a radioisotope that decays by emitting alpha particles. The difference in mass in MeV/c^2 between an americium nucleus and the products of the decay is Δm.

The energy released in the decay is given by

☒ **A** Δm MeV

☒ **B** Δm MeV/c

☒ **C** Δm MeV/c^2

☒ **D** Δm MJ

(Total for Question 3 = 1 mark)

4 Standard candles can **not** be used to determine distances to

☒ **A** nearby stars.

☒ **B** distant stars.

☒ **C** nearby galaxies.

☒ **D** distant galaxies.

(Total for Question 4 = 1 mark)

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5 A suspension bridge is being driven into oscillation as cars move across it. The energy of oscillation of the bridge doubles.

The amplitude of oscillation increases by a factor of

☒ **A** $\frac{1}{2}$

☒ **B** $\frac{1}{\sqrt{2}}$

☒ **C** $\sqrt{2}$

☒ **D** 2

(Total for Question 5 = 1 mark)

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6 A mixture of hydrogen and nitrogen is used to inflate a balloon.

On average, the nitrogen molecules in the mixture

☒ **A** are travelling at the same speed as the hydrogen molecules.

☒ **B** are travelling faster than the hydrogen molecules.

☒ **C** have the same momentum as the hydrogen molecules.

☒ **D** have a greater momentum than the hydrogen molecules.

(Total for Question 6 = 1 mark)

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7 Deuterium is an isotope of hydrogen. A nucleus of deuterium has a mass m_d.
It contains one proton of mass m_p and one neutron of mass m_n.

Which of the following can be used to calculate the binding energy of a deuterium nucleus?

☒ **A** $[m_d - (m_p + m_n)] \times c^2$

☒ **B** $[m_d - (m_p + m_n)] / c^2$

☒ **C** $[(m_p + m_n) - m_d] \times c^2$

☒ **D** $[(m_p + m_n) - m_d] / c^2$

(Total for Question 7 = 1 mark)

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8 When two protons are placed a small distance apart, electric and gravitational forces act on each proton.

Which statement about this situation is **not** correct?

☒ **A** The forces act along the line joining the centres of the two protons.

☒ **B** The electric force is greater than the gravitational force.

☒ **C** The electric force may be attractive or repulsive.

☒ **D** The gravitational force is attractive.

(Total for Question 8 = 1 mark)

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9 The properties of a young group of stars are compared with those of an old group of stars. Both groups contain a similar number of stars.

In the young group there will be more

☒ **A** high mass main sequence stars.

☒ **B** low mass main sequence stars.

☒ **C** red giant stars.

☒ **D** white dwarf stars.

(Total for Question 9 = 1 mark)

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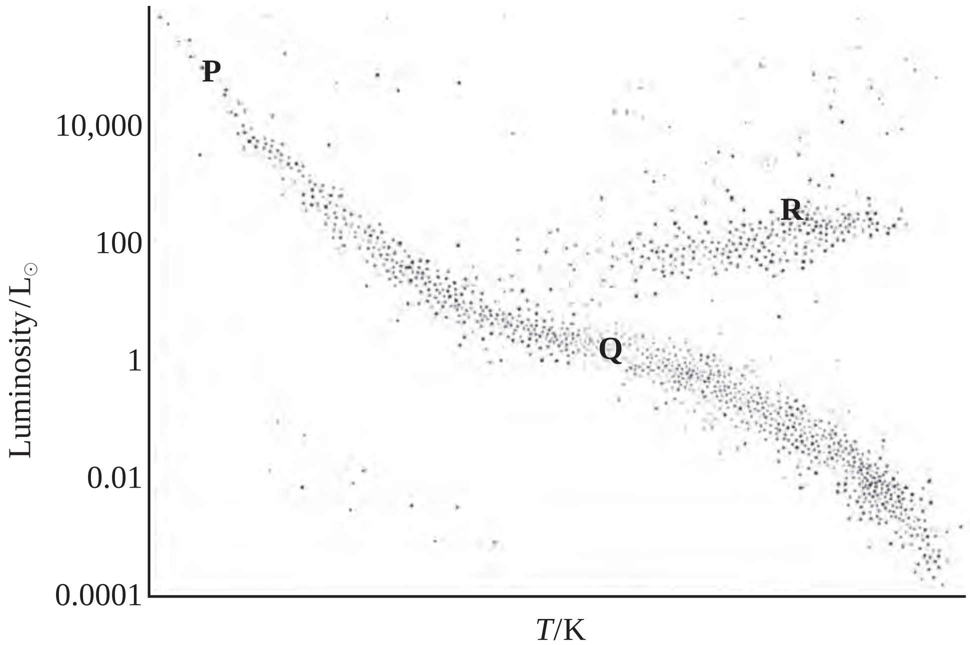
10 A Hertzsprung-Russell diagram is shown below.



As stars burn hydrogen they evolve.

Which of the following is a possible evolutionary path of a star?

☒ **A** P to Q

☒ **B** Q to R

☒ **C** Q to P

☒ **D** R to P

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 An electric heater of power 6.2 kW is used to heat the water in a shower. Water enters the shower at a temperature of 18 °C and the flow rate is adjusted to 0.075 kg s^{-1}.

(a) Calculate the temperature of the water leaving the shower.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(3)

Temperature of water leaving the shower = ...

(b) When measured, the temperature of the water leaving the shower was not as calculated. Explain why.

(2)

(Total for Question 11 = 5 marks)

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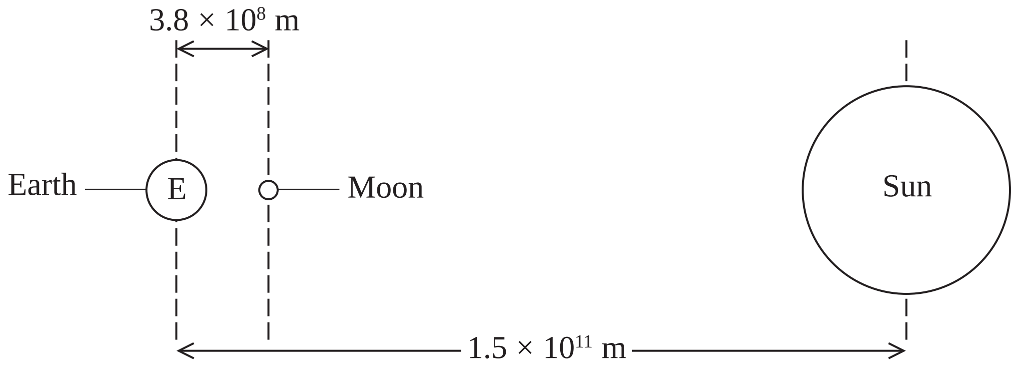
12 Tides are caused by the gravitational forces exerted by the Sun and the Moon on the water in the Earth's oceans. The diagram below (not to scale) shows the distances from the Earth to the Sun and from the Earth to the Moon.



mass of Sun = 2.0×10^{30} kg

mass of Moon = 7.0×10^{22} kg

(a) Show that the gravitational force of the Sun on the Earth is about 200 times greater than the gravitational force of the Moon on the Earth.

(2)

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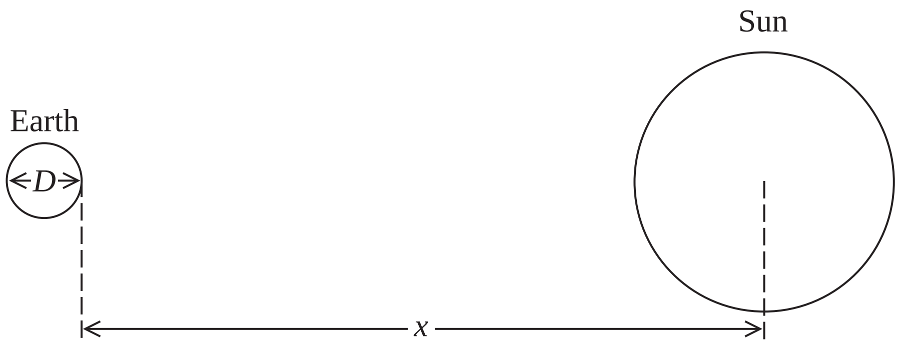
(b) The tides depend on the difference in the gravitational field strength produced by the Sun and the Moon on opposite sides of the Earth.

Gravitational field strength at a point, due to the Sun, is given by $g = \frac{GM}{r^2}$

where M = mass of Sun

r = distance of the point from the centre of Sun (not to scale).

The diagram shows the Earth and the Sun.



(i) State two expressions for the gravitational field strength at opposite sides of the Earth, due to the Sun.

(1)

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(ii) Use these expressions to explain why the Sun has a relatively small effect on the tides.

(2)

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(Total for Question 12 = 5 marks)

13 Observations of supernovae were made in the 1990s by the Hubble Space Telescope. Measurements taken from these observations gave a value for the Hubble constant of $2.365 \times 10^{-18}\ s^{-1}$.

In 2013, data from the Planck satellite gave a value for the Hubble constant of $2.171 \times 10^{-18}\ s^{-1}$.

(a) State, with a reason, a conclusion about the age of the universe that can be drawn from the change in the value of the Hubble constant.

(2)

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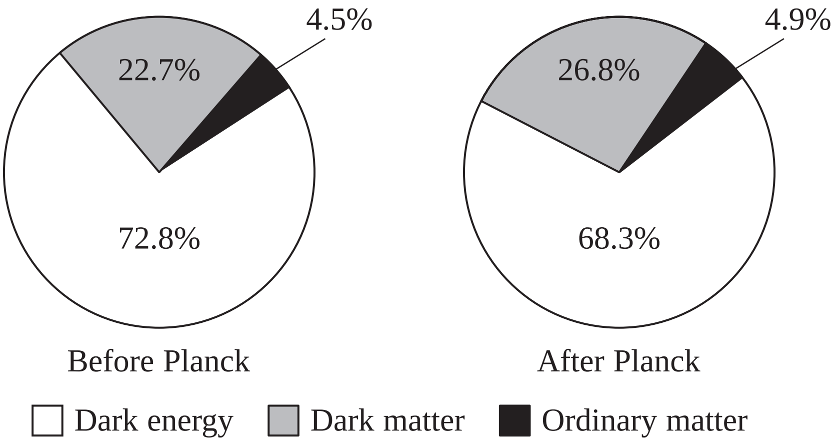
(b) The universe is believed to consist of dark energy, dark matter and ordinary matter.

The relative amounts of dark energy, dark matter and ordinary matter believed to exist in the universe have changed as a result of data from the Planck satellite.



(i) Explain what is meant by dark matter.

(2)

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(ii) Suggest how data from the Planck satellite, concerning dark matter, might change our ideas on the future of the universe.

(2)

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(Total for Question 13 = 6 marks)

14 Some sensitive scientific equipment is being transported by road. To protect the equipment, it is placed in a box which is mounted on springs. There are four springs, one at each corner of the box. Each spring has a force constant of 450 N m^{-1}.

The total mass of the equipment and the box is 4.3 kg.

The period T of a mass m attached to a spring of force constant k and set into oscillation is given by

$$T = 2\pi\sqrt{\frac{m}{k}}$$

(a) Calculate the natural frequency of oscillation of the box when it is carrying the equipment.

(3)

Natural frequency = ...

(b) State what is meant by simple harmonic motion and why the oscillation of the box is an example of this.

(3)

(Total for Question 14 = 6 marks)

15 Party balloons are often filled with helium so that they float in the air. The helium is supplied from a small, metal canister containing helium gas under pressure.

The canister contains enough helium to inflate 50 balloons, each to a volume of 8.2×10^{-3} m^3. When inflated each balloon contains 2.2×10^{23} atoms of helium.

(a) Show that at a temperature of 293 K the pressure exerted by the gas in a balloon is about 1×10^5 Pa.

(2)

(b) At a temperature of 293 K the pressure in the canister when full of helium is 2.3×10^6 Pa. Calculate the volume of the canister.

(2)

Volume = ...

(c) The pressure in the canister decreases as helium is used to fill the balloons. Explain why this is the case, including ideas of momentum in your answer.

(3)

(Total for Question 15 = 7 marks)

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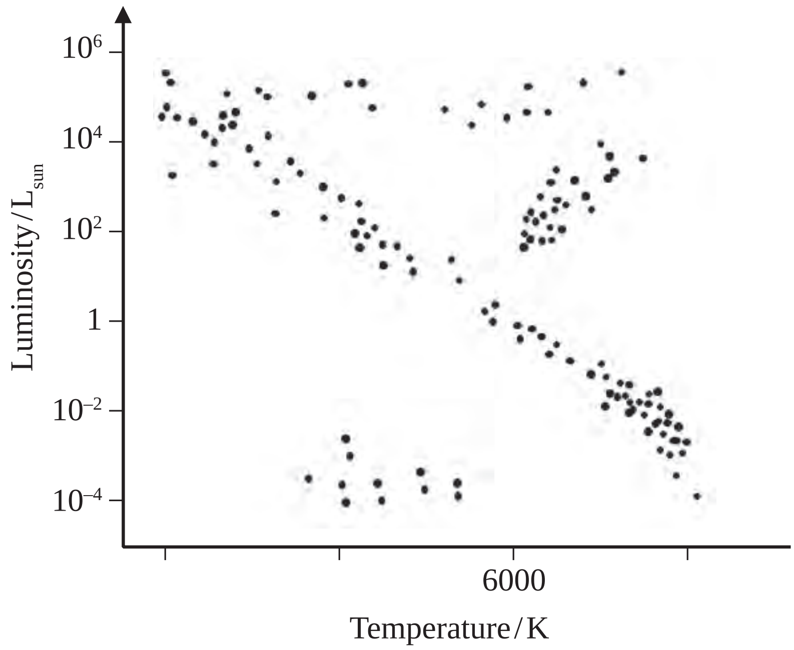
16 The Hertzsprung-Russell diagram is a plot of luminosity against temperature for a range of stars.



(a) Add a suitable temperature scale to the diagram.

(2)

(b) (i) Circle the area on the diagram where you would expect white dwarf stars to be located.

(1)

*(ii) Explain, in terms of the physical processes occurring in the star, why white dwarf stars are so named and would be located in this area.

(4)

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(Total for Question 16 = 7 marks)

17 A drum is played by striking a circular membrane with a drumstick. The resulting vibration of the membrane may produce resonance.

(a) (i) Explain what is meant by resonance.

(2)

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(ii) Suggest why a larger diameter membrane would produce a lower frequency note when the drum is struck.

(1)

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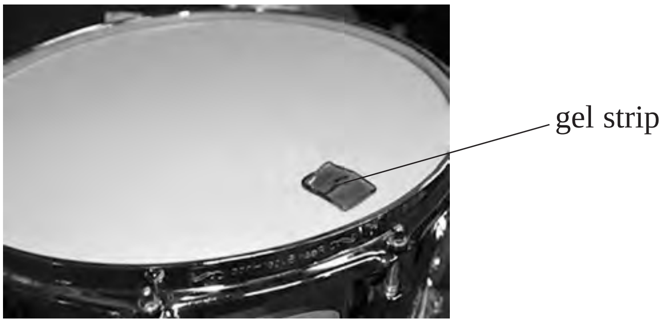
(b) The sound produced when the drum is struck may persist for too long and so damping is used. Some drummers attach strips of a gel to the drum membrane. The gel is able to deform plastically and hence shorten the time that the drum sounds.

gel strip



gel strip attached to drum skin

(i) State what is meant by damping.

(2)

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(ii) Explain how a gel that can deform plastically is able to produce damping.

(3)

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(Total for Question 17 = 8 marks)

18 At the top of the Earth's atmosphere the measured radiation flux of the Sun is 1.36 kW m^{-2}.

(a) (i) Show that the luminosity of the Sun is about 4×10^{26} W.

distance from Earth to the Sun = 1.50×10^{8} km

(2)

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(ii) The luminosity of a star depends on its surface area and temperature.

Calculate the radius of a star that has a surface temperature of 4000 K and luminosity 100 times that of the Sun.

(2)

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Radius of star = ...

(b) B030D is a supergiant star in the Andromeda galaxy. Through a telescope this star is observed to be a yellow star.

(i) When the spectrum of light from B030D is analysed a line, identified as the hydrogen α line, occurs at a wavelength 654.58 nm. The wavelength of this line in the laboratory is 656.29 nm.

State what conclusion can be made about B030D from this data. Your answer should include a calculation.

(3)

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(ii) A student states that blue stars are cooler than yellow stars. Use Wien's law to comment on the accuracy of this statement.

(2)

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(Total for Question 18 = 9 marks)

19 Carbon-12 is the stable isotope of carbon; most carbon exists in this form.

Carbon-14 is formed in the upper atmosphere. Carbon-14 is radioactive and decays randomly by emitting β^- particles.

(a) Carbon-14 is formed when a nitrogen nucleus absorbs a neutron.

(i) Complete the nuclear equation representing the formation of carbon-14 and identify the particle X.

(3)

$$^{\dots}_{\dots}\mathrm{n} + {}^{14}_{7}\mathrm{N} \rightarrow {}^{14}_{6}\mathrm{C} + {}^{\dots}_{\dots}\mathrm{X}$$

X is ....

(ii) State what is meant by decays randomly.

(1)

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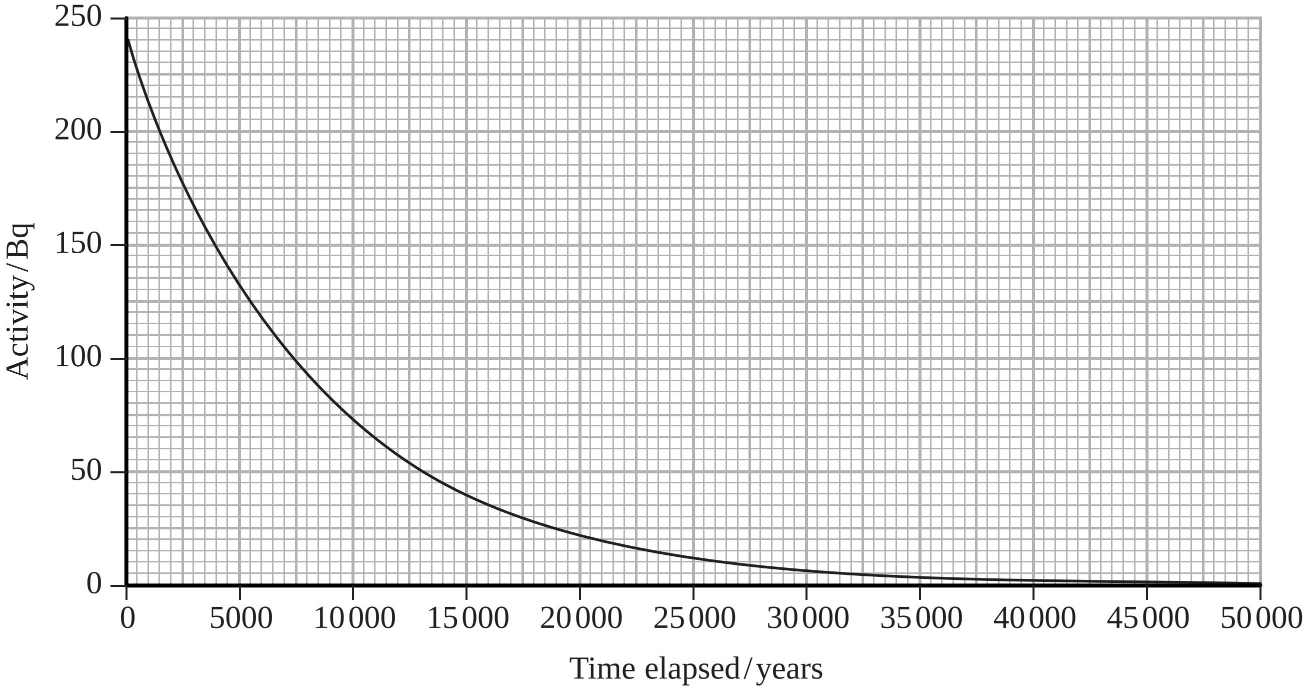
(b) Carbon is taken in by living organisms throughout their lives. Whilst an organism is alive, the ratio of carbon-14 to carbon-12 in the organism stays the same.

From the time that the organism dies, the ratio of carbon-14 to carbon-12 decreases. Hence certain ancient objects can be dated using the decay of carbon-14.

An activity-time graph for carbon-14 is shown.



Use the graph to show that the half-life of carbon-14 is about 6000 years.

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(c) A scientist is trying to determine the age of an ancient wooden object. A sample prepared from this object gives a corrected count rate of 10.9 Bq. The corrected count rate of a sample obtained from living wood is 29.6 Bq. The two samples have the same mass.

(i) State why the count rates have to be corrected.

(1)

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(ii) State one procedure that would increase the accuracy obtained for the count rates of these samples.

(1)

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(iii) Calculate the age of the ancient object.

Assume the half-life of carbon-14 is 6000 years.

(3)

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Age of ancient object = ...

(d) A news report claims that a dinosaur skull has been found, and suggests that the skull is 68 million years old.

Explain why carbon-14 dating could not have been used to determine the age of this skull.

(2)

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*(e) A website includes the following statement about heavy nuclei:

> Particles in the nucleus are held together by a force scientists call nuclear binding energy. It is possible to overcome the binding energy in some large atoms, such as uranium atoms, causing the atoms to undergo fission.

Comment on this statement.

(4)

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(Total for Question 19 = 17 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

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	$v = u + at$ $s = ut + ½at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = ½mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
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	$E_{el} = ½F\Delta x$

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	$hf = \phi + ½mv^2_{max}$

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	$W = ½QV$
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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{\frac{1}{2}}$
	$N = N_0 \mathrm{e}^{-\lambda t}$

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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