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

Wednesday 21 June 2017 – 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.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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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 Astronomers use standard candles to make measurements of distances to star clusters.

A standard candle is an object of known

☒ **A** brightness.

☒ **B** distance.

☒ **C** luminosity.

☒ **D** size.

(Total for Question 1 = 1 mark)

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2 Some mobile phones may be set to vibrate rather than ring. A mobile phone is placed on a wooden table and sets the table into oscillation as it vibrates. The vibration now sounds louder.

This is an example of

☒ **A** free oscillation.

☒ **B** forced oscillation.

☒ **C** resonance.

☒ **D** standing waves.

(Total for Question 2 = 1 mark)

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3 Radioactive decay is a random process.

'Random' means that we cannot know

☒ **A** how much energy will be released.

☒ **B** the probability that a nucleus will decay per unit time.

☒ **C** what type of radiation will be emitted.

☒ **D** which nucleus will decay next.

(Total for Question 3 = 1 mark)

4 If hot liquid wax is left to cool, it will start to solidify at 45 °C. The temperature of the wax will remain constant until all the wax has solidified.

Select the row in the table that correctly describes how molecular energy will change as the wax solidifies.

	Molecular kinetic energy	Molecular potential energy
☒ **A**	decreases	decreases
☒ **B**	decreases	stays constant
☒ **C**	stays constant	decreases
☒ **D**	stays constant	stays constant

(Total for Question 4 = 1 mark)

5 In a damped oscillation, a force acts to change the amplitude of oscillation.

Which of the following statements about the direction of this force is correct?

☒ **A** The force is in the opposite direction to the displacement.

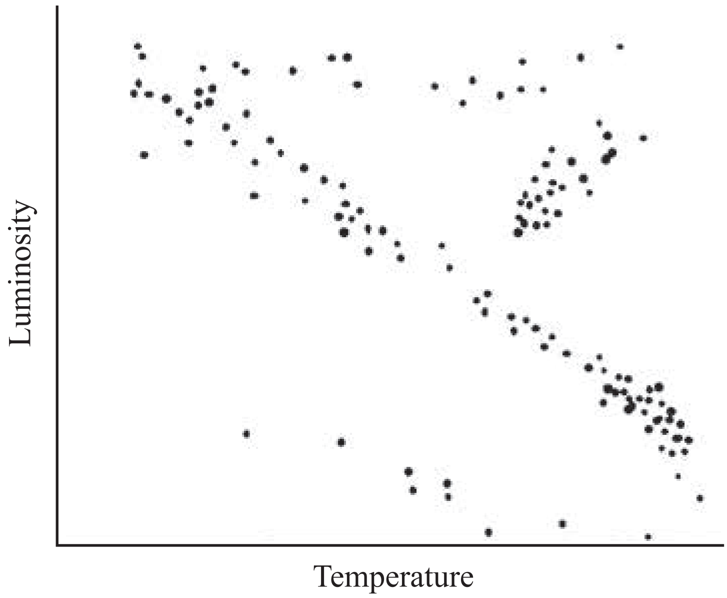
☒ **B** The force is in the opposite direction to the velocity.

☒ **C** The force is in the same direction as the displacement.

☒ **D** The force is in the same direction as the velocity.

(Total for Question 5 = 1 mark)

6 The Hertzsprung-Russell diagram is a scatter graph of luminosity against temperature for stars.



A star is located near to the top end of the main sequence.

Select the row in the table that correctly compares the mass and temperature of the star to those of the Sun.

	Mass	Temperature
☒ **A**	larger	higher
☒ **B**	larger	lower
☒ **C**	smaller	higher
☒ **D**	smaller	lower

(Total for Question 6 = 1 mark)

7 Stellar parallax is used by astronomers to determine the distances to stars.

Why can this method only be used for some stars?

☒ **A** The effect is too small for nearby stars.

☒ **B** The effect is too large for nearby stars.

☒ **C** The effect is too small for distant stars.

☒ **D** The effect is too large for distant stars.

(Total for Question 7 = 1 mark)

8 Nuclear fusion requires extreme conditions for the hydrogen fuel.

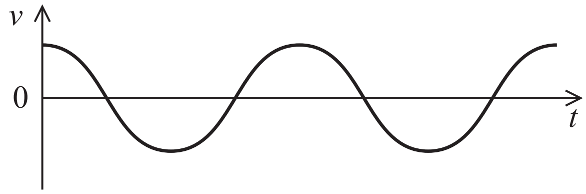
In order for any nuclei to fuse, which of the following is essential?

- ☒ **A** very high density
- ☒ **B** very high pressure
- ☒ **C** very high temperature
- ☒ **D** very large mass

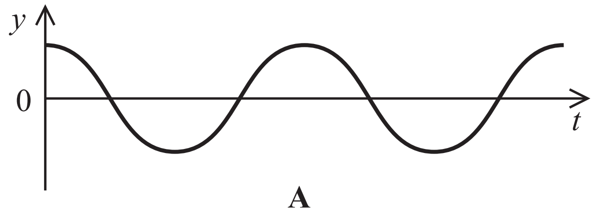
(Total for Question 8 = 1 mark)

Questions 9 and 10 relate to the graph below.

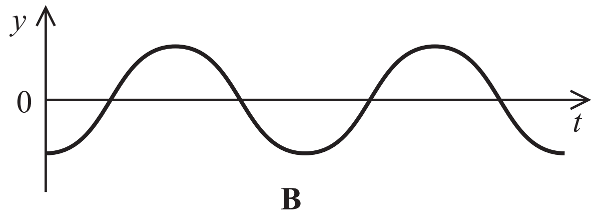
The graph shows how the velocity *v* varies with time *t* for an object undergoing simple harmonic motion.



The following graphs show how other quantities for the object may vary with *t* over the same time period.



A



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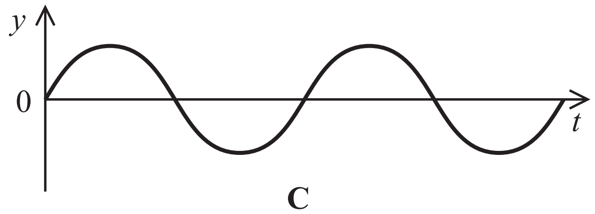
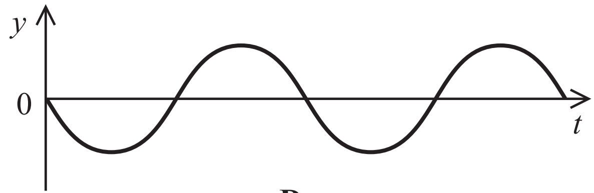


C



D

9 Select the graph which shows the variation of displacement from the equilibrium position with time.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

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10 Select the graph which shows the variation of acceleration with time.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

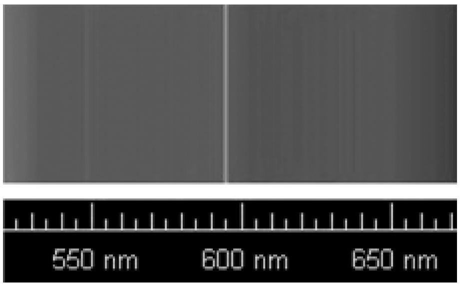
TOTAL FOR SECTION A = 10 MARKS

SECTION B

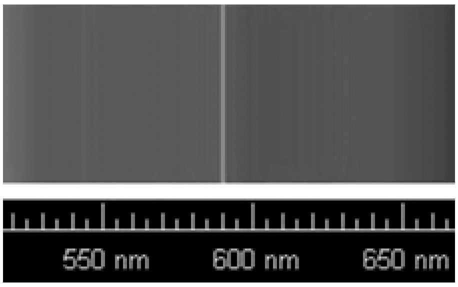
Answer ALL questions in the spaces provided.

11 The two images show a small part of the spectrum produced by helium. One image is a spectrum produced in a laboratory and the other is a spectrum produced by the light from a star.

Both images contain a bright yellow line. In the spectrum produced by light from the star, the yellow line is shifted in wavelength.



spectrum produced in a laboratory



spectrum produced by light from a star

Calculate the magnitude of the velocity of the star relative to the Earth.

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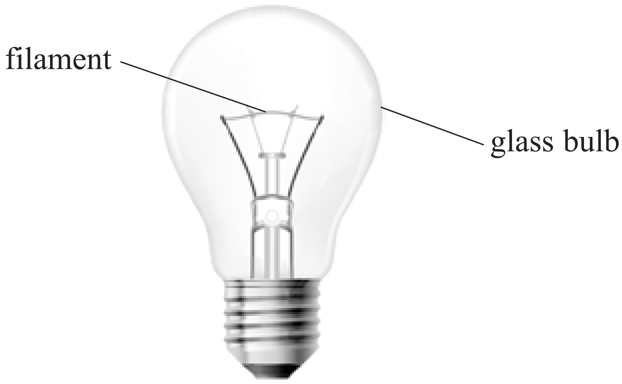
Velocity of star = ...

(Total for Question 11 = 3 marks)

12 Some light bulbs consist of a metal filament inside a glass bulb. The bulb may be filled with a mixture of gases to reduce vaporisation of the filament.



(a) The glass bulb contains a mixture of krypton gas and xenon gas at room temperature. The mean squared speed of the krypton molecules is 8.72×10^4 m^2 s^{-2}.

Calculate the mean squared speed of the xenon molecules.

mass of 1 molecule of krypton = 1.39×10^{-25} kg
mass of 1 molecule of xenon = 2.18×10^{-25} kg

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Mean squared speed = ... m^2 s^{-2}

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*(b) When a current flows through the filament, the gas in the bulb heats up and the pressure exerted by the gas increases.

Explain, including ideas of momentum, why the pressure exerted by the gas increases.

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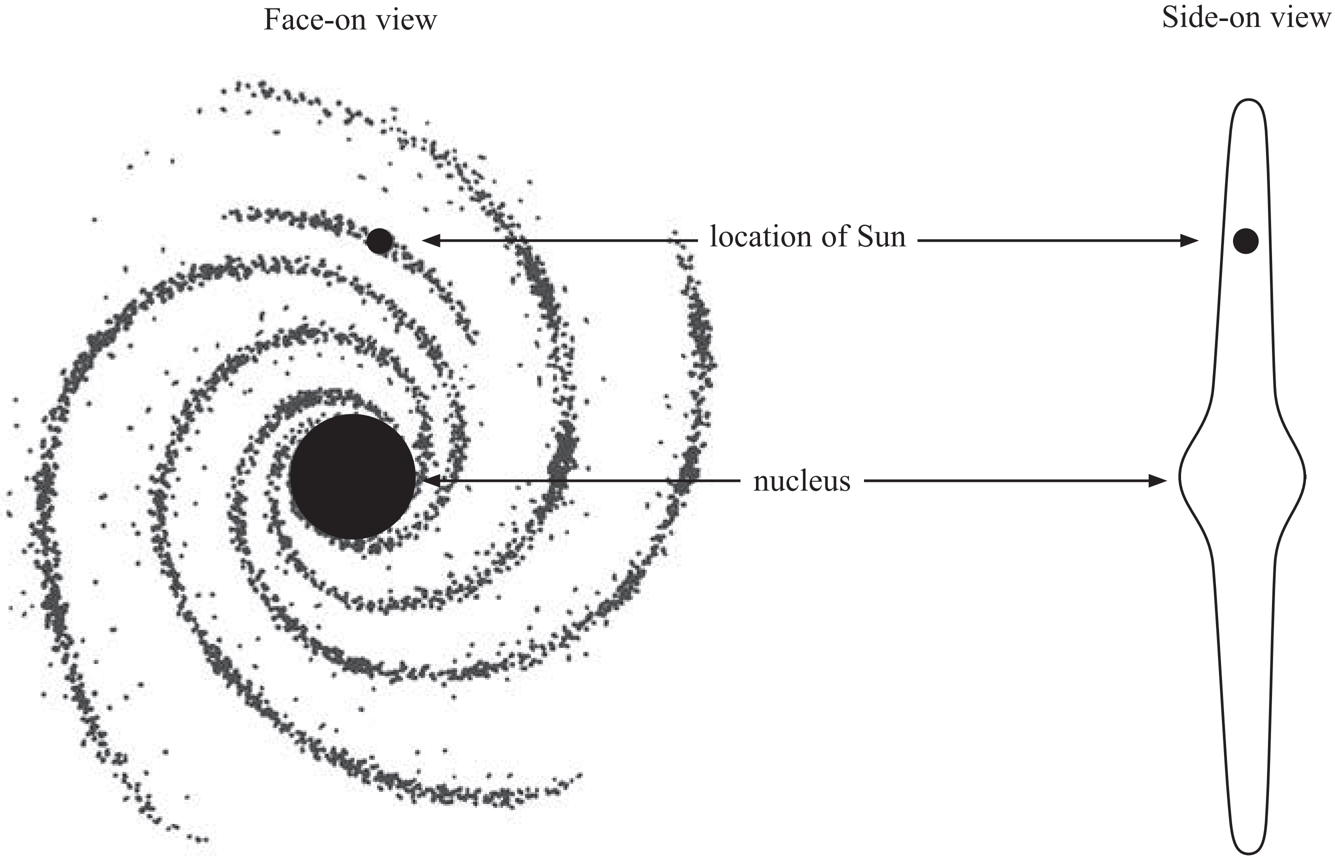
(Total for Question 12 = 6 marks)

13 The Sun is one of about 10^{11} stars in the Milky Way galaxy. The vast majority of stars in the Milky Way are observed to be within its nucleus. The Sun lies on the Sagittarius arm of the Milky Way, about 27 000 light years from the centre of the galaxy, as shown.



(a) The galaxy is rotating about its centre and astronomers estimate that the Sun makes one complete revolution every 240 million years.

(i) Show that the angular velocity of the Sun ω_{Sun}, about the centre of the galaxy, is about 8×10^{-16} rad s^{-1}.

1 year = 3.15×10^{7} s

(2)

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(ii) Use Newton's law of gravitation to show that, for any star outside the nucleus, $\omega^2 \propto 1/r^3$ where r is the distance between the star and the centre of the galaxy.

(2)

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(iii) Use the expression from (ii), together with the value of ω_{Sun} from (i), to calculate a value for the angular velocity ω_{star} of a star similar to the Sun, but located at the edge of the Milky Way.

diameter of galaxy ≈ 100 000 light years

(2)

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ω_{star} = ...

(b) In fact, stars similar to the Sun, but further away from the centre of the galaxy, are observed to have angular velocities that are all approximately the same.

Explain what astronomers can conclude from these observations.

(2)

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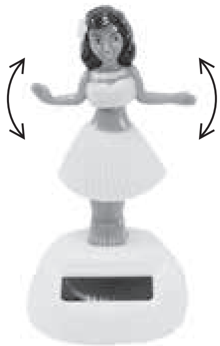
(Total for Question 13 = 8 marks)

14 The photograph shows a dancing "hula girl" toy. The toy uses energy from the Sun to make the girl dance. When the solar cell is illuminated the girl's arms move with simple harmonic motion.



(a) State the conditions for an object to move with simple harmonic motion.

(2)

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(b) (i) The time t for 50 oscillations of the arms is measured three times and the values obtained are recorded in the table.

t_1/s	t_2/s	t_3/s
18.9	19.2	19.1

Show that the arms oscillate with a frequency of about 2.6 Hz.

(3)

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(ii) From the top to the bottom of the movement, the hands travel a distance of 0.75 cm.

Calculate the maximum speed of the hands.

(3)

Maximum speed of hands = ...

(Total for Question 14 = 8 marks)

15 Basketballs are usually made from a leather composite and are filled with air. A standard basketball has a total mass of 0.620 kg and a volume of 8.18×10^{-3} m^3.

(a) A basketball is filled with air at a pressure of 1.55×10^5 Pa and at a temperature of 20 °C.

Calculate the number of air molecules inside the basketball.

(3)

Number of air molecules = ...

(b) A standard basketball rebounds to a height of between 1.40 m and 1.60 m when dropped onto a hard surface from a height of 1.80 m.

(i) Show that the maximum allowable decrease in kinetic energy during the bounce is about 2.4 J.

(3)

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(ii) The specific heat capacity of the basketball can be taken to be 1170 J kg^{-1} K^{-1}.

Calculate the number of times a standard basketball must be dropped from 1.80 m to increase the temperature of the basketball and the air inside by 0.5 °C.

(3)

Number of times basketball must be dropped = ...

(iii) State one assumption that you had to make to calculate the number of times that the basketball had to be dropped.

(1)

(Total for Question 15 = 10 marks)

16 One method for sterilising metallic surgical instruments is irradiating them. The instruments are sealed in plastic packages and then passed in front of a radioactive isotope.

*(a) By considering relevant properties of each type of radiation, determine whether α, β, or γ radiation would be most appropriate for this method.

(4)

(b) A radioactive isotope commonly used as a source for the radiation has a half-life of 5.27 years. A sample of this isotope contains 5.02×10^{13} unstable nuclei when it is new.

(i) Show that the activity of the sample when it is new is about 2×10^5 Bq.
1 year = 3.15×10^7 s

(3)

(ii) The activity of the sample decreases over time.

Calculate the time, in years, until the activity of the sample decreases to 8.0 kBq.

(3)

Time = ... years

(c) A technician is checking the activity of a radioactive source.

Describe how the technician should safely handle the source.

(2)

(Total for Question 16 = 12 marks)

17 Americium-241(Am) is an artificially produced radioactive isotope which was commonly used in smoke detectors. It decays through emission of an α-particle to neptunium (Np).

(a) (i) Complete the nuclear equation which represents the decay of americium.

(2)

$$^{241}_{95}\text{Am} \rightarrow \;^{\cdots}_{\cdots}\text{Np} + \;^{\cdots}_{\cdots}\alpha$$

*(ii) Explain why most of the energy released in the decay becomes kinetic energy of the α-particle.

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(b) The table gives masses of an americium nucleus and its constituent particles.

	Mass / u
^{1}p	1.00728
^{1}n	1.00866
^{241}Am	241.00471

Calculate the binding energy per nucleon, in J, of americium-241.

(4)

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Binding energy per nucleon = ... J

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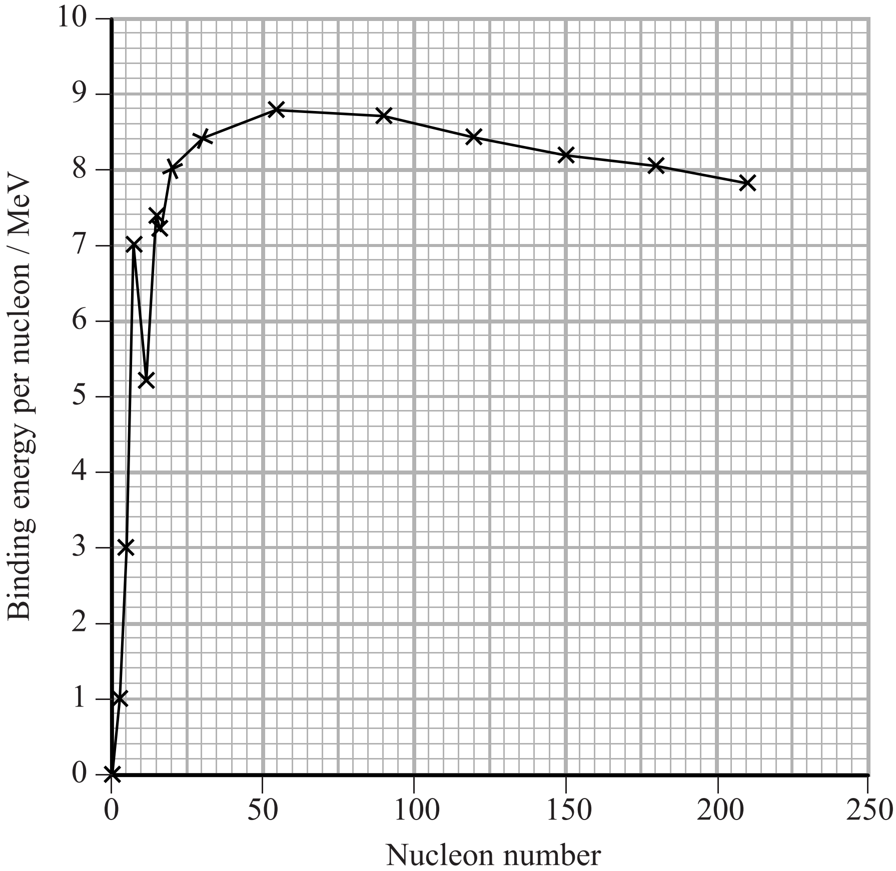
(c) The graph shows how the binding energy per nucleon varies with nucleon number for a range of nuclides.



Use the graph to explain why the fission of nuclei with large numbers of nucleons releases large amounts of energy.

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(Total for Question 17 = 12 marks)

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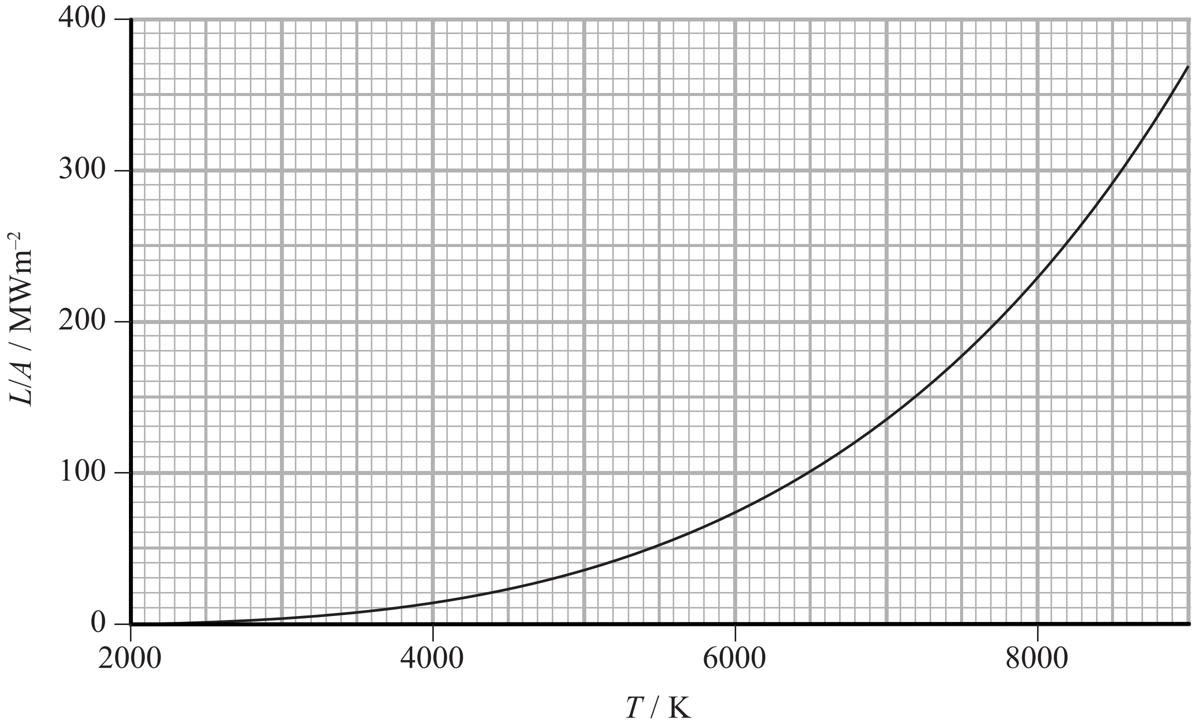
18 A black body of surface area A has luminosity L. The graph shows how the radiated flux L/A varies with temperature T.



(a) (i) Using data from the graph show that the luminosity of the Sun is about 4×10^{26} W.

surface temperature of the Sun = 5900 K

radius of the Sun = 6.96×10^{8} m

(3)

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(ii) Calculate the radiation flux F from the Sun at the top of the Earth's atmosphere.

distance from Sun to Earth = 1.50×10^{11} m

(2)

F = ...

(iii) Suggest why the total rate at which energy from the Sun arrives at the top of the Earth's atmosphere is much less than $F \times A$, where A is the area of the spherical surface representing the top of the atmosphere.

(2)

(b) The Sun is often referred to as a yellow star.

(i) Show that the wavelength λ_{max} at which peak energy emission occurs for the Sun is about 5×10^{-7} m.

(2)

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(ii) The visible region of the electromagnetic spectrum extends from a wavelength of about 400 nm to a wavelength of about 700 nm.

Suggest why light from the Sun is white rather than yellow.

(2)

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(Total for Question 18 = 11 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	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
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	$F = 6\pi\eta rv$
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	$E_{el} = \frac{1}{2}F\Delta x$

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	$hf = \phi + \frac{1}{2}mv^2_{max}$

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	$Q = Q_0 e^{-t/RC}$
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	$v = H_0 d$