Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 15 January 2026

Morning (Time: 1 hour 45 minutes)

Paper reference **WPH15/01**

Physics

International Advanced Level
UNIT 5: Thermodynamics, Radiation, Oscillations and Cosmology

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- **Show all your working out** in calculations and **include units** where appropriate.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- The list of data, formulae and relationships is printed at the end of this booklet.

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 7 9 1 4 7 R A 0 1 3 6

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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 student investigated the absorption of gamma radiation. He measured the background radiation.

Which of the following should he do to correct the count rate for the gamma radiation?

☒ **A** add the background count

☒ **B** subtract the background count

☒ **C** add the background count rate

☒ **D** subtract the background count rate

(Total for Question 1 = 1 mark)

2 Earthquakes can cause buildings to oscillate. The effects can be reduced by damping the oscillations using ductile materials.

Which of the following describes a ductile material?

☒ **A** It behaves elastically under compression.

☒ **B** It can undergo significant plastic deformation.

☒ **C** It withstands a large stress before breaking.

☒ **D** It has a large Young modulus.

(Total for Question 2 = 1 mark)

3 Which of the following is a unit for intensity?

☒ **A** $\mathrm{W\,m^{-2}}$

☒ **B** $\mathrm{N\,m}$

☒ **C** $\mathrm{J\,s^{-1}}$

☒ **D** $\mathrm{J\,m^{-1}}$

(Total for Question 3 = 1 mark)

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4 The distances to nearby stars can be determined using trigonometric parallax. Star X has twice the parallax angle of Star Y.

Which of the following statements is correct?

- ☒ **A** The distance to X is 4 times the distance to Y.
- ☒ **B** The distance to X is 2 times the distance to Y.
- ☒ **C** The distance to X is 0.5 times the distance to Y.
- ☒ **D** The distance to X is 0.25 times the distance to Y.

(Total for Question 4 = 1 mark)

5 The ultimate fate of the universe is uncertain.

Which of the following is true for an open universe?

- ☒ **A** The average density of the universe is equal to the critical density of the universe.
- ☒ **B** The average density of the universe is less than the critical density of the universe.
- ☒ **C** The mass of the universe is equal to the critical mass of the universe.
- ☒ **D** The mass of the universe is greater than the critical mass of the universe.

(Total for Question 5 = 1 mark)

6 Which of the following describes the spontaneous nature of radioactive decay?

- ☒ **A** The decay is a natural process.
- ☒ **B** The decay is a random process.
- ☒ **C** We cannot influence when the next decay will occur.
- ☒ **D** We cannot predict when the next decay will occur.

(Total for Question 6 = 1 mark)

7 Star cluster P is twice as far from Earth as star cluster Q.

The intensity of light from a standard candle in P is I_P.

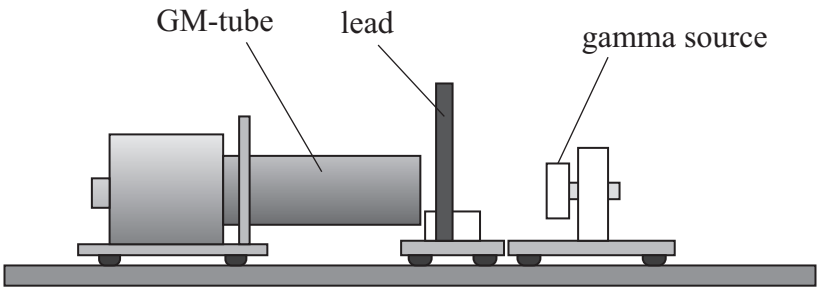
The intensity of light from the same type of standard candle in Q is I_Q.

Which of the following is equal to the ratio $\frac{I_P}{I_Q}$?

- ☒ **A** $\frac{1}{4}$
- ☒ **B** $\frac{1}{2}$
- ☒ **C** 2
- ☒ **D** 4

(Total for Question 7 = 1 mark)

8 A student investigated the absorption of gamma radiation by lead. She placed a GM-tube a few centimetres from a gamma source, as shown.



The corrected count rate without the lead was 240 counts per minute.
Lead with a thickness of 2.5 mm absorbs 50% of gamma radiation.

Which of the following could be the corrected count rate when lead with a thickness of 4.0 mm is used?

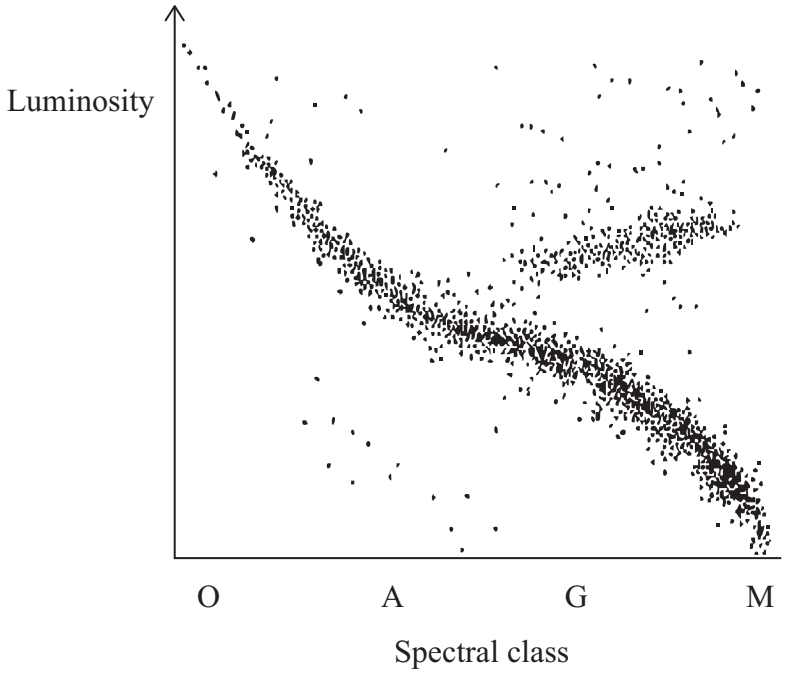
- ☒ **A** 60 counts per minute
- ☒ **B** 80 counts per minute
- ☒ **C** 120 counts per minute
- ☒ **D** 150 counts per minute

(Total for Question 8 = 1 mark)

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9 A student finds the diagram shown on a website. He notices that the labels on the axes are different from those in his textbook.

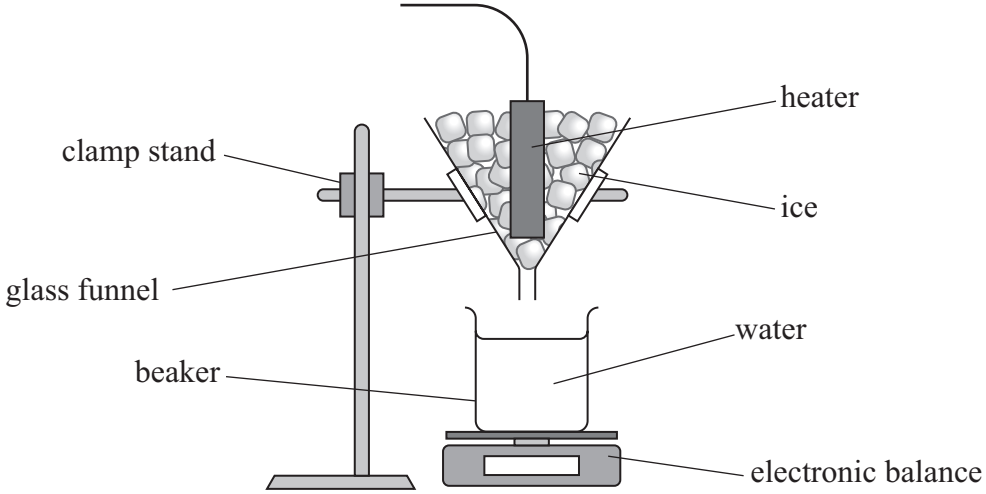


Which row of the table gives the spectral class of each type of star?

	Cool giant stars	Hot giant stars	Cool dwarf stars	Hot dwarf stars
☒ **A**	O	G	A	M
☒ **B**	O	G	M	A
☒ **C**	G	O	A	M
☒ **D**	G	O	M	A

(Total for Question 9 = 1 mark)

10 A student used a heater to melt ice, as shown.



The heater was switched on for time *t*.

The student measured the mass of water that dripped into the beaker. She used her results to calculate the specific latent heat of fusion of water *L*.

Which of the following explains why the calculated value of *L* was less than the accepted value?

☒ **A** The initial temperature of the ice was less than 0 °C.

☒ **B** The time recorded by the student was greater than *t*.

☒ **C** Some of the melted water did not drip into the beaker.

☒ **D** Some energy was transferred to the ice from the surroundings.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

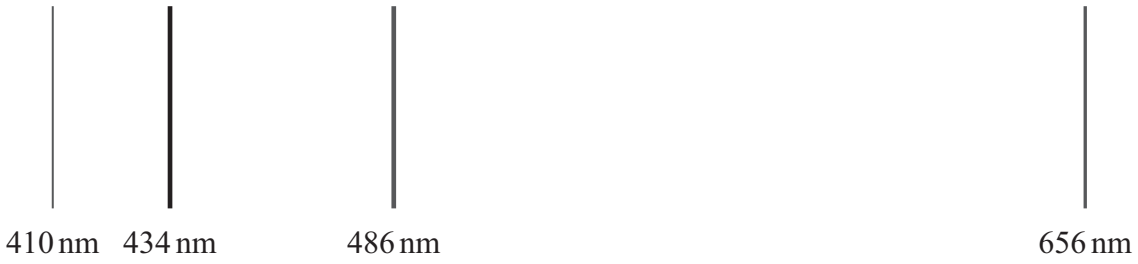
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SECTION B

Answer ALL questions in the spaces provided.

11 The spectrum of atomic hydrogen has four lines in the visible region, as shown.



The hydrogen spectrum for light from a nearby galaxy is analysed. The 486 nm line is observed at a wavelength of 508 nm.

Calculate the magnitude of the velocity of the nearby galaxy relative to Earth.

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Magnitude of velocity = ...

(Total for Question 11 = 2 marks)

12 A student pours 210 g of a solution of dilute acid into a beaker. She adds 95 g of a solution of dilute alkali. The initial temperature of both solutions is 18.2 °C.

The temperature of the mixture in the beaker increases to 27.5 °C.

Calculate the total energy change as the temperature increases.

specific heat capacity of each solution = 4180 $J\,kg^{-1}\,K^{-1}$

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Total energy change = ...

(Total for Question 12 = 2 marks)

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13 Many cars have airbags that fill with nitrogen gas if the car stops suddenly.

An airbag contains 0.0875 kg of nitrogen gas at a temperature of 22 °C. The pressure in the airbag is 103 kPa.

Calculate the volume of the airbag.

mass of a nitrogen molecule = 4.67×10^{-26} kg

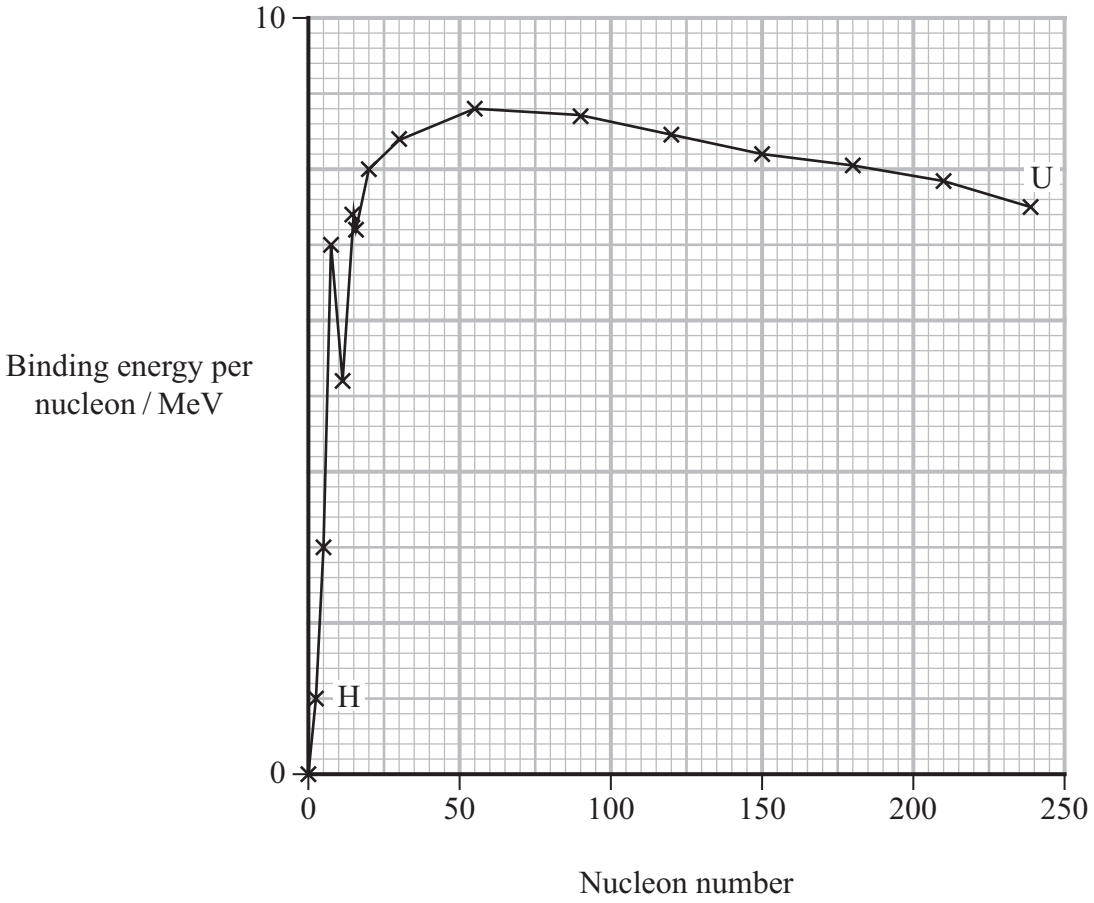
Volume of airbag = ...

(Total for Question 13 = 4 marks)

14 Nuclear fission and nuclear fusion can release enormous amounts of energy.

(a) The graph shows how the binding energy per nucleon varies with nucleon number.

Uranium, U, and hydrogen, H, are marked on the graph.



Explain why the fission of a uranium nucleus emits much more energy than the fusion of two hydrogen nuclei.

You do not need to carry out any calculations.

(3)

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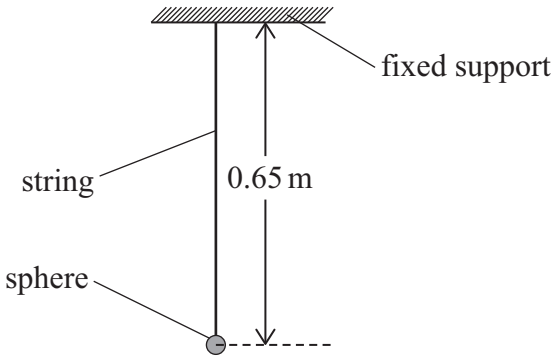
*(b) Nuclear fusion occurs in the cores of main sequence stars.

Explain the conditions that bring about and maintain fusion in a main sequence star.

(6)

(Total for Question 14 = 9 marks)

15 A simple pendulum has a length of 0.65 m, as shown.



The sphere is displaced and then released.

(a) Show that the period of oscillation of the pendulum is about 1.6 s.

(2)

(b) The amplitude of the oscillation is 2.5 cm.

Calculate the maximum kinetic energy of the sphere.

mass of sphere = 9.5×10^{-2} kg

(4)

Maximum kinetic energy = ...

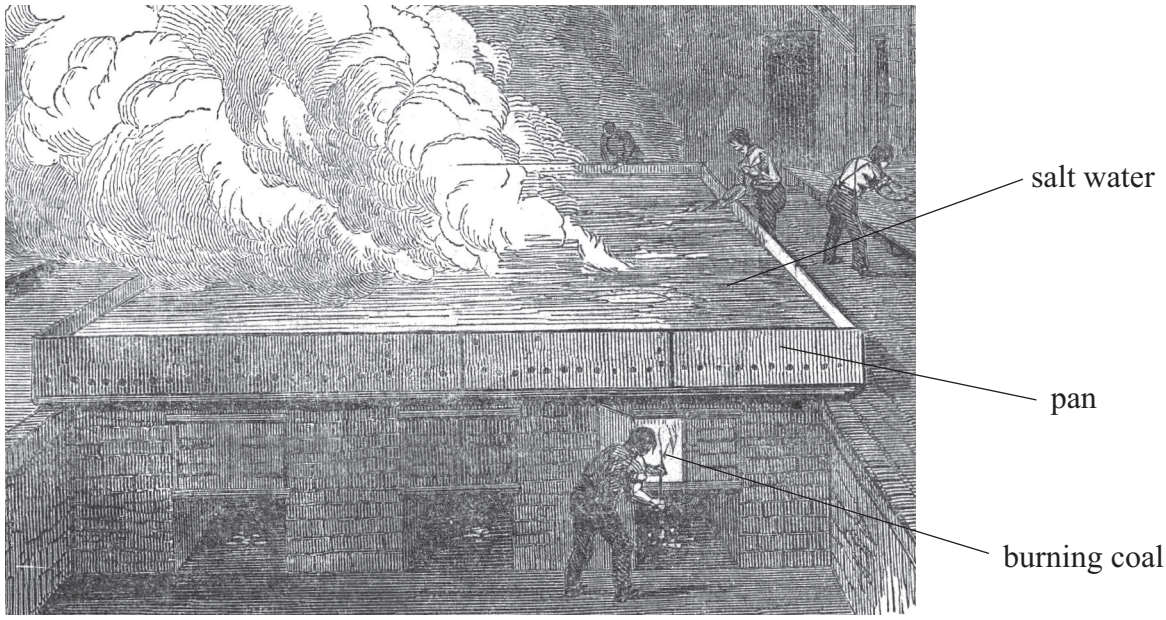
(Total for Question 15 = 6 marks)

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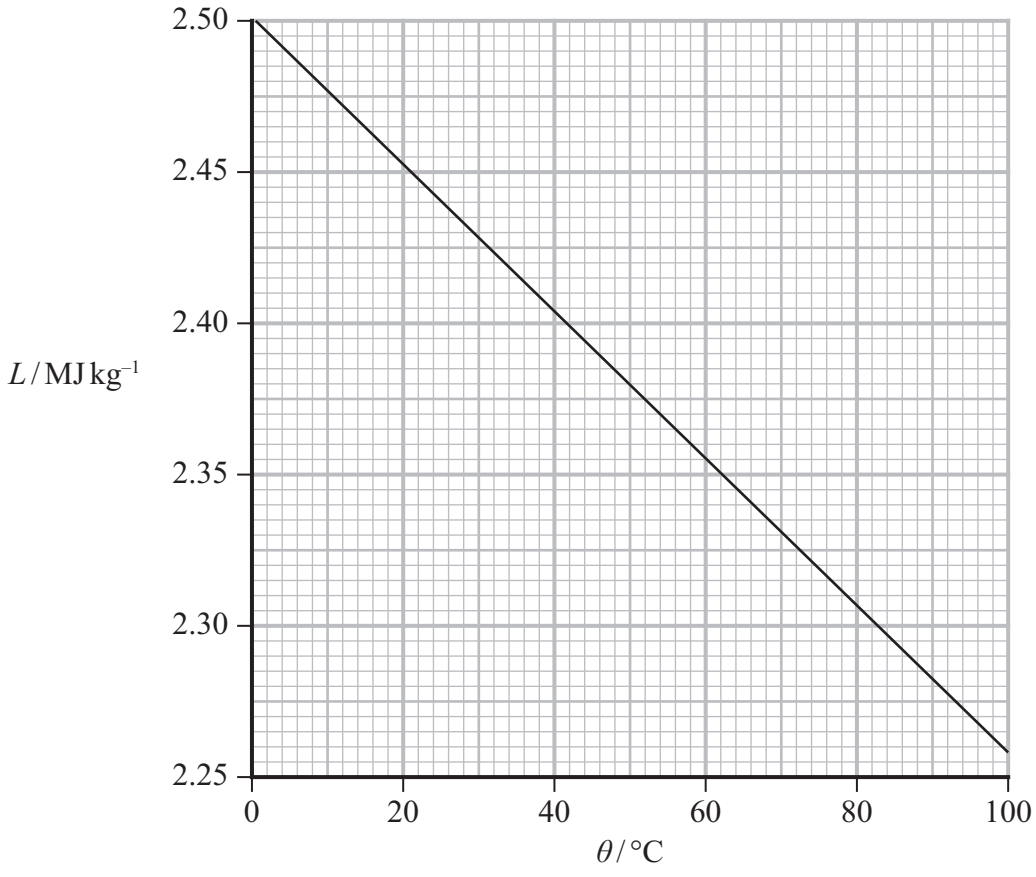
16 In 18th century England, salt was extracted on a large scale by heating salt water in open pans. The pans were heated by burning coal, as shown.



(Source: © The Print Collector/Alamy Stock Photo)

Each pan was 24 m long and 9.1 m wide. The salt water was maintained at a temperature of 66 °C.

The graph shows how the latent heat of vaporisation L of salt water varies with temperature θ.



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The following information is given in historical records:

'The pan is filled with salt water to a depth of 0.50 m.
6000 kg of coal is burned to evaporate half the water in the pan.'

Evaluate the accuracy of this information.

energy released by burning 1 kg of coal = 24 MJ
density of salt water = 1200 kg m^{-3}

(Total for Question 16 = 6 marks)

17 The International Space Station (ISS) is in a low Earth orbit.

(a) Astronauts on the ISS carry out experiments. One of the experiments is designed to detect dark matter.

State what is meant by dark matter.

(2)

(b) The ISS moves in an approximately circular orbit and has a mean height of 420 km above the surface of the Earth.

Calculate the number of complete orbits of the Earth, by the ISS, in 1 day.

mass of Earth = 6.0×10^{24} kg
radius of Earth = 6.4×10^{6} m
1 day = 86 400 s

(5)

Number of complete orbits in 1 day = ...

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(c) A student reads on a website that astronauts on the ISS experience 'weightlessness'.

The student states that astronauts on the ISS have no weight.

Assess the validity of the student's statement.

(4)

(Total for Question 17 = 11 marks)

18 Exoplanets are planets outside our solar system. Seven exoplanets orbit the star Trappist-1.

(a) Trappist-1 has a surface temperature of 2570 K and is described as a red dwarf star. A typical red dwarf star has a radius approximately equal to 10% of the radius of the Sun.

(i) Deduce whether Trappist-1 is a typical red dwarf star.

luminosity of Trappist-1 = 2.13×10^{23} W
radius of Sun = 6.96×10^{8} m

(4)

(ii) Trappist-1 emits radiation with a peak at wavelength λ_{max}

Show that λ_{max} is about 1.1×10^{-6} m.

(2)

(iii) The visible spectrum has a range of wavelengths from 400 nm to 750 nm.

Explain why Trappist-1 can be described as a red star.

(2)

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(b) One of the exoplanets is a rocky, Earth-sized planet. Scientists think this planet has an atmosphere.

(i) The exoplanet has a radius that is 92% of the radius of the Earth.

Calculate the value of the gravitational field strength at the surface of the exoplanet.

radius of Earth = 6.4×10^6 m
mass of exoplanet = 4.15×10^{24} kg

(2)

Gravitational field strength = ...

(ii) Calculate the mean kinetic energy of gas molecules at the surface of the exoplanet.

mean temperature at surface = 235 K

(2)

Mean kinetic energy = ...

(iii) Higher up in the atmosphere, the movement of charged particles causes a heating effect.

Suggest why heating the upper atmosphere may cause the density of the atmosphere to decrease.

(2)

(Total for Question 18 = 14 marks)

19 Polonium-214 is part of a naturally occurring decay chain.

(a) The nuclear equation shows the decay of polonium into lead by the emission of an alpha particle.

$$^{214}_{84}\text{Po} \rightarrow ^{210}_{82}\text{Pb} + ^{4}_{2}\alpha$$

(i) Calculate the energy in MeV released in this decay.

Isotope	Mass / u
^{214}Po	213.995186
^{210}Pb	209.984173
^{4}He	4.002603

(5)

Energy released = ... MeV

(ii) Explain why the maximum energy of the alpha particle is less than the energy released in the decay.

(2)

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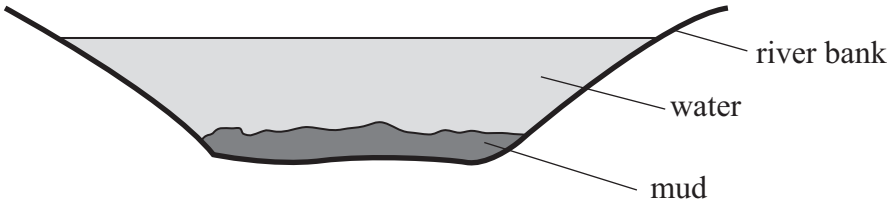
(b) The lead-210 decays to bismuth by beta emission.

(i) Complete the nuclear equation for the decay of lead-210.

(2)

$$^{210}_{82}\text{Pb} \rightarrow \text{.....} \quad \text{Bi} + \text{.....} \quad \beta^- + {}^{0}_{0}\overline{\nu}_{e}$$

(ii) A cross-section of a river is shown. Mud at the bottom of the river contains lead-210.



The activity of the lead-210 in the mud can be used to determine the age of the mud.

This method is only accurate when the activity of the lead is greater than 2.5% of the initial activity.

A textbook states that this method is **not** accurate for mud more than 100 years old.

Deduce whether the textbook is correct.

half-life of lead = 22.3 years

(4)

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(c) Radon-218 is also produced as part of this decay chain. Radon-218 is a radioactive gas that decays by emitting alpha particles.

Explain why radon gas is a potential hazard.

(2)

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(Total for Question 19 = 15 marks)

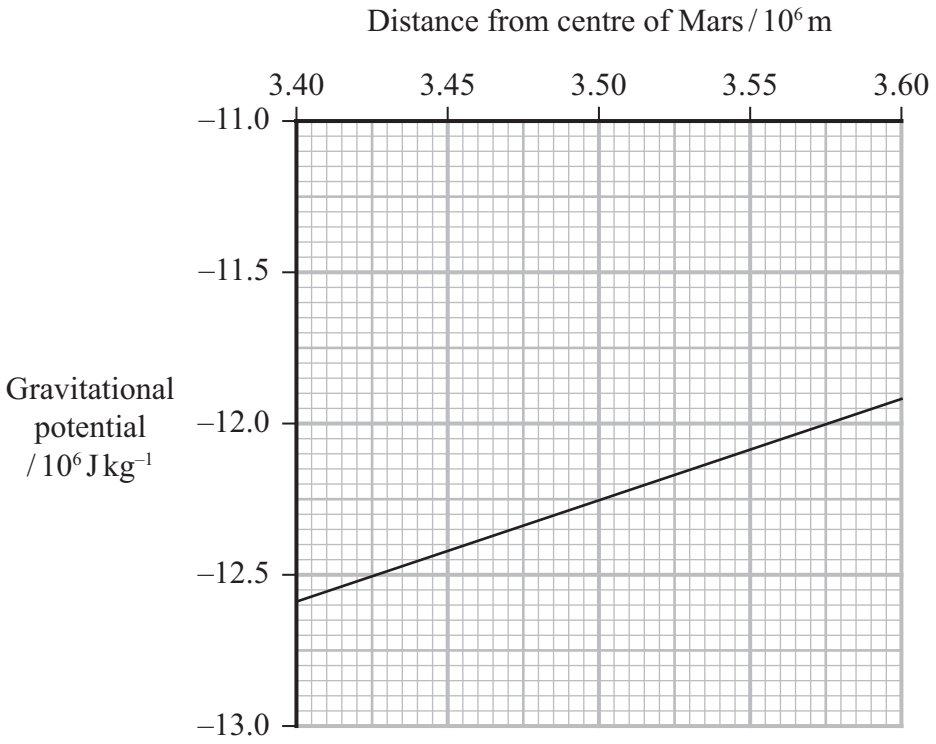
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20 The InSight Lander is a robot explorer designed to study the planet Mars.

(a) The graph shows how the gravitational potential varies above the surface of Mars.



(i) Show that the mass of Mars is about 6.4×10^{23} kg.

(3)

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(ii) In the final stage of landing, InSight moved from a height of 124 km down to the surface of Mars.

Determine the change in gravitational potential energy of InSight.

radius of Mars = 3.40×10^6 m
mass of InSight = 358 kg

(3)

Change in gravitational potential energy = ...

(iii) A parachute was used during the final stage of InSight landing on Mars.

Explain why a parachute was needed.

You should not do any further calculations.

(4)

(b) If InSight had landed on Earth, a much smaller parachute could have been used.

Suggest why the parachute used to land on Mars needed to be much larger.

(1)

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(Total for Question 20 = 11 marks)

TOTAL FOR SECTION B = 80 MARKS
TOTAL FOR PAPER = 90 MARKS

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List of data, formulae and relationships

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

Unit 1

Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

$$\Delta W = F\Delta s$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

Power

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$



Efficiency

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

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

Materials

Density $\rho = \frac{m}{V}$

Stokes' law $F = 6\pi\eta r v$

Hooke's law $\Delta F = k\Delta x$

Elastic strain energy $\Delta E_{el} = \frac{1}{2} F \Delta x$

Young modulus $E = \frac{\sigma}{\varepsilon}$ where

Stress $\sigma = \frac{F}{A}$

Strain $\varepsilon = \frac{\Delta x}{x}$

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Unit 2

Waves

Wave speed	$v = f\lambda$
Speed of a transverse wave on a string	$v = \sqrt{\frac{T}{\mu}}$
Intensity of radiation	$I = \frac{P}{A}$
Refractive index	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
	$n = \frac{c}{v}$
Critical angle	$\sin C = \frac{1}{n}$
Diffraction grating	$n\lambda = d\sin\theta$

Electricity

Potential difference	$V = \frac{W}{Q}$
Resistance	$R = \frac{V}{I}$
Electrical power, energy	$P = VI$
	$P = I^2R$
	$P = \frac{V^2}{R}$
	$W = VIt$
Resistivity	$R = \frac{\rho l}{A}$
Current	$I = \frac{\Delta Q}{\Delta t}$
	$I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Particle nature of light

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$
de Broglie wavelength	$\lambda = \frac{h}{p}$

Unit 4

Further mechanics

Impulse	$F\Delta t = \Delta p$
Kinetic energy of a non-relativistic particle	$E_k = \frac{p^2}{2m}$
Motion in a circle	$v = \omega r$
	$T = \frac{2\pi}{\omega}$
	$a = \frac{v^2}{r}$
	$a = r\omega^2$
Centripetal force	$F = ma = \frac{mv^2}{r}$
	$F = mr\omega^2$

Electric and magnetic fields

Electric field	$E = \frac{F}{Q}$
Coulomb's law	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \frac{V}{d}$
Electrical potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \frac{Q}{V}$
Energy stored in capacitor	$W = \frac{1}{2}QV$
	$W = \frac{1}{2}CV^2$
	$W = \frac{1}{2}\frac{Q^2}{C}$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$

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Resistor-capacitor discharge $I = I_0 e^{-t/RC}$

$$V = V_0 e^{-t/RC}$$

$$\ln Q = \ln Q_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln V = \ln V_0 - \frac{t}{RC}$$

In a magnetic field $F = Bqv \sin \theta$

$$F = BIl \sin \theta$$

Faraday's and Lenz's laws $\mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$

Nuclear and particle physics

In a magnetic field $r = \frac{p}{BQ}$

Mass-energy $\Delta E = c^2 \Delta m$

Unit 5

Thermodynamics

Heating

$$\Delta E = mc\Delta\theta$$

$$\Delta E = L\Delta m$$

Ideal gas equation

$$pV = NkT$$

Molecular kinetic theory

$$\tfrac{1}{2}m\langle c^2\rangle = \tfrac{3}{2}kT$$

Nuclear decay

Mass-energy

$$\Delta E = c^2\Delta m$$

Radioactive decay

$$A = \lambda N$$

$$\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$$

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$N = N_0 \mathrm{e}^{-\lambda t}$$

$$A = A_0 \mathrm{e}^{-\lambda t}$$

Oscillations

Simple harmonic motion

$$F = -kx$$

$$a = -\omega^2 x$$

$$x = A\cos\omega t$$

$$v = -A\omega\sin\omega t$$

$$a = -A\omega^2\cos\omega t$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$\omega = 2\pi f$$

Simple harmonic oscillator

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

$$T = 2\pi\sqrt{\frac{l}{g}}$$

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Astrophysics and cosmology

Gravitational field strength	$g = \frac{F}{m}$
Gravitational force	$F = \frac{Gm_1m_2}{r^2}$
Gravitational field	$g = \frac{Gm}{r^2}$
Gravitational potential	$V_{grav} = \frac{-Gm}{r}$
Stefan-Boltzmann law	$L = \sigma AT^4$
Wien's law	$\lambda_{max}T = 2.898 \times 10^{-3}\,\text{m K}$
Intensity of radiation	$I = \frac{L}{4\pi d^2}$
Redshift of electromagnetic radiation	$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$
Cosmological expansion	$v = H_0 d$

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