Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Friday 27 January 2012 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

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.
- 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 3 9 8 5 0 A 0 1 2 8

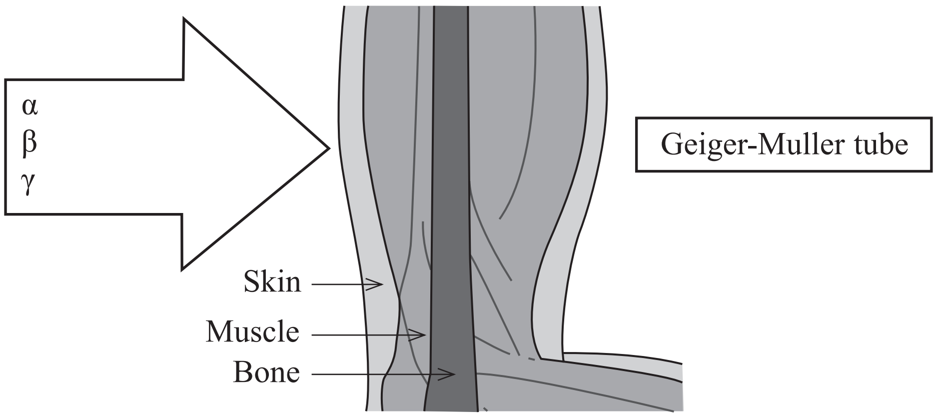
PEARSON

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 The diagram shows radiation from a radium source approaching a person's arm. A Geiger-Muller tube on the other side of the arm detects radiation.



The radiation detected is substantially less than would be detected without the arm in position. This is because the

☒ **A** bone is absorbing α-radiation.

☒ **B** muscle is absorbing α-radiation.

☒ **C** muscle is absorbing β-radiation.

☒ **D** skin is absorbing γ-radiation.

(Total for Question 1 = 1 mark)

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2 In the equation $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$, the term $\langle c^2\rangle$ represents

☒ **A** the mean speed of the molecules.

☒ **B** the mean speed of the molecules squared.

☒ **C** the mean square speed of the molecules.

☒ **D** the mean velocity of the molecules.

(Total for Question 2 = 1 mark)

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3 A bridge vibrates gently as cars are driven across it. This is an example of

☒ **A** forced oscillation.

☒ **B** free oscillation.

☒ **C** resonance.

☒ **D** stationary waves.

(Total for Question 3 = 1 mark)

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4 A Hertzsprung-Russell diagram is plotted for an old star cluster. Compared with a young cluster containing a similar number of stars there will be fewer

☒ **A** light main sequence stars.

☒ **B** massive main sequence stars.

☒ **C** red giant stars.

☒ **D** white dwarf stars.

(Total for Question 4 = 1 mark)

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5 About 25% of the mass of our Universe is thought to consist of dark matter. A key property of dark matter is that it

☒ **A** absorbs all electromagnetic-radiation.

☒ **B** cannot be detected.

☒ **C** emits no detectable electromagnetic-radiation.

☒ **D** exerts no gravitational force.

(Total for Question 5 = 1 mark)

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6 Cosmologists describe the universe as being open, closed or flat.
A closed universe is one which

☒ **A** has always been the same size.

☒ **B** has a maximum size.

☒ **C** has an uncertain future.

☒ **D** will expand forever.

(Total for Question 6 = 1 mark)

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7 The total number of free neutrons immediately after a fission reaction

☒ **A** goes down.

☒ **B** goes up.

☒ **C** may increase or decrease.

☒ **D** must stay constant.

(Total for Question 7 = 1 mark)

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8 The pressure exerted by an ideal gas, maintained at a constant temperature, is inversely proportional to the volume occupied by the gas.

Which of the following statements is **not** true?

☒ **A** The average molecular kinetic energy remains constant.

☒ **B** The gas must consist of identical molecules.

☒ **C** The mass of gas is fixed.

☒ **D** The number of molecules in the gas doesn't change.

(Total for Question 8 = 1 mark)

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9 In many ways electrical and gravitational forces are similar.

One key difference is that only

☒ **A** electrical forces can be attractive and repulsive.

☒ **B** electrical forces have an infinite range.

☒ **C** gravitational forces can be attractive and repulsive.

☒ **D** gravitational forces have an infinite range.

(Total for Question 9 = 1 mark)

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10 The magnitude of the fractional change in frequency, $\Delta f/f$, produced in the Doppler effect depends upon

☒ **A** the relative velocity of the source and the observer.

☒ **B** the wavelength of the radiation being emitted by the source.

☒ **C** whether it is the source or the observer that is moving.

☒ **D** whether the source and observer are approaching or receding.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 In a physics lesson a student learns that the Earth is 81 times more massive than the Moon. Searching the Internet, she is surprised to discover that the gravitational field strength at the surface of the Earth is only 6 times greater than that at the surface of the Moon.

Use the above data to compare the radius of the Earth with that of the Moon.

(3)

(Total for Question 11 = 3 marks)

12 The Earth can be considered to be a black body radiator at a temperature of 25 °C.

radius of Earth = 6380 km

(a) Calculate the total power radiated from the Earth.

(2)

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Total power radiated = ...

(b) Calculate the wavelength of the peak energy radiation for the Earth.

(2)

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Wavelength of the peak energy radiation = ...

(c) State the region of the electromagnetic spectrum in which this wavelength is found.

(1)

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(Total for Question 12 = 5 marks)

13 (a) Define simple harmonic motion.

(2)

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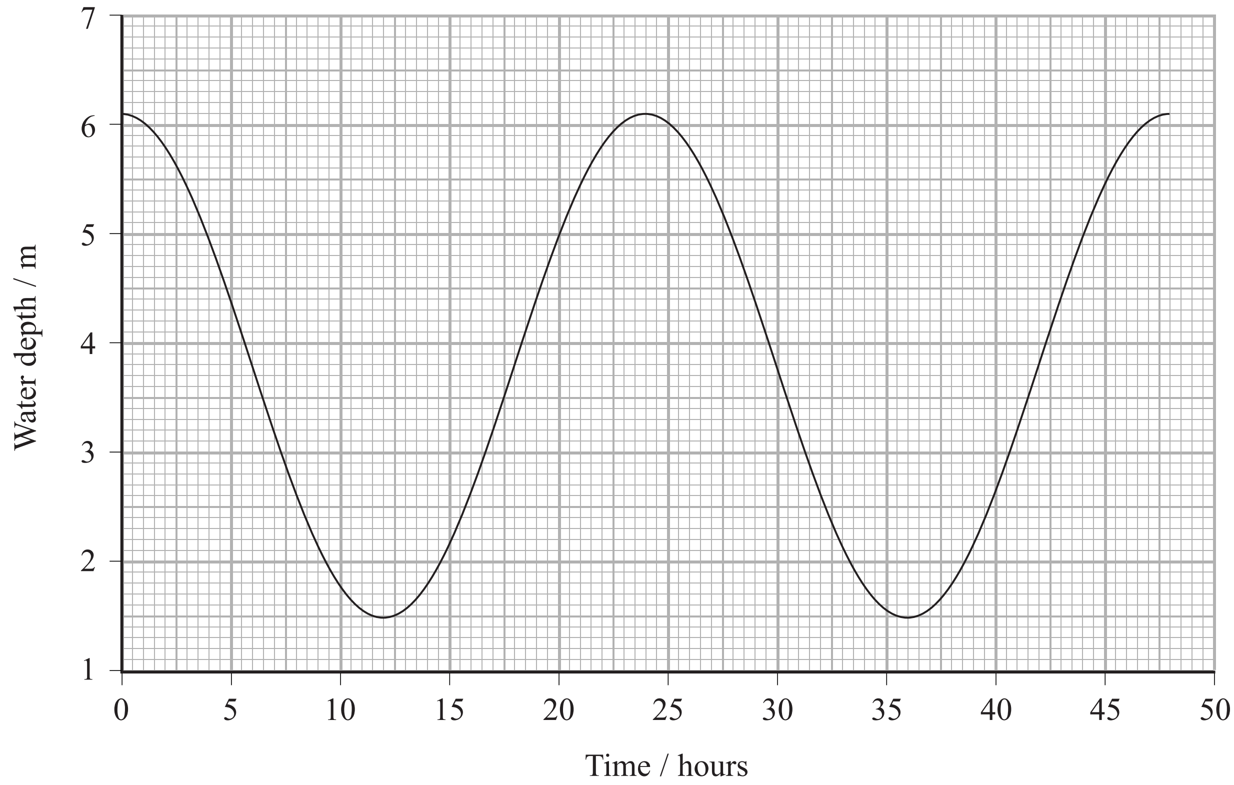
(b) The graph shows the variation in water level displacement with time for the water in a harbour. The water level displacement varies with simple harmonic motion.



(i) Use the graph to calculate the amplitude and the time period of the variation in the water level displacement.

(2)

Amplitude = ...

Time period = ...

(ii) Show that the maximum rate of change of water level displacement is about 0.6 m hour^{-1}.

(3)

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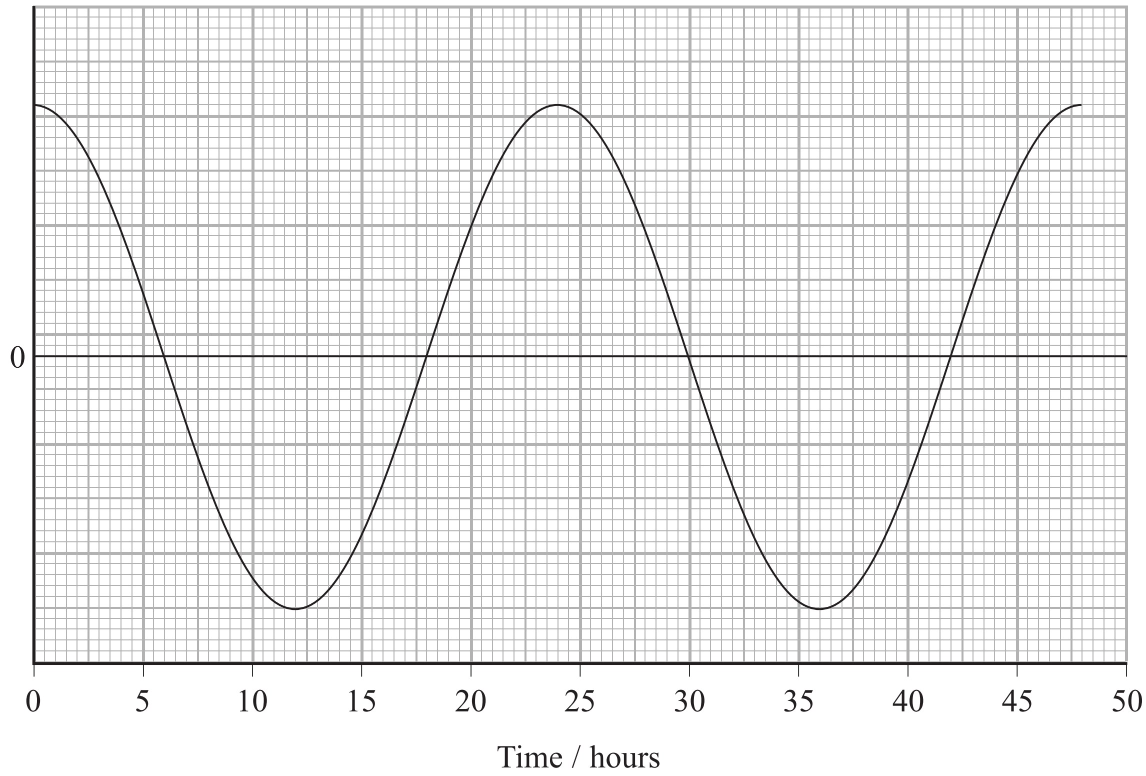
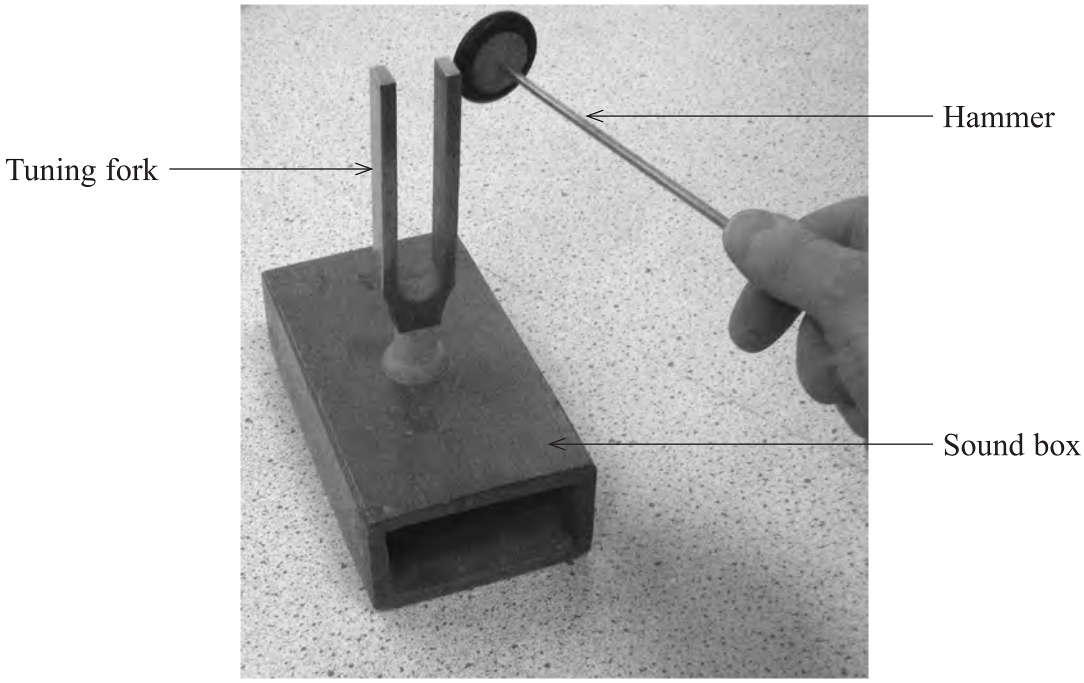
(iii) On the axis below sketch how the rate of change of water level displacement varies with time for the interval 0–30 hours. The variation in water level displacement with time has been drawn for you. You need not add any numerical values to the y-axis.

(2)



(Total for Question 13 = 9 marks)

***14** When a tuning fork is struck with a rubber hammer, a pure sound of fixed frequency is produced. The photograph shows a tuning fork connected to a wooden sounding box.



- The sounding box amplifies the sound produced when the tuning fork is struck.
- The sound lasts for a shorter time than if the tuning fork were to be struck identically but without the sounding box.

Explain these observations.

(5)

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(Total for Question 14 = 5 marks)

15 A washing machine uses 15 litres of water in a hot-wash cycle in which the machine is set to wash at 60 °C.

1.0 litre of water has a mass of 1.0 kg

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

(a) On a particular day the inlet temperature of the water is 15 °C. Show that the energy that must be supplied in order to bring the water to the correct temperature is about 3 MJ.

(2)

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(b) (i) The power of the heater is 2.5 kW. Calculate the minimum time it takes for the water to be brought to the correct temperature.

(2)

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Minimum time = ...

(ii) State an assumption you made in your calculation.

(1)

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(c) The washing machine is connected to a 230 V supply. What current is drawn from the supply by the heater?

(2)

Current = ...

(Total for Question 15 = 7 marks)

16 (a) The Moon orbits the Earth in a circular path.

Explain why the Moon maintains this circular path and what determines the radius of the path.

(2)

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(b) A bucket is swung in a vertical, circular path as shown.

The bucket is half filled with water and swung. The water stays in the bucket, even at the top of the circular path, as long as the speed of the bucket exceeds a certain value.

Explain why.

(3)

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(Total for Question 16 = 5 marks)

17 A pan attached to a spring balance is used to determine the mass of fruit and vegetables in a supermarket.

A bunch of bananas is dropped into the pan. The pan oscillates with an initial amplitude of 10 cm. The total mass of bananas and pan is 0.55 kg.

The spring constant of the system is 120 N m^{-1}.

(a) Calculate the period of oscillation of the pan.

(2)

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Period = ...

(b) The oscillations of the pan are damped.

(i) Explain what is meant by this statement.

(2)

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(ii) Sketch a graph to show how the displacement of the damped pan varies with time.

(3)

(Total for Question 17 = 7 marks)

18 The radioactive isotope carbon-14 undergoes decay with a half-life of 5730 years. While an organism is living, it takes in carbon from the atmosphere and the ratio of carbon-14 to the stable isotope carbon-12 in the organism is constant. After death the ratio changes, as the carbon-14 continues to decay but no more carbon is taken in. This is the basis of radiocarbon dating.

Archaeologists have used radiocarbon dating to pinpoint the date of construction of Stonehenge, an ancient stone circle in south west England. The archaeologists unearthed dead organic material from under the stones and sent a sample of it to Oxford University for analysis. Scientists at the university determined that the ratio of carbon-14 to carbon-12 in the sample was only 60% of that found in living organisms.

(a) Explain what is meant by a radioactive isotope.

(2)

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(b) Radioactive decay is a random process. Explain what this means.

(2)

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(c) Calculate the decay constant of carbon-14 and hence the time since Stonehenge was constructed.

(6)

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Time = ...

(d) The rate of production of carbon-14 in the atmosphere has decreased since Stonehenge was constructed. Explain how this would affect the scientists' calculations of when Stonehenge was constructed.

(3)

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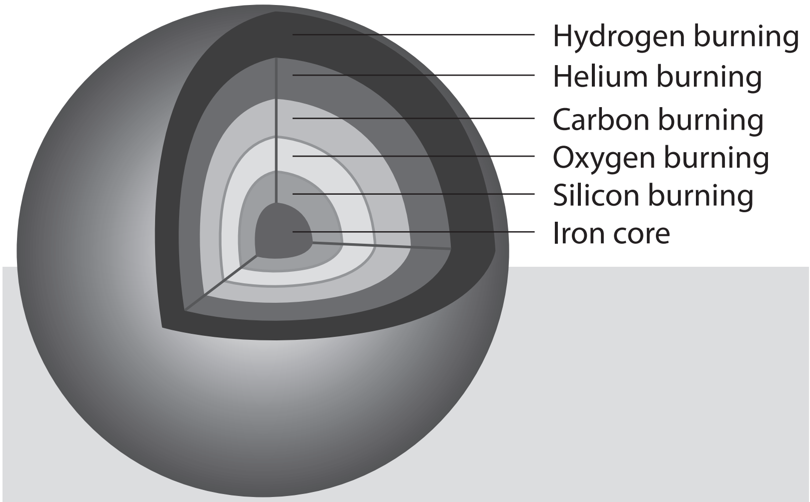
(Total for Question 18 = 13 marks)

19 The following passage is taken from a newspaper article.

Stars exist by fusing hydrogen within their cores. This process generates heat which pushes the star outwards. This outward pressure is matched by the gravitational forces pulling the star inwards. This maintains an equilibrium, allowing the star to radiate away vast amounts of energy for long periods of time. Our Sun has been in this state for about 4.5 billion years.

Eventually the star runs out of hydrogen to fuse, and so changes occur which allow fusion of helium to form heavier elements. Massive stars can produce elements up to iron in their cores by fusion.



Once a star's core has been converted into iron no further fusion can take place and the rapid collapse of the star results in a supernova explosion.

The remnant of the supernova may be a neutron star or black hole, depending upon the remnant's mass.

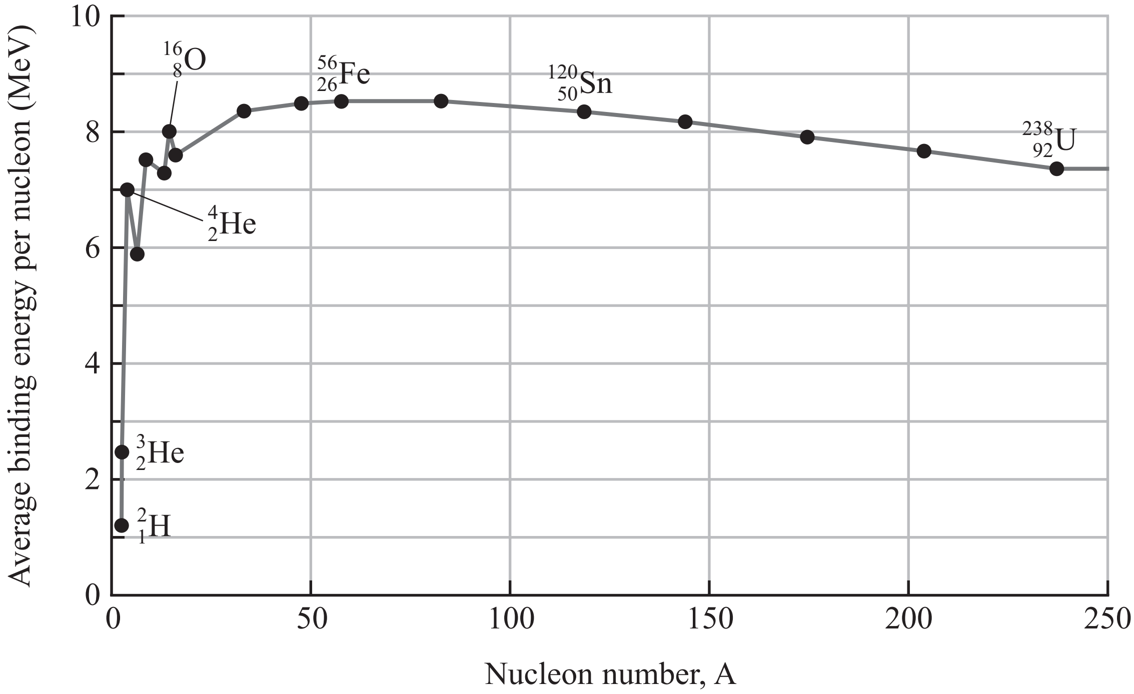
*(a) The conditions needed for fusion to occur make it difficult to replicate outside of a star.

State and explain:

- how the process of fusion is able to release energy
- the conditions necessary for fusion to occur
- why the conditions are difficult to replicate outside of a star.

(6)

(b) The graph shows the average binding energy per nucleon for a range of isotopes.



Massive stars can only produce elements up to iron (Fe) in their cores by fusion. Use information from the graph to explain why.

(3)

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A type 1a supernova occurs when a white dwarf star in a close binary system accumulates matter from its companion star. This eventually leads to a supernova outburst. Type 1a supernovae are used by astronomers as standard candles.

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

(1)

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(ii) A type 1a supernova is observed in a distant galaxy. Its flux at the Earth is measured to be 1.84×10^{-15} W m^{-2}. Theory predicts that it has a luminosity of 2.0×10^{36} W.

Show that the distance of the galaxy from the Earth is about 9×10^{24} m.

(2)

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(iii) The light from the galaxy is found to be red-shifted. State what this tells us about the galaxy.

(1)

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(iv) The redshift is measured to be 0.064. Calculate a value for the Hubble constant.
(3)

Hubble constant = ...

(Total for Question 19 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

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

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

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	$v = H_0 d$