Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number

Candidate Number

Monday 5 November 2018

Morning (Time: 1 hour 35 minutes) | Paper Reference **WPH05/01**

Physics

Advanced
Unit 5: Physics from Creation to Collapse

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 on these questions with your spelling, punctuation and grammar, as well as the clarity of expression.*
- 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

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 initial count rate recorded by a detector placed close to a radioactive sample is 4800 Bq. After 12 hours the count rate has fallen to 300 Bq.

Which of the following is the half-life of the sample?

☒ **A** 2.4 hours

☒ **B** 3.0 hours

☒ **C** 4.0 hours

☒ **D** 12 hours

(Total for Question 1 = 1 mark)

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2 Which of the following can be used to determine the age of the universe?

☒ **A** standard candles

☒ **B** the Hubble constant

☒ **C** the Planck constant

☒ **D** the temperature of deep space

(Total for Question 2 = 1 mark)

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3 The activity of a radioactive source depends on the number of unstable nuclei in the source and the half-life of the source.

Which row in the table corresponds to a source with the greatest activity?

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

(Total for Question 3 = 1 mark)

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4 Trigonometric parallax is used to determine the distances to two stars, P and Q. The radiation flux from P is greater than that from Q. The parallax angle for P is smaller than that for Q.

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

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

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

☒ **C** P is closer to the Earth than Q.

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

(Total for Question 4 = 1 mark)

5 The release of energy from uranium fuel in a nuclear reactor arises from the process of nuclear

☒ **A** decay.

☒ **B** emission.

☒ **C** fission.

☒ **D** fusion.

(Total for Question 5 = 1 mark)

6 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 nitrogen gas liquefies.

☒ **C** It is the lowest temperature reached so far in an experiment.

☒ **D** It is the temperature at which the internal energy of an ideal gas is a minimum.

(Total for Question 6 = 1 mark)

7 On which of the following does the ultimate fate of the universe depend?

☒ **A** the density of the universe

☒ **B** the mass of the universe

☒ **C** the time since the Big Bang

☒ **D** the temperature of space

(Total for Question 7 = 1 mark)

8 Some buildings contain materials that can dissipate the energy from earthquakes. These materials deform as the ground shakes.

Which of the following properties of the material is necessary for the energy dissipation to be effective?

☒ **A** elastic

☒ **B** plastic

☒ **C** stiff

☒ **D** strong

(Total for Question 8 = 1 mark)

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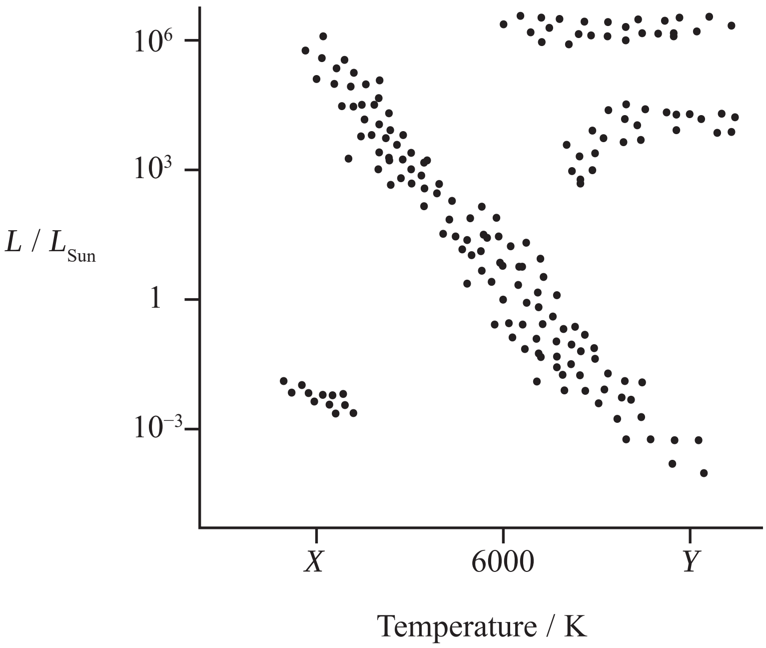
9 On the Hertzsprung-Russell diagram shown, the temperature scale is incomplete.



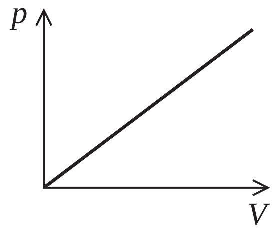
Select the row in the table with possible values for X and Y.

		X / K	Y / K
☒	**A**	2000	10 000
☒	**B**	3000	12 000
☒	**C**	12 000	3000
☒	**D**	10 000	2000

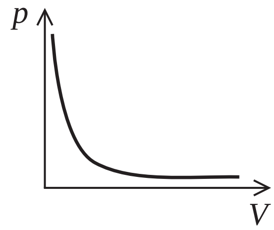
(Total for Question 9 = 1 mark)

10 A fixed mass of gas is kept at a constant temperature.

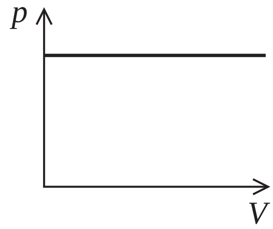
Which of the following graphs represents the pressure p exerted by the gas as its volume V is varied?



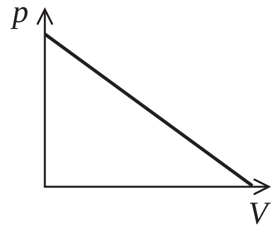
☒ **A**



☒ **B**



☒ **C**



☒ **D**

(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 distance to the galaxy Messier 33 has been determined by means of a standard candle.

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

(1)

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*(b) Describe how the distance of Messier 33 from the Earth can be determined by means of a standard candle.

(3)

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(c) State why trigonometric parallax would not be a suitable method to determine the distance to Messier 33.

(1)

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(Total for Question 11 = 5 marks)

12 In a dishwasher water at 16 °C is heated to a temperature of 50 °C before being used to wash the dishes.

(a) Show that the energy that must be supplied to the water to bring it to the correct temperature is about 3×10^6 J.

mass of water used = 18 kg
specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(2)

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(b) The power of the heater in the dishwasher is 1800 W.

Calculate the time it takes for the water to be brought to the correct temperature.

(2)

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Time = ...

(c) State the assumption necessary to perform the calculation in (b).

(1)

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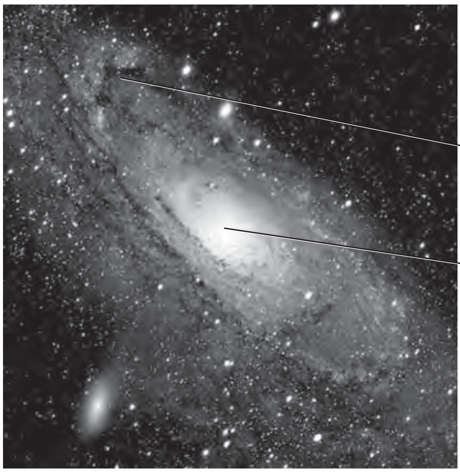
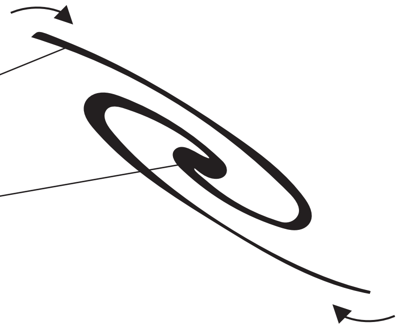
(Total for Question 12 = 5 marks)

13 The Sun is one of billions of stars in the Milky Way galaxy. The nearest galaxy to the Milky Way is the Andromeda galaxy. The Andromeda galaxy has spiral arms around its centre as shown.





spiral arms

centre

www.space-facts.com

(a) The spiral arms of the Andromeda galaxy are rotating about its centre with a large velocity. The centre of Andromeda is approaching the Milky Way at a velocity of about $120\,km\,s^{-1}$.

(i) Light of wavelength 486.0 nm is emitted from atoms in the centre of Andromeda. Calculate the wavelength of this light when measured by an observer on the Earth.

(2)

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Wavelength = ...

(ii) Explain why this wavelength would **not** be obtained when measuring the wavelength of light from atoms in the outer part of the spiral arms of Andromeda.

(2)

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(b) Analysis of the light emitted by Andromeda enables a value for the mass of Andromeda to be calculated.

Calculations based on the rate of rotation of the spiral arms produce a much greater value for the mass of the galaxy.

Explain what scientists have concluded from this difference in values.

(2)

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(Total for Question 13 = 6 marks)

14 A volleyball contains air at a temperature of 22.5 °C and a pressure of 1.32×10^5 Pa. The volleyball is left in direct sunlight, and the temperature of the air inside it increases to 38.5 °C.

(a) (i) Show that the new pressure exerted by the air inside the volleyball is about 1.4×10^5 Pa. Assume air behaves as an ideal gas.

(2)

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(ii) State another assumption you have made in your calculation.

(1)

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(b) Air is released from the volleyball until the pressure returns to its original value. The temperature of the air remains constant. Calculate the number of molecules of air that escape from the volleyball.

diameter of volleyball = 21.4 cm

(3)

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Number of molecules escaping = ...

(Total for Question 14 = 6 marks)

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15 The following equation relates to molecular kinetic theory.

$$N \times \frac{1}{2}m\langle c^2\rangle = \frac{3}{2}NkT$$

where N is the number of molecules in a sample of an ideal gas.

(a) State what physical quantity is given by the following expressions:

(i) $\frac{1}{2}m\langle c^2\rangle$

(1)

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(ii) $\frac{3}{2}NkT$

(1)

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(b) Calculate the mean square speed $\langle c^2\rangle$ of hydrogen molecules at 25 °C.

mass of a hydrogen molecule = 3.3×10^{-27} kg

(2)

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$\langle c^2\rangle$ = ...

*(c) The volume of a closed container of hydrogen gas is reduced at constant temperature.

Explain, using ideas of momentum, what happens to the pressure exerted by the hydrogen gas.

(4)

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(Total for Question 15 = 8 marks)

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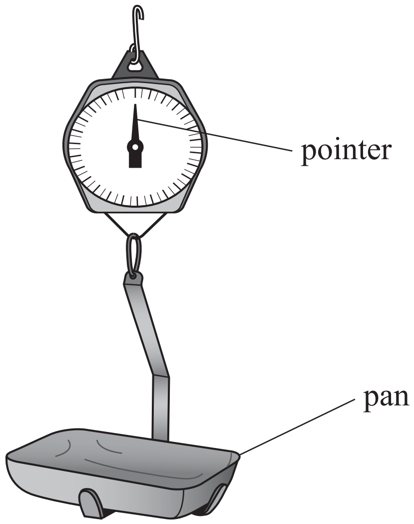
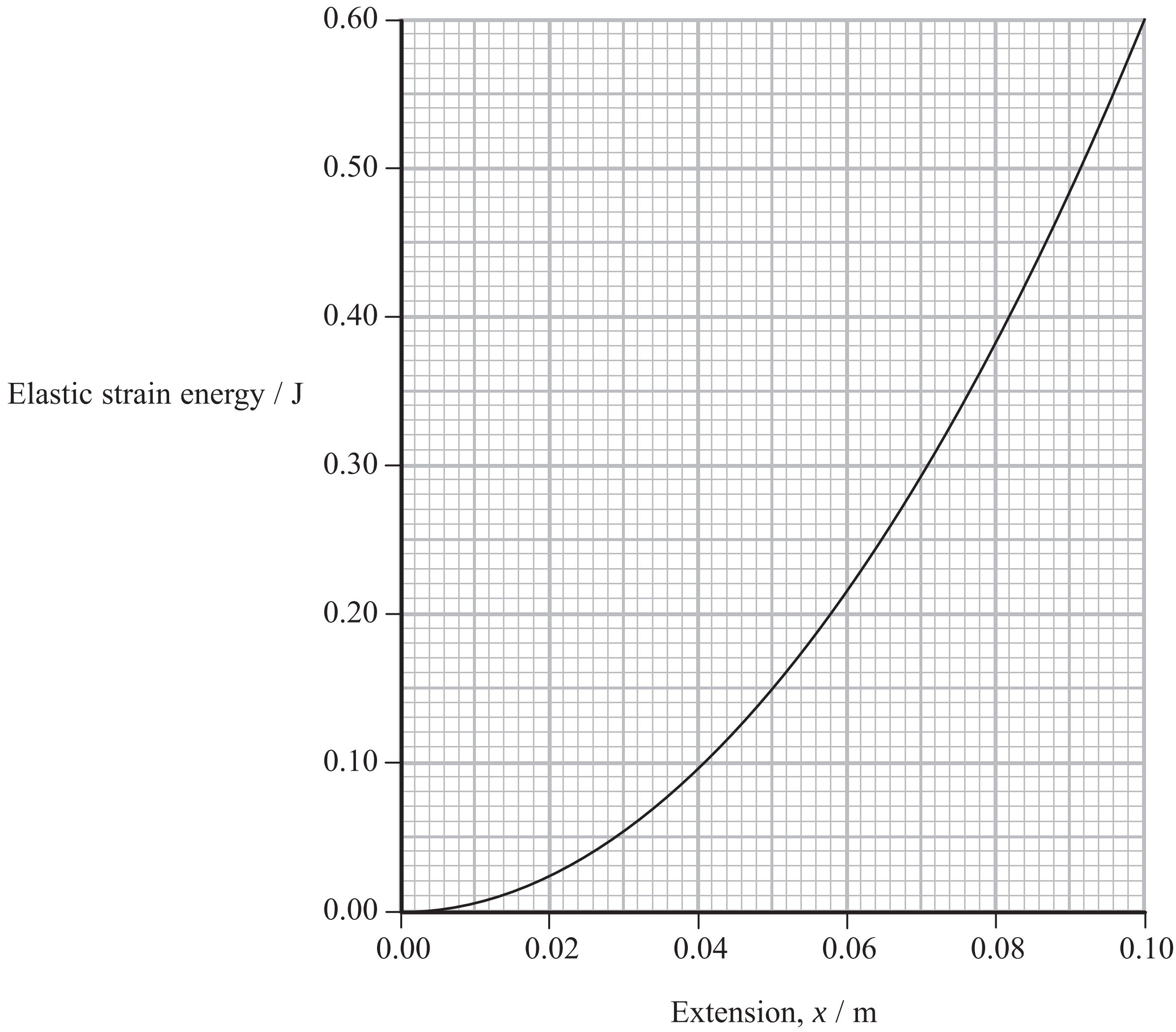
16 A set of scales used to weigh vegetables in a shop is shown.



When vegetables are added to the pan, the weight of the vegetables causes a spring to extend, moving the pointer on the scale.

(a) The graph shows how the elastic strain energy stored in the spring varies for extensions up to 10 cm.



(i) Show that the force constant of the spring system is about $100\,N\,m^{-1}$.

(3)

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(ii) A potato is placed in the pan. The total mass of the potato and pan is 0.45 kg.

When the pan is pulled down and released, it begins to oscillate.
Calculate the frequency of oscillation of the pan.

(3)

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Frequency of oscillation of pan = ...

(b) The system is an example of a damped oscillator.

(i) Explain what would be observed when a potato is dropped into the pan.

(2)

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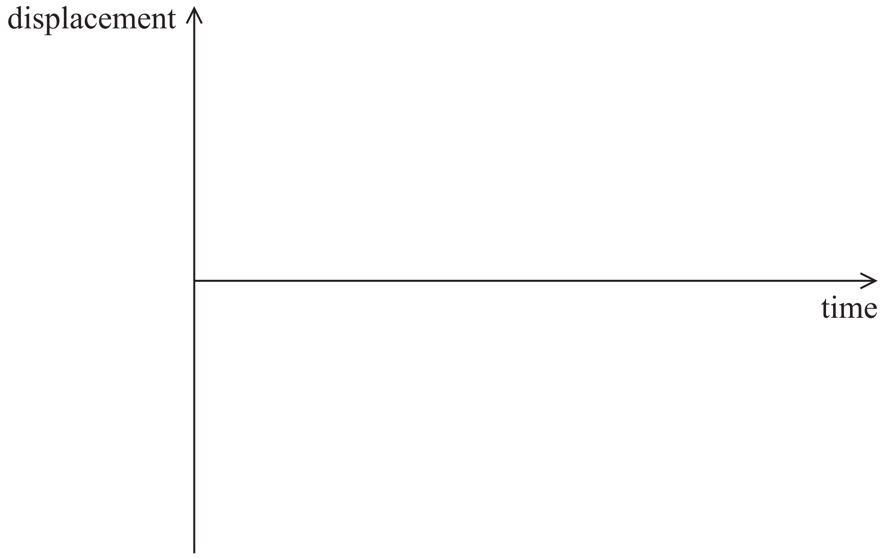
(ii) Sketch a graph to show how the displacement of the pan from its final equilibrium position varies with time.

(2)



(Total for Question 16 = 10 marks)

P 5 5 4 5 4 R A 0 1 6 2 8

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17 The planet Venus is sometimes described as Earth's twin, because its radius and mass are very similar to those of the Earth.

(a) (i) Show that the gravitational field strength g at a distance r from a point mass M is given by

$$g = \frac{GM}{r^2}$$

(2)

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(ii) Calculate the gravitational field strength g_v at the surface of Venus.

radius of Venus = 6050 km
mass of Venus = 4.9×10^{24} kg

(2)

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g_v = ...

(b) At the top of the Earth's atmosphere, the radiation flux F_E from the Sun is $1370\,\mathrm{W\,m^{-2}}$.

Calculate the radiation flux F_v from the Sun at the top of Venus' atmosphere.

radius of Venus' orbit about the Sun = 0.72 × radius of Earth's orbit about the Sun

(3)

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F_v = ...

(c) Venus can be considered to be a black body radiator at a temperature of 730 K.

(i) Calculate the total power radiated from Venus.

(2)

Total power radiated = ...

(ii) Calculate the wavelength of peak energy radiation for Venus.

(2)

Wavelength of peak energy radiation = ...

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

(1)

Region of electromagnetic spectrum = ...

(Total for Question 17 = 12 marks)

18 The isotope most widely used in medicine is technetium-99m.

(a) Technetium-99m is produced in a technetium generator containing molybdenum-99. Molybdenum-99 decays to technetium-99m with a half-life of 66.0 hours.

The generator contains 1.25×10^{16} atoms of molybdenum-99 when it is new.

(i) Show that the initial activity of the molybdenum-99 is about 3.6×10^{10} Bq.

(3)

(ii) Calculate the time taken for the activity of the molybdenum-99 to decrease to 2.6×10^{10} Bq.

(2)

Time taken = ...

*(b) The isotope technetium-99m has a half-life of six hours and decays by emitting gamma rays.

The isotope thallium-201 is another gamma emitter used in medical applications. Thallium-201 has a half-life of just over 3 days.

Assess the suitability of these two isotopes for use in hospitals to produce an image of the inside of a patient.

(4)

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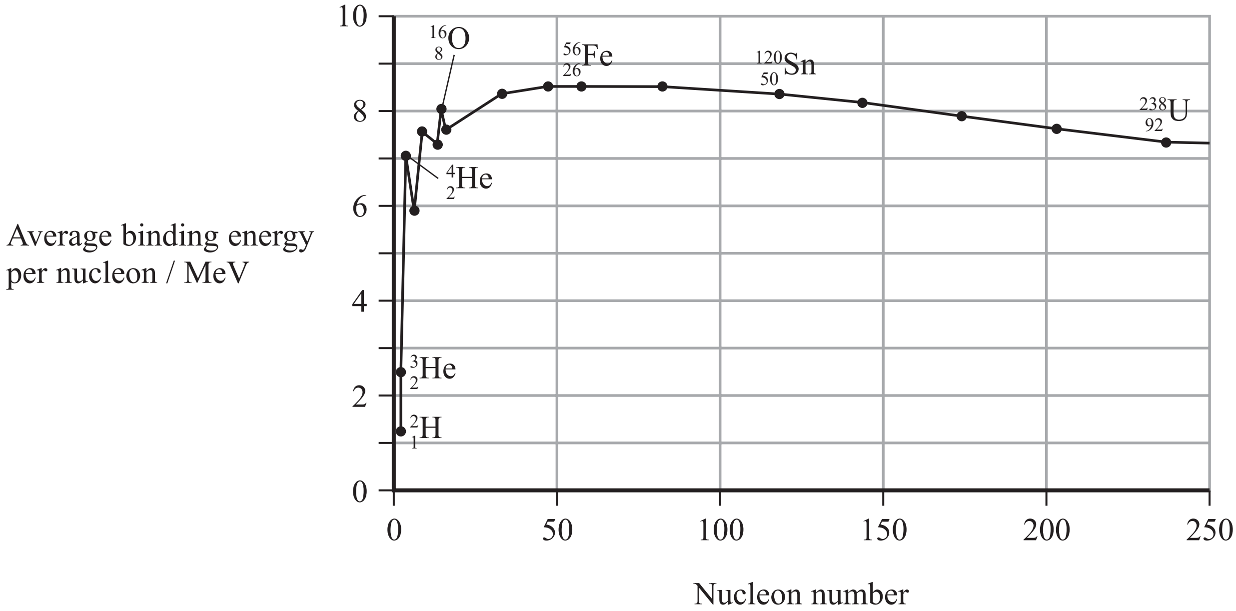
(Total for Question 18 = 9 marks)

19 More than a century ago the alpha particle was shown by Rutherford to be the same as a nucleus of helium.

The graph shows the binding energy per nucleon for a range of isotopes.



(a) Explain what is meant by isotopes.

Your answer should include reference to information from the graph.

(2)

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P 5 5 4 5 4 R A 0 2 2 2 8

(b) When a nucleus forms, its mass is less than the total mass of its constituent nucleons. This decrease in mass is known as the mass defect.

Use data from the graph to determine the mass defect in kg of a ${}^{4}_{2}$He nucleus.

(5)

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Mass defect = ... kg

(c) Some large unstable nuclei emit ${}^{4}_{2}$He nuclei to achieve stability.

Explain, using data from the graph, why a large unstable nucleus is more likely to emit a ${}^{4}_{2}$He nucleus than a ${}^{3}_{2}$He nucleus.

(2)

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(Total for Question 19 = 9 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	$F = 6\pi\eta rv$
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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{1/2}$
	$N = N_0 \mathrm{e}^{-\lambda t}$

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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