UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9792/02**

Paper 2 Part A Written Paper **May/June 2013**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
You are advised to spend about 1 hour 30 minutes on this section.

Section B
Answer the **one** question.
You are advised to spend about 30 minutes on this section.
The question is based on the material in the Insert.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

This document consists of **22** printed pages, **2** blank pages and **1** insert.

DC (NH/JG) 66326/4

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[Turn over

Data

gravitational field strength close to Earth's surface	$g = 9.81\,\mathrm{N\,kg^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
speed of light in vacuum	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$
electron mass	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
proton mass	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion

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

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

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

heating

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

change of state

$$\Delta E = mL$$

refraction

$$n = \frac{\sin\theta_1}{\sin\theta_2}$$

$$n = \frac{v_1}{v_2}$$

diffraction
single slit, minima $n\lambda = b \sin\theta$

grating, maxima $n\lambda = d \sin\theta$

double slit interference $\lambda = \frac{ax}{D}$

Rayleigh criterion $\theta \approx \frac{\lambda}{b}$

photon energy $E = hf$

de Broglie wavelength $\lambda = \frac{h}{p}$

simple harmonic motion $x = A \cos \omega t$

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

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

$F = -m\omega^2 x$

$E = \frac{1}{2}mA^2\omega^2$

energy stored in a capacitor $W = \frac{1}{2}QV$

electric force $F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$

electrostatic potential energy $W = \frac{Q_1Q_2}{4\pi\varepsilon_0 r}$

gravitational force $F = -\frac{Gm_1m_2}{r^2}$

gravitational potential energy $E = -\frac{Gm_1m_2}{r}$

magnetic force $F = BIl \sin\theta$

$F = BQv \sin\theta$

electromagnetic induction $E = -\frac{\mathrm{d}(N\Phi)}{\mathrm{d}t}$

Hall effect $V = Bvd$

time dilation $t' = \frac{t}{\sqrt{1-\frac{v^2}{c^2}}}$

kinetic theory $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$

work done on/by a gas $W = p\Delta V$

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

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

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

attenuation losses $I = I_0 e^{-\mu x}$

mass-energy equivalence $\Delta E = c^2 \Delta m$

hydrogen energy levels $E_n = \frac{-13.6\,\mathrm{eV}}{n^2}$

Heisenberg uncertainty principle $\Delta p \Delta x \geqslant \frac{h}{2\pi}$

$\Delta E \Delta t \geqslant \frac{h}{2\pi}$

Wien's law $\lambda_{max} \propto \frac{1}{T}$

Stefan's law $L = 4\pi\sigma r^2 T^4$

electromagnetic radiation from a moving source $\frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$

Section A

You are advised to spend 1½ hours answering this section.

1 A golf ball is hit from point A on the ground and moves through the air to point B. The path of the ball is illustrated in Fig. 1.1.

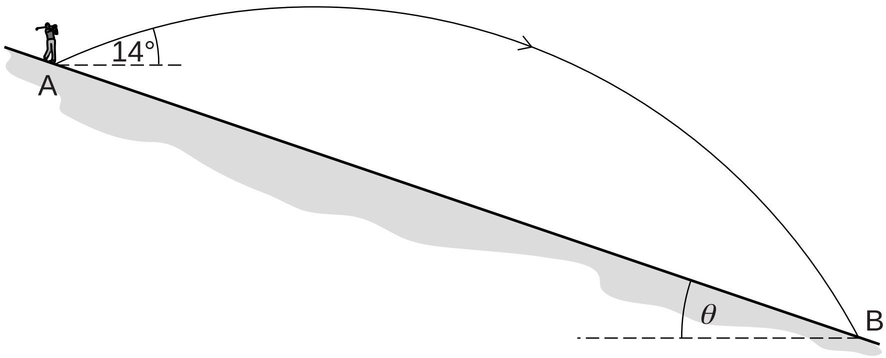

Fig. 1.1 (not to scale)

The ground slopes downhill with constant gradient. The ball has an initial velocity of 63 m s^{-1} at an angle of 14° to the horizontal. The ball hits the ground at B after 4.9 s.

(a) Ignoring air resistance, calculate

(i) the horizontal and vertical components of the ball's velocity at A,

horizontal component at A = ... m s^{-1} [1]

vertical component at A = ... m s^{-1} [1]

(ii) the horizontal displacement from A to B,

horizontal displacement = ... m [1]

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(iii) the vertical displacement from A to B,

vertical displacement = ... m [2]

(iv) the angle of the slope to the horizontal, θ.

angle θ = ... ° [2]

(b) In a real situation, air resistance provides a force on the ball in the opposite direction to its motion.

(i) On Fig. 1.1, sketch a likely path of the ball hit from A when air resistance is taken into account. [1]

(ii) Give reasons for the shape you have drawn in **(b)(i)** for

1. the path of the ball at the start,

....

....

....

2. the position of the highest point,

....

....

....

3. the angle at which the ball hits the ground.

....

....

....
[4]

[Total: 12]

2 A workman uses a long handled hammer to knock down a brick wall, as shown in Fig. 2.1.

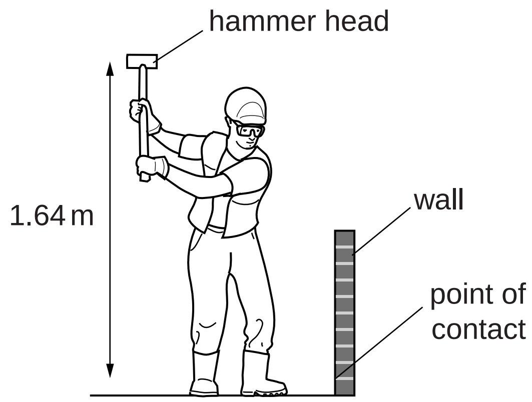

Fig. 2.1

The hammer head has a mass of 6.0 kg. The hammer is lifted by the workman so that the head of the hammer is 1.64 m above the point of contact. The hammer is then swung down and hits the brick at the point of contact.

During the swing, the workman does 134 J of work on the hammer to increase its speed.

(a) Calculate

(i) the total kinetic energy of the hammer head at the bottom of its swing, assuming no energy losses,

total kinetic energy = ... J [3]

(ii) the momentum of the hammer head at the bottom of its swing.

momentum = ... kg m s^{-1} [3]

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(b) The hammer head makes contact with the wall for a time of 0.013 s before stopping.

Calculate the average force the hammer head exerts on the wall during its time of contact.

force = ... N [2]

(c) Explain the advantage of the time in **(b)** being very short.

....

....

....[2]

[Total: 10]

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3 An old steam engine, such as the one shown in Fig. 3.1, heats water to its boiling point and then converts the water to steam.

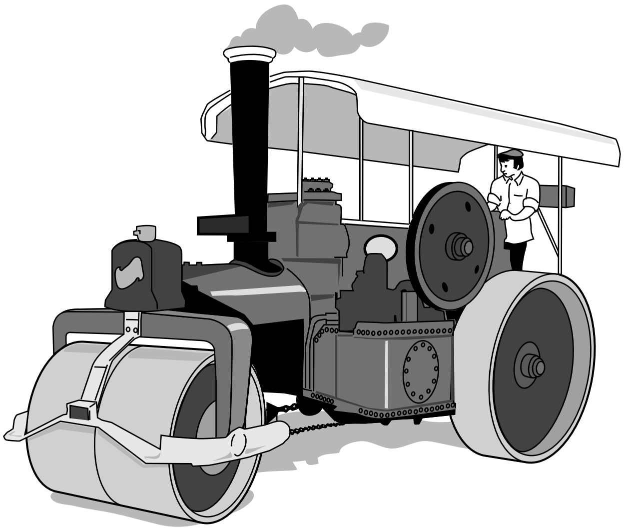

Fig. 3.1

Every 20 minutes the engine converts 65 kg of water at a temperature of 23 °C to steam at 100 °C.

Specific heat capacity of water = 4200 J kg^{-1} K^{-1}.
Specific latent heat of vaporisation of water = 2.26 × 10^{6} J kg^{-1}.

(a) Calculate

(i) the total amount of heat energy required every 20 minutes,

heat energy = ... J [4]

(ii) the average power required for the heating and vaporising processes.

average power = ... W [2]

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(b) The steam engine exerts a driving force of 1800 N when travelling at a constant speed of 3.2 m s^{-1}.

(i) Calculate the power output of the steam engine.

power output = ... W [2]

(ii) Calculate the percentage efficiency of the steam engine.

efficiency = ...% [1]

[Total: 9]

4 **(a)** Define the following electrical terms,

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(i) *electromotive force* (emf),

....

....[2]

(ii) *resistance*.

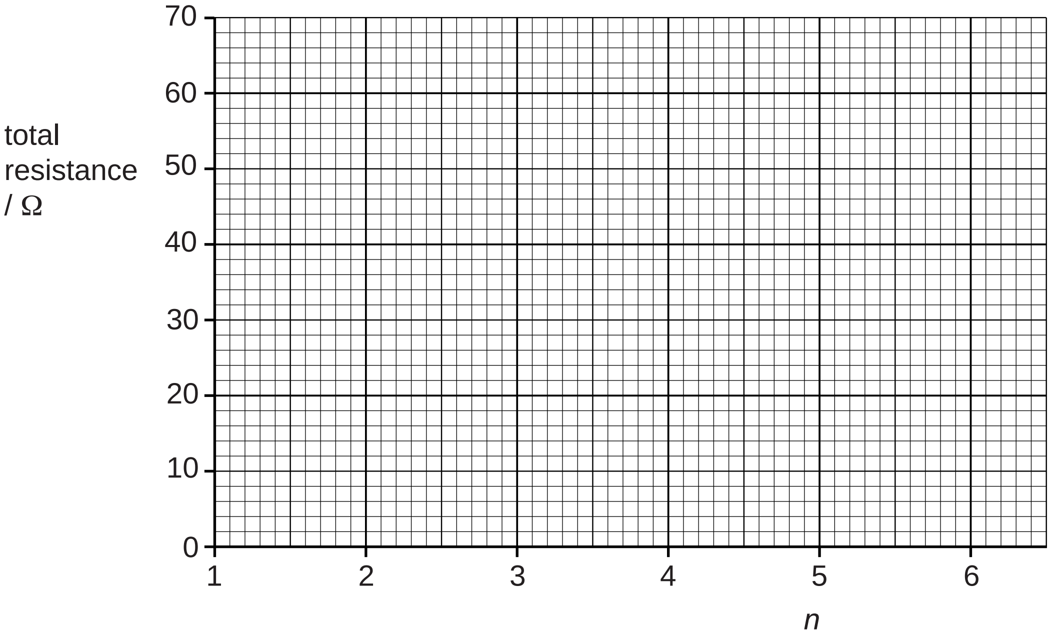
....

....[1]

(b) **(i)** **1.** Give an expression for the total resistance of n resistors, each of resistance $10\,\Omega$, connected in **series**, where n is the number of resistors.

resistance = ... Ω [1]

2. On Fig. 4.1, plot a graph showing the values of the total resistance for n = 1, 2, 3, 4, 5 and 6. Label the line S.



[2]

Fig. 4.1

(ii) **1.** Give an expression for the total resistance of n resistors, each of resistance $10\,\Omega$, connected in **parallel**, where n is the number of resistors.

resistance = ... Ω [1]

2. On Fig. 4.1, plot a graph showing the values of the total resistance for n = 1, 2, 3, 4, 5 and 6. Label the line P. [2]

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(c) (i) Fig. 4.2 shows a network of 16 resistors, each of resistance 10 Ω, connected in 4 parallel lines of 4 resistors in series.

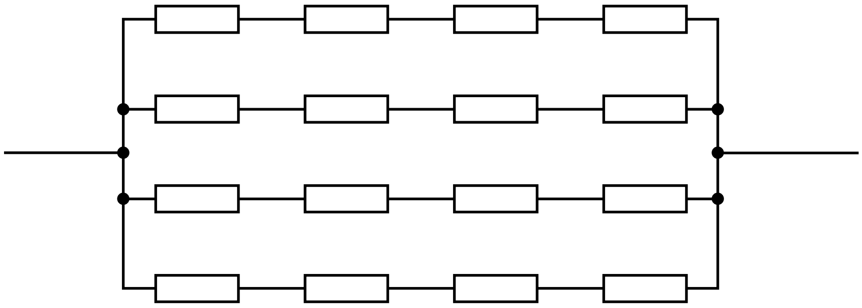

Fig. 4.2

Calculate the total resistance of the network.

total resistance = ... Ω [2]

(ii) State the total resistance of a network of *n* parallel lines of *n* resistors in series where every resistor has a resistance of 10 Ω.

resistance = ... Ω [1]

(iii) Explain one practical advantage of using many individual resistors in this way, rather than using a single resistor.

....

....[2]

[Total: 14]

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5 **(a)** State, by completing the sentences below, whether the following waves are longitudinal or transverse.

Radio waves are .... waves.

Ultrasound waves are .... waves.

Microwaves are ....waves.

Ultra-violet waves are .... waves. [2]

(b) Explain, using a diagram, what is meant by a *plane polarised* wave.

....

....[2]

(c) A narrow beam of polarised light has an amplitude *A* and intensity *I*. The plane of polarisation is vertical.

It is passed through a polarising filter whose axis of polarisation is at 30° to the vertical.

(i) Calculate, in terms of *A*, the amplitude of the emerging beam.

amplitude = ...[1]

(ii) State the direction of polarisation of the emerging beam.

direction = ... ° to the vertical [1]

(iii) The beam emerging from the polarising filter is then passed through another polarising filter at an angle of 60° to the vertical.

Calculate, in terms of A and I, the amplitude and the intensity of the emerging beam.

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amplitude = ...

intensity = ...
[3]

[Total: 9]

6 Waves of wavelength 8.0 mm are incident on a pair of narrow slits, A and B, as shown in the full scale drawing of Fig. 6.1. An interference pattern is caused along the line PQ, which is a distance *D* from the slits. Y is the centre of the pattern.

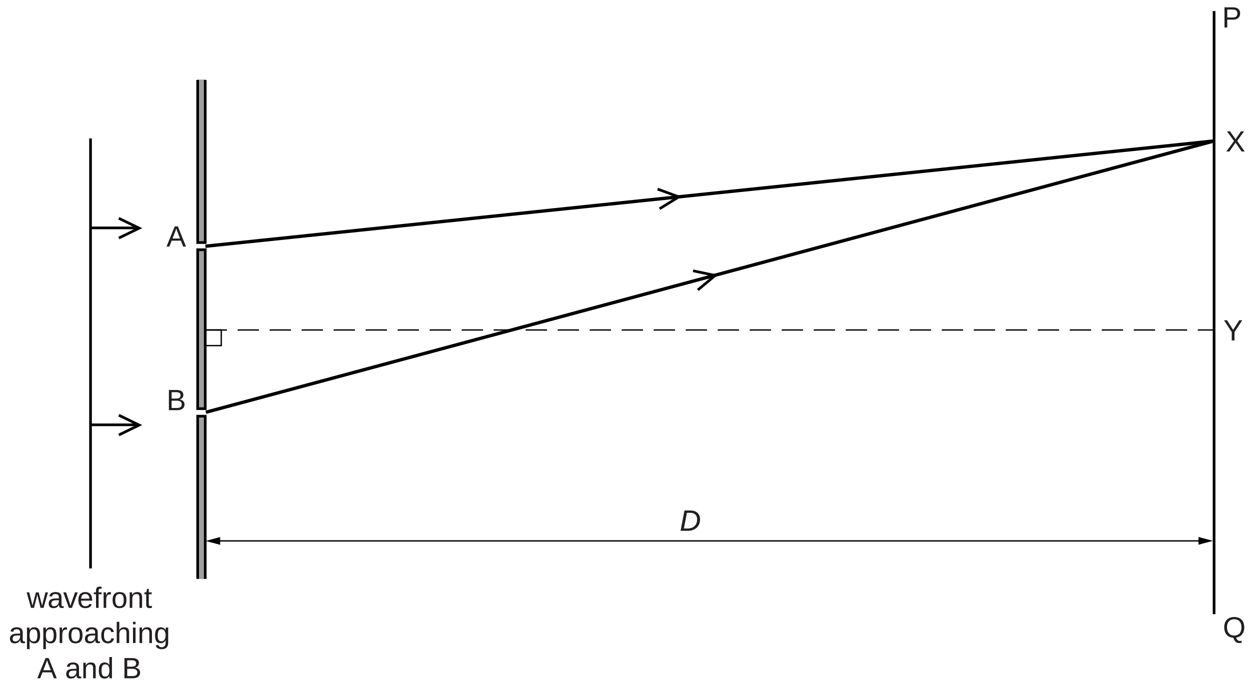

Fig. 6.1

(a) **(i)** On Fig. 6.1, measure the path distance waves from slit A travel to reach point X.

distance AX = ... mm [1]

(ii) The distance BX is half a wavelength longer than the distance AX.

State the phase difference between waves arriving at X.

phase difference = ... [1]

(iii) The separation *x* between regions of high intensity along PQ is given by the approximate formula $x = \frac{\lambda D}{a}$ where *a* is the separation of the slits.

Measure *a* and *D* on the diagram and use these values to find the percentage difference between the actual value of *x* and the value given by the approximate formula.

difference = ...% [3]

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(iv) State **two** reasons why the above formula is only approximate.

1. ....

....

....

2. ....

....

.... [2]

(b) Explain the meaning of the term *amplitude modulation*, using the terms *signal* and *carrier* appropriately. Draw a sketch diagram to illustrate your answer.

....

....

....

....[3]

(c) Determine the three frequencies that are present in the complex wave drawn in Fig. 6.2.

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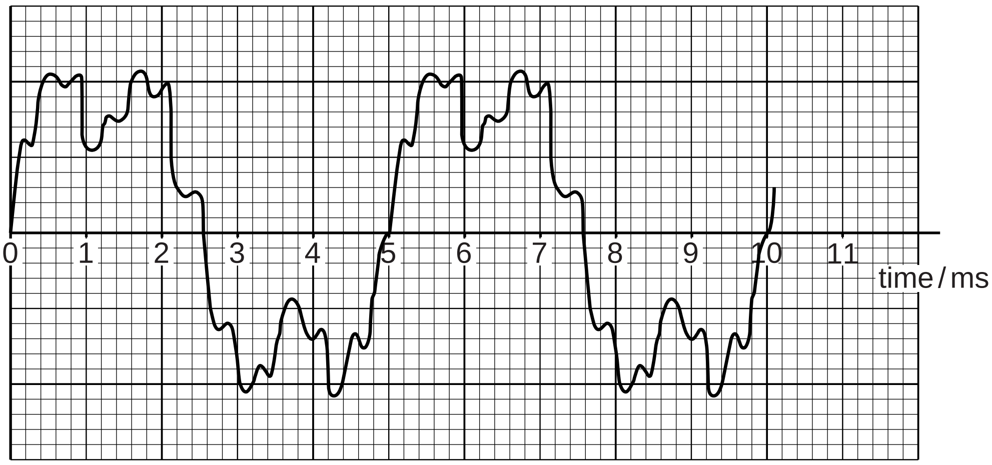

Fig. 6.2

frequencies = ... Hz, ... Hz, ... Hz [3]

[Total: 13]

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7 **(a)** The power output from a lamp supplying monochromatic light of wavelength 644 nm is 7.87 W.

(i) Calculate the energy of a photon of wavelength 644 nm. Give your answer in both joules and electron volts.

energy = ... J [2]

energy = ... eV [2]

(ii) Calculate the number of photons being emitted by the light per second.

number = ... s^{-1} [2]

(b) Explain why these photons are unlikely to cause the photoelectric effect from a metal.

....

....

....

....[2]

[Total: 8]

Section B

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You are advised to spend about 30 minutes answering this section.
Your answers should, where possible, make use of any relevant Physics.

8 A recently mined sample of uranium ore contains 1.00 kg of uranium. The number of uranium-235 atoms in the sample is 1.82×10^{22}.

(a) Since the Earth was formed, the value of the atomic abundance ratio of uranium-235 has gradually decreased. Nowadays, the atomic abundance ratio of uranium-235 is 0.00718.

(i) Determine the **total** number of atoms of uranium present in the recently mined sample of uranium ore.

number = ... [2]

(ii) The half-life of uranium-235 is 7.10×10^{8} years.

Calculate the number of atoms of uranium-235 there would have been in the sample 2.13×10^{9} years ago, just before the fission reaction at Oklo was set off.

number = …………………………….. [2]

(iii) There were 3.65×10^{24} atoms of uranium in the sample 2.13×10^{9} years ago.

Calculate the value of the atomic abundance ratio of uranium-235 at that time.

ratio = ... [1]

(iv) A nuclear fission chain reaction, such as that which took place at Oklo, could not, nowadays, take place in naturally occurring uranium on Earth.

Explain why the present value of the atomic abundance ratio of uranium-235 prevents such a reaction occurring.

....

....

.... [2]

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(b) In naturally occurring uranium, there are atoms of a third isotope of uranium, uranium-234. These atoms are present because uranium-238 is radioactive.

(i) An atom of uranium-238 decays by α-emission.

$$^{238}_{92}\text{U} \rightarrow\ ^{234}_{90}\text{Th} +\ ^{4}_{2}\alpha$$

State and explain what subsequent radioactive emissions must take place before an atom of uranium-234 is produced.

....

....

....[2]

(ii) The half-life of uranium-234 is very much less than that of uranium-235. Despite this, the atomic abundance ratio of uranium-234 has hardly changed in the last 2.13×10^9 years.

Explain why this is so.

....

....

....[2]

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(c) A neutron hits a uranium-235 nucleus. Fig. 8.1 shows the resulting fission reaction.

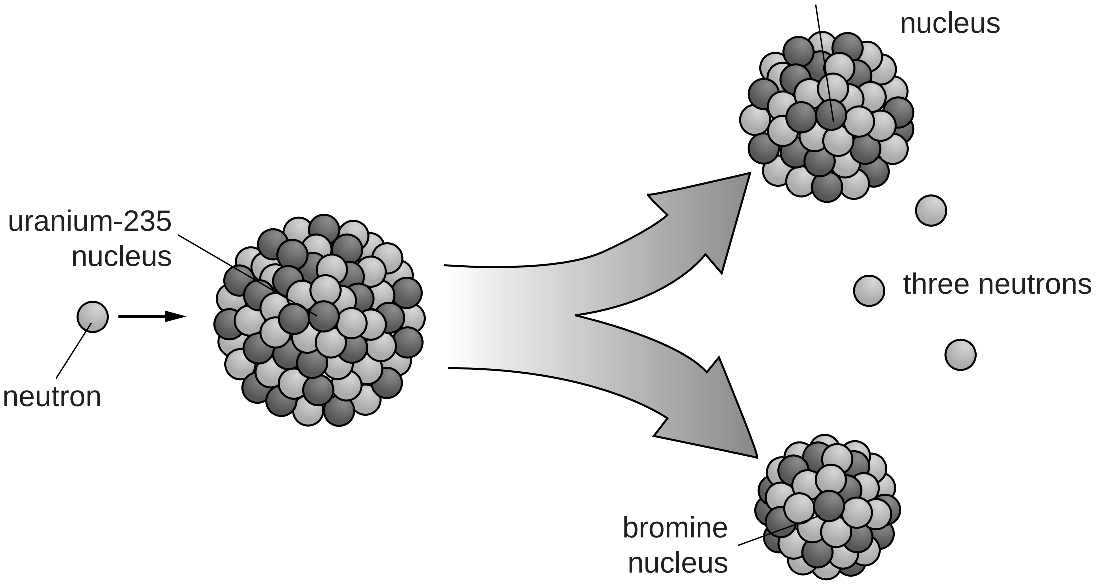

Fig. 8.1

The fission produces a lanthanum-144 nucleus, a bromine nucleus and three neutrons.

An incomplete equation for this is

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{144}_{\dots\dots}La + {}^{\dots\dots}_{35}Br + 3^{1}_{0}n$$

(i) Determine

1. the atomic number of lanthanum,

atomic number = ... [1]

2. the atomic mass number of this bromine isotope.

mass number = ... [1]

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(ii) When the masses of the particles involved in this reaction are determined accurately, it is found that the combined mass of all the fission products is less than the combined mass of the original neutron and uranium-235 nucleus. The mass difference Δm is 0.181 u.

1. Use the Einstein equation $E = c^2\Delta m$ to determine the energy released when one nucleus of uranium-235 undergoes fission in this way.

energy = ... J [2]

2. Estimate the quantity of energy available from the fission of the uranium-235 atoms in the 1.00 kg sample of recently mined uranium. Assume that all the fission reactions that occur release a similar amount of energy.

energy = ……………………………..J [1]

(d) When uranium is prepared for use as a fuel in a nuclear power station, the value of the uranium-235 atomic abundance ratio has to be increased above the present value for naturally occurring uranium.

(i) Explain why this enrichment cannot be achieved by chemical means.

....

....[1]

(ii) Enriched uranium is made into long, thin rods which are stored end to end. If a neutron from space happens to hit a uranium-235 nucleus in a fuel rod, this shape prevents a chain reaction developing.

Suggest why this is so.

....

....[1]

(e) The high standard of living, enjoyed by the inhabitants of many countries, depends on readily available sources of cheap energy. Some countries rely heavily on nuclear power to supply this energy. Other countries have chosen not to build any nuclear power stations or are gradually decommissioning those already in use.

Suggest the advantages and disadvantages of using nuclear power stations for the generation of electricity. You may use information from any of the extracts.

Your answer should include some social, environmental or economic effects of nuclear power.

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