GCE A level

1324/01

PHYSICS – PH4

Oscillations and Fields

P.M. WEDNESDAY, 11 June 2014

1 hour 30 minutes plus your additional time allowance

Surname ______________________________

Other Names ______________________________

Centre Number ______________________________

Candidate Number 2 ______________________________

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	12	
2.	8	
3.	5	
4.	12	
5.	10	
6.	12	
7.	10	
8	11	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a DATA BOOKLET.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

Write your name, centre number and candidate number in the spaces provided on the front cover.

Answer ALL questions.

Write your answers in the spaces provided in this booklet.

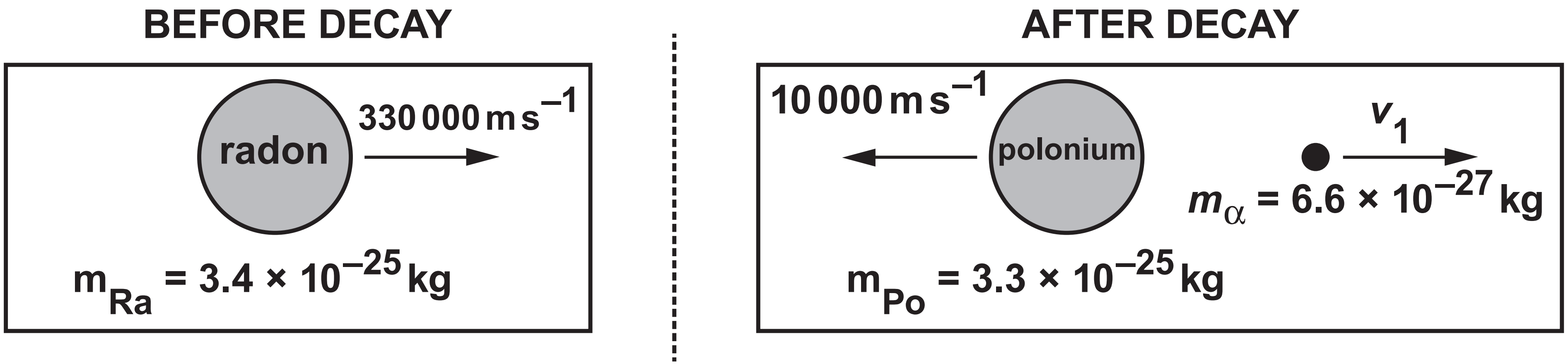
INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.


BEFORE DECAY
radon
330 000 m s–1
mRa = 3.4 × 10–25 kg
AFTER DECAY
10 000 m s–1
polonium
v1
mα = 6.6 × 10–27 kg
mPo = 3.3 × 10–25 kg

Answer ALL questions

1. A radon nucleus travelling at 330 000 m s^{-1} decays to produce a polonium nucleus and an alpha particle as shown opposite.

(a) Use the principle of conservation of momentum to calculate the velocity (v_1) of the alpha particle. [3]

1(b) The polonium nucleus then emits a gamma ray PERPENDICULAR to its direction of motion as shown opposite.

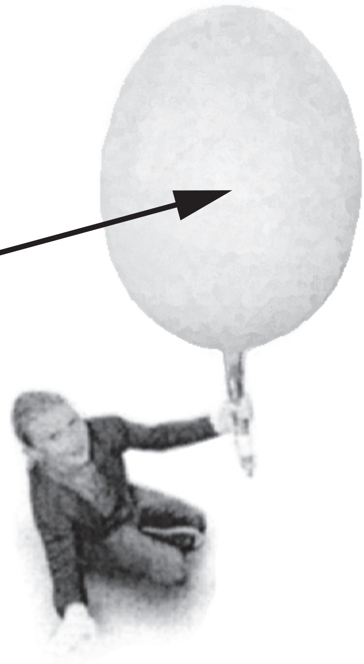
(i) Explain why the horizontal velocity component ($10\,000\,\mathrm{m\,s^{-1}}$) of the polonium nucleus is unchanged. [1]

1(b) (ii) **Show that the downward velocity component (v_2) of the polonium nucleus after emitting the gamma ray photon is approximately 2 000 m s^{-1}. [4]**

1(b) (iii) Calculate the final resultant velocity (magnitude and direction) of the polonium nucleus. [4]

2(a) A helium weather balloon is to be released.

volume = $0.113\,m^3$
temperature = $293\,K$
pressure = $1.02 \times 10^5\,Pa$

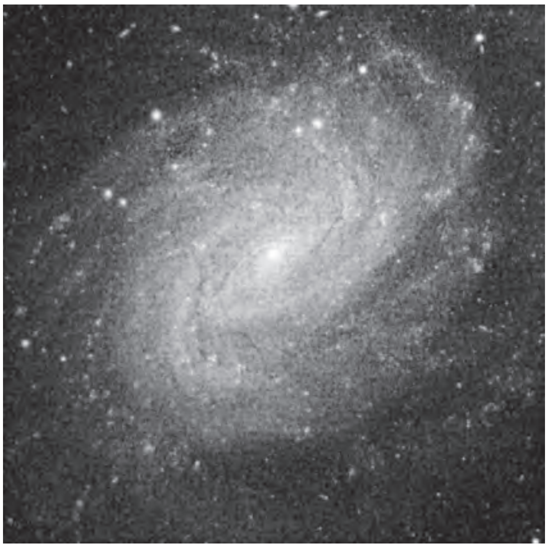


(i) Show that the density of the helium in the balloon is approximately $0.17\,kg\,m^{-3}$. (The molar mass of helium is $4.00 \times 10^{-3}\,kg\,mol^{-1}$.) [3]

2(a) (ii) Calculate the rms speed of helium molecules in the balloon. [2]

2(b) The balloon is released and rises to a height where the pressure inside it decreases to 4.5×10^4 Pa and its volume increases to $0.212\,m^3$. Calculate the new rms speed of the helium molecules in the balloon (assume no helium molecules have escaped). [3]

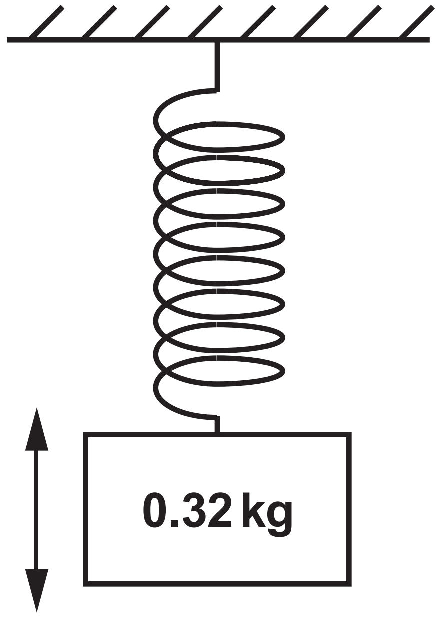
3. A spiral galaxy is analysed and its mass is estimated as 3.5×10^{41} kg.



(a) Use the equation $V = \sqrt{\frac{GM}{r}}$ to ESTIMATE the orbital speed of dust particles at a distance of 9.3×10^{20} m from the centre of the galaxy. [2]

3(b) **The MEASURED velocity of the dust particles is different. Explain how dark matter is thought to be responsible for the difference between the MEASURED and the ESTIMATED velocities. [3]**

4. A mass of 0.32 kg oscillates with simple harmonic motion vertically on a spring with a frequency of 3.47 Hz.



(a) Calculate the spring constant of the spring. [3]

4(b) Show that the angular velocity, ω, of the oscillations is 21.8 rad s^{-1}. [1]

(c) The amplitude of oscillation of the spring is 8.5 cm. Calculate:

(i) the maximum kinetic energy of the mass; [3]

4(c) (ii) the maximum resultant force acting on the mass. [2]

(d) The displacement of the mass is given by the equation $x = A\sin(\omega t + \varepsilon)$. Calculate a valid value for ε given that the displacement of the mass is –1.4 cm at time t = 0.100 s. [3]

5(a) Define:

(i) the gravitational field strength at a point; [1]

(ii) the gravitational field strength at a point. [1]

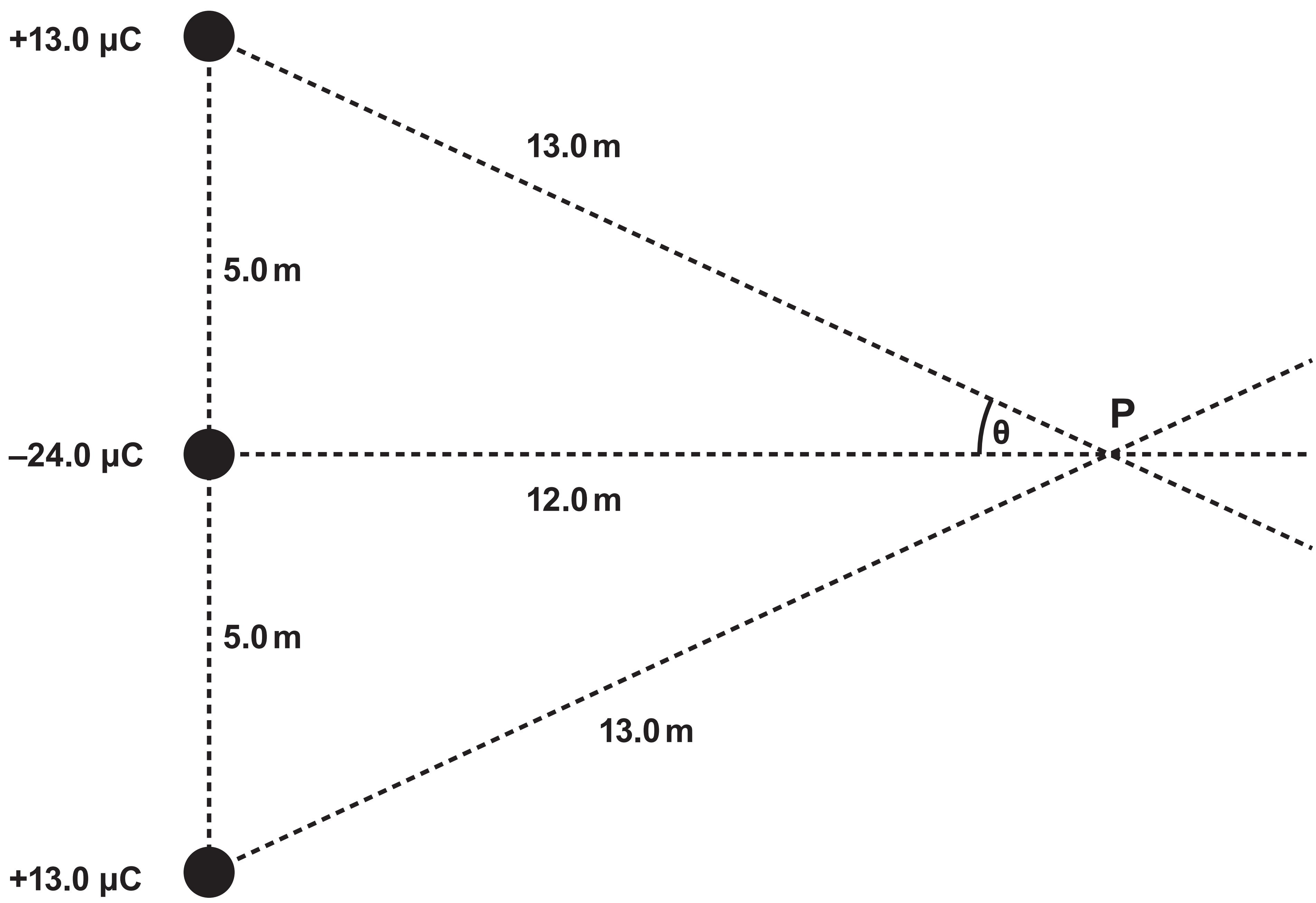
5(b) Charon is the moon of Pluto; it has a mass of 1.5×10^{21} kg and its radius is 600 km.

(i) Calculate the gravitational force exerted by Charon on an object of mass 82 kg on its surface. [2]

(ii) Calculate the gravitational potential energy of the 82 kg mass on Charon's surface (you may ignore Pluto). [2]

5(c) Pluto has a mass of 1.3×10^{22} kg and radius of 1150 km. Calculate the potential energy of the 82 kg mass if it were on the surface of Pluto (you may ignore Charon). [2]

(d) The 82 kg mass is fired from Charon's surface to Pluto. Neglecting any losses due to resistive forces, calculate the change in kinetic energy of the 82 kg mass from the instant it was fired to the instant just before it collides with Pluto. [2]


+13.0 μC
13.0 m
5.0 m
θ
P
–24.0 μC
12.0 m
5.0 m
13.0 m
+13.0 μC

6. Three charges are arranged as shown opposite.

(a) DRAW THREE ARROWS AT P to represent the electric fields due to EACH of the three charges. [2]

(b) Calculate the electric field strength at P due to the –24.0 μC charge only (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ F^{-1}\ m$). [2]

___

___

___

___

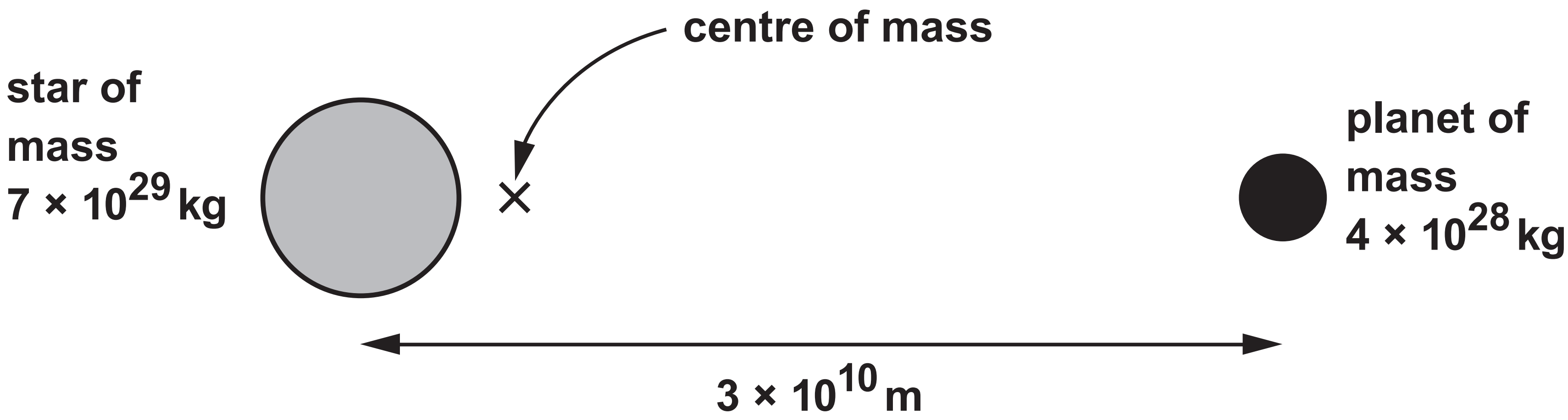
___

___

6(c) **Calculate the resultant electric field strength at P (you may use the approximation $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \mathrm{F}^{-1}\ \mathrm{m}$). [3]**

6(d) Show that the electric potential at P is zero. [2]

6(e) A negative charge is released from rest at point P and encounters NO RESISTIVE FORCES. Explain in terms of energy and forces why the charge initially accelerates to the right but eventually becomes stationary a long way away from the three charges. [3]


centre of mass
star of
mass
7 × 10^29 kg
planet of
mass
4 × 10^28 kg
3 × 10^10 m

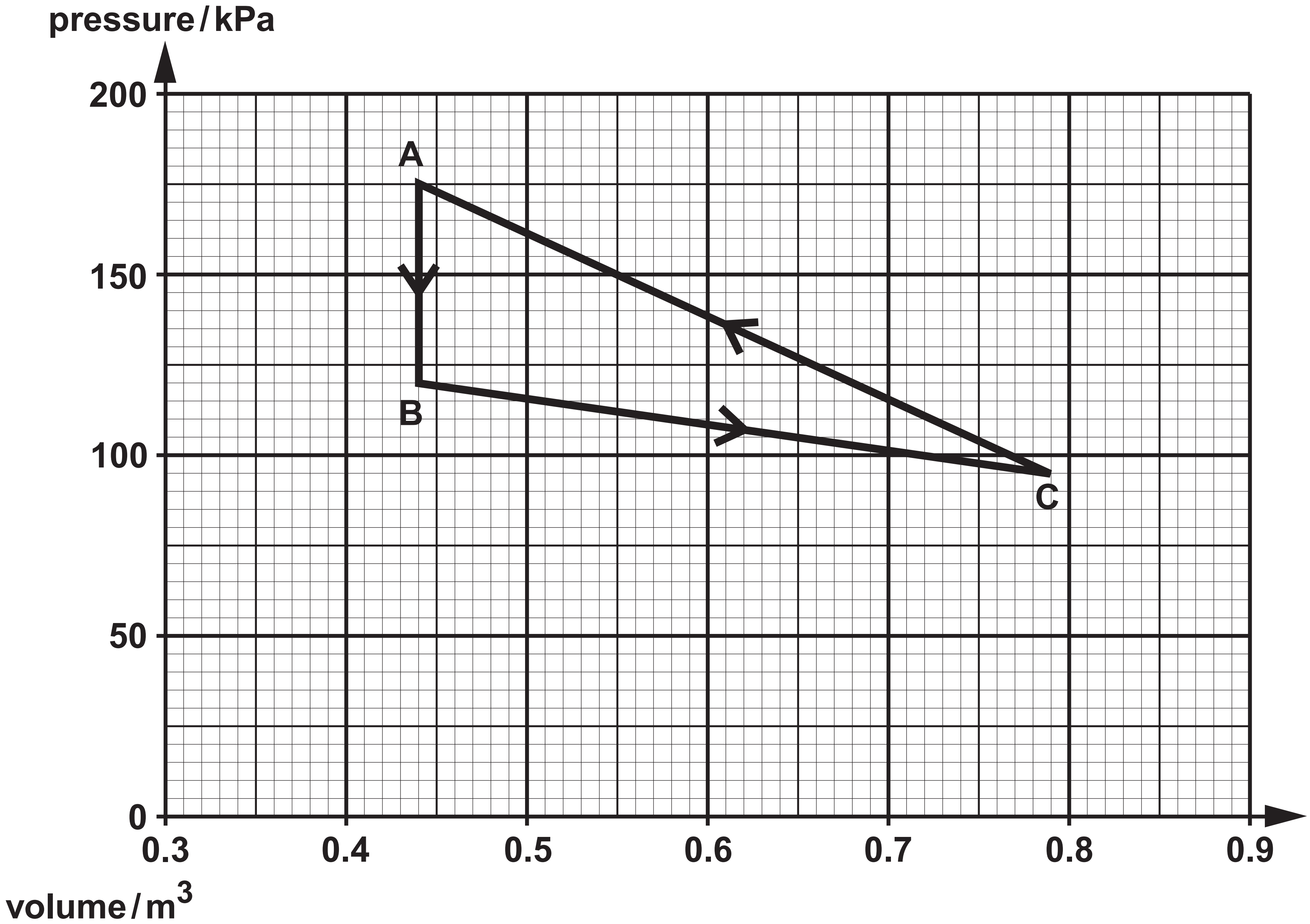
7. A star and planet orbit their mutual centre of mass as shown opposite.

(a) Calculate the period of orbit. [2]

(b) Calculate the distance of the centre of mass from the centre of the star. [2]

7(c) Calculate the maximum red shift (or blue shift) measured by a distant observer when light of wavelength 656 nm from this star is analysed. (The centre of mass of the star-planet system is at rest relative to the observer and the system is viewed edge-on.) [4]

7(d) The planet is 5 times closer to the star than the Earth is to the Sun but the star emits $\frac{1}{20}$ of the electromagnetic radiation of the Sun. Discuss whether or not this planet is hotter or colder than the Earth. [2]



pressure / kPa
200
150
100
50
0
A
B
C
0.3
0.4
0.5
0.6
0.7
0.8
0.9
volume / m3

8. **A sample of an ideal monatomic gas is taken through the closed cycle ABCA as shown opposite.**

(a) **There are 28.9 mol of gas. The temperatures of points A and B are 321 K and 220 K respectively.**

(i) **Show that the temperature of C is 313 K. [2]**

8(a) (ii) **Calculate the change in internal energy, ΔU, for AB. [2]**

8(b) Determine the work done by the gas, *W*, for:

(i) AB; [1]

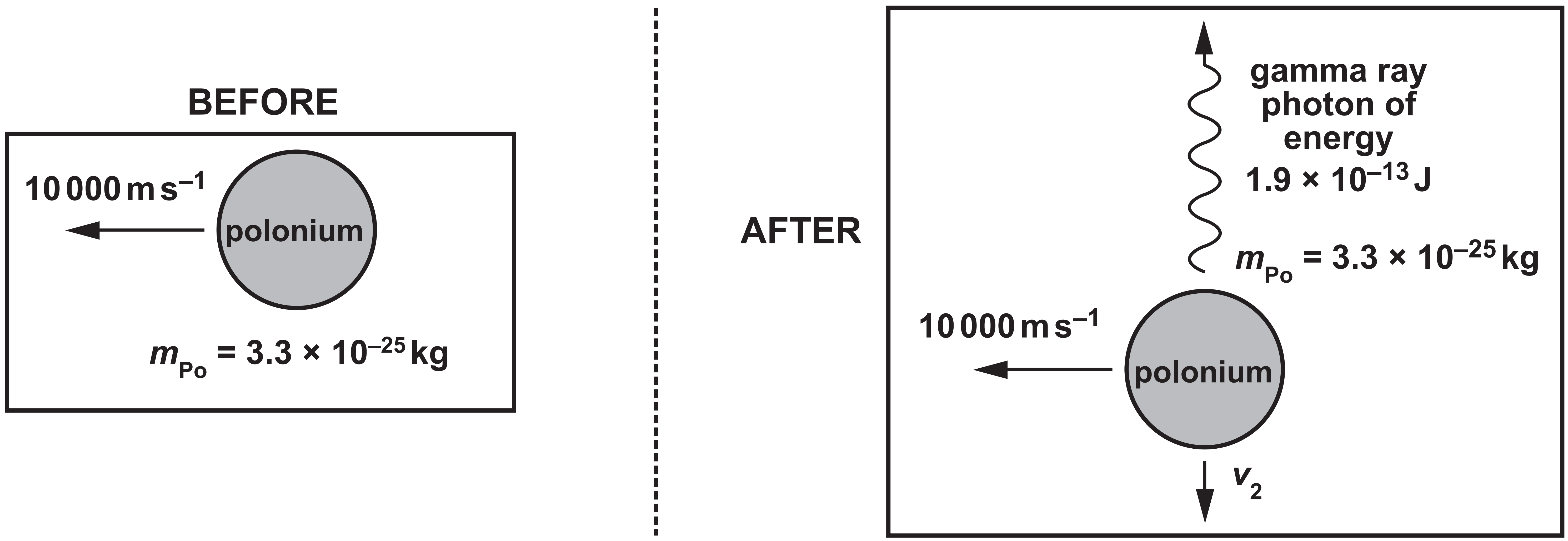
(ii) CA. [2]

8(c) For EACH of the processes **AB**, **BC**, **CA** and the whole cycle **ABCA**, write the values of W (the work done by the gas), ΔU (the change in internal energy of the gas) and Q (the heat supplied to the gas). The numbers in bold have been added to save time with repeated calculations. [4]

	Process			
	AB	BC	CA	ABCA
W		37.6 kJ		
ΔU		33.5 kJ	2.9 kJ	
Q				

8(c) Space for calculations:

END OF PAPER


BEFORE
10 000 m s–1
polonium
mPo = 3.3 × 10–25 kg
AFTER
gamma ray
photon of
energy
1.9 × 10–13 J
mPo = 3.3 × 10–25 kg
10 000 m s–1
polonium
v2