| Surname | Centre Number | Candidate Number |
|---|---|---|
| Other Names | | 2 |

# GCE A level

1324/01

## PHYSICS – PH4
## Oscillations and Fields

P.M. WEDNESDAY, 16 January 2013

1½ hours

| For Examiner's use only | | |
|---|---|---|
| Question | Maximum Mark | Mark Awarded |
| 1. | 17 | |
| 2. | 7 | |
| 3. | 10 | |
| 4. | 13 | |
| 5. | 10 | |
| 6. | 10 | |
| 7. | 13 | |
| Total | 80 | |

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**ADDITIONAL MATERIALS**

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

**INSTRUCTIONS TO CANDIDATES**

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

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.

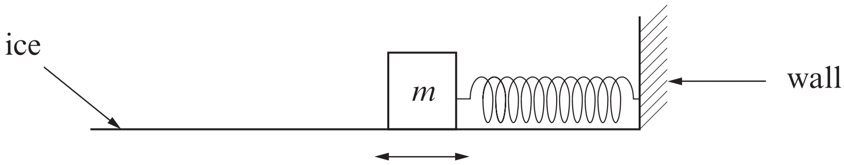
The number of marks is given in brackets at the end of each question or part question.

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.

Examiner only

**1.** *(a)* A mass, $m$, is attached to a spring and oscillates horizontally with simple harmonic motion on the floor of an ice rink. Its frequency of oscillation is 0.625 Hz and the spring constant of the spring is $2\,640\,\mathrm{N\,m^{-1}}$.




(i) Show that the mass, $m$, is approximately 170 kg. [3]

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(ii) The maximum kinetic energy of the mass is 2.15 kJ. Calculate its maximum speed. [2]

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(iii) State the maximum potential energy stored in the spring and explain your reasoning. [2]

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(iv) Calculate the amplitude of oscillation. [2]

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(v) At time $t = 0$, the displacement of the mass is zero. Calculate the **acceleration** of the mass at time $t = 1.40$ s. [3]

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*(b)* Explain briefly, why pushing the mass every 1.60 s would result in large amplitude oscillations. [2]

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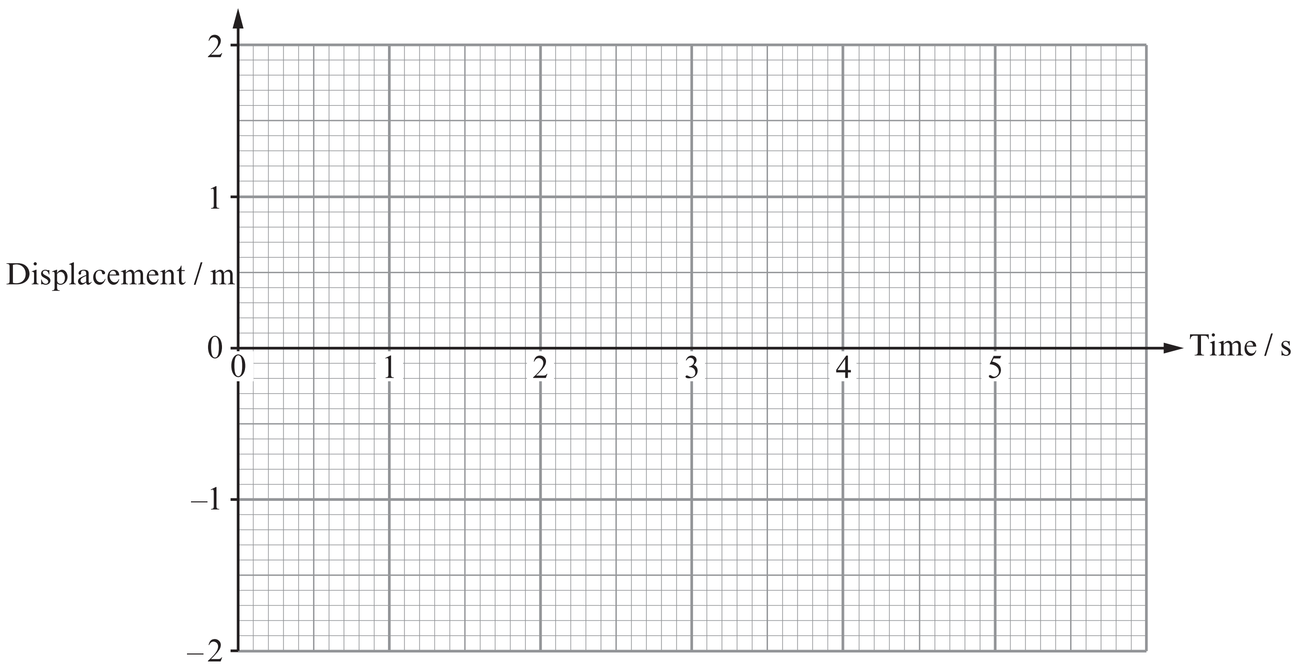
*(c)* Later, when the mass is released from its maximum displacement of 2.00 m an observer starts a stopwatch. After 5.0 s, the amplitude of oscillation has decreased to 1.40 m. Sketch a displacement-time graph of the damped oscillations on the grid below. [3]

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Examiner only

**2.** *(a)* The following equation relates to ideal gases.

$$N \times \frac{1}{2}m\overline{c^2} = \frac{3}{2}nRT$$

In terms of **energy**, explain the meaning of:

$\frac{1}{2}m\overline{c^2}$ [1]

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$\frac{3}{2}nRT$ [1]

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*(b)* (i) By applying the above equation to one mole of helium gas (or otherwise), calculate the rms speed of helium molecules at 20 °C (the mass of a helium molecule is $6.64 \times 10^{-27}$ kg). [3]

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(ii) Use your answer to *(b)*(i) to calculate the pressure of helium gas at 20 °C and density 0.19 $\text{kg m}^{-3}$. [2]

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**3.** *(a)* State the *Principle of Conservation of Momentum.* [2]

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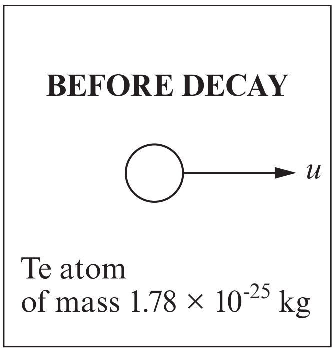
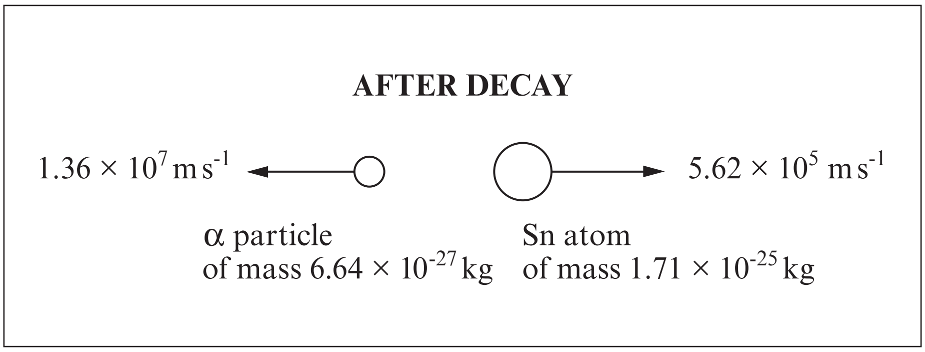
*(b)* A tellurium (Te) atom undergoes alpha (α) decay into tin (Sn) as shown below.




(i) Calculate the initial speed, $u$, of the tellurium (Te) atom. [3]

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(ii) Show that the momentum, $p$, of a photon is related to its energy, $E$, by the equation [2]

$$E = pc$$

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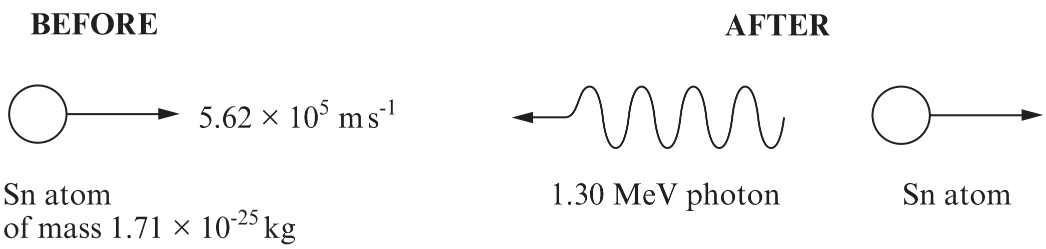
(iii) Use the equation $E = pc$ to calculate the **percentage** change in the momentum of the tin (Sn) atom when it emits a gamma ray photon of energy 1.30 MeV as shown. [3]

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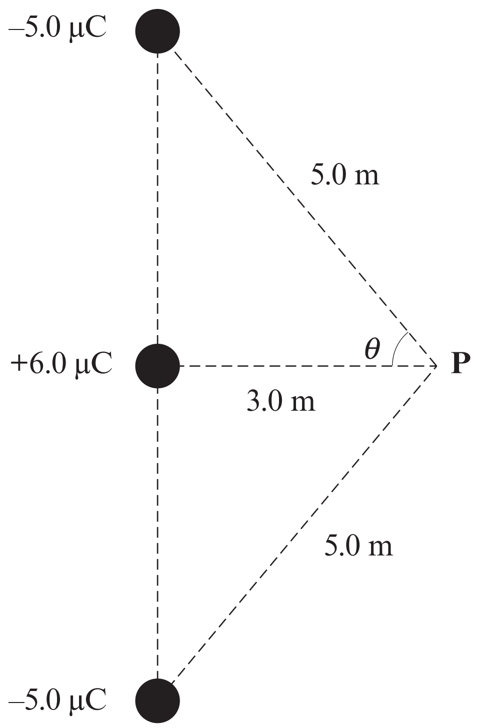
**4.** Three charges are placed in a line as shown.




[use the approximation $\frac{1}{4\pi\varepsilon_0} = 9.0 \times 10^9\,\mathrm{F^{-1}\,m}$ ]

*(a)* Draw **three arrows** at **P** representing the electric fields due to **each** of the three charges. [2]

*(b)* Calculate the electric field at **P** due to the +6.0 µC charge only. [2]

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*(c)* Calculate the resultant electric field at **P** (hint: cos $\theta$ = 0.6). [3]

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*(d)* (i) Show that the total electric potential at **P** is zero. [3]

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(ii) A positive 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]

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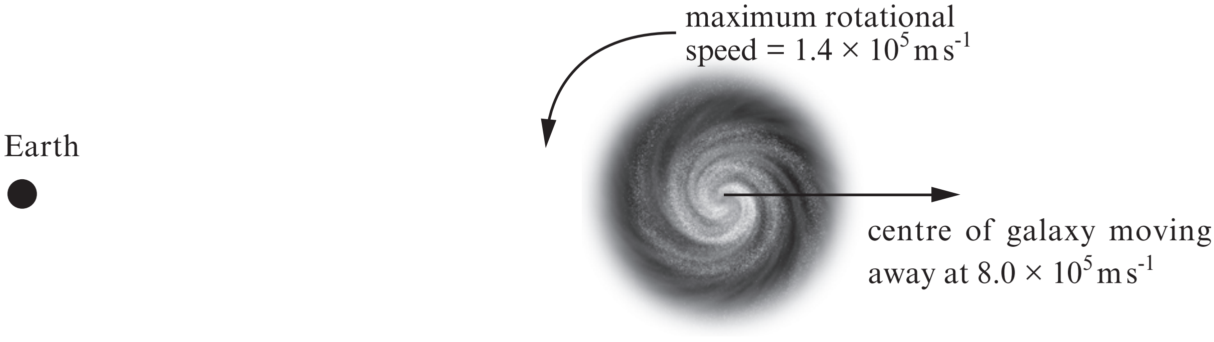
**5.** A spiral galaxy is moving away from the Earth and rotating as shown.




*(a)* Calculate the maximum and minimum red shift measured by an Earth observer when light of wavelength 656 nm is analysed from this spiral galaxy. [3]

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*(b)* The mass of the spiral galaxy is estimated to be $8.0 \times 10^{39}$ kg (based upon the amount of light that it emits). Use this figure to calculate the gravitational force exerted on a unit mass at a distance of $1.5 \times 10^{20}$ m from the centre of the spiral galaxy. [2]

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*(c)* (i) Show that, for an object in a circular orbit of radius, $r$, about a body of mass, $M$, the orbital speed $v$ is given by $v = \sqrt{\frac{GM}{r}}$ . [2]

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(ii) For this galaxy, the maximum rotational speed is $1.4 \times 10^5 \, \text{m s}^{-1}$ and this was measured at a radius of $1.5 \times 10^{20}$ m. Use the equation $v = \sqrt{\frac{GM}{r}}$ to investigate whether dark matter might exist in this spiral galaxy. [3]

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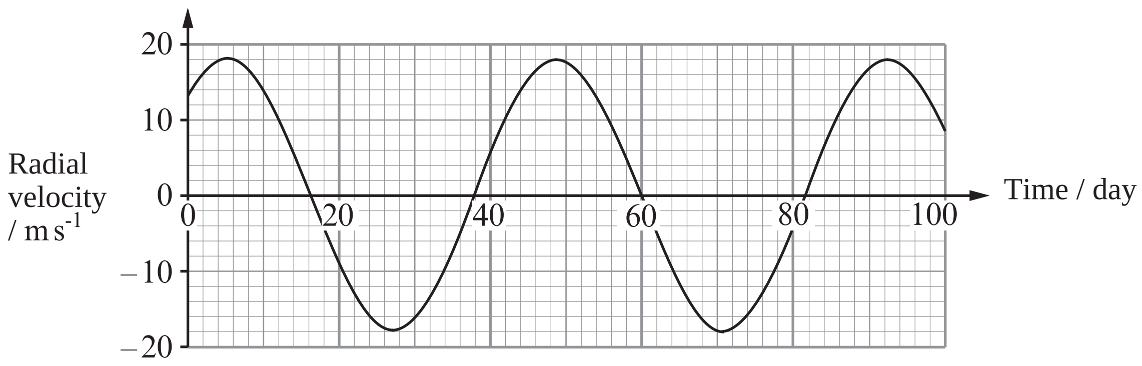
**6.** The light spectrum from a star 41 light years from Earth was analysed. It was found that this light was Doppler shifted due to the star orbiting the mutual centre of mass of the star and a nearby planet. The following graph is derived from the data obtained.




*(a)* From the graph, calculate the period of the orbit in **seconds**. [2]

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*(b)* Show that the radius of orbit of the star about the centre of mass is approximately $1.1 \times 10^7$ m. [2]

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*(c)* The mass of the star is $1.9 \times 10^{30}$ kg. Calculate the distance between the star and the planet, ensuring that you state any approximation that you make. [3]

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*(d)* Using the centre of mass equation, or otherwise, estimate the mass of the planet and compare its mass with that of the Earth ($M_E = 5.9 \times 10^{24}$ kg). [3]

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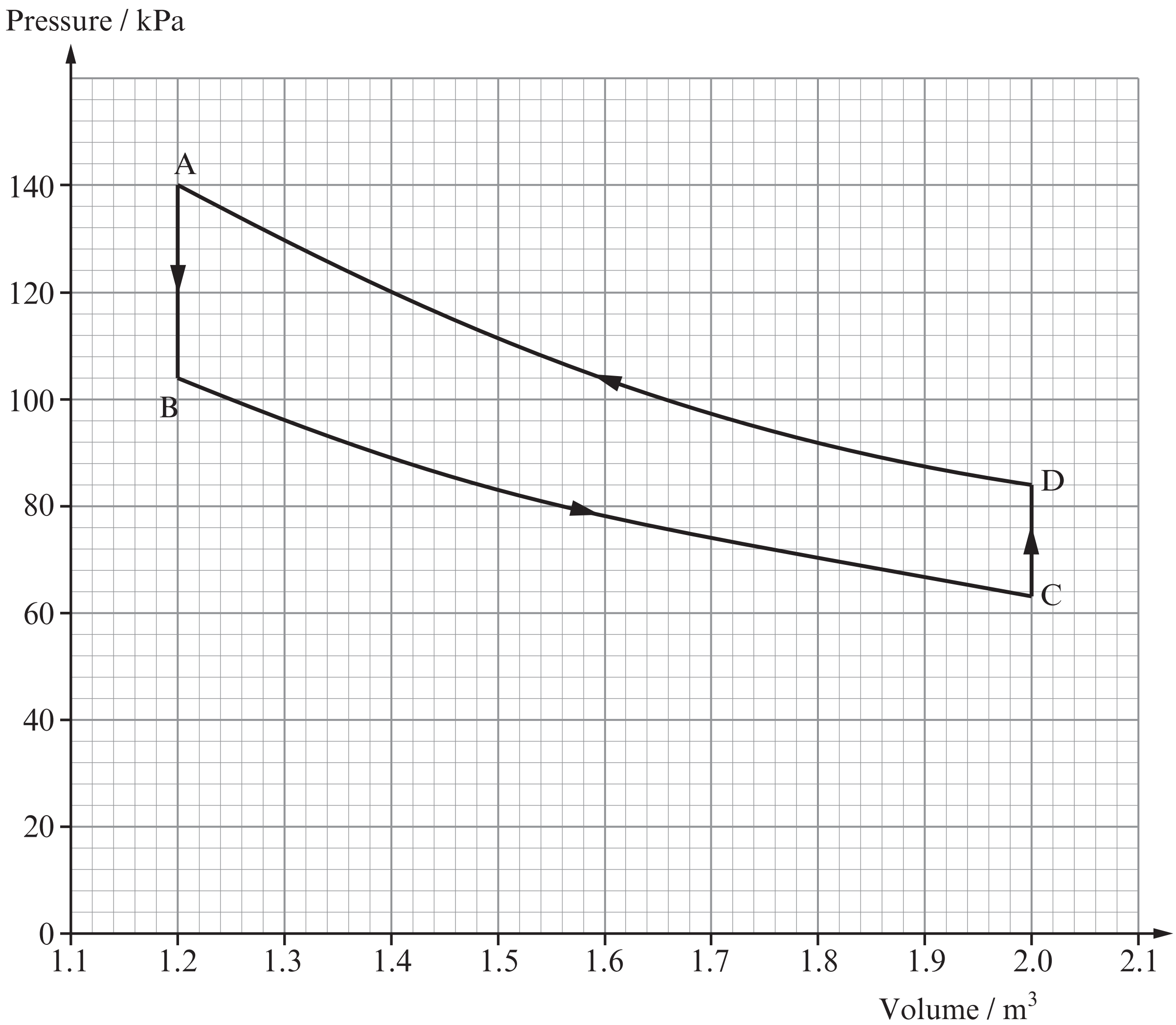
**7.** An ideal monatomic gas undergoes the cycle ABCDA shown below.




**BC and DA are isotherms** (the temperature along each of BC and DA is constant) and there are **49.3 mol** of ideal gas.

*(a)* By considering one point on BC and one on DA, show that the temperature of BC is approximately 300 K and that of DA is approximately 400 K. [2]

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*(b)* (i) Calculate the internal energy of the gas for BC, [1]

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(ii) and DA. [1]

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*(c)* Explain why the work is zero for both AB and CD. [1]

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*(d)* Explain why the change in internal energy is zero for both BC and DA. [1]

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*(e)* (i) Show that the work done by the gas for DA is approximately –90 kJ. [2]

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(ii) Estimate the work done for BC. [1]

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*(f)* For **each** of the processes AB, BC, CD, DA and the whole cycle ABCDA, write the values of $W$ (the work done by the gas), $\Delta U$ (the **change** in internal energy of the gas) and $Q$ (the heat supplied to the gas). [4]

| | Process | | | | |
|---|---|---|---|---|---|
| | AB | BC | CD | DA | ABCDA |
| $W$ | 0 | | 0 | –90 kJ | |
| $\Delta U$ | | 0 | | 0 | |
| $Q$ | | | | –90 kJ | |

**THERE ARE NO MORE QUESTIONS IN THE EXAMINATION.**