THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS B (ADVANCING PHYSICS)

2863/01

Rise and Fall of the Clockwork Universe

Candidates answer on the Question Paper

OCR Supplied Materials:
- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic calculator

Monday 18 January 2010
Afternoon

Duration: 1 hour 15 minutes

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.
- Show clearly the working in all calculations, and give answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES

- You are advised to spend about 20 minutes on Section A and 55 minutes on Section B.
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **70**.
- Four marks are available for the quality of written communication in Section B.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.
- This document consists of **16** pages. Any blank pages are indicated.

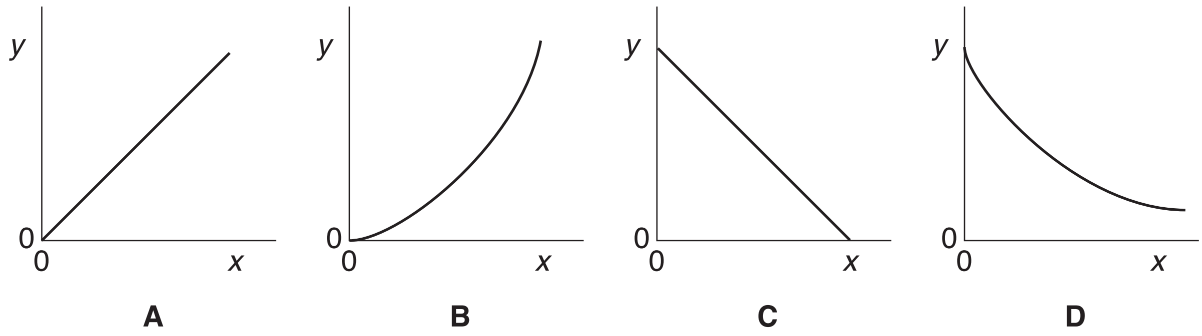
FOR EXAMINER'S USE		
Section	**Max.**	**Mark**
A	**20**	
B	**50**	
TOTAL	**70**	

Turn over

Answer **all** the questions.

Section A

1 Study the graphs **A**, **B**, **C**, **D**.



(a) Choose the graph that best shows the relationship between the **number of nuclei of a radioisotope** (y) and **time** (x).

answer ....**[1]**

(b) Choose the graph that best shows the relationship between the **charge stored on a capacitor** (y) and **potential difference across the capacitor** (x).

answer ....**[1]**

2 A balloon contains a volume of $2.3 \times 10^{-3}\,m^3$ of gas. The temperature of the gas is 285 K. The gas is at a pressure of 2.1×10^5 Pa. It behaves as an ideal gas.

(a) Show that the balloon contains about 0.2 mol of gas. State the equation you use.

$R = 8.3\,J\,mol^{-1}\,K^{-1}$

[2]

(b) Calculate the pressure of the gas when the temperature is increased to 300 K. The volume remains the same.

pressure of gas = ... Pa **[2]**

3 Here is a list of astronomical phenomena:

A red shift of light from distant galaxies
B microwave background radiation
C stellar parallax
D black holes

From the list, choose the phenomenon that gives the clearest evidence that the Universe is expanding.

answer ....**[1]**

4 The energy ε required for one molecule of ethanol to evaporate is 6.4×10^{-20} J.

(a) Calculate the Boltzmann factor, $e^{-\varepsilon/kT}$, for the vaporisation of ethanol at 298 K.

k, the Boltzmann constant $= 1.4 \times 10^{-23}\,\mathrm{J\,K^{-1}}$

Boltzmann factor = ...**[2]**

(b) State the units of the quantity kT.

units = ...**[1]**

5 A can of drink contains a chemical heating pack that releases 2.9×10^{4} J of energy into the drink when activated.

Calculate the final temperature of the drink assuming no energy is lost to the can or surroundings.

mass of drink = 0.19 kg
specific thermal capacity of drink = $4200\,\mathrm{J\,kg^{-1}\,K^{-1}}$
initial temperature of drink = 22°C

final temperature of drink = ... °C **[3]**

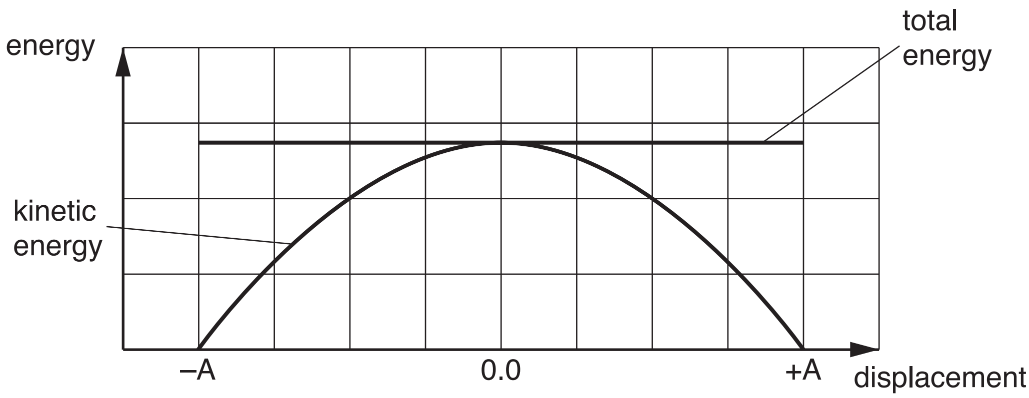
6 The nearest star, Proxima Centauri, is at a distance of 4.1×10^{16} m from Earth.

Calculate the distance to Proxima Centauri in **light years**.

$c = 3.0 \times 10^{8}\,\text{m}\,\text{s}^{-1}$
1 year $= 3.2 \times 10^{7}$ s

distance = ………………… light years **[2]**

7 The graph below shows how the total energy of an undamped oscillator varies with displacement. The graph also shows how the kinetic energy of the oscillator varies with displacement.



On the same axes draw a curve showing how the potential energy of the oscillator varies with displacement. **[2]**

8 Fig. 8.1 shows a force-extension graph for an elastic spring.

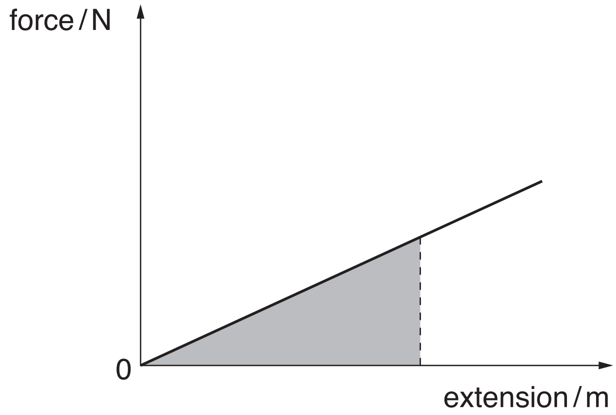


Fig. 8.1

State what is represented by the shaded area.

[1]

9 Calculate the energy stored on a 4700 μF capacitor when a p.d. of 9.0 V is applied across it.

energy stored = ……………………..J **[2]**

[Section A Total: 20]

Section B

In this section, four marks are available for quality of written communication.

10 This question is about using a radioisotope of potassium to find the age of a rock.

(a) A sample of potassium-40 has a mass of 2.3×10^{-6} g.

(i) Calculate the number of potassium nuclei in the sample.

molar mass of potassium-40 = 40 g mol^{-1}
$N_A = 6.0 \times 10^{23}$ mol^{-1}

number of nuclei in sample = ………………………… **[2]**

(ii) The activity of the sample is 0.57 Bq. Calculate the decay constant λ for potassium-40.

decay constant = ……………… s^{-1} **[2]**

(iii) Use the value of λ to calculate the half-life of potassium-40 in years.

1 year = 3.2×10^{7} s

half-life = …………………… years **[2]**

(b) Potassium-40 decays into a stable isotope of argon.

A particular rock sample was found to contain numbers of potassium and argon nuclei in a ratio of one nucleus of potassium to three nuclei of argon.

It is assumed that all the argon in the rock has been produced from the decay of potassium, and that none has escaped.

(i) Estimate the number of half lives passed since the rock was formed and calculate the age of the rock.

age of rock = ...years **[2]**

(ii) In fact, some argon does escape from the rock. Explain the effect this would have on the calculated age of the rock.

[3]

[Total: 11]

11 This question is about the gravitational field around an asteroid. The asteroid is spherical and has uniform density.

(a) Fig. 11.1 shows some equipotential lines around the asteroid. There is a constant gravitational potential difference between each equipotential line.

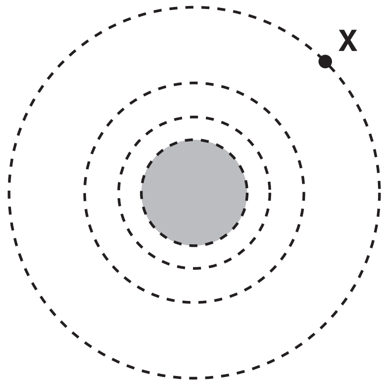


Fig. 11.1

(i) Draw the gravitational field line through point **X**. **[2]**

(ii) State the feature of the diagram which shows that the gravitational field strength decreases as the distance from the surface of the asteroid increases.

[1]

(b) Here are some data about the asteroid.

radius = 1.6×10^5 m

mass = 8.1×10^{19} kg

(i) Show that the magnitude of the gravitational field strength on the surface of the asteroid is about $0.2\,\text{N kg}^{-1}$.

$G = 6.7 \times 10^{-11}\,\text{N m}^2\,\text{kg}^{-2}$

[2]

(ii) It may be possible for a space vehicle to land on the asteroid to search for minerals.

Calculate the gravitational force on a vehicle of mass 3.5×10^2 kg on the surface of the asteroid.

gravitational force = ……………………..N **[1]**

(c) The asteroid is spinning. It makes one complete rotation every 5.6 hours.

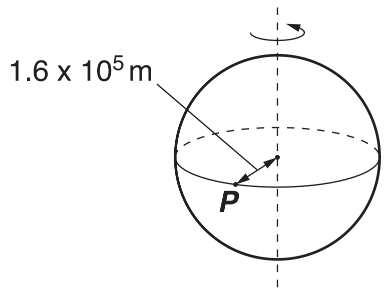


Fig. 11.2

(i) Show that the speed of point ***P*** on the surface of the asteroid (Fig. 11.2) is about $50\,\mathrm{m\,s^{-1}}$.

[1]

(ii) Calculate the centripetal force needed to keep the vehicle on the surface of the asteroid at this point.

centripetal force = …………N **[2]**

(iii) Explain why the vehicle will stay on the surface of the asteroid despite the rotation of the asteroid.

[1]

(iv) An asteroid of similar size and mass is found to spin at four times the speed. Explain whether the vehicle would stay on the surface of this asteroid.

[3]

[Total: 13]

12 This question is about the relationship

force = rate of change of momentum.

The relationship is often written in the form $F = \frac{(mv - mu)}{t}$.

(a) A ball of mass 0.065 kg is fired at a wall. The velocity of the ball when it strikes the wall is 18 m s^{-1}. It leaves the wall with a velocity of –14 m s^{-1}.

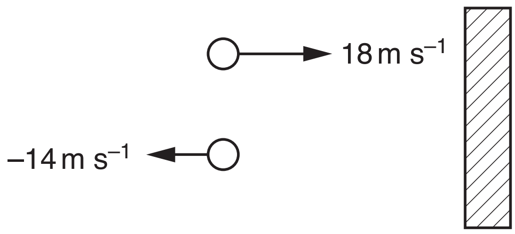


Fig. 12.1

(i) Show that the change of momentum of the ball is about –2.1 kg m s^{-1}.

[2]

(ii) The ball is in contact with the wall for 0.13 s.

Calculate the average force exerted on the ball by the collision.

average force on ball = ………………………….N **[2]**

(iii) State how the average force exerted on the **wall** during the collision compares with the average force on the **ball**.

[2]

(b) The behaviour of an ideal gas can be modelled as many particles in constant motion. The particles collide with the walls of the container without energy loss.

Use the ideas about force and rate of change of momentum from **(a)** to explain why the pressure of a fixed mass of gas at constant volume increases as the temperature of the gas increases.

[3]

(c) When an oxygen (O_2) molecule with a speed of $540\,\mathrm{m\,s^{-1}}$ bounces off the shaded wall of the container shown in Fig. 12.2, it experiences a maximum change of momentum of about $6 \times 10^{-23}\,\mathrm{kg\,m\,s^{-1}}$.

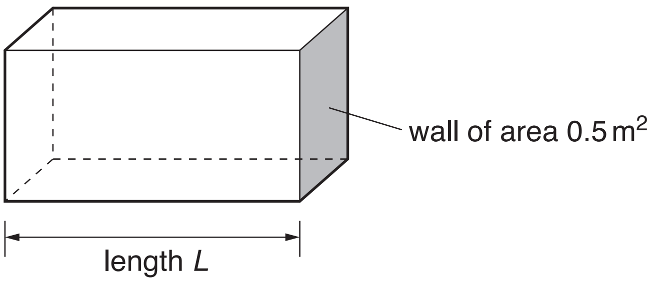


Fig. 12.2

Calculate the minimum number of collisions per second required for oxygen molecules at a speed of $540\,\mathrm{m\,s^{-1}}$ to exert a pressure of $1 \times 10^5\,\mathrm{N\,m^{-2}}$ on a wall of area $0.5\,\mathrm{m^2}$.

minimum number of collisions per second = ... $\mathrm{s^{-1}}$ **[2]**

(d) When the speed of an O_2 molecule is halved, its maximum change of momentum on collision with the wall is also halved.

Explain why the pressure on the walls of the container in Fig. 12.2 is **less than** half of its previous value when the speed of the particles in the container is halved.

[2]

[Total:13]

13 This question is about the vibrational testing of a satellite.

The vibrations simulate the shaking the satellite would undergo during launch. Assume the vibrations are simple harmonic.

(a) When oscillating, the velocity of the satellite is given by the equation

$$\text{velocity} = 2\pi fA\cos(2\pi ft)$$

where f = frequency
A = amplitude
t = time.

(i) Explain how the equation shows that the maximum velocity of the satellite is given by

$$\text{maximum velocity} = 2\pi fA.$$

[1]

(ii) Calculate the maximum velocity of the satellite when it oscillates at a frequency of 11 Hz with an amplitude of oscillation of 42 mm.

maximum velocity = ……………… $m\,s^{-1}$ **[2]**

(iii) State the acceleration of the satellite at the instant that maximum velocity occurs.

acceleration = …………………………… $m\,s^{-2}$ **[1]**

(iv) Calculate the maximum acceleration of the satellite with this oscillation.

maximum acceleration ………………………….. $m\,s^{-2}$ **[2]**

(b) The communications aerial on the satellite is observed to shake violently at one particular frequency. This is an example of resonance.

Explain why the aerial behaves in this way and suggest how the aerial could be modified in order to reduce the problem of resonance.

[3]

[Total: 9]

[Quality of Written Communication: 4]

[Section B Total: 50]

END OF QUESTION PAPER

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