Rewarding Learning

ADVANCED
General Certificate of Education

Centre Number

Candidate Number

Physics

Assessment Unit A2 1

assessing
Deformation of Solids, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

[APH11]

APH11

Assessment

Assessment Level of Control:
Tick the relevant box (✓)

Controlled Conditions	
Other	

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**
Answer **all nine** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part-question.
Quality of written communication will be assessed in Question **5(b)**.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

1 Naturally occurring radioactive substances emit three types of radiation called alpha, beta and gamma. These can be identified by their different ionising power, penetrating ability and behaviour in a magnetic field.

(a) List the three types of nuclear decay in order of increasing:

(i) magnitude of charge _____ _____ _____ [1]

(ii) ionising power _____ _____ _____ [1]

(b) Staff working in nuclear medicine departments of a hospital are required to wear a personal dosimeter film badge on their outer clothing. Within the badge holder are a number of filters which may either absorb radiation or allow it to pass through to a photographic film emulsion and expose it, making a record of the dose of radiation received by that member of staff.

(i) Explain why the dosimeter badge worn on the outer layer of clothing is unlikely to be exposed to alpha radiation.

_____

_____

_____ [1]

(ii) One filter is a 3 mm thick layer of plastic with a density similar to that of aluminium. Explain how this will distinguish between the two other types of radiation.

_____

_____

_____ [1]

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(Questions continue overleaf)

[Turn over

2 **(a)** **(i)** On the axes of **Fig. 2.1** sketch the graph of load against extension that you would expect for a metal wire being stretched over a range of forces up to and beyond its elastic limit. [1]

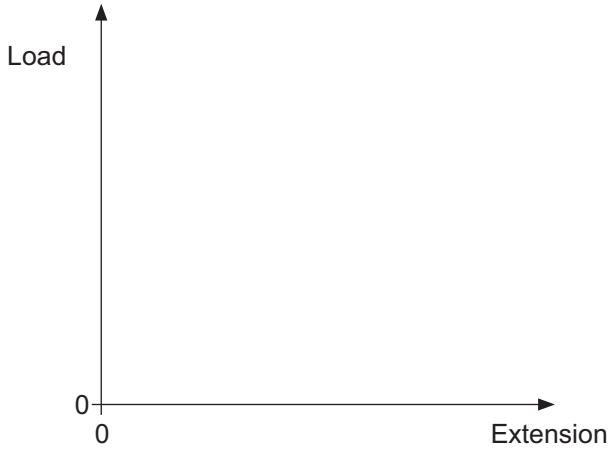

Fig. 2.1

(ii) On the graph you have drawn in **Fig. 2.1**, label the limit of proportionality, the elastic limit and the region where the wire exhibits plastic behaviour. [3]

(b) Concrete is used in construction to support large loads. In the testing of concrete, a cylinder of height 2.40 m and diameter 12 cm supports a large load. The reduction in its length when the load is applied is measured as 1.9×10^{-4} m and the strain energy stored within the cylinder is 1.43 J. The material behaves elastically.

(i) Calculate the size of the load being supported.

Load = _____ N [2]

(ii) Determine the Young modulus for concrete. Include the unit.

Young modulus = _____

Unit _____ [5]

(iii) How would you verify that the concrete cylinder has undergone elastic deformation only?

_____

_____ [2]

(c) The Young modulus is an important factor to be considered when choosing a material for engineering projects. State two other factors which should be considered when choosing a suitable material.

_____

_____

_____ [2]

[Turn over

3 A simple pendulum of length L is displaced 11.0 cm from its equilibrium point O to a point A. It is then released and allowed to oscillate freely. See **Fig. 3.1** below.

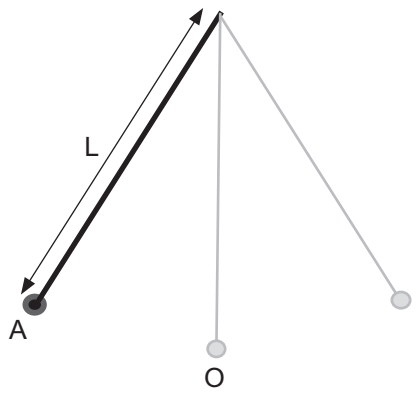

Fig. 3.1

(a) The pendulum is undergoing simple harmonic motion. Explain what this means.

_____

_____

_____ [2]

(b) The pendulum completes fifteen oscillations in a time of 8.70 seconds.

(i) Calculate the magnitude of the maximum acceleration of the pendulum.

Maximum acceleration = _____ m s^{-2} [6]

(ii) State the position at which the maximum acceleration will occur.

_____ [1]

(iii) Calculate the length L of the pendulum.

Length L = _____ m [2]

(c) After a number of oscillations the effect of damping is noticeable.
How does this affect:

(i) the maximum acceleration of each oscillation?

_____ [1]

(ii) the time period of each oscillation?

_____ [1]

[Turn over

4 A gas law is being tested using the apparatus shown in **Fig. 4.1**.

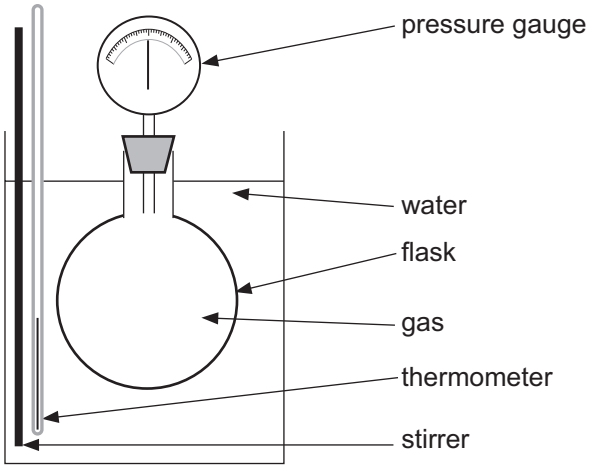

Fig. 4.1

(a) State the law which is being investigated.

_____

_____

_____ [2]

(b) (i) Describe the procedure followed to obtain the results needed to verify this law.

_____

_____

_____

_____

_____

_____ [2]

(ii) How can the law be verified **graphically** from the results?

_____

_____

_____ [2]

(c) The volume of the flask is 1200 cm^3.

(i) Calculate the number of moles of gas in the sample when the temperature is 22 °C and pressure is 1.10×10^5 Pa.

Number of moles = _____ [3]

(ii) When the gas pressure is reduced to 1.05×10^5 Pa, calculate the mean kinetic energy of a molecule of the gas.

Mean kinetic energy of a molecule = _____ J [4]

[Turn over

5 The quality of your written communication will be assessed in part (b) of this question.

The ITER prototype fusion reactor is located in southern France and is an international collaboration between scientists working to develop a viable source of energy from nuclear fusion. It is based on a tokamak reactor design, in which a plasma is confined at extremely high temperatures.

(a) Explain what is meant by a plasma and why such high temperatures are required in the reactor.

[4]

(b) Describe the three methods by which heating of the plasma is achieved.

[6]

(c) Give an explanation of two advantages that nuclear fusion would have over nuclear fission as a power source.

[2]

[Turn over

6 A laboratory investigation is carried out to determine the half-life of the radioactive isotope protactinium using a Geiger–Muller tube connected to a ratemeter as shown in **Fig. 6.1**.

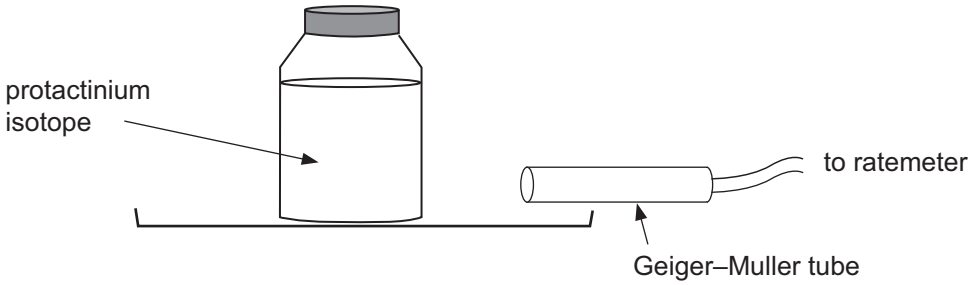

Fig. 6.1

Table 6.1 contains data collected by a student.

Table 6.1

Time / s	Corrected count rate / Bq
0	110
40	75
80	52
120	35

(a) Explain what is meant by the word **corrected** in the term 'corrected count rate' and describe how the corrected count rate is obtained.

[3]

(b) Using the data from **Table 6.1**, calculate a reliable value for the half-life of protactinium.

Half-life = _____ s [4]

(c) **(i)** Using the equation $A = \lambda N$, find a value for N, the number of undecayed nuclei that cause an activity equal to 35 Bq at 120 seconds.

N = _____ [1]

(ii) Why is the value of N obtained using data from this experiment much smaller than the number of undecayed nuclei present in the sample at 120 seconds?

_____

_____

_____ [1]

[Turn over

7 A circular section of a horizontal racing track has a radius of 60 metres. A racing car can travel around this section with a maximum velocity of 83 km h^{-1}, the constant frictional force between the tyres and the road provides the centripetal force.

(a) Calculate the angular velocity of the car as it travels around the circular section at maximum velocity.

Angular velocity = _____ rad s^{-1} [4]

(b) Describe the path that the car would take if the driver exceeds the maximum velocity. Explain why it takes this path.

_____

_____ [2]

In order to increase race speeds, the track designers 'bank' the circular section as shown in **Fig. 7.1**. The car can now follow the same circular path of radius 60 m with a greater maximum velocity.

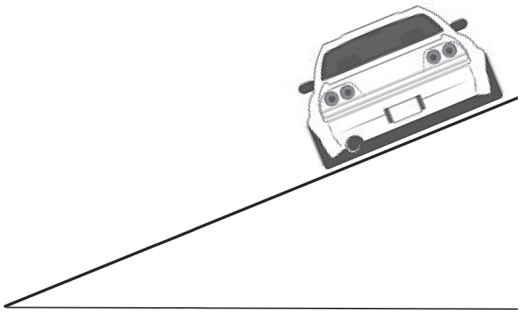

Fig. 7.1

(c) (i) Explain why banking the track in this way allows for a greater maximum velocity.

_____

_____

_____

_____ [2]

(ii) When the centripetal force is doubled, calculate the new maximum velocity for the same car mass and track radius.

New maximum velocity = _____ km h^{-1} [3]

[Turn over

8 **(a)** Rutherford's famous alpha-scattering experiment was the basis for the nuclear model of the atom, replacing Thomson's 'plum-pudding' model. He concluded that the diameter of a nucleus is many times smaller than that of an atom and that the nucleus contains almost all of the mass of the atom. Which experimental observations led to these two conclusions?

_____

_____

_____

_____ [2]

(b) Further scattering experiments have led to the relationship given in **Equation 8.1**.

$$r = r_o A^{1/3} \qquad \textbf{Equation 8.1}$$

(i) What does the constant r_o represent, whose value may be taken as $r_o = 1.2\,\text{fm}$?

_____

_____ [1]

(ii) Use **Equation 8.1** to calculate the radius of the nucleus of a carbon atom $^{12}_{6}C$.

Radius = _____ m [2]

(iii) Calculate the density of the nucleus of a carbon atom $^{12}_{6}C$.

Density = _____ kg m^{-3} [4]

(c) The stability of a nucleus is linked to the value of its binding energy per nucleon. Use the data below to calculate the binding energy per nucleon for a carbon nucleus, atomic number 6 and mass number 12.

Mass of $^{12}_{6}C$ nucleus = 11.9967 u

Mass of proton = 1.00728 u

Mass of neutron = 1.00866 u

BE per nucleon = _____ J [6]

[Turn over

9 A domestic coal-fuelled stove can maintain the temperature in a room at a steady 23 °C, despite a steady draught of cool air through the room.

The air flowing in from outside is at a temperature of 10 °C.

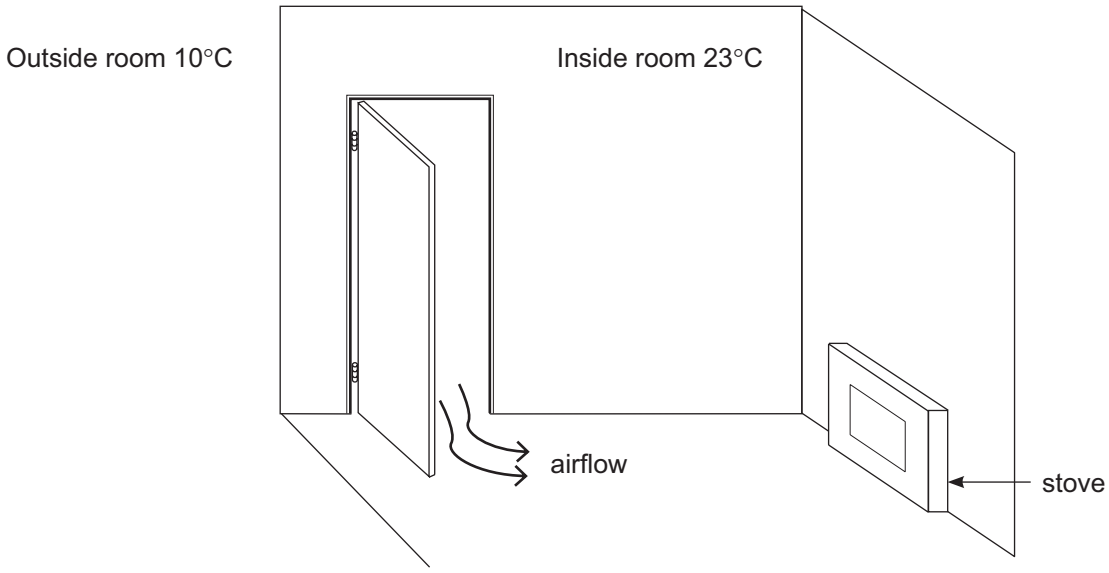

Fig. 9.1

(a) Assume that the stove is 65% efficient, and that the cool air flows into the room at a rate of 0.25 m^3 per second. Calculate the power of the stove.

The specific heat capacity of air can be taken as 1.02 kJ kg^{-1} K^{-1} and the density of air as 1.23 kg m^{-3}.

Power = _____ W [5]

(b) (i) Calculate the current that would be drawn by a mains-powered electric heater of the same efficiency and power.

Current = _____ A [2]

(ii) Explain whether or not a plug-in electric heater is a practical alternative to the stove.

_____

_____

_____ [1]

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For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total Marks	

Examiner Number