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# Thursday 11 June 2015 – Morning

## A2 GCE PHYSICS A

**G484/01** The Newtonian World

Candidates answer on the Question Paper.

**OCR supplied materials:**
- Data, Formulae and Relationships Booklet (sent with general stationery)

**Other materials required:**
- Electronic calculator

**Duration:** 1 hour 15 minutes

| Candidate forename | | Candidate surname | |
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| Centre number | | | | | | Candidate number | | | | |
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**INSTRUCTIONS TO CANDIDATES**

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

**INFORMATION FOR CANDIDATES**

- 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 **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means, for example, you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **20** pages. Any blank pages are indicated.

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Answer **all** the questions.

**1** **(a)** Apollo-11 was the first manned spacecraft to land on the Moon. Fig. 1.1 shows part of the equipment left on the surface by the astronauts and the forces acting upon it.

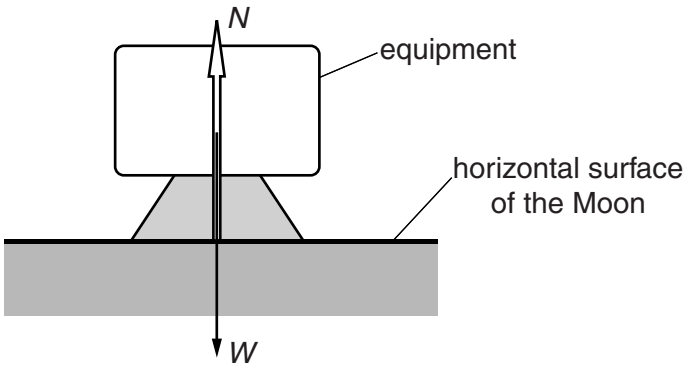



**Fig. 1.1**

According to Newton's third law interacting forces always occur in pairs. A student states that the normal contact force *N* is equal in magnitude to the weight *W* because of Newton's third law.

**(i)** Give **two** reasons why the student's statement is incorrect.

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..... **[2]**

**(ii)** Use Newton's third law to state the magnitude and location of the force pairing up with the weight *W*.

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

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**(b)** While on the surface of the Moon one of the astronauts hit a golf ball with a club and declared that it went for 'miles and miles'. The ball was given an initial velocity $u$ at a fixed angle $\theta$ to the horizontal. Show that the horizontal distance travelled by the ball is directly proportional to $u^2$.

**[3]**

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**2** **(a)** A solar-powered ion propulsion engine creates and accelerates xenon ions. The ions are ejected at a constant rate from the rear of a spacecraft, as shown in Fig. 2.1.
The ions have a fixed mean speed of $3.2 \times 10^4\,m\,s^{-1}$ relative to the spacecraft.
The initial mass of the spacecraft is $5.2 \times 10^3\,kg$.

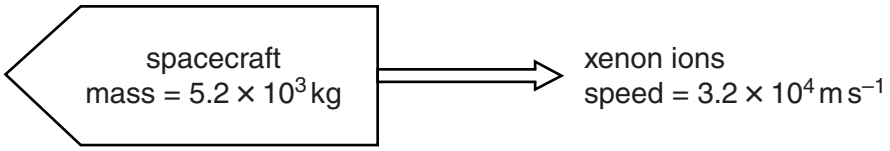



**Fig. 2.1**

**(i)** Calculate the mass of one xenon ion.
molar mass of xenon = $0.131\,kg\,mol^{-1}$

mass ..... kg **[1]**

**(ii)** The engine is designed to eject $9.5 \times 10^{18}$ xenon ions per second.
Determine the initial acceleration of the spacecraft.

acceleration = ..... $m\,s^{-2}$ **[3]**

**(iii)** State in words the law that you have used to solve **a(ii)**.

*In your answer, you should use appropriate technical terms spelled correctly.*

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

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**(iv)** State and explain how you would expect the acceleration of the spacecraft to change, if at all, while the engine is running.

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..... **[3]**

**(b)** A small rocket is used to detach a satellite of mass 180 kg from the spacecraft. Fig. 2.2 shows the variation of the force $F$ created by the rocket on the satellite with time $t$.

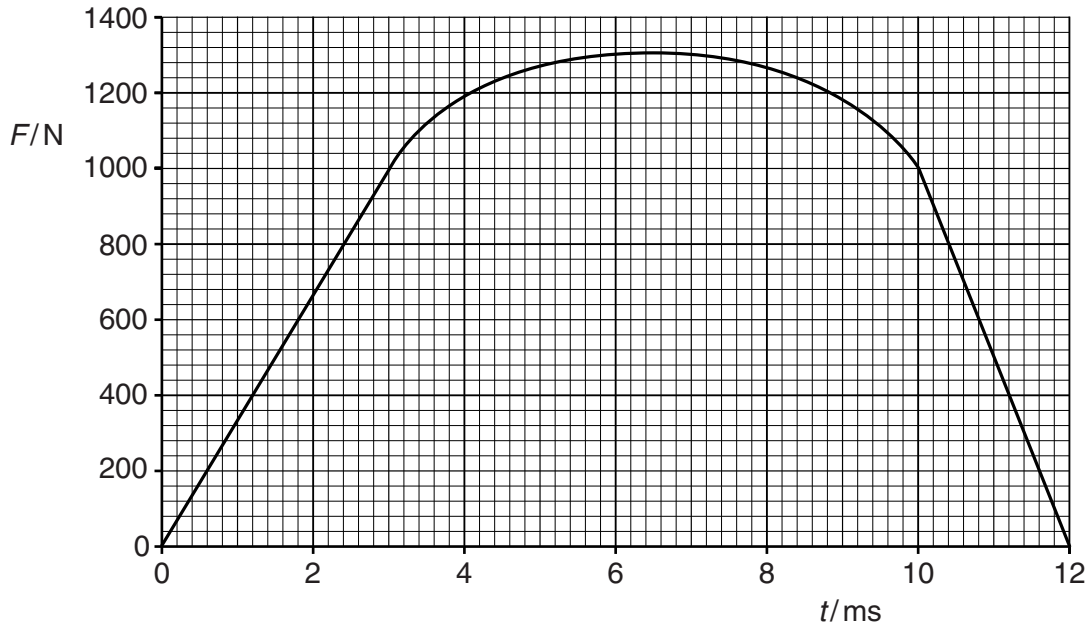



**Fig. 2.2**

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Use Fig. 2.2 to

**(i)** determine the change in the velocity of the satellite as a result of the force *F* applied for the period of 12 ms.

change in velocity = ..... $m\,s^{-1}$ **[4]**

**(ii)** describe how the acceleration of the satellite varies between 0 and 10 ms.

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..... **[2]**

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**3** Fig. 3.1 shows a metal plate attached to the end of a spiral spring. The end **A** of the spring is fixed to a rigid clamp. The plate is pulled down by a small amount and released. The plate performs simple harmonic motion in a vertical plane at a natural frequency of 8 Hz and the spring remains in tension at all times.

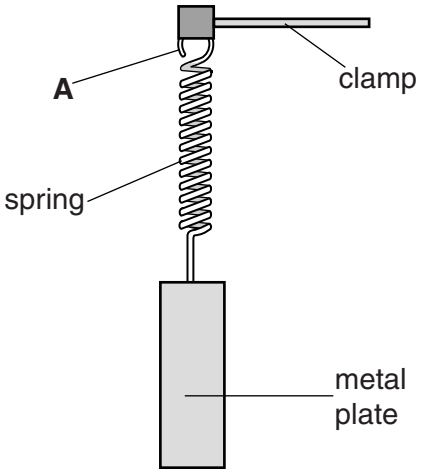



**Fig. 3.1**

**(a) (i)** On Fig. 3.2 sketch an acceleration *a* against displacement *x* graph for the motion of the metal plate. You are not required to give values on the axes.

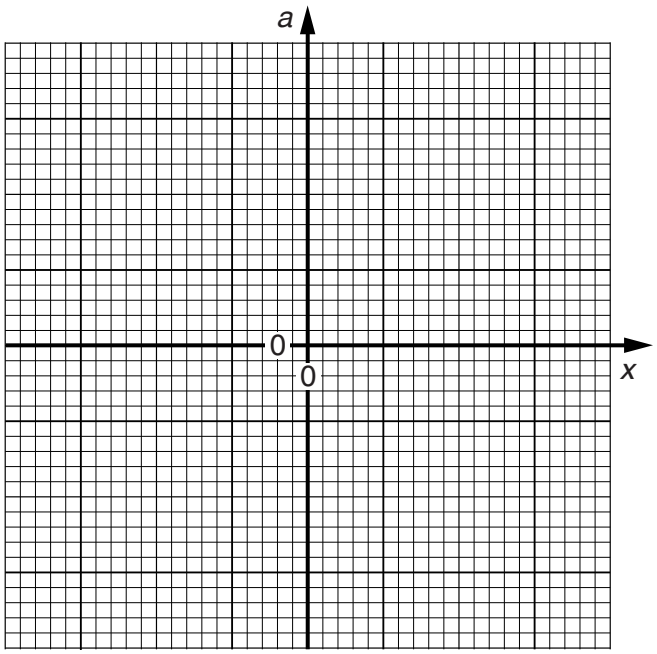



**Fig. 3.2**

**[2]**

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**(ii)** Explain how your graph could be used to determine the frequency of oscillation of the metal plate.

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..... **[2]**

**(b)** Fig. 3.3 shows the variation of the vertical velocity $v$ of the plate with time $t$ at a frequency of 8 Hz.

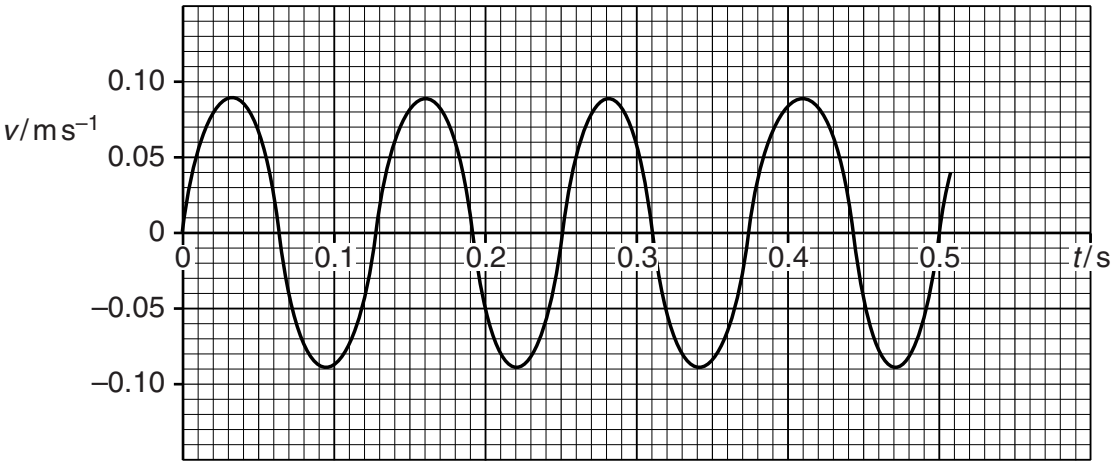



**Fig. 3.3**

Use the graph to determine

**(i)** the amplitude of the motion

amplitude = ..... m **[2]**

**(ii)** the maximum vertical acceleration of the plate.

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

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**(c)** The metal plate is now immersed in light oil which provides a constant frictional force to the plate. On Fig. 3.4 draw carefully the graph you would expect to obtain for the variation of the vertical velocity $v$ with time $t$. As a guide a copy of the graph in Fig. 3.3 is drawn for you.

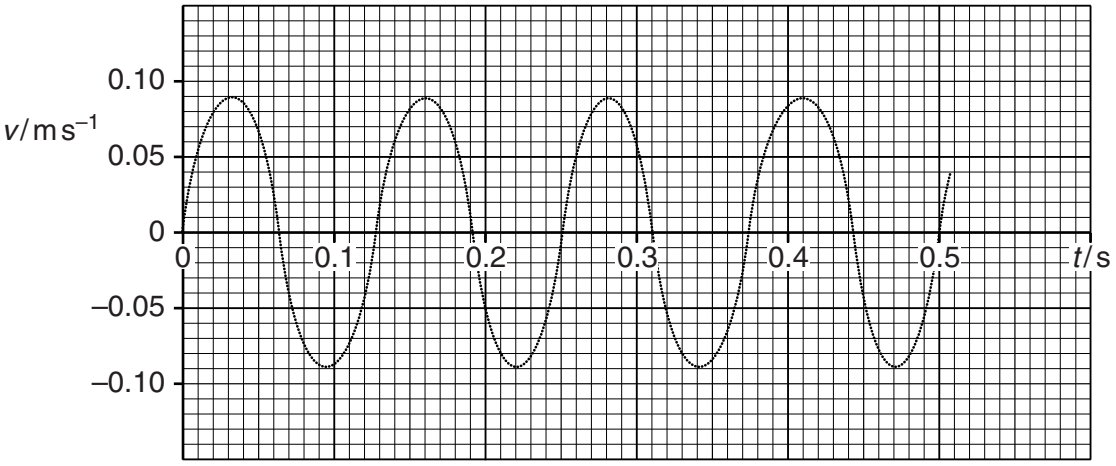



**Fig. 3.4**

**[2]**

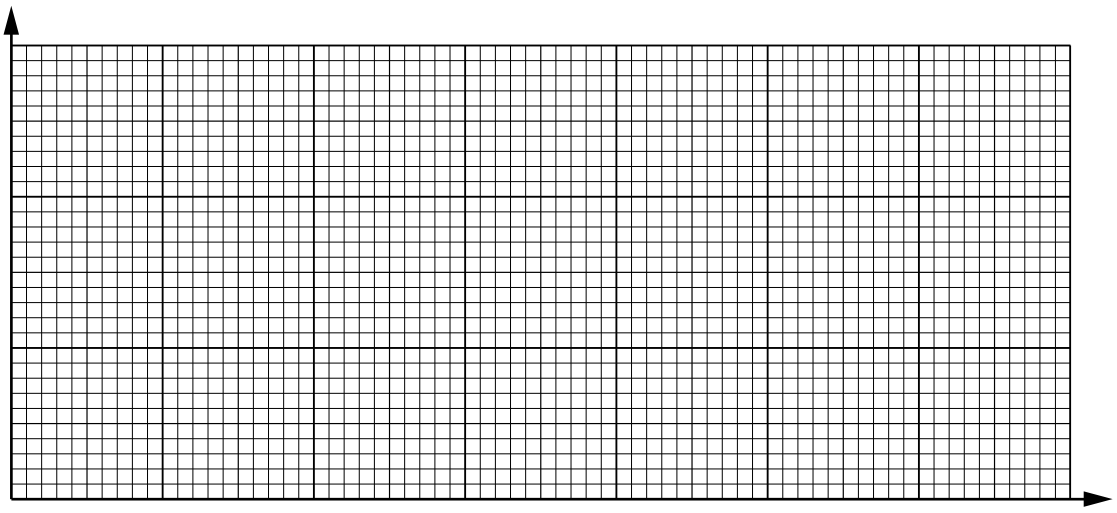
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**(d)** The plate is now removed from the oil and the point **A** on the spring connected to an oscillator that vibrates vertically with constant amplitude. The frequency of the oscillator is increased slowly from 0 Hz to 12 Hz.

Describe and explain the motion of the metal plate during this procedure.

Sketch a labelled graph to help with your explanation.

*In your answer, you should use appropriate technical terms spelled correctly.*



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..... **[3]**

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**4** **(a)** Write a word equation which states Newton's law of gravitation.

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.....

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

**(b)** A planet of mass *m* moves in a circular orbit of radius *r* about a star of mass *M*. The planet has an orbital period *T*.

Use your knowledge of circular motion and Newton's law of gravitation to derive Kepler's third law.

**[4]**

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**(c)** The star HD10180 in the constellation Hydrus is notable for its large planetary system. The period $T$ and the mean orbital radius $r$ for HD10180's planets have been deduced from recent observations. Fig. 4.1 has been constructed using these data.

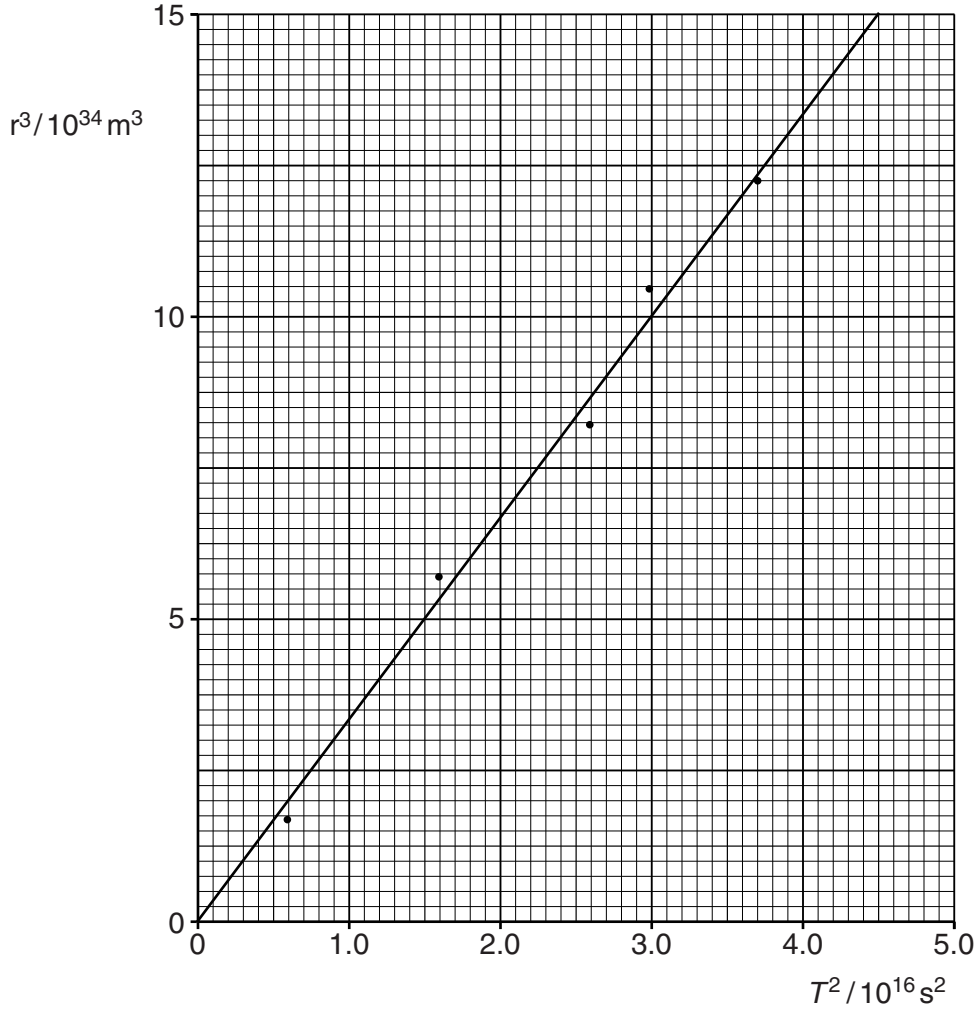



**Fig. 4.1**

**(i)** State what features of Fig. 4.1 support the view that Kepler's third law may be applied to this system.

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

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**(ii)** Use Fig. 4.1 to determine the mass of the star HD10180.

mass = ..... kg **[3]**

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**5** Lasers are often used to form precision-welded joints in titanium. To form one such joint it is first necessary to increase the temperature of the titanium to its melting point. Fig. 5.1 shows the joint and the volume of titanium to be heated.

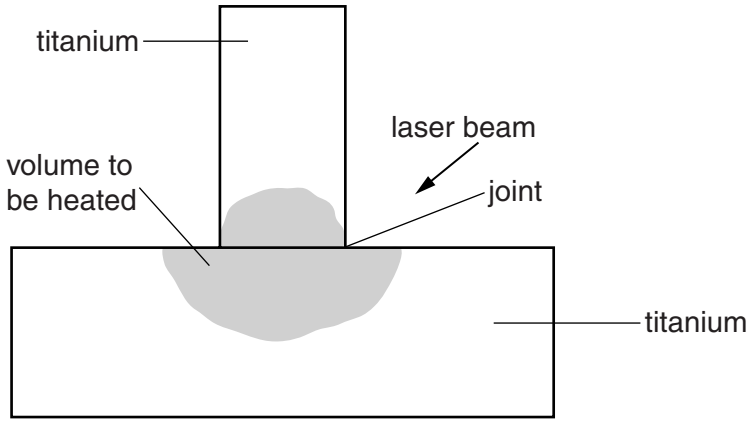



**Fig. 5.1**

The photon beam from the laser is focused onto the shaded volume of the joint and is converted into thermal energy in the titanium.

**(a)** The wavelength of the photons is $1.1 \times 10^{-6}$ m.

Show that the energy of a photon in the beam is $1.8 \times 10^{-19}$ J.

**[1]**

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**(b)** Photons are emitted from the laser at a constant rate of $6.3 \times 10^{19}\,s^{-1}$.

Estimate the time taken to raise the temperature of the shaded volume of titanium shown in Fig. 5.1 to melting point. Use the data below for your calculations.

initial temperature = 20 °C
melting point of titanium = 1700 °C
density of titanium = $4.5 \times 10^{3}\,kg\,m^{-3}$
specific heat capacity of titanium = $520\,J\,kg^{-1}\,K^{-1}$
shaded volume of titanium being heated = $8.1 \times 10^{-12}\,m^{3}$.

time = ..... s **[3]**

**(c)** In practice it takes a longer time to reach the melting point.
State and explain **two** factors that will increase the time taken.

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..... **[2]**

**(d)** To complete the weld more photons must be focused onto the joint. During this final stage the temperature remains constant. Explain why this is to be expected.

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

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**6** **(a)** Fig. 6.1 shows how the volume $V$ of a fixed mass of an ideal gas at constant pressure varies with temperature $\theta$ from 0 °C to 120 °C.

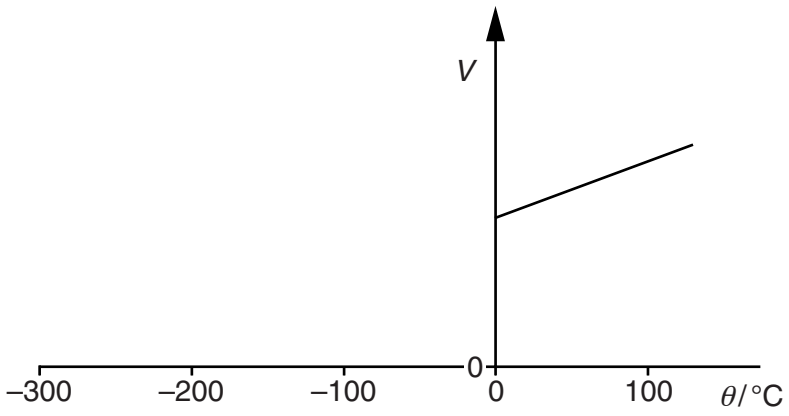



**Fig. 6.1**

Describe how this graph leads to the concept of an absolute zero of temperature.

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..... **[2]**

**(b)** A mass of gas is enclosed in a tank. The gas is cooled until it becomes a liquid. During this process its internal energy changes.

**(i)** State what is meant by the *internal energy* of the gas.

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

**(ii)** Explain why the internal energy of the gas differs from that of its liquid phase.

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..... **[2]**

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**(c)** A scuba diver uses air in which the percentage of nitrogen is reduced by adding helium to form a substance known as Trimix. A $1.2 \times 10^{-2}\,m^3$ rigid steel scuba diving tank contains 45 mol of air at a temperature of 20 °C.

**(i)** Calculate the pressure in the tank.

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

**(ii)** The tank is then connected to a cylinder of volume $2.0 \times 10^{-3}\,m^3$ containing helium at a pressure of $5.0 \times 10^{7}$ Pa and a temperature of 20 °C as shown in Fig. 6.2.

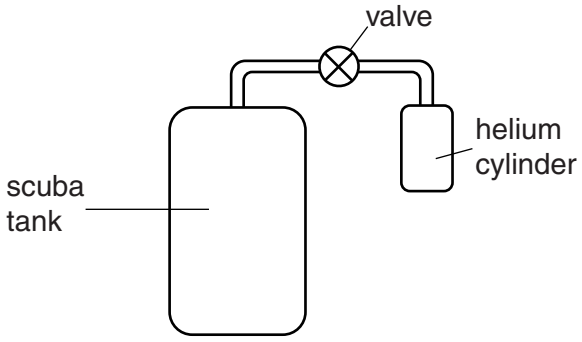



**Fig. 6.2**

The valve is opened allowing the gases to mix. When mixed the final temperature is 20 °C. Calculate the final pressure of the resulting Trimix in the scuba tank helium cylinder system.

pressure = ..... Pa **[3]**

**(iii)** Explain why you would expect this pressure to decrease when the tank is used by a diver in water where the temperature is 4 °C.

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

**END OF QUESTION PAPER**

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## ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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