OXFORD
INTERNATIONAL
AQA EXAMINATIONS

# OXFORD AQA INTERNATIONAL A-LEVEL
# PHYSICS
## (9630)

## PAPER 4

Specimen 2019 | Morning | Time allowed: 2 hours

**Materials**
For this paper you must have:
- a pencil
- a ruler
- a calculator
- a data and formula booklet.

**Instructions**
- use black ink or ball-point pen
- answer **all** questions
- show all your working.

**Information**
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80 marks.

Please write clearly in block capitals.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname

Forename(s)

Candidate signature ______________________

V2.0

## Section A

Answer **all** questions in this section.

**0 1** **Table 1** gives the surface areas and *U*-values for the external parts of a house before and after additional insulation has been added.

**Table 1**

| **part of house** | **walls** | **doors** | **windows** | **roof** |
|---|---|---|---|---|
| **area / $m^2$** | 90 | 4 | 16 | 70 |
| ***U*-value with standard insulation / $W\ m^{-2}\ K^{-1}$** | 1.0 | 2.4 | 5.0 | 0.6 |
| ***U*-value with additional insulation / $W\ m^{-2}\ K^{-1}$** | 0.6 | 2.4 | 2.9 | 0.3 |

**0 1 . 1** A house has standard insulation for the walls, windows, doors and roof. The temperature inside the house is 23 °C and the temperature outside is 34 °C.

Calculate the total rate of heat transfer into the house.

**[4 marks]**

rate of heat transfer = ______________ W

**0 1 . 2** An example of induced fission is shown below.

$$^{235}_{92}\text{U} + {}^{\_\_}_{\_\_}\text{n} \rightarrow {}^{90}_{38}\text{Sr} + {}^{\_\_}_{\_\_}\text{Xe} + 2\,{}^{\_\_}_{\_\_}\text{n}$$

Complete the equation.

**[2 marks]**

**0 1 . 3** Each fission reaction transforms 200 MeV of energy into useful forms. A reactor produces 600 MW.

Calculate, in g $s^{-1}$, the rate of use of uranium-235

**[3 marks]**

rate of use of uranium-235 = ____________________________ g $s^{-1}$

**0 1 . 4** Determine which single part of the house should be insulated to give the best reduction in the rate of heat transfer. Use the data from **Table 1**.
Justify your answer.

**[3 marks]**

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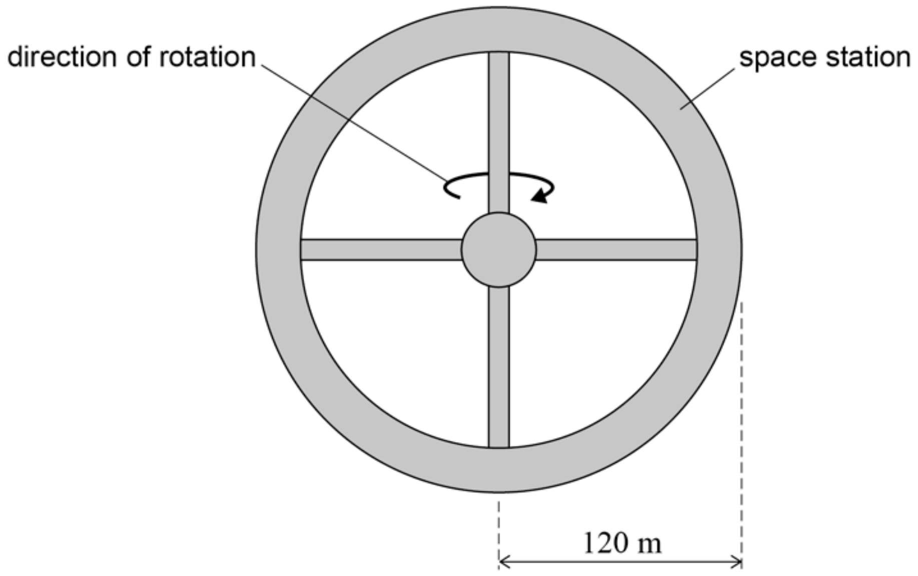
**0 1 . 5** Boron is used to make control rods for use in many fission reactors.

Explain the purpose of control rods and why boron is a suitable material for this use.

**[3 marks]**

**0 2** **Figure 1** shows an idea for a future space station. The station rotates about its axis to simulate gravity in its outer section.




**0 2 . 1** The space station has a moment of inertia of $5.2 \times 10^{10}$ kg m$^2$.
It is accelerated from rest with a torque of $4.4 \times 10^4$ N m for 3.0 days.

Show that angular speed of the space station is approximately 0.22 rad s$^{-1}$.

**[3 marks]**

**0 2 . 2** Calculate the work done accelerating the space station from rest to an angular velocity of 0.22 rad s$^{-1}$.

**[1 mark]**

work done = ________________________ J

**0 2 . 3** An astronaut moves from the centre of the space station to the outer rim.
Discuss the effect that the change in position of the astronaut will have on the angular velocity of the space station.

**[3 marks]**

**0 3 . 1** A conventional pump storage system has a power output of $8.0 \times 10^7$ W.
The height difference between its reservoir and its turbine is 610 m.
The generation process is 95% efficient.

Calculate the mass of water passing through the turbine each second.

**[4 marks]**

mass per second = ________________ kg

**0 3 . 2** The annual output of electrical energy is 180 GW h.

Show that the average time for which the power station operates is approximately 6 hours per day.

**[3 marks]**

**0 3 . 3** Identify **one** advantage of using a pump storage system to generate electricity.

**[1 mark]**

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**0 4** The volume of air in a fully expanded human lung is $2.5 \times 10^{-3}$ $m^3$.
The pressure of the air in the lung is $1.0 \times 10^5$ Pa and its temperature is 37 °C.

**0 4 . 1** Determine the number of moles of air in the lung.

**[2 marks]**

number of moles __________________.

**0 4 . 2** Calculate the average kinetic energy of an air molecule in the lung.

**[2 marks]**

average kinetic energy __________________J

**0 4 . 3** Air is a mixture of oxygen and nitrogen molecules. The mass of an oxygen molecule is greater than the mass of a nitrogen molecule.

Explain the effect this has on the mean square speeds of the oxygen and nitrogen molecules in the lungs.

**[3 marks]**

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**0 5** The mass of a nucleus $^{4}_{2}\mathrm{He}$ is 4.00151 u. The mass of a proton is 1.00728 u and the mass of a neutron is 1.00867 u.
1 u = 1.661 × $10^{-27}$ kg

**0 5 . 1** Calculate the mass defect $\Delta \boldsymbol{m}$ of this nucleus in a.m.u.

**[3 marks]**

$\Delta m =$ ____________________.

**0 5 . 2** Calculate the binding energy per nucleon of this nucleus.

**[2 marks]**

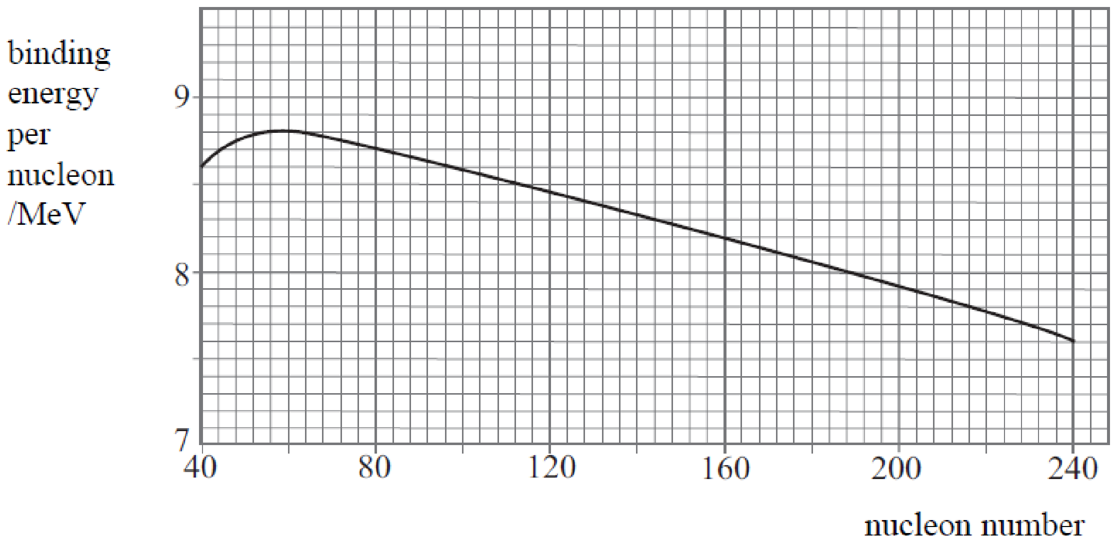
Binding energy per nucleon = ________________.

.

**Turn over for the next question**

**Figure 1** shows an enlarged portion of a graph indicating how the binding energy per nucleon of various nuclides varies with their nucleon number.

**Figure 1**




**0 5 . 3** A textbook states that "When fission of Uranium 235 takes place, the nucleus splits into two roughly equal parts and approximately 200 MeV of energy is released".

Comment on the validity of this energy value, using **Figure 1** to help you.
Explain your reasoning. **[3 marks]**

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**0 6**

A student immerses a 2.0 kW electric heater in a beaker of water. The heater is switched on for 120 s. At this point the heater is switched off and immediately removed from the water.

The data below was collected during the experiment.

initial mass of beaker 25 g
initial mass of beaker and water 750 g
initial temperature of water 20 °C
final temperature of water 95 °C

**0 6 . 1** Calculate the specific heat capacity of water.
Give an appropriate unit.

**[4 marks]**

Specific heat capacity _______________ Unit ___________.

**0 6 . 2** State and explain **two** ways in which the student could improve the accuracy of the value obtained for the specific heat capacity.

**[4 marks]**

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**0 7** The first law of thermodynamics can be represented by $\Delta U = Q + W$.

**0 7 . 1** State and explain, with reference to the equation, **two** ways in which the internal energy of a gas can be decreased.

**[4 marks]**

A volume of 20 $m^3$ of exhaust gas from a diesel engine leaves the exhaust pipe at a pressure of $1.0 \times 10^5$ Pa. The gas is cooled by the surrounding atmosphere, which is also at a pressure of $1.0 \times 10^5$ Pa, and, as a result, the exhaust gas contracts to half its volume.

**0 7 . 2** Calculate the work done by the atmosphere on the gas during this contraction.

**[1 mark]**

**0 7 . 3** During the cooling 4.9 MJ of energy is transferred to the atmosphere.

Calculate the change in internal energy of the gas using the first law of thermodynamics.

**[1 mark]**

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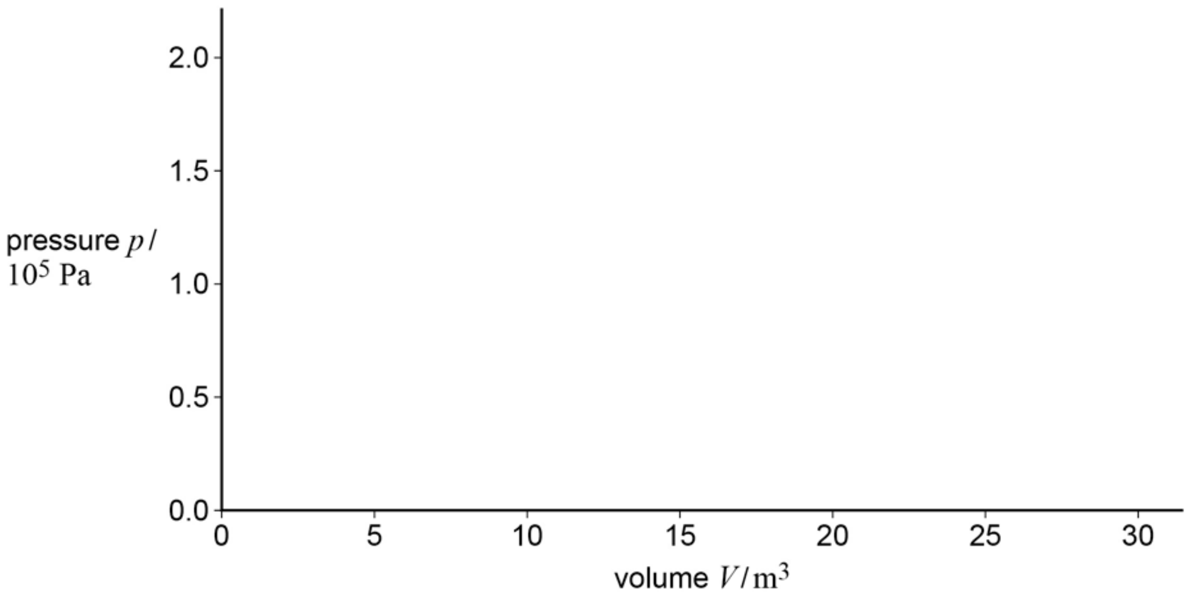
**0 7 . 4** Use **Figure 2** to represent this process as a *p*-*V* diagram, showing the direction of the process.

**[2 marks]**

**Figure 2**




**Turn over for the next question**

**0 8** This question is about the kinetic theory of gases.

**0 8 . 1** State **two** assumptions of the kinetic theory of gases.

**[2 marks]**

Assumption 1

______________________________________________

______________________________________________

Assumption 2

______________________________________________

______________________________________________

**0 8 . 2** Show that the mean kinetic energy of one molecule of an ideal gas at a temperature of 21 °C is about $6 \times 10^{-21}$ J.

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

**[2 marks]**

## Section B

Each of the questions in this section is followed by four responses, **A**, **B**, **C**, and **D**. For each question select the best response.

Only **one** answer per question is allowed.

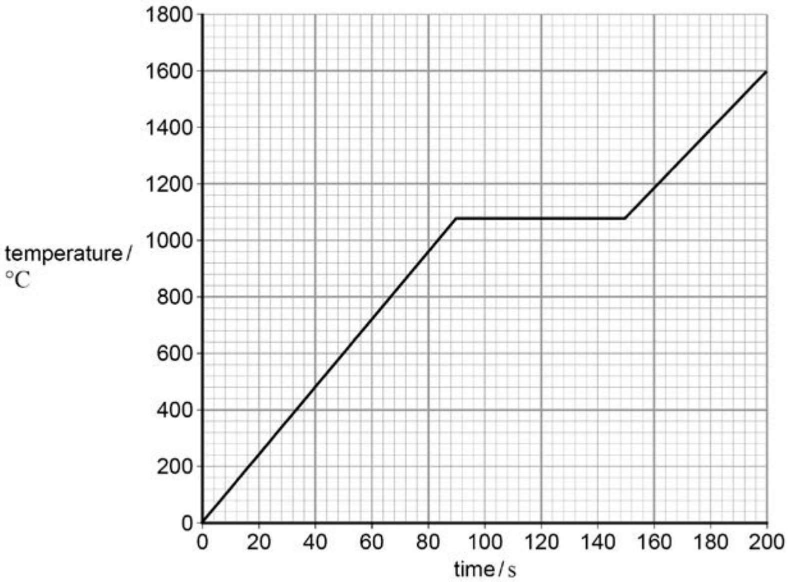
For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD    WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

**0 9** A 60 g solid metal sample is heated by an electric heater. The heater operates at a voltage of 230 V and with a current of 1.0 A. The temperature of the sample changes as shown below:




What is the specific latent heat of vaporisation of the metal?

**[1 mark]**

**A** $\frac{1}{230}$ J kg$^{-1}$

**B** $\frac{1}{23}$ J kg$^{-1}$

**C** 230 J kg$^{-1}$

**D** 230 x $10^3$ J kg$^{-1}$

**1 0** A gas molecule of mass *m* moving at velocity $u$ collides at right angles with the side of a container and rebounds elastically.

Which of the following statements concerning the motion of the molecule is **incorrect?**

**[1 mark]**

**A** The magnitude of the change in momentum of the molecule is zero. ⬭

**B** The magnitude of the change in momentum of the molecule is $2mu$. ⬭

**C** The force exerted by the molecule on the side of the container is equal to the force exerted by the container on the molecule. ⬭

**D** The change in kinetic energy of the molecule is zero. ⬭

**1 1** The mean kinetic energy of the molecules in a gas is:

**[1 mark]**

**A** directly proportional to the absolute temperature ⬭

**B** directly proportional to the square root of temperature ⬭

**C** independent of absolute temperature ⬭

**D** inversely proportional to the absolute temperature ⬭

**1 2** A liquid flows continuously through a chamber that contains an electric heater. When the steady state is reached, the liquid leaving the chamber is at a higher temperature than the liquid entering the chamber. The difference in temperature is $\Delta T$

Which of the following will increase $\Delta T$ with no other change?

**[1 mark]**

**A** Increasing the volume flow rate of the liquid ⬭

**B** Changing the liquid to one with a lower specific heat capacity ⬭

**C** Using a heating element with a higher resistance ⬭

**D** Changing the liquid to one that has a higher density ⬭

**1 3** The temperature of a hot liquid in a container falls at a rate of 2 K per minute just before it begins to solidify. The temperature then remains steady for 20 minutes by which time all the liquid has all solidified. Assume the rate of heat loss remains constant throughout this process.

What is the quantity $\frac{\text{Specific heat capacity of the liquid}}{\text{Specific latent heat of fusion}}$ ?

**[1 mark]**

**A** $\frac{1}{40}\ \mathrm{K}^{-1}$ ⬭

**B** $\frac{1}{10}\ \mathrm{K}^{-1}$ ⬭

**C** $10\ \mathrm{K}^{-1}$ ⬭

**D** $40\ \mathrm{K}^{-1}$ ⬭

**1 4** A fixed mass of gas occupies a volume $V$. The temperature of the gas increases so that the root mean square velocity of the gas molecules is doubled.

What will the new volume be if the pressure remains constant?

**[1 mark]**

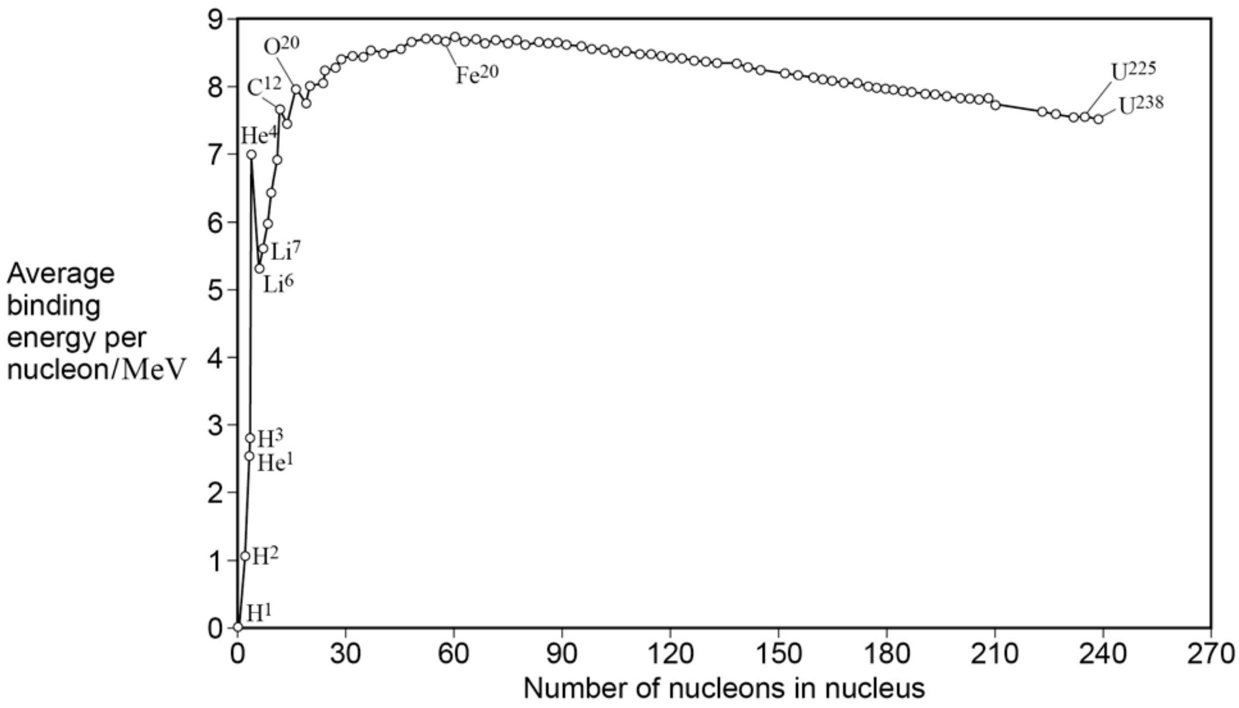
**A** $\frac{V}{2}$ ⬭

**B** $\frac{V}{\sqrt{2}}$ ⬭

**C** $2V$ ⬭

**D** $4V$ ⬭

**1 5** The graph shows how the binding energy per nucleon varies with the nucleon number for stable nuclei.




What is the approximate total binding energy for a nucleus of $^{184}_{74}W$?

**[1 mark]**

**A** 1.28 pJ

**B** 94.7 pJ

**C** 103 pJ

230 pJ

**1 6** Which of the following is the ratio of the nuclear radii of elements with mass numbers 216 and 125?

**[1 mark]**

**A** 6 : 5

**B** 216:125

**C** $\sqrt{216} : \sqrt{125}$

**D** $216^3 : 125^3$

**1 7** A perfect gas at 27 °C is heated at constant pressure so as to double its volume.

What is the increase in temperature of the gas?

**[1 mark]**

**A** 54 °C ⬭

**B** 300 °C ⬭

**C** 327 °C ⬭

**D** 600 °C ⬭

**1 8** *n* moles of an ideal gas is at pressure *P*.

What is the pressure of 4*n* moles of the same gas at three times the temperature and half the volume?

**[1 mark]**

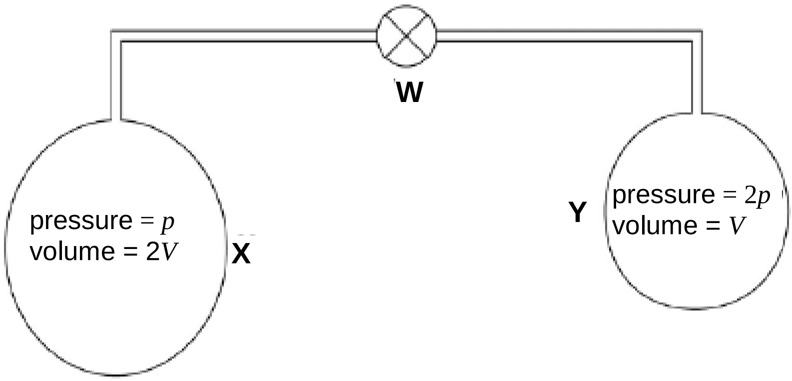
**A** P/6 ⬭

**B** 6P ⬭

**C** 12P ⬭

**D** 24P ⬭

**1 9** **X** and **Y** are two gas bottles that are connected by a tube that has negligible volume compared with the volume of each bottle.




Initially the valve **W** is closed.

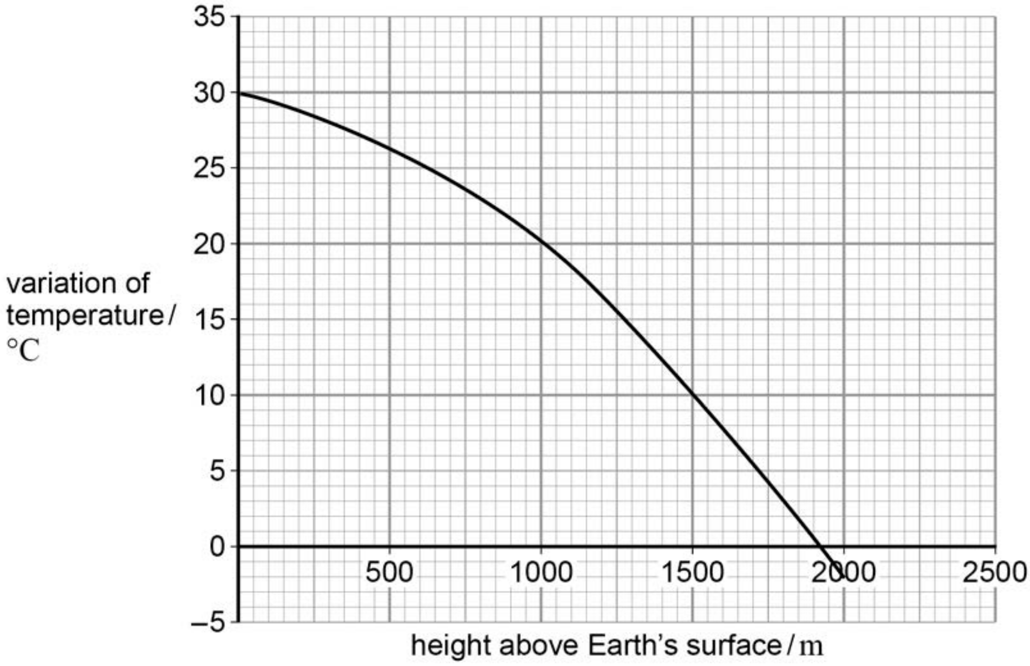
**X** has a volume $2V$ and contains hydrogen at a pressure of $p$.
**Y** has a volume $V$ and contains hydrogen at a pressure of $2p$.
**X** and **Y** are both initially at the same temperature.

**W** is now opened. Assuming that there is no change in temperature.
What is the new gas pressure?

**[1 mark]**

| | | |
|---|---|---|
| A | $\frac{2}{3}p$ | ○ |
| B | $\frac{5}{3}p$ | ○ |
| C | $\frac{4}{3}p$ | ○ |
| D | $\frac{3}{2}p$ | ○ |

**2 0** A spherical balloon, of radius 12 cm, is filled with helium at a pressure of 14 kPa. The balloon is released from the surface of the earth and travels to a height of 1500 m. The graph below shows the variation of temperature with height above the Earth's surface.




Calculate the pressure in the balloon at 1500 m.

**[1 mark]**

**A** 4.2 Pa

**B** 4.6 Pa

**C** 4500 Pa

**D** 4700 Pa

**2 1** What is the mass defect of the $^{7}_{3}$Li nucleus?

Use the following data:
mass of a proton = 1.00728 u
mass of a neutron = 1.00867 u
mass of $^{7}_{3}$Li nucleus = 7.01436 u

**[1 mark]**

**A** 0.93912 u ⬭

**B** 0.04051 u ⬭

**C** 0.04077 u ⬭

**D** 0.04216 u ⬭

**2 2** One of the possible steps in the fusion of Helium in the sun is shown below:

$3\ ^{4}_{2}He \rightarrow\ ^{12}_{6}C$

The mass of a Helium -4 nucleus is 4.001505 u
The mass of a Carbon-12 nucleus is 12.000000 u

Calculate the energy released in this process in Joules.

**[1 mark]**

**A** $6.73 \times 10^{-13}$ J ⬭

**B** $3.97 \times 10^{-10}$ J ⬭

**C** $1.19 \times 10^{-9}$ J ⬭

**D** $2.45 \times 10^{-9}$ J ⬭

**2 3** A company makes small solar cells for use in toys. They make two types. Both are square and the sides of Type A are 4 times as long as those for Type B. The efficiency of both cells is the same. In a test, a Type A cell is positioned 20 cm from a light source.

At what distance from the source will the Type B cell have the same output power?

**[1 mark]**

**A** 5 cm ⬭

**B** 10 cm ⬭

**C** 100 cm ⬭

**D** 160 cm ⬭

**END OF QUESTIONS**

**There are no questions printed on this page**

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**ANSWER IN THE SPACES PROVIDED**