Q1.(a) The concept of an absolute zero of temperature may be explained by reference to the behaviour of a gas.
Discuss **one** experiment that can be performed using a gas which would enable you to explain absolute zero and determine its value.
It is not necessary to give full details of the apparatus. Your answer should:

- include the quantities that are kept constant
- identify the measurements to be taken
- explain how the results may be used to find absolute zero
- justify why the value obtained is absolute zero.

The quality of your written communication will be assessed in your answer.

(6)

(b) (i) State **two** assumptions about the **movement** of molecules that are used when deriving the equation of state, $pV = \frac{1}{3} N m (c_{rms})^2$ for an ideal gas.

1 ....

....

2 ....

....

(2)

(ii) Three molecules move at the speeds shown in the table below.

molecule	**speed / m s^{-1}**
1	2000
2	3000
3	7000

Calculate their mean square speed.

mean square speed .... $m^2\ s^{-2}$

(1)

(c) The average molecular kinetic energy of an ideal gas is 6.6×10^{-21} J. Calculate the temperature of the gas.

temperature.. K

(2)
(Total 11 marks)

Q2. In stars, helium-3 and helium-4 are formed by the fusion of hydrogen nuclei. As the temperature rises, a helium-3 nucleus and a helium-4 nucleus can fuse to produce beryllium-7 with the release of energy in the form of gamma radiation.

The table below shows the masses of these nuclei.

Nucleus	**Mass / u**
Helium-3	3.01493
Helium-4	4.00151
Beryllium-7	7.01473

(a) (i) Calculate the energy released, in J, when a helium-3 nucleus fuses with a helium-4 nucleus.

energy released .... J

(4)

(ii) Assume that in each interaction the energy is released as a single gamma-ray photon.

Calculate the wavelength of the gamma radiation.

wavelength .... m

(3)

(b) For a helium-3 nucleus and a helium-4 nucleus to fuse they need to be separated by no more than 3.5×10^{-15} m.

(i) Calculate the minimum total kinetic energy of the nuclei required for them to reach a separation of 3.5×10^{-15} m.

total kinetic energy .... J

(3)

(ii) Calculate the temperature at which two nuclei with the average kinetic energy for that temperature would be able to fuse.
Assume that the two nuclei have equal kinetic energy.

temperature .... K

(3)

(c) Scientists continue to try to produce a viable fusion reactor to generate energy on Earth using reactors like the Joint European Torus (JET). The method requires a plasma that has to be raised to a suitable temperature for fusion to take place.

(i) State **two** nuclei that are most likely to be used to form the plasma of a fusion reactor.

1 ....

2 ....

(2)

(ii) State **one** method which can be used to raise the temperature of the plasma to a suitable temperature.

....

....

(1)
(Total 16 marks)

Q3.(a) State **two** assumptions made about the **motion** of the molecules in a gas in the derivation of the kinetic theory of gases equation.

....

....

....

....

(2)

(b) Use the kinetic theory of gases to explain why the pressure inside a football increases when the temperature of the air inside it rises. Assume that the volume of the ball remains constant.

....

....

....

....

(3)

(c) The 'laws of football' require the ball to have a circumference between 680 mm and 700 mm. The pressure of the air in the ball is required to be between 0.60×10^5 Pa and 1.10×10^5 Pa above atmospheric pressure.

A ball is inflated when the atmospheric pressure is 1.00×10^5 Pa and the temperature is 17 °C. When inflated the mass of air inside the ball is 11.4 g and the circumference of the ball is 690 mm.

Assume that air behaves as an ideal gas and that the thickness of the material used for the ball is negligible.

Deduce if the inflated ball satisfies the law of football about the pressure.

molar mass of air = 29 g mol^{-1}

(6)
(Total 11 marks)

Q4. 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?

A $\frac{V}{2}$ ○

B $\frac{V}{\sqrt{2}}$ ○

C $2V$ ○

D $4V$ ○

(Total 1 mark)

Q5. The pressure inside a bicycle tyre of volume 1.90×10^{-3} m^3 is 3.20×10^5 Pa when the temperature is 285 K.

(i) Calculate the number of moles of air in the tyre.

answer = ... mol

(1)

(ii) After the bicycle has been ridden the temperature of the air in the tyre is 295 K.
Calculate the new pressure in the tyre assuming the volume is unchanged.
Give your answer to an appropriate number of significant figures.

answer = ... Pa

(3)

(b) Describe **one** way in which the motion of the molecules of air inside the bicycle tyre is similar and **one** way in which it is different at the two temperatures.

similar ....

....

different ....

....

(2)

(Total 6 marks)