1 A magazine article states that an inflated balloon contains about two hundred billion trillion (2×10^{23}) air molecules.

(a) Taking the balloon to be a sphere of volume 8.2×10^{3} m^3 in a room at a temperature of 22 °C, show that this figure for the number of molecules is correct.

pressure of air in balloon 1.1×10^5 Pa

(2)

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*(b) The article also states that the internal energy of the air in the balloon could become zero if the temperature of the gas became low enough.

Explain what is meant by the internal energy of the air and discuss whether the statement is correct.

(4)

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(Total for Question 6 marks)

2 A football has a diameter of 22.5 cm. It contains air at a temperature of 20 °C and a pressure of 1.65×10^5 Pa. When the football is left in direct sunlight, the temperature of the air in the football increases to 40 °C.

In the following calculations, assume that the volume of the football remains constant.

(a) (i) Show that the new pressure exerted by the air in the football is about 2×10^5 Pa.

(2)

(ii) State another assumption you made in your calculation.

(1)

(b) Air is then released from the football until the pressure returns to its original value. Assuming that the temperature remains at 40 °C, calculate the number of molecules that escape.

(3)

Number of molecules escaping =

(Total for Question = 6 marks)

3 (a) A typical aerosol can is able to withstand pressures up to 12 atmospheres before exploding. A 3.0×10^{-4} m^3 aerosol contains 3.0×10^{22} molecules of gas as a propellant. Show that the pressure would reach 12 atmospheres at a temperature of about 900 K.

1 atmosphere 1.0×10^5 Pa

(2)

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*(b) Some such aerosol cans contain a liquid propellant. The propellant exists inside the can as a liquid and a vapour. Explain what happens when such an aerosol can is heated to about 900 K.

(3)

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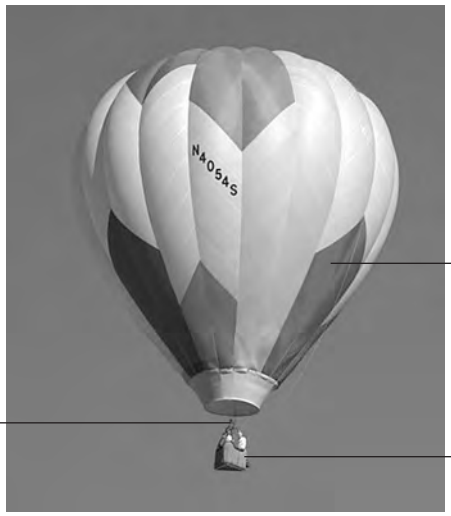
(Total for Question 5 marks)

4 Hot air ballooning is one way to explore the landscape. Air in a balloon is heated from underneath by a set of burners and the balloon starts to rise.



(a) Explain why heating the air causes the balloon to rise.

(2)

(b) In 1991, Per Lindstrand and Richard Branson become the first people to cross the Pacific in a hot air balloon.

With a volume of 7.4×10^4 m^3 the balloon was, at the time, the largest ever built.

Calculate the energy supplied by the burners to heat the air from 20.0 °C to 35.0 °C.

average density of air in the balloon = 1.20 kg m^{-3}

specific heat capacity of air = 1010 J kg^{-1} K^{-1}

(3)

Energy =

(c) The first balloons used were filled with hydrogen and sealed to keep the volume constant. As the balloon rose there would be changes in the pressure of the hydrogen due to the temperature changes of the atmosphere.

(i) Calculate the new pressure exerted by the hydrogen if the temperature changed from 20.0 °C to −5.0 °C, as the balloon rose from ground level.

pressure exerted by the hydrogen in the balloon at ground level = 1.01×10^5 Pa

(2)

New pressure =

(ii) State **two** assumptions that you must make to calculate this change.

(2)

*(iii) By considering the motion of molecules in the gas, explain why the pressure exerted by the gas decreases as it cools.

(3)

(Total for Question = 12 marks)