LONDON SCIENCE COLLEGE

Name:

Date:

THERMAL PHYSICS
TEST 2

A2-Level

Mark | Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

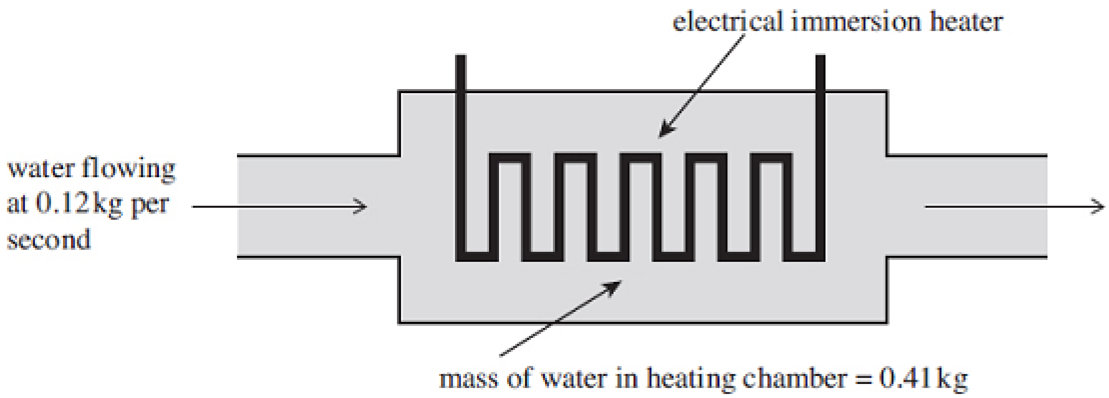
Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

1 An electrical immersion heater supplies 8.5 kJ of energy every second. Water flows through the heater at a rate of 0.12 kg s^{-1} as shown in the figure below.



(a) Assuming all the energy is transferred to the water, calculate the rise in temperature of the water as it flows through the heater.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}

answer = ____________________ K

(2)

(b) The water suddenly stops flowing at the instant when its average temperature is 26 °C. The mass of water trapped in the heater is 0.41 kg. Calculate the time taken for the water to reach 100 °C if the immersion heater continues supplying energy at the same rate.

answer = ____________________ s

(2)
(Total 4 marks)

2 (a) 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)

3 An electrical heater is placed in an insulated container holding 100 g of ice at a temperature of –14 °C. The heater supplies energy at a rate of 98 joules per second.

(a) After an interval of 30 s, all the ice has reached a temperature of 0 °C. Calculate the specific heat capacity of ice.

answer = ______________________ J $kg^{-1}K^{-1}$

(2)

(b) Show that the final temperature of the water formed when the heater is left on for a further 500 s is about 40 °C.

specific heat capacity of water = 4200 J $kg^{-1}K^{-1}$

specific latent heat of fusion of water = 3.3×10^5 J kg^{-1}

(3)

(c) The whole procedure is repeated in an uninsulated container in a room at a temperature of 25 °C.

State and explain whether the final temperature of the water formed would be higher or lower than that calculated in part (b).

____

____

____

____

(2)

(Total 7 marks)

4 Molten lead at its melting temperature of 327°C is poured into an iron mould where it solidifies. The temperature of the iron mould rises from 27°C to 84°C, at which the mould is in thermal equilibrium with the now solid lead.

mass of lead = 1.20 kg
specific latent heat of fusion of lead = 2.5×10^4 J kg^{-1}
mass of iron mould = 3.00 kg
specific heat capacity of iron = 440 J $kg^{-1}K^{-1}$

(a) Calculate the heat energy absorbed by the iron mould.

answer = ______________________ J

(2)

(b) Calculate the heat energy given out by the lead while it is changing state.

answer = ______________________ J

(1)

(c) Calculate the specific heat capacity of lead.

answer = ______________________ J kg^{-1} K^{-1}

(3)

(d) State **one** reason why the answer to part (c) is only an approximation.

____

____

____

(1)

(Total 7 marks)

5

Figure 1

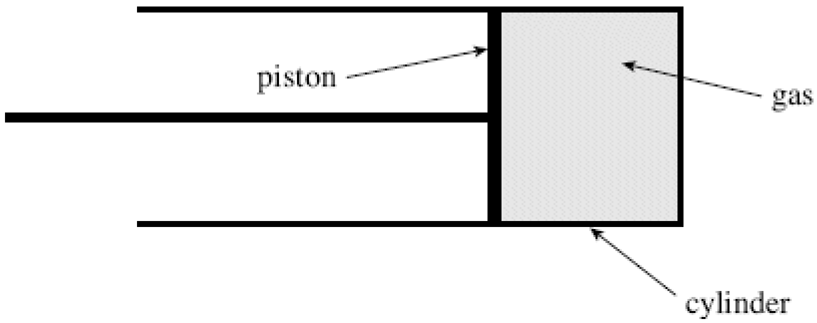
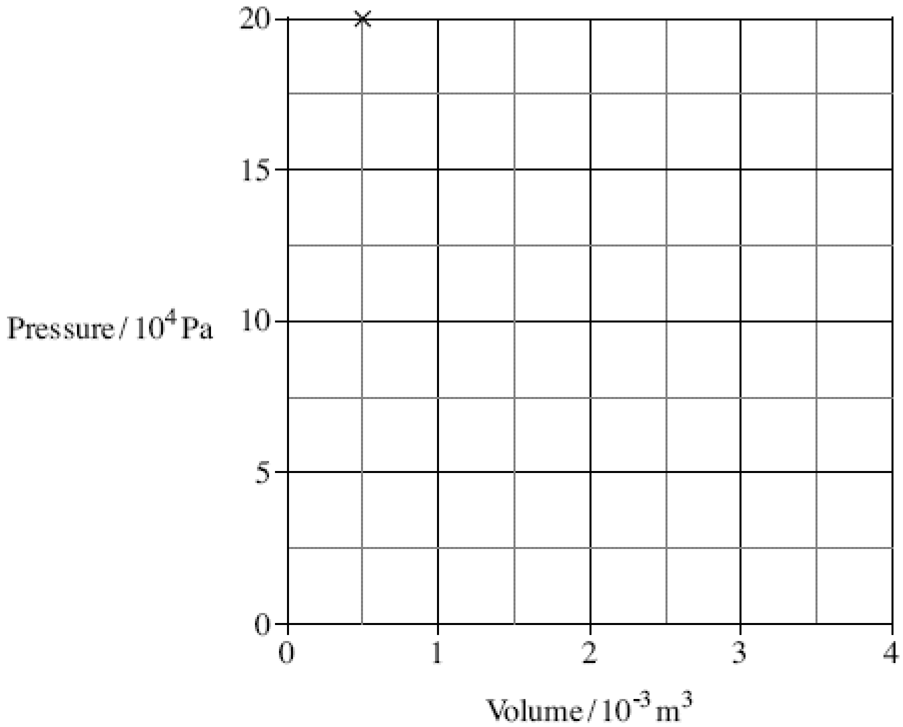


Figure 1 shows a cylinder, fitted with a gas-tight piston, containing an ideal gas at a constant temperature of 290 K. When the pressure, p, in the cylinder is 20×10^4 Pa the volume, V, is 0.5×10^{-3} m^3.

Figure 2 shows this data plotted.

Figure 2



(a) By plotting two or three additional points draw a graph, on the axes given in **Figure 2**, to show the relationship between pressure and volume as the piston is slowly pulled out. The temperature of the gas remains constant.

(3)

(b) (i) Calculate the number of gas molecules in the cylinder.

answer = ______________________ molecules

(2)

(ii) Calculate the total kinetic energy of the gas molecules.

answer = ______________________ J

(3)

(c) State **four** assumptions made in the molecular kinetic theory model of an ideal gas.

(i) ____

____

(ii) ____

____

(iii) ____

____

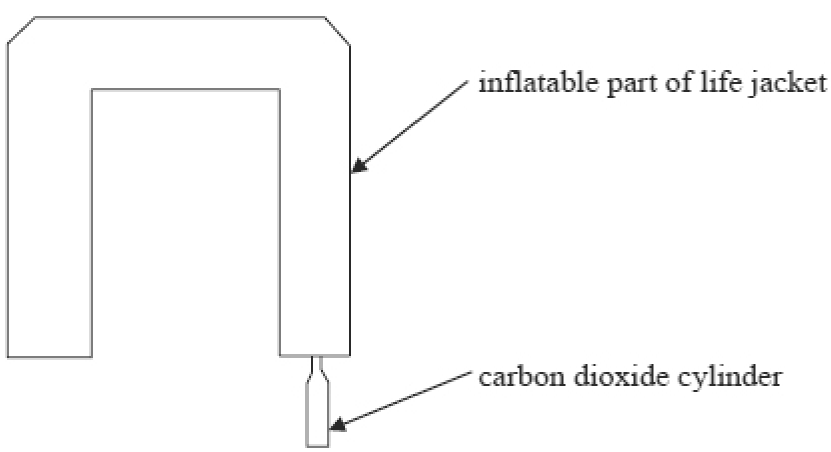
(iv) ____

____

(4)

(Total 12 marks)

6 A life jacket inflates using gas released from a small carbon dioxide cylinder. The arrangement is shown in the following figure.



(a) The cylinder initially contains 1.7×10^{23} molecules of carbon dioxide at a temperature of 12 °C and occupying a volume of 3.0×10^{-5} m^3.

(i) Calculate the initial pressure, in Pa, in the carbon dioxide cylinder.

(2)

(ii) When the life jacket inflates, the pressure falls to 1.9×10^5 Pa and the final temperature is the same as the initial temperature. Calculate the new volume of the gas.

(2)

(iii) Calculate the mean molecular kinetic energy, in J, of the carbon dioxide in the cylinder.

(2)

(b) (i) Explain, in terms of the kinetic theory model, why the pressure drops when the carbon dioxide is released into the life jacket.

___

___

___

___

___

___

(3)

(ii) Explain why the kinetic theory model would apply more accurately to the gas in the inflated life jacket compared with the gas in the small cylinder.

____

____

____

____

____

____

(3)

(c) Explain, in terms of the first law of thermodynamics, how the temperature of the gas in the system can be the same at the beginning and the end of the process.

____

____

____

____

____

____

(4)

(Total 16 marks)

7 What is the total internal energy of 2.4 mol of an ideal gas which has a temperature of 15 °C?

A 6.0×10^{-21} J ☐

B 1.4×10^{-20} J ☐

C 4.5×10^{2} J ☐

D 8.6×10^{3} J ☐

(Total 1 mark)

8 An ice cube of mass 0.010 kg at a temperature of 0 °C is dropped into a cup containing 0.10 kg of water at a temperature of 15 °C.

What is the maximum estimated change in temperature of the contents of the cup?

specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific latent heat of fusion of ice = 3.4×10^5 J kg^{-1}

A 1.5 K ☐

B 8.7 K ☐

C 13.5 K ☐

D 15.0 K ☐

(Total 1 mark)

9 Specimens **P** and **Q** of the same gas exert the same pressure. **P** is at a temperature of 280 K and contains 10^{20} molecules per unit volume. The temperature of **Q** is 350 K.

What is the number of molecules per unit volume in **Q**?

A 0.09×10^{20} ☐

B 0.75×10^{20} ☐

C 0.80×10^{20} ☐

D 1.25×10^{20} ☐

(Total 1 mark)

10 Which of the following is **not** used as valid assumption when deriving the equation $P = \frac{1}{3} Nm (c_{rms})^2$ in the simple kinetic theory of gases?

A The molecules suffer negligible change of momentum on collision with the walls of the container. ☐

B Attractive forces between molecules are negligible. ☐

C The duration of a collision is negligible compared with the time between collisions. ☐

D The volume of the molecules is negligible compared with the volume of the gas. ☐

(Total 1 mark)