H2 Physics Revision Topic : Kinetic Theory of Gases

Structured Questions Name: ______________________

1 **(a)** A solid cylinder of height h and density ρ rests on a flat surface as shown in Fig. 1.1.

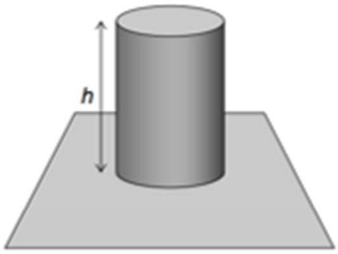


Fig. 1.1

Show that $p_C = h\rho g$ where p_C is the pressure exerted by the cylinder on the surface.

[2]

(b) Fig 1.2 shows a tube of constant circular cross-section, sealed at one end, contains an ideal gas trapped by a cylinder of mercury of length 0.035 m. The whole arrangement is in the Earth's atmosphere. The density of mercury is 1.36×10^4 kg m^{-3}.

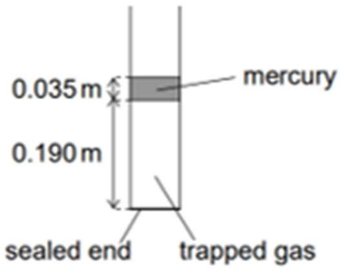


Fig. 1.2

When the mercury is above the gas column the length of the gas column is 0.190 m.

1 **(i)** Explain what is meant by *an ideal gas*.

....

....

....

....

.... [2]

(ii) Given

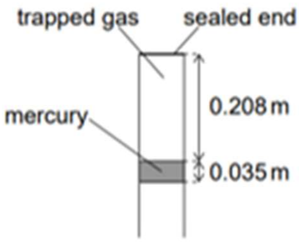
p_o = atmospheric pressure
p_m = pressure due to the mercury column
T = temperature of the trapped gas
n = number of moles of the trapped gas
A = cross-sectional area of the tube

Show that $(p_o + p_m) \times 0.190 = \dfrac{nRT}{A}$.

[1]

1

(iii) The tube is slowly rotated until the gas column is above the mercury.



The length of the gas column is now 0.208 m. The temperature of the trapped gas does not change during the process.

Determine p_o.

p_o = ... Pa [2]

(iv) Using the First Law of Thermodynamics, explain the heat exchange between the gas and the surrounding during the process mentioned in **(b)(iii)**.

....

....

....

....

.... [2]

2 **(a)** The kinetic theory of gases is based on a number of assumptions about the molecules of a gas.

State the assumption that is related to the volume of the molecules of the gas.

....

.... [1]

(b) An ideal gas occupies a volume of 2.40×10^{-2} m^3 at a pressure of 4.60×10^5 Pa and a temperature of 23 °C. Each molecule has a diameter of approximately 3×10^{-10} m.

Estimate the total volume of the gas molecules.

volume = ... m^3 [3]

(c) By reference to your answer in **(b)**, suggest why the assumption in **(a)** is justified.

....

.... [1]

2 **(d)** The ideal gas undergoes the cycle of changes PQRP as shown in Fig. 2.1.

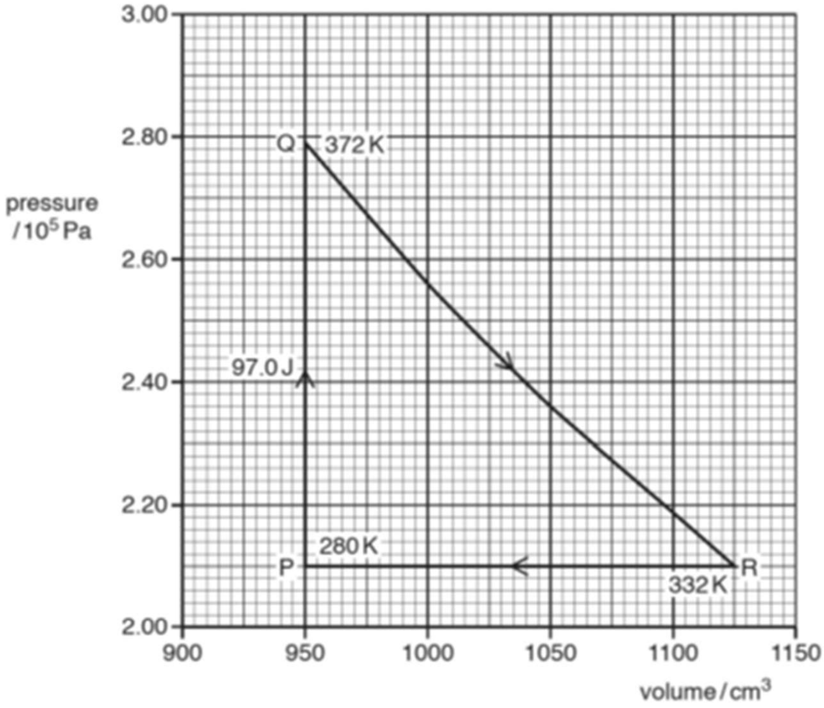


Fig. 2.1

Some energy changes during one cycle PQRP are shown in Fig. 2.2.

	change P → Q	change Q → R	change R → P
thermal energy transferred to gas / J	+97.0	0	....
work done on gas / J	....	–42.5	....
increase in internal energy of gas / J	....	....	....

Fig. 2.2

On Fig. 2.2, complete the energy changes for the gas. [5]

[Total: 10]

3 The volume of air in the cylinder of a car engine is 540 cm^3 at a pressure of 1.1 x 10^5 Pa and a temperature of 27 °C. The air is suddenly compressed to a volume of 30 cm^3. No heat energy enters or leaves the gas during the compression. The pressure then rises to 6.5 x 10^6 Pa. Assume that air behaves as an ideal gas.

(a) Determine the temperature of the gas after the compression.

temperature = …………………… K [2]

(b) **(i)** State the *first law of thermodynamics*.

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(ii) Use the law to explain why the temperature of the air changes during compression.

……………………………………………………………………………………………

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…………………………………………………………………………………………… [3]

3

(c) The temperature of a gas depends on the root-mean-square (r.m.s.) speed of its molecules.

Calculate the ratio:

$$\frac{\text{r.m.s. speed of gas molecules at 350 K}}{\text{r.m.s. speed of gas molecules at 300 K}}$$

ratio = …………………… [2]

4 A large container of volume 85 m^3 is filled with 110 kg of an ideal gas. The pressure of the gas is 1.0×10^5 Pa at temperature *T*.

The mass of 1.0 mol of the gas is 32 g.

(a) Show that the temperature *T* of the gas is approximately 300 K.

[3]

(b) The temperature of the gas is increased to 350 K at constant volume. The specific heat capacity of the gas for this change is 0.66 J kg^{-1} K^{-1}.

Calculate the energy supplied to the gas by heating.

energy = ... J [2]

(c) Explain how movement of the gas molecules causes pressure in the container.

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....

....

.... [3]

4 **(d)** The temperature of a gas depends on the root-mean-square (r.m.s.) speed of its molecules.

Calculate the ratio:

$$\frac{\text{r.m.s. speed of gas molecules at 350 K}}{\text{r.m.s. speed of gas molecules at 300 K}}.$$

ratio = ... [2]

[Total: 10]

5 **(a)** State how the temperature of an ideal gas is related to the energy of its molecules.

....

.... [1]

(b) An oven with volume 0.029 m^3 contains air at a pressure and temperature of 1.0×10^5 Pa and 27°C respectively. The mass of one mole of air is 0.030 kg. Assume that the air behaves as an ideal gas.

(i) Determine the root-mean-square speed of the air molecules in the oven.

root-mean-square speed = ... $m\ s^{-1}$ [2]

(ii) Calculate the number of moles of air molecules in the oven.

number of moles = ... [2]

(iii) The oven is heated to a temperature of 220°C.

Use your answer in **(a)** and the kinetic theory of gases to explain why the pressure of the air in the oven increases.

....

....

....

.... [2]

5 **(iv)** The oven door is opened.

Calculate the mass of air that must escape from the oven for the pressure in the oven to return to 1.0×10^5 Pa.

mass of air = ... kg [2]