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# 3.2 Modelling a Gas

Hard

# PHYSICS

## IB HL

EXAM PAPERS PRACTICE

# 3.2 Modelling a Gas

## Question Paper

| | |
|---|---|
| Course | DP IB Physics |
| Section | 3. Thermal Physics |
| Topic | 3.2 Modelling a Gas |
| Difficulty | Hard |



**Time allowed:** 20

**Score:** /10

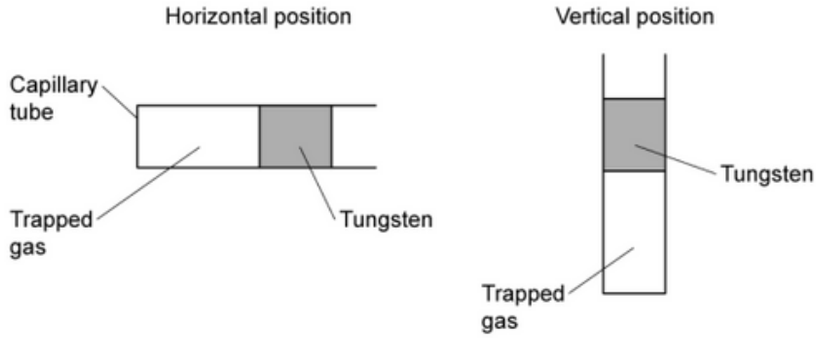
**Percentage:** /100

## Question 1

A capillary tube has an internal diameter of 6 mm and is closed at one end. It contains a sample of gas enclosed by a tungsten thread which is 0.2 m long, tungsten has a density of 5000 kg $m^{-3}$.

On a day when the atmospheric air pressure is $1 \times 10^5 \pi$ Pa the length of the sample of trapped gas is 0.4 m when the capillary tube is in the horizontal position.

Assume the temperature in the capillary tube remains constant and that the length of the tungsten thread does not change when the tube is moved into the vertical position.




What is the length of the air column when the tube is turned into the vertical position?

A. $0.2\pi$ mm

B. $9\pi$ cm

C. $0.2\pi$ m

D. $3.6\pi$ m



**[1 mark]**

## Question 2

A fish swimming in a lake expels an air bubble at a depth of 30.0 m. At this depth the temperature of the water is –33 °C and the pressure is four times the pressure at the surface. The bubble rises to the surface where the temperature is 27 °C.

What is the percentage change of the volume of the air bubble as it rises to the surface from a depth of 30.0 m?

A. 20 %

B. 100 %

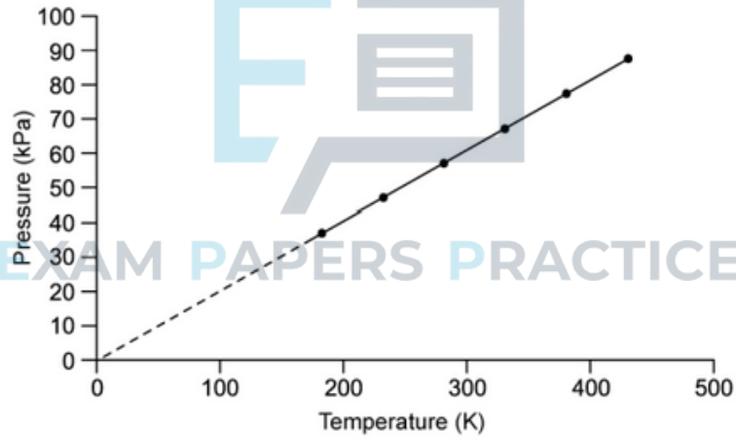
C. 400 %

D. 600 %

**[1 mark]**

## Question 3

The variation of pressure *p* with temperature *T* is shown on the graph for a fixed mass of an ideal gas at constant volume.






What is the ratio of pressure and temperature of the ideal gas?

A. 200 Pa $K^{-1}$

B. 300 Pa $K^{-1}$

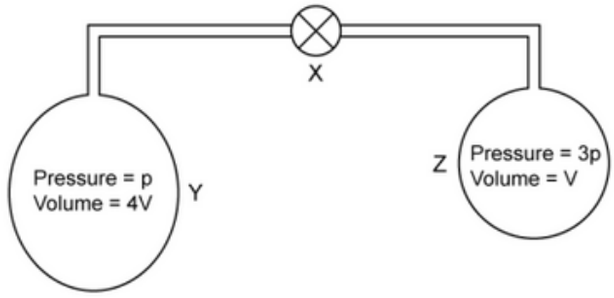
C. 400 Pa $K^{-1}$

D. 500 Pa $K^{-1}$

**[1 mark]**

## Question 4

A mass of $5 \times 10^{-3}$ kg of Hydrogen is split between two gas bottles Y and Z. Y and Z are connected by a tube that has a negligible volume compared with the volume of each bottle.




Initially the valve X is closed and gas bottle Y has a volume $4V$ and contains Hydrogen at a pressure $p$. Gas bottle Z has a volume $V$ and contains Hydrogen at a pressure of $3p$. Y and Z are initially at the same temperature.

X is now opened.

What is the new gas pressure assuming there is no change in temperature?

A. $\frac{3}{8}p$

B. $\frac{1}{6}p$

C. $\frac{8}{5}p$

D. $\frac{7}{5}p$



**[1 mark]**

## Question 5

A materials scientist carries out an experiment to investigate the relationship between the volume and temperature of an ideal gas. The pressure of the gas is kept constant throughout the experiment. Two of their readings are shown below.

| Temperature / °C | Volume of gas / $cm^3$ |
|---|---|
| 0 | 55 |
| 100 | 76 |

What is the value for absolute zero that can be calculated from these results?

A. –273.15 °C

B. –261.9 °C

C. 0 °C

D. 100 °C

**[1 mark]**

## Question 6

An ideal gas is initially at a temperature of 127 °C. It is heated and the root mean square velocity of the gas is then tripled. Use $1 \times 10^{-23}$ as the Boltzmann Constant.

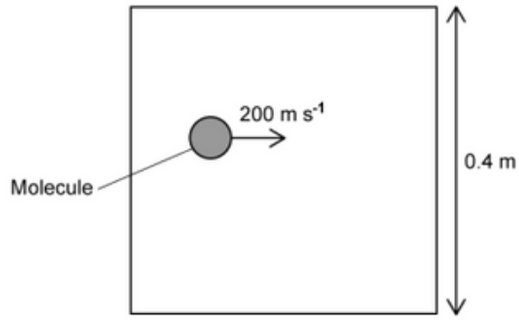
| | Kinetic Energy /J | Temperature °C |
|---|---|---|
| **A.** | $6 \times 10^{-21}$ | 3000 |
| **B.** | $5.4 \times 10^{-20}$ | 3600 |
| **C.** | $6 \times 10^{-21}$ | 3327 |
| **D.** | $5.4 \times 10^{-20}$ | 3327 |

What are the values for the temperature of the gas and the mean kinetic energy of the molecules after it has been heated?

**[1 mark]**

## Question 7

A single molecule of mass $5 \times 10^{-28}$ kg moves with a speed of 200 m $s^{-1}$ in a rigid cubical container with a side length of 0.4 m.




Assume all collisions between the molecule and the walls of the container are perfectly elastic.

What is the average pressure exerted on the wall by the molecule?

A. $5.0 \times 10^{-23}$ Pa

B. $1.25 \times 10^{-22}$ Pa

C. $3.125 \times 10^{-22}$ Pa

D. $6.35 \times 10^{-20}$ Pa

**[1 mark]**



## Question 8

Air consists of 0.9% argon molecules and 0.002% neon molecules. Argon has a relative molecular mass of 40 and neon a relative molecular mass of 20.

What is the ratio of the root mean square speed of argon to that of neon molecules in the air?

A. $\sqrt{\frac{1}{2}}$

B. $\sqrt{\frac{1}{4}}$

C. $\sqrt{\frac{1}{8}}$

D. $\sqrt{\frac{2}{9}}$

**[1 mark]**

## Question 9

In a car factory laboratory, the atmospheric pressure is 101 kPa and the temperature is 47 °C. The pressure in the car tyre under investigation is 180 kPa and the temperature 227 °C.

Assume no air is lost from the tyre.

What is the percentage increase in the root mean square speed of the air molecules due to the experiment?

A. 10%

B. 20%

C. 25%

D. 30%

**[1 mark]**

## Question 10

An ideal gas is stored in a sealed container of fixed volume and has molecules with a root mean square speed of $c$ m s$^{-1}$. The temperature of the gas changes resulting in a decrease in pressure by one-third of the previous value.

What is the new expression for the root mean square speed of the molecules after the temperature has changed?

A. $\frac{c^2}{\sqrt{3}}$

B. $\frac{c}{\sqrt{3}}$

C. $\frac{c}{3}$

D. $c\sqrt{3}$

**[1 mark]**