3.2 Modelling a Gas

Question Paper

Course	DP IB Physics
Section	3. Thermal Physics
Topic	3.2 Modelling a Gas
Difficulty	Medium

Time allowed: 70

Score: /58

Percentage: /100

Question 1a

This question is about a monatomic ideal gas.

(a)
Outline what is meant by an ideal monatomic gas.

[2 marks]

Question 1b

(b)
Neon gas is kept in a container of volume 7.1×10^{-2} m^3, temperature 325 K and pressure 3.7×10^5 Pa.

(i)
Calculate the number of moles of neon in the container.

[2]

(ii)
Calculate the number of atoms in the gas.

[2]

[4 marks]

Question 1c

(c)
The volume of the gas is increased to 4.2×10^{-2} m^3 at a constant temperature.

(i)
Calculate the new pressure of the gas in Pa

[2]

(ii)
Explain this change in pressure, in terms of molecular motion.

[2]

[4 marks]

Question 1d

Energy is supplied to the gas at a rate of 10 J s^{-1} for 10 minutes. The specific heat capacity of neon is 904 J kg^{-1} K^{-1} and its atomic mass number is 21. The volume of the gas does not change.

(d)
Determine the new pressure of the gas.

[3 marks]

Question 2a

This question is about an ideal gas in a container.

An ideal gas is held in a glass gas syringe.

(a)
Calculate the temperature of 0.726 mol of an ideal gas kept in a cylinder of volume 2.6×10^{-3} m^3 at a pressure of 2.32×10^5 Pa.

[2 marks]

Question 2b

(b)
The average kinetic energy of the gas is directly proportional to one particular property of the gas.

(i)
Identify this property.

[1]

(ii)

Calculate the average kinetic energy, $\bar{E}$, per molecule of the gas.

[1]

[2 marks]

Question 2c

Energy is supplied to the gas at a rate of 0.5 J s^{-1} for 4 minutes. The specific heat capacity of the gas is 519 J kg^{-1} K^{-1}.

(c)
Calculate the change in kinetic energy per molecule of the gas.

[4 marks]

Question 2d

The gas is heated until its temperature doubles.

(d)
Determine the factor the average speed of the molecules increases by.

[2 marks]

Question 3a

This question is about the specific heat capacity of an ideal gas.

(a)
Outline two assumptions made in the kinetic model of an ideal

[2 marks]

Question 3b

Xenon-131 behaves as an ideal gas over a large range of temperatures and pressures.

(b)
One mole of Xenon-131 is stored at 20 °C in a cylinder of fixed volume. The Xenon gas is heated at a constant rate and the internal energy increased by 450 J. The new temperature of the Xenon gas is 41.7 °C.

(i)
Define one mole of Xenon.

[1]

(ii)
Calculate the specific heat capacity of gaseous Xenon-131.

[2]

(iii)
Calculate the average kinetic energy of the molecules of Xenon at this new temperature.

[2]

[5 marks]

Question 3c

The volume of the sealed container is 0.054 m^3.

(c)
Calculate the change in pressure of the gas due to the energy supplied in part (b).

[4 marks]

Question 3d

One end of the container is replaced with a moveable piston. The piston is compressed until the pressure of the container is 67000 Pa.

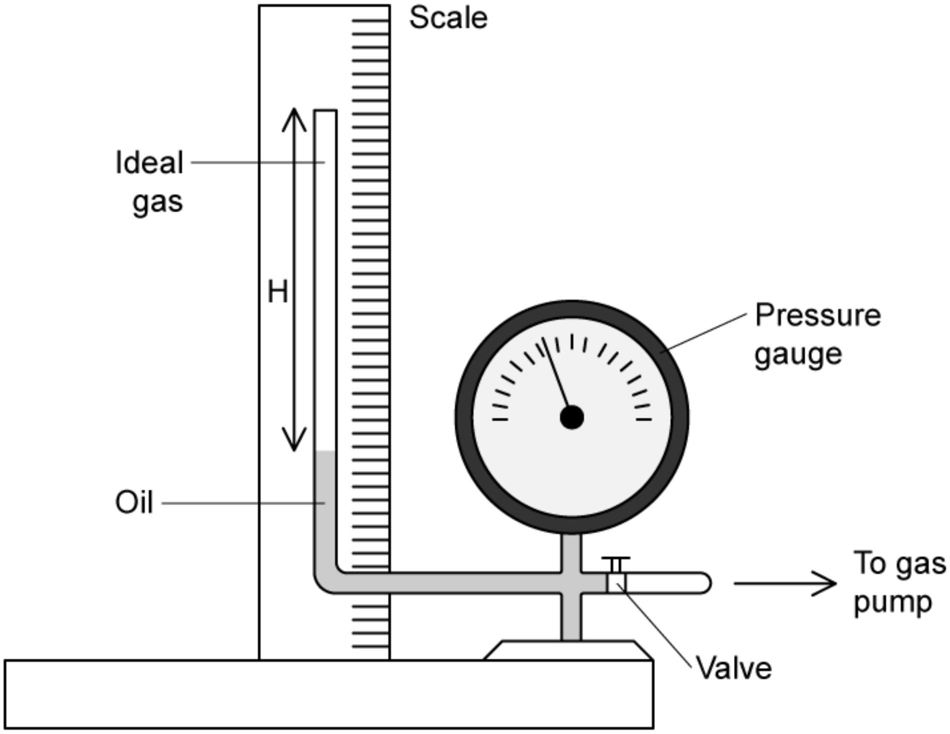
(d)
Determine the new volume of the container.

[2 marks]

Question 4a

This question is about an experiment to investigate the variation in the pressure *p* of an ideal gas with changing volume *V*.

The gas is trapped in a cylindrical tube of radius 0.5 cm above a column of oil.



The pump forces the oil to move up the tube and so reduces the volume of the gas. The scientist measures the pressure *p* of the gas and the height *H* of the column of gas.

(a)
Calculate the volume of the gas when the height is 1 cm.

[2 marks]

Question 4b

When the system is at a constant temperature of 20 °C, the pressure is 9600 Pa.

(b)
Calculate:

(i)
the amount of moles of gas trapped in the cylinder

[2]

(ii)
the average kinetic energy of the molecules of trapped gas

[1]

[3 marks]

Question 4c

The scientist plots their results of *p* against $\frac{1}{H}$ on a graph.

(c)
Explain the shape of the graph and why this is to be expected.

[3 marks]

Question 4d

(d)
When conducting the experiment, the scientist waits for a period of time between taking each reading.

(i)
Explain the reason for waiting this short period of time.

[1]

(ii)
Describe what will happen to the shape of the graph if the scientist does not wait a sufficient period of time between readings.

[2]

[3 marks]

Question 5a

(a)
State the Pressure law of ideal gases.

[2 marks]

Question 5b

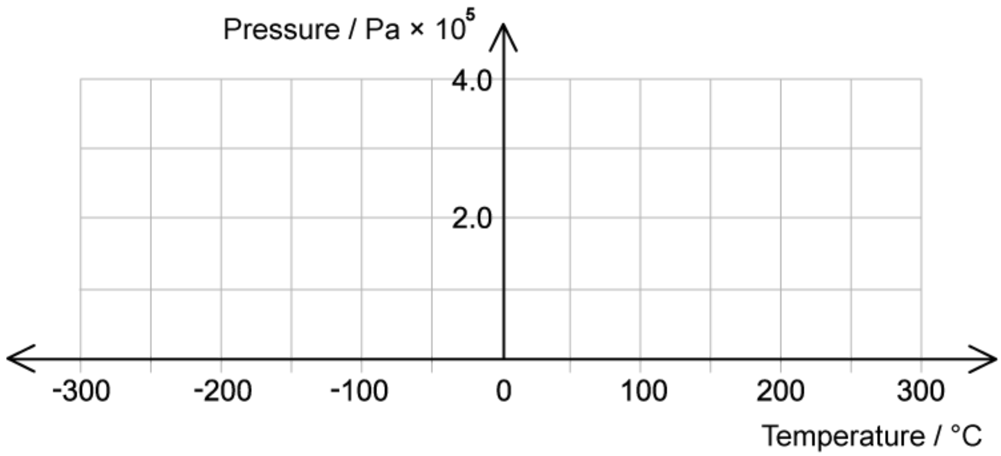
The pressure exerted by an ideal gas containing 9.7×10^{20} molecules in a container of volume 1.5×10^{-5} m^3 is 2.8×10^5 Pa.

(b)
Calculate the temperature of the gas in the container in °C.

[3 marks]

Question 5c

The pressure of the gas is measured at different temperatures whilst the volume of the container and the mass of the gas remain constant.



(c)
On the grid, sketch a graph to show how the pressure varies with the temperature.

[3 marks]

Question 5d

The container described in part (a) has a release valve that allows gas to escape when the pressure exceeds 3.5×10^5 Pa.

(d)
Calculate the number of gas molecules that escape when the temperature of the gas is raised to 380°C.

[3 marks]