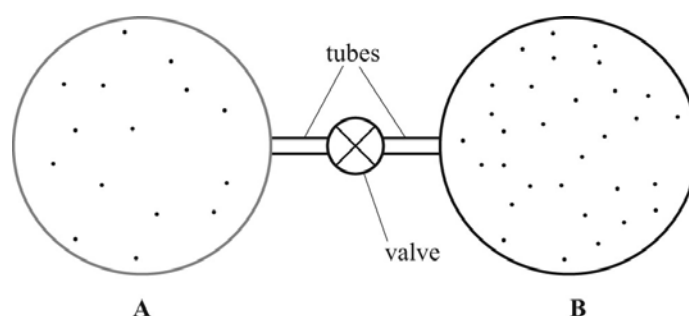


22 Worksheet (A2)

Data needed to answer questions can be found in the Data, formulae and relationships sheet.

- 1 Determine the number of atoms or molecules in each of the following.
 - a 1.0 mole of carbon [1]
 - b 3.6 moles of water [1]
 - c 0.26 moles of helium [1]
- 2 The molar mass of helium is 4.0 g.
Determine the mass of a single atom of helium in kilograms. [2]
- 3 The molar mass of uranium is 238 g.
 - a Calculate the mass of one atom of uranium. [2]
 - b A small rock contains 0.12 g of uranium. For this rock, calculate the number of:
 - i moles of uranium [2]
 - ii atoms of uranium. [1]
- 4 Explain what is meant by the **absolute zero** of temperature. [3]
- 5
 - a Write the ideal gas equation in words. [1]
 - b One mole of an ideal gas is trapped inside a rigid container of volume 0.020 m^3 .
Calculate the pressure exerted by the gas when the temperature within the container is 293 K. [3]
- 6 A fixed amount of an ideal gas is trapped in a container of volume V .
The pressure exerted by the gas is P and its absolute temperature is T .
 - a Using a sketch of PV against T , explain how you can determine the number of moles of gas within the container. [4]
 - b Sketch a graph of PV against P when the gas is kept at a constant temperature.
Explain the shape of the graph. [3]
- 7 A rigid cylinder of volume 0.030 m^3 holds 4.0 g of air. The molar mass of air is about 29 g.
 - a Calculate the pressure exerted by the air when its temperature is 34°C . [4]
 - b What is the temperature of the gas in degrees Celsius when the pressure is **twice** your value from part a? [4]

- 8 The diagram shows two insulated containers holding gas. The containers are connected together by tubes of negligible volume.

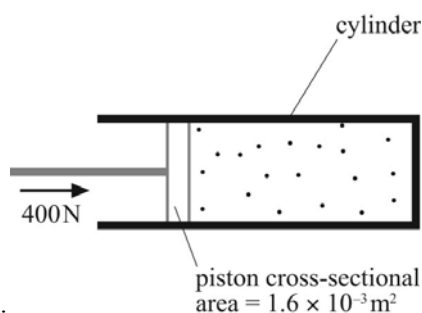


The internal volume of each container is $2.0 \times 10^{-2} \text{ m}^3$.

The temperature within each container is -13°C . The gas in container **A** exerts a pressure of 180 kPa and the gas in container **B** exerts a pressure of 300 kPa.

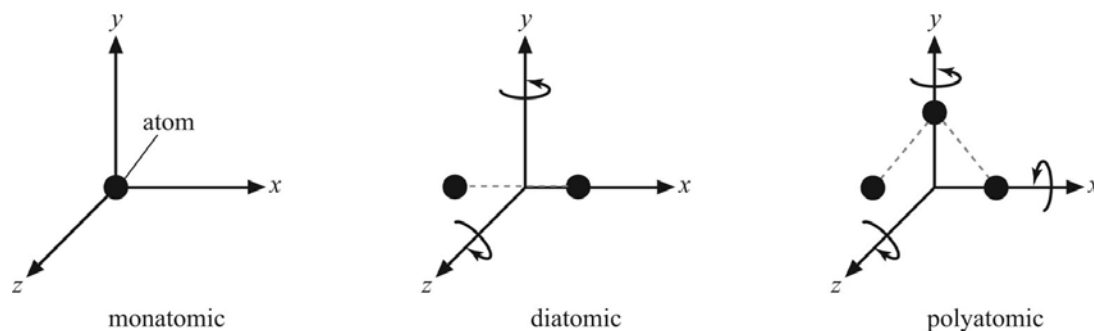
- a Show that the amount of gas within the two containers is about 4.4 moles. [3]
- b The valve connecting the containers is slowly opened and the gases are allowed to mix. The temperature within the containers remains the same. Calculate the new pressure exerted by the gas within the containers. [3]

- 9 The diagram shows a cylinder containing air at a temperature of 5.0°C . The piston has a cross-sectional area $1.6 \times 10^{-3} \text{ m}^2$. It is held stationary by applying a force of 400 N applied normally to the piston. The volume occupied by the compressed air is $2.4 \times 10^{-4} \text{ m}^3$.



- a Calculate the pressure exerted by the compressed air. [2]
 - b Determine the number of moles of air inside the cylinder. [3]
 - c Use your answer to **b** to determine:
 - i the mass of air inside the cylinder [1]
 - ii the density of the air inside the cylinder. [2]
- 10 The mean speed of a helium atom at a temperature of 0°C is 1.3 km s^{-1} . Estimate the mean speed of helium atoms on the surface of a star where the temperature is 10 000 K. [6]
- 11 The surface temperature of the Sun is about 5400 K. On its surface, particles behave like the atoms of an ideal gas. The atmosphere of the Sun mainly consists of hydrogen nuclei. These nuclei move in random motion.
- a Explain what is meant by **random motion**. [1]
 - b i Calculate the mean translational kinetic energy of a hydrogen nucleus on the surface of the Sun. [2]
 - ii Estimate the mean speed of such a hydrogen nucleus. (The mass of hydrogen nucleus is $1.7 \times 10^{-27} \text{ kg}$.) [3]
- 12 a Calculate the mean translational kinetic energy of gas atoms at 0°C . [2]
- b Estimate the mean speed of carbon dioxide molecules at 0°C . (The molar mass of carbon dioxide is 44 g.) [5]
 - c Calculate the change in the internal energy of one mole of carbon dioxide gas when its temperature changes from 0°C to 100°C . [3]

13 The diagram below shows three different types of arrangements of gas particles.



A gas whose particles consist of single atoms is referred to as **monatomic** – for example helium (He). A gas with two atoms to a molecule is called **diatomic** – for example oxygen (O_2). A gas with more than two atoms to a molecule is said to be **polyatomic** – for example water vapour (H_2O).

A single atom can travel independently in the x , y and z directions: it is said to have three **degrees of freedom**. From the equation for the mean translational kinetic energy of the atom, we can generalise that a gas particle has mean energy of $\frac{1}{2}kT$ per degree of freedom.

Molecules can also have additional degrees of freedom due to their rotational energy.

a Use the diagram above to explain why:

i the mean energy of a diatomic molecule is $\frac{5}{2}kT$ [2]

ii the mean energy of a polyatomic molecule is $3kT$. [2]

b Calculate the internal energy of one mole of water vapour (steam) per unit kelvin. [3]

Total: $\frac{\quad}{75}$ Score: $\quad\%$