Assignment 08: Kinetic particle model of matter

1. The set of statements below compare the energy or the motion of substances in different states of matter. State if each statement is true (T) or false (F). [6]

(a) Comparing a piece of ice at -28 ºC and a piece of ice at -1 ºC,

(i) the molecules in both substances have very low potential energy. ( )

(ii) the molecules in ice at -28 ºC move faster than molecules in ice at -1 ºC. ( )

(b) Comparing a bottle of water vapour at 25 ºC and a bottle of liquid water at 25 ºC,

(i) the molecules in the bottle of water vapour are further apart than the molecules in the bottle of liquid water. ( )

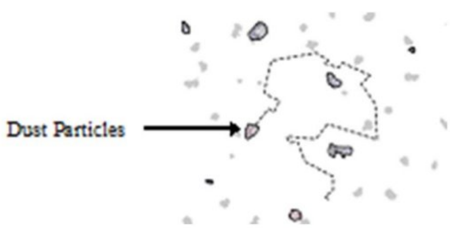
(ii) the molecules in both bottles have different amounts of average kinetic energy ( )

(c) Comparing ammonia gas at 15 ºC and ammonia liquid at -15 ºC,

(i) the molecules in ammonia gas have higher potential energy than the molecules in ammonia liquid. ( )

(ii) the molecules in ammonia liquid have a lower average kinetic energy than the molecules in ammonia gas. ( )

2. A student conducts an experiment to observe the behaviour of dust particles when placed in an illuminated glass cell. Under the microscope, the following motion was observed.



(a) Describe the motion of this particle. [1]

(b) Explain what could have caused the motion observed. [2]

(c) Explain the following: [3]

(i) The dust particles appear as bright sparks of light when seen through the microscope.

(ii) The smaller dust particles move faster while the larger dust particles move slower.

(iii) When temperature increases, the dust particles move faster.

3. Fig. 3.1 shows a gas jar full of air at atmospheric pressure. Fig. 3.2 shows an identical jar of which air has been pumped out. Each jar is connected to a reservoir containing a dark brown liquid which vaporises very quickly into a brown gas.

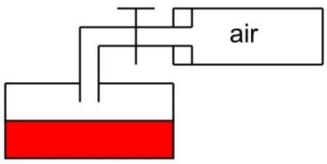


Fig. 3.1: gas jar full of air

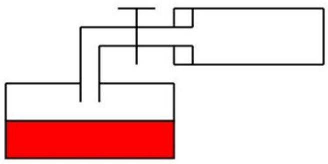


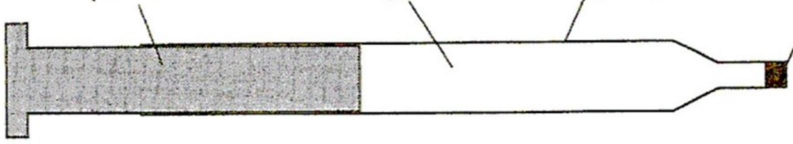
Fig. 3.2: evacuated gas jar

The taps connecting the jar to the reservoirs are open at the same time.

(a) What is the likely observation of the brown gas in the two gas jars? [1]

(b) Explain your observations in (a) using ideas about molecules. [3]

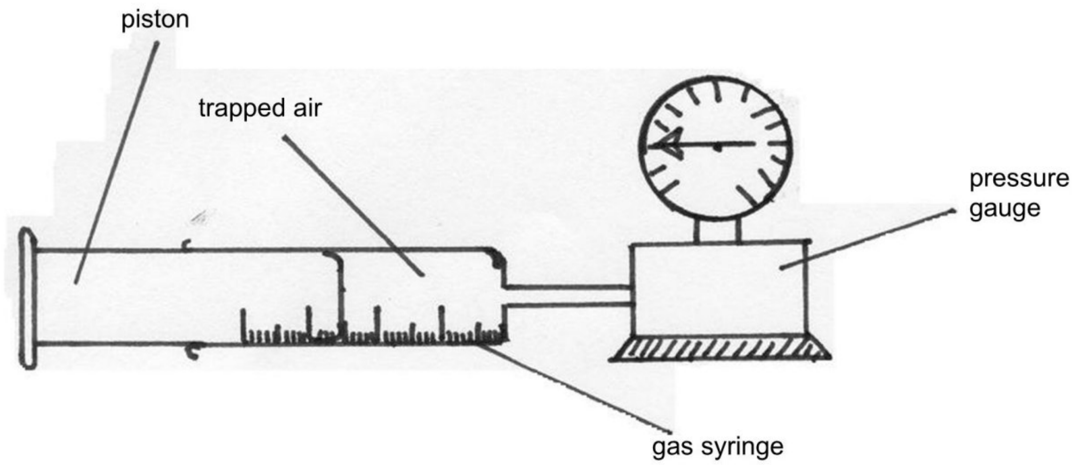
4. The diagram shows some gas trapped inside a cylinder by a light frictionless piston in a syringe.



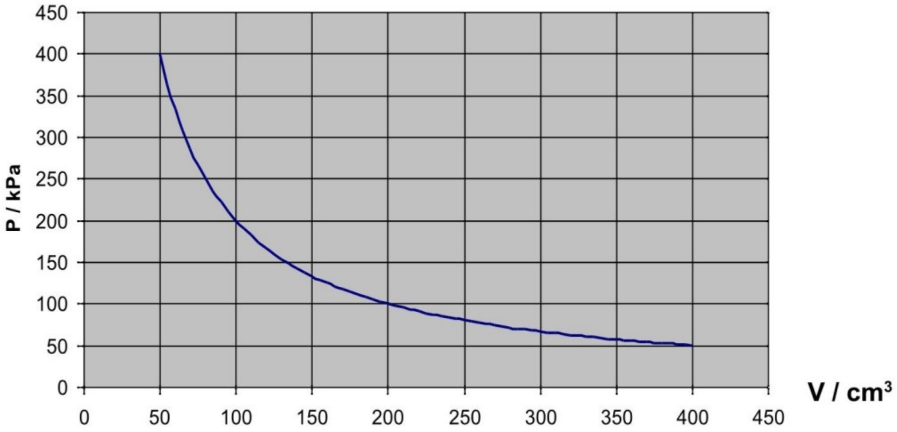
State how the value of each quantity below compares before and after the piston is gradually **pushed in** by 20 cm^3. For each quantity, write either "*greater than*", "*the same as*" or "*smaller than*" in the space below. [3]

quantity	comparison
the average distance between the gas molecules	
the pressure of the gas after the piston stops moving	
the average speed of the gas molecules	
the frequency of collisions between the gas molecules and the piston and cylinder walls	
the total force exerted by the gas molecules per unit area on the piston and cylinder walls	
the temperature of the gas after the piston stops moving	

5. A student pulls the piston of a large calibrated gas syringe to draw in a fixed mass of air. Then he connects the nozzle of the syringe to a pressure gauge. The syringe is not thermally insulated.



The piston is gradually pulled out within the syringe and the student measures the volume **V** of the trapped air and its pressure **P** at several different positions of the piston. A graph of **P** against **V** is plotted as shown below.



(a) The student was told that **P** and **V** are related by the equation:

$$PV = \text{constant}$$

(i) If this relationship is correct, state in words, how **P** is related to **V**, [1]

(ii) By using an exact point from the graph, calculate the value of the constant in the equation and state its unit. [2]

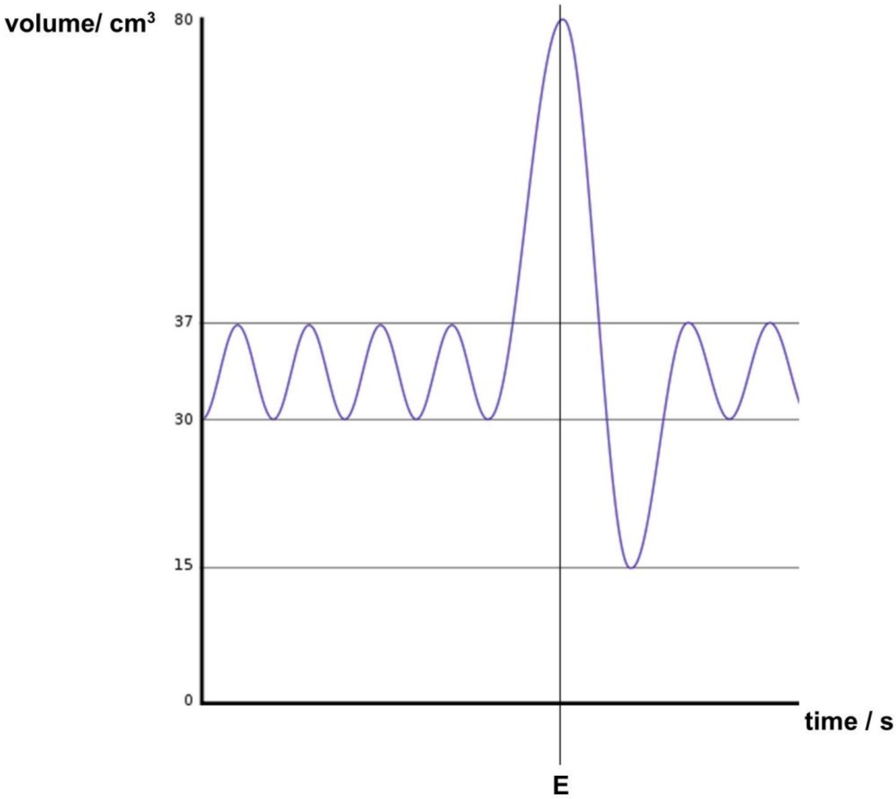
(b) Given that the volume of the syringe is increased from 150 cm^3 to 300 cm^3, describe the change in pressure of the trapped air in the syringe. Support your answer with suitable calculations. [2]

(c) A warning is printed on the side of the syringe stating that the gas inside must not exceed a pressure of 500 kPa. State the numerical limit that this pressure constraint has on the volume of the trapped air. [1]

(d) State one step taken during the experiment to keep the temperature of the air in the syringe approximately constant. [1]

(e) Explain, using ideas of molecules, why the pressure of the trapped air decreases as its volume increases when its temperature is kept constant. [3]

6. The diagram below shows the graph of the volume of a person's lungs over a period of time while he breathes normally. The person took a deep breath at **E**.

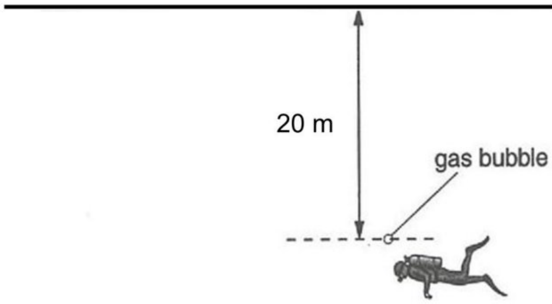


(a) Describe, using ideas about molecules, how air pressure comes about in the human lungs. [2]

(b) (i) Using ideas about molecules, explain the effect the volume change at time **E** has on the air pressure of the lungs at constant temperature. (process: inhalation) [3]

(ii) Explain how this helps him take in more air. [1]

7. The diagram shows a gas bubble rising from a diver to the surface of a lake.

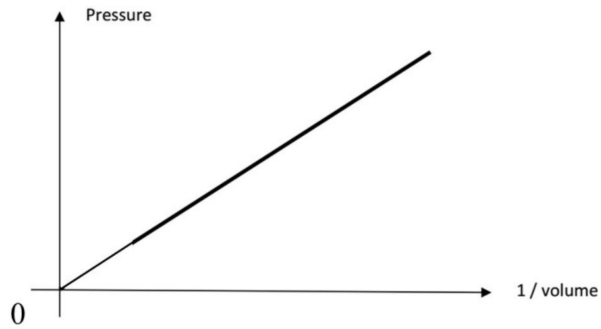


The normal atmospheric pressure is approximately 1 bar.

For every 10 m depth of water, an object experiences approximately 1 bar of pressure due to the weight of the surrounding water.

The bubble starts to move up from a depth of 20 m below the surface of the lake. Assume that the temperature of the gas in the bubble remains constant while it is rising.

(a) On the diagram below, sketch a graph to show the relationship between the pressure of the gas in the bubble and $\frac{1}{volume}$ of the bubble. [1]



(b) Using the ideas about molecules,

(i) describe how the gas in the bubble can cause pressure to happen, [2]

(ii) explain how the gas pressure in the bubble would change as the volume of the bubble increases. [2]

(c) If the volume of the gas bubble is 2.0 cm^3 when it is 20 m below the surface of the lake, determine the volume of the gas bubble when it is at the surface of the lake. [2]