PRESSURE OF A GAS IN A PISTON

1 **(a)** Fig. 4.1 shows some gas contained in a cylinder by a heavy piston. The piston can move up and down in the cylinder with negligible friction.

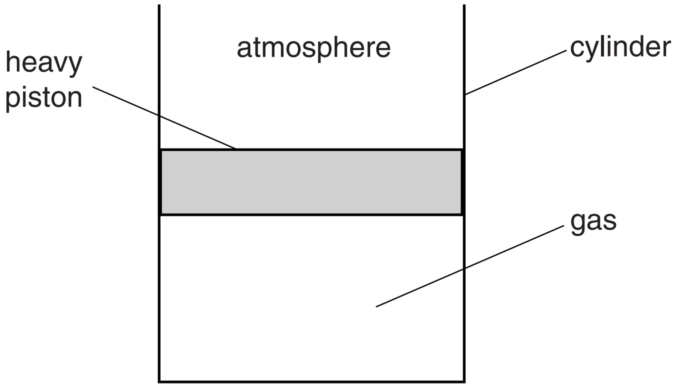


Fig. 4.1

There is a small increase in the pressure of the atmosphere above the piston.

(i) On Fig. 4.1, draw a possible new position for the lower face of the piston.

(ii) Explain, in terms of the molecules of the gas and the molecules of the atmosphere, your answer to **(a)(i)**.

....

....

....

....

....

.... [3]

(b) The pressure of the atmosphere above the piston returns to its original value, and the piston returns to its original position, as shown in Fig. 4.2.

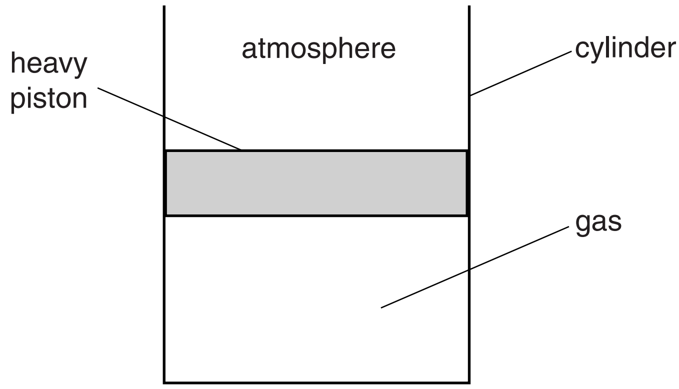


Fig. 4.2

The gas, piston and cylinder are now heated to a much higher temperature.

(i) On Fig. 4.2, draw a possible new position for the lower face of the piston.

(ii) Explain, in terms of the molecules of the gas and the molecules of the atmosphere, your answer to **(b)(i)**.

....

....

....

....

.... [2]

[Total: 7]

(a)	**(i)**	piston lower than original/single line below original lower face	B1	[1]
	(ii)	three points from:		
		they OR air/gas molecules/particles move/collide ignore faster	B1	
		they OR air/gas molecules/particles collide with piston/walls		
		ignore collisions between molecules	B1	
		force exerted on piston	B1	
		greater force/pressure on top (than bottom initially)		
		number of collisions of gas molecules with piston increases		
		piston moves until pressures/forces equal		[3]
(b)	**(i)**	piston higher than original/single line below above original lower face	B1	[1]
	(ii)	two points from:		
		molecules of gas moving faster OR more momentum/KE	B1	
		more/harder collisions of gas molecules with piston/walls	B1	
		greater force/pressure on bottom (than top initially)		
		piston moves up until pressures/forces equal		[2]

2 A vertical cylinder has a smooth well-fitting piston in it. Weights can be added to or removed from a tray on the top of the piston.

(a) Weights are added to the tray, as shown in Fig. 6.1.

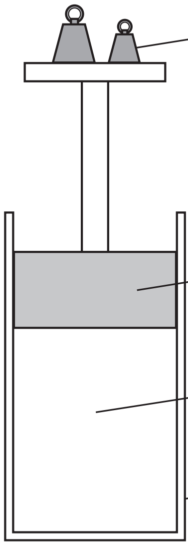


Fig. 6.1

(i) State what happens to the pressure of the air in the cylinder as a result of adding these weights.

.... [1]

(ii) The initial pressure of the trapped air is 1.05×10^5 Pa. When the weights are added, the volume of the air decreases from 860 cm^3 to 645 cm^3.

The temperature of the air does not change.

Calculate the final pressure of the trapped air.

pressure = ... [3]

(iii) The area of the piston is 5.0×10^{-3} m^2.

Calculate the weight that is added to the piston.

weight added = ... [4]

(b) The weights are kept as shown in Fig. 6.1. The temperature of the air in the cylinder is increased.

(i) State what happens to the volume of the air in the cylinder as a result of this temperature rise.

.... [1]

(ii) State how, if at all, the pressure of the air changes as the temperature changes.

.... [1]

(iii) State what must be done to prevent the volume change in **(b)(i)**.

.... [1]

(iv) The volume change in **(b)(i)** is prevented. State what happens to the pressure of the air in the cylinder.

.... [1]

[Total: 12]

(a)	**(i)**	increases	B1
	(ii)	pV = const in any form	C1
		$1.05\ (\times 10^5) \times 860\ (\times 10^{-6}) = p \times 645\ (\times 10^{-6})$	C1
		1.4×10^5 Pa	A1
	(iii)	F = pA in any form — accept weight for F	C1
		EITHER — increase in pressure = 0.35×10^5 (Pa)	C1
		$0.35 \times 10^5 \times 5.0 \times 10^{-3}$	C1
		175 N (minimum 2 s.f.) c.a.o.	A1
		OR $1.05 \times 10^5 \times 5.0 \times 10^{-3}$ or 525 N or $1.4 \times 10^5 \times 5.0 \times 10^{-3}$ or 700 N	(C1)
		700 – 525 N e.c.f. from **(a) (ii)**	(C1)
		175 N (minimum 2 s.f.) c.a.o.	(A1)
(b)	**(i)**	increases	B1
	(ii)	no change	B1
	(iii)	extra weight (on tray/piston)	B1
	(iv)	increases	B1

[12]

3 Fig. 5.1 shows a gas contained in a cylinder enclosed by a piston.

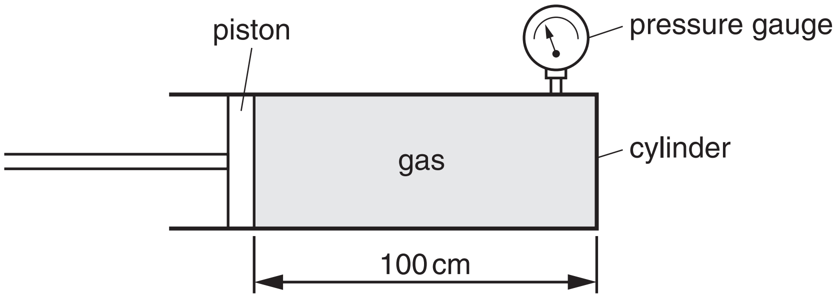


Fig. 5.1

At first, the length of cylinder containing the gas is 100 cm. The pressure of the gas, shown by the pressure gauge, is 300 kPa. The area of cross-section of the cylinder is 0.12 m^2.

(a) **(i)** Describe the motion of the molecules of the gas.

....

....

....[1]

(ii) Explain how the molecules exert a force on the walls of the cylinder.

....

....[1]

(iii) Calculate the force exerted by the gas on the piston.

force = ...[2]

(b) The piston is moved so that the new length of cylinder occupied by the gas is 50 cm. The temperature of the gas is unchanged.

(i) Calculate the new pressure of the gas.

pressure = ...[2]

(ii) Explain, in terms of the behaviour of the molecules, why the pressure has changed.

....

....

....[1]

[Total: 7]

(a) **(i)**	(Molecules) move randomly / in random directions (Molecules) have high speeds (Molecules) collide with each other / with walls	B1	
(ii)	(Force is caused by) collision (and rebound) of molecules (with the walls) o.w.t.t.e	C1	
(iii)	$p = F/A$ OR (force =) pA OR 300 × 0.12 OR 300 000 × 0.12 OR any other recognisable pressure × area	C1	
	= 36 kN / 36 000 N	A1	
(b) **(i)**	$p_1V_1 = p_2V_2$ / 300 × 0.1 (× 0.12) = p_2 × 0.05 (× 0.12) OR if V is halved, p is doubled OR vice versa	C1	
	p_2 = 600 kPa	A1	
(ii)	(molecules) collide <u>with walls</u> more often o.w.t.t.e. OR more collisions <u>with walls</u> per second or per unit time o.w.t.t.e	B1	[7]

4 **(a)** One of the laws about the behaviour of gases states that

"For a fixed amount of gas at constant temperature, the pressure is inversely proportional to the volume".

In the space below, write an **equation** that represents this law.

[1]

(b) Table 4.1 gives a series of pressures and their corresponding volumes, obtained in an experiment with a fixed amount of gas. The gas obeys the law referred to in **(a)**.

pressure / kPa	100	200	400	500	1000
volume / cm^3	50.0	25.0	12.5	10.0	5.0

Table 4.1

How do these figures indicate that the temperature was constant throughout the experiment?

....

....

....

.... [2]

(c) Air is trapped by a piston in a cylinder. The pressure of the air is 1.2×10^5 Pa. The distance from the closed end of the cylinder to the piston is 75 mm.

The piston is pushed in until the pressure of the air has risen to 3.0×10^5 Pa.

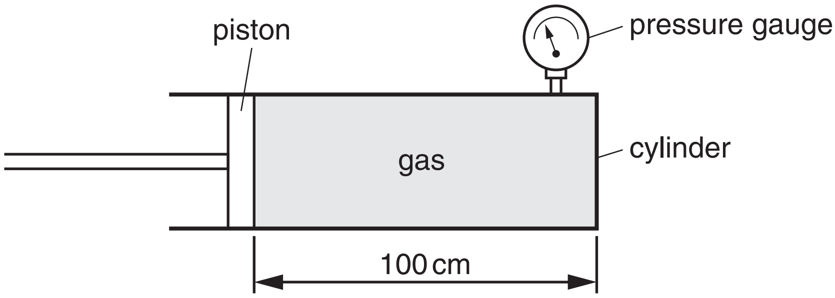
Calculate how far the piston has moved.

distance moved = ... [4]

[Total: 7]

(a)	typical random path drawn, at least 3 abrupt changes of direction	B1	
(b)	air molecules hit dust particles in all directions/move it in all directions	B1	
	just as likely to be up as down	B1	
	(allow marks scored on diagram)		
(c)	random movements smaller OR slower movement OR less energy OR movement decreases	B1	[4]

5 Fig. 5.1 shows a gas contained in a cylinder enclosed by a piston.



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....

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(ii) Explain how the molecules exert a force on the walls of the cylinder.

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....[1]

(iii) Calculate the force exerted by the gas on the piston.

force = ...[2]

(b) The piston is moved so that the new length of cylinder occupied by the gas is 50 cm. The temperature of the gas is unchanged.

(i) Calculate the new pressure of the gas.

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[Total: 7]

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	(iii)	*p* = *F*/*A* OR (force =) *pA* OR 300 × 0.12 OR 300 000 × 0.12 OR any other recognisable pressure × area	C1	
		= 36 kN / 36 000 N	A1	
(b)	**(i)**	$p_1V_1 = p_2V_2$ / 300 × 0.1 (× 0.12) = p_2 × 0.05 (× 0.12) OR if *V* is halved, *p* is doubled OR vice versa	C1	
		p_2 = 600 kPa	A1	
	(ii)	(molecules) collide <u>with walls</u> more often o.w.t.t.e. OR more collisions <u>with walls</u> per second or per unit time o.w.t.t.e	B1	[7]

6 **(a)** Fig. 4.1 shows some gas contained in a cylinder by a heavy piston. The piston can move up and down in the cylinder with negligible friction.

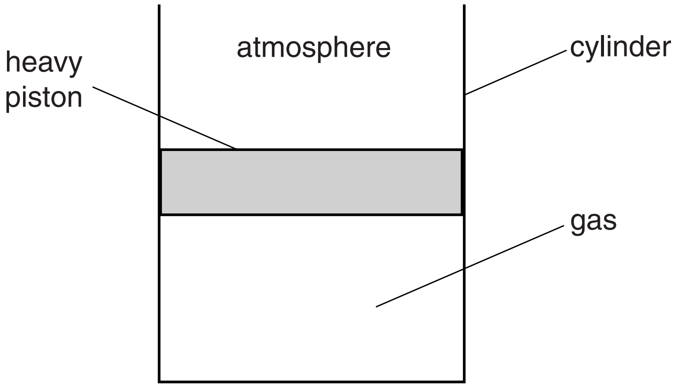

Fig. 4.1

There is a small increase in the pressure of the atmosphere above the piston.

(i) On Fig. 4.1, draw a possible new position for the lower face of the piston.

(ii) Explain, in terms of the molecules of the gas and the molecules of the atmosphere, your answer to **(a)(i).**

....

....

....

....

....

.... [3]

(b) The pressure of the atmosphere above the piston returns to its original value, and the piston returns to its original position, as shown in Fig. 4.2.

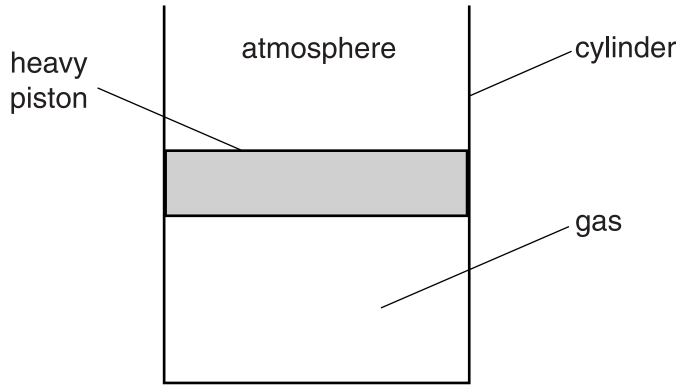

Fig. 4.2

The gas, piston and cylinder are now heated to a much higher temperature.

(i) On Fig. 4.2, draw a possible new position for the lower face of the piston. [1]

(ii) Explain, in terms of the molecules of the gas and the molecules of the atmosphere, your answer to **(b)(i)**.

....

....

....

....

.... [2]

[Total: 7]

(a)	**(i)**	piston lower than original/single line below original lower face	B1	[1]
	(ii)	three points from: they OR air/gas molecules/particles move/collide ignore faster they OR air/gas molecules/particles collide with <u>piston/walls</u> ignore collisions between molecules force exerted on <u>piston</u> greater force/pressure on top (than bottom initially) number of collisions of <u>gas</u> molecules with piston increases piston moves until <u>pressures/forces</u> equal	B1 B1 B1	[3]
(b)	**(i)**	piston higher than original/single line below above original lower face	B1	[1]
	(ii)	two points from: molecules of <u>gas</u> moving <u>faster</u> OR more momentum/KE more/harder collisions of gas molecules with piston/walls greater force/pressure on bottom (than top initially) piston moves <u>up</u> until <u>pressures/forces</u> equal	B1 B1	[2]

7 Fig. 2.1 shows a cylinder containing gas compressed by the movement of a piston.

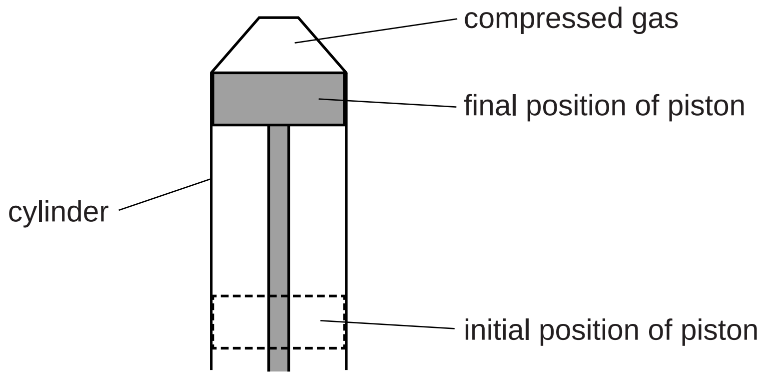

Fig. 2.1

Initially the volume of the gas was 470 cm^3. The piston moves up and compresses the gas to a volume of 60 cm^3. The whole arrangement is left for some time until the gas cools to its original temperature. The pressure of the gas is now 800 kPa.

(a) Calculate the initial pressure of the gas.

pressure = ...[3]

(b) Explain, in terms of molecules, the effect on the pressure of the gas if it was not given time to cool to its original temperature.

....

....

....

....[3]

(c) The area of the piston is 5.5×10^{-3} m^2 (0.0055 m^2).

Calculate the force exerted by the gas on the piston when the pressure is 800 kPa.

force = ...[2]

[Total: 8]

(a)	$p_1V_1 = p_2V_2$ in any form OR (p_1 =) $p_2V_2 \div V_1$	C1
	$p_1 \times 470 = 800 \times 60$ OR (p_1 =) $800 \times 60 \div 470$	C1
	102 OR 100 kPa	A1
(b)	molecules would move faster/have more KE	B1
	more (frequent)/harder collisions with walls/cylinder/piston	B1
	pressure increases	B1
(c)	use of $p = F \div A$ in any form OR (F =) pA	C1
	(F =) 4400 N	A1