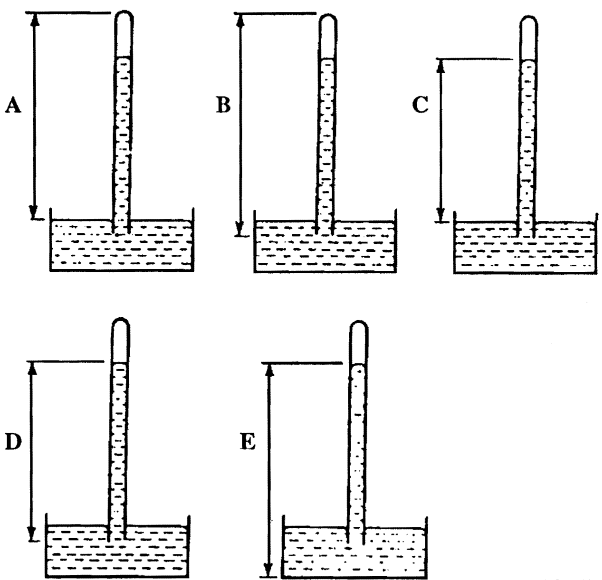
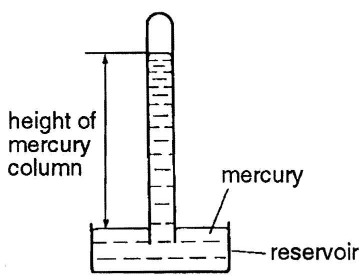
TOPIC 6 Pressure

1 The diagrams show a simple mercury barometer. Which one shows the distance to be measured to find atmospheric pressure?



J90/I/9

2 The diagram shows a simple mercury barometer.



Which of the following does **not** cause the height of the mercury column to vary?

A changes in atmospheric pressure
B changes in the temperature of the mercury
C changes in the value of *g*
D evaporation of mercury from the barometer reservoir
E leakage of air into the tube

J93/I/10; N90/I/9

3 In one minute, a diver breathes 1 litre of air at an atmospheric pressure of 100 kPa.

To breathe in the same mass of air in one minute, how much air would he need to breathe when the total pressure on him under water is 300 kPa?

A $^1/_3$ litre　　**D** 2 litres
B $^1/_2$ litre　　**E** 3 litres
C 1 litre

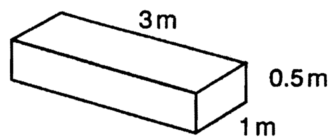
N90/I/11

4 In which of the following examples is the greatest pressure exerted?

A a barefooted person standing on the beach
B a brick resting on the ground
C a book resting on a table
D an elephant standing on the ground
E a knife cutting a piece of meat

N91/I/11

5 A tank 3 m long, 1 m wide and 0.5 m deep is filled with oil which weighs 12 000 N.



What is the pressure on the base of the tank due to the oil?

A 4000 Pa
B 6000 Pa
C 8000 Pa
D 18 000 Pa
E 24 000 Pa

92/I/10; N96/I/11

6 An Eskimo stands on snow wearing snow-shoes. The mass of the Eskimo is 40 kg and the snow-shoes have a total area of 0.5 m^2 in contact with the snow. A 1 kg mass has a gravitational force of 10 N acting on it.

What pressure does the Eskimo exert on the snow?

A 20 N/m^2　　**D** 200 N/m^2
B 80 N/m^2　　**E** 800 N/m^2
C 100 N/m^2

N92/I/11

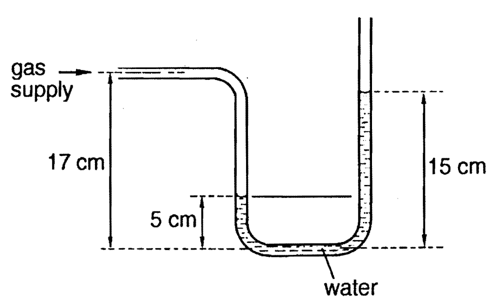
7 A given mass of air occupies 12 m^3 at normal atmospheric pressure.

If the pressure is increased to 4 times the original value without changing the temperature, what volume will the air occupy?

A 3 m^3　　**D** 48 m^3
B 6 m^3　　**E** 192 m^3
C 24 m^3

N92/I/13

8 The diagram shows the water levels in a water manometer used to measure the pressure of a gas supply.

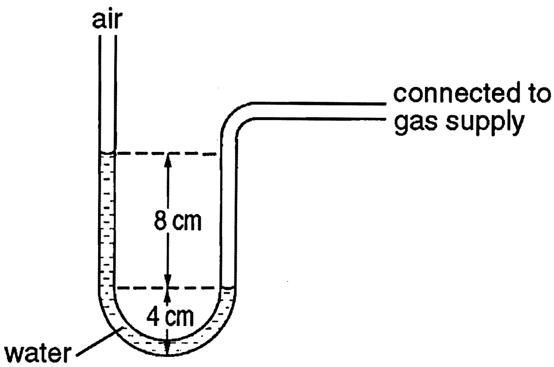


How much greater than atmospheric pressure is the pressure of the gas supply?

A 2 cm of water
B 5 cm of water
C 10 cm of water
D 12 cm of water
E 15 cm of water

N93/I/10

9 A manometer is connected to a gas supply.



Pressure can be measured in cm of water.

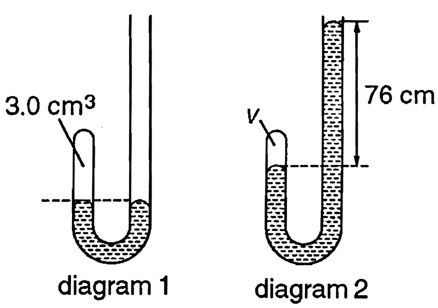
What is the pressure of the gas?

A 8 cm of water more than atmospheric pressure
B 12 cm of water more than atmospheric pressure
C 8 cm of water less than atmospheric pressure
D 12 cm of water less than atmospheric pressure

J94/I/11

10 Diagram 1 shows a J-shaped tube containing 3.0 cm^3 of air trapped by mercury. The mercury levels are the same on both sides of the tube.

More mercury is poured into the open tube until the levels differ by 76 cm, as shown in diagram 2. The atmospheric pressure remains constant at 76 cm of mercury.



(diagrams not drawn to scale)

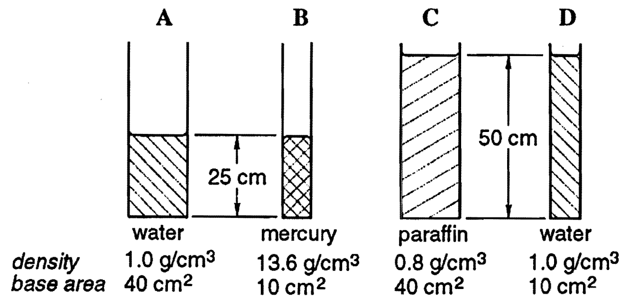
What is the volume V of trapped air shown in diagram 2?

A 0.50 cm^3
B 0.67 cm^3
C 1.0 cm^3
D 1.5 cm^3

J90/I/12 ; N94/I/13

11 The diagrams show liquids in containers.

Which column of liquid exerts the greatest pressure on the base of its container?



J95/I/10

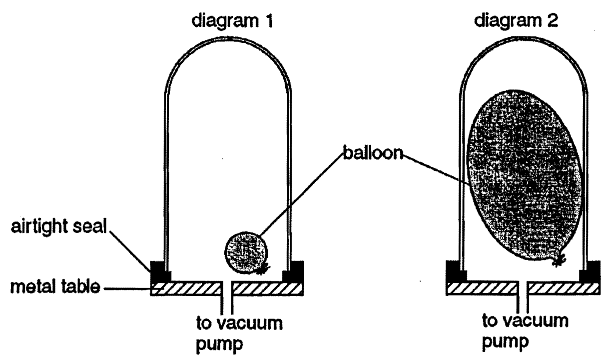
12 A gas occupies a volume of 2.0 m^3 in a cylinder at a pressure of 240 kPa. A piston compresses the gas until the volume is 0.5 m^3, the temperature remaining constant.

What is the new pressure of the gas?

A 60 kPa
B 240 kPa
C 480 kPa
D 960 kPa

J95/I/12

13 A partially inflated toy balloon is placed under a bell jar (diagram 1).



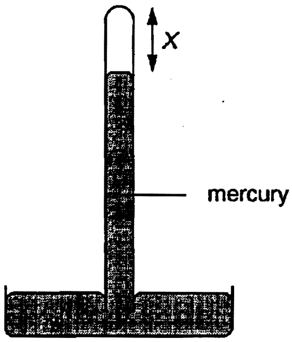
After the vacuum pump has been turned on for several minutes, the volume of the balloon has increased (diagram 2).

Which pressure changes have occurred within the bell jar and within the balloon?

	pressure change in the bell jar	*pressure change in the balloon*
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

N95/I/11 ; J2000/I/13

14 A simple mercury barometer is carried to the top of a mountain, where the atmospheric pressure is less than at its base.

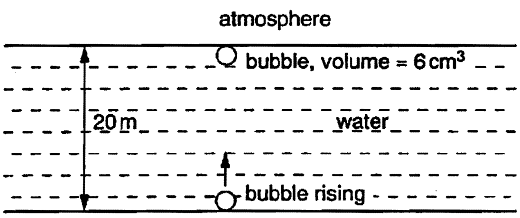


How does the length X of the space above the mercury, and the pressure in this space, change as the barometer is taken from the base to the top of the mountain?

	length of X	*pressure*
A	decreases	decreases
B	decreases	no change
C	increases	decreases
D	increases	no change

J97/I/10

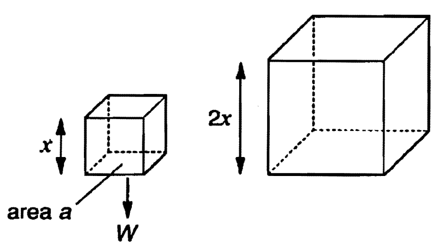
15 Water of depth 10 m exerts a pressure equal to atmospheric pressure. An air bubble rises to the surface of a lake which is 20 m deep. When the bubble reaches the surface, its volume is 6 cm^3.



What was the volume of the air bubble at the bottom of the lake?

A 2 cm^3 **C** 12 cm^3
B 3 cm^3 **D** 18 cm^3 J97/I/12

16 Two cubes are made from the same material. One cube has sides that are twice as long as the other.

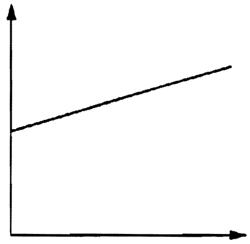


Standing on one face, the small cube exerts a pressure $p = \frac{W}{a}$, where a is the area of the face.

What is the pressure exerted by the larger cube standing on one of its faces?

A $2p$ **C** $8p$
B $4p$ **D** $16p$ N97/I/12

17 The graph indicates properties of a fixed mass of gas.



Which of the following could describe what is plotted on the graph?

	vertical axis	*horizontal axis*	*conditions*
A	density	temperature	constant pressure
B	pressure	volume	constant temperature
C	volume	temperature	constant pressure
D	volume	pressure	constant temperature

N97/I/15

18 Which equation relates pressure, force and area?

A area = force × pressure

B $\text{force} = \frac{\text{pressure}}{\text{area}}$

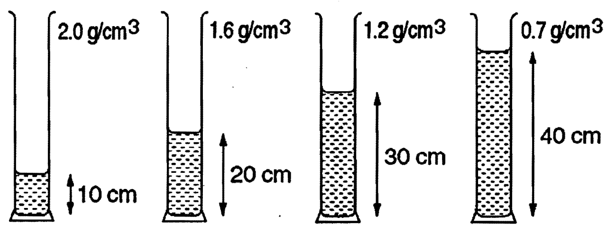
C pressure = force × area

D $\text{pressure} = \frac{\text{force}}{\text{area}}$ J98/I/9

19 Four different liquids are poured into identical measuring cylinders. The diagrams show the heights of the liquids and their densities.

Which liquid causes the largest pressure on the base of its measuring cylinder?

A B C D

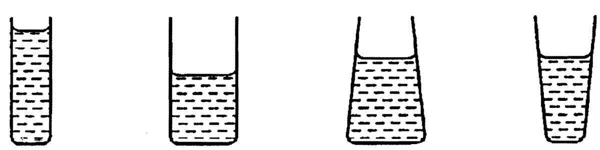


J98/I/10

20 Equal masses of water are poured into four jars as shown.

In which jar is the pressure exerted by the water on the base the greatest?

A B C D



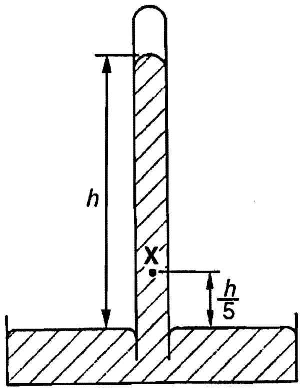
J99/I/9

21 Atmospheric pressure is 10 000 Pa (100 000 N/m^2).

What is the total weight of the atmosphere pressing down on a flat horizontal roof of dimensions 4 m × 2 m?

A 1 250 N
B 12 500 N
C 100 000N
D 800 000 N J99/I/10

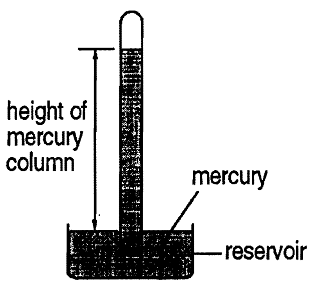
22 The height of a mercury barometer is *h* when the atmospheric pressure is 100 000 Pa.



What is the pressure at **X**?

A 20 000 Pa
B 80 000 Pa
C 120 000 Pa
D 180 000 Pa N95/I/12 ; N99/I/10

23 The diagram shows a simple mercury barometer.



Which of the following does **not** cause the height of the mercury column to vary?

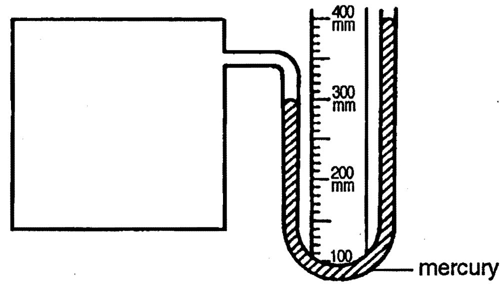
A changes in the atmospheric pressure
B changes in the value of *g*
C evaporation of mercury from the barometer reservoir
D leakage of air into the tube J2000/I/9

24 A barometer is carried from the 1st floor to the 20th floor of a building.

Why does the reading on the barometer fall?

A Air pressure has increased.
B Gravity has decreased.
C Temperature has increased.
D There is less air above the barometer. N2000/I/10

25 When a mercury manometer is connected to a large vessel V containing gas, the steady levels of the mercury are as shown in the diagram.



If the atmospheric pressure is 760 mmHg, what is the pressure, of the gas in V?

Mark on the diagram two points, one in each tube of the manometer, at which the pressure is 150 mmHg greater than atmospheric pressure. N79/I/4

26 Fig. 1 shows a mercury barometer used to measure air pressure and Fig. 2 shows a mercury manometer used to measure the pressure of the gas in a container.

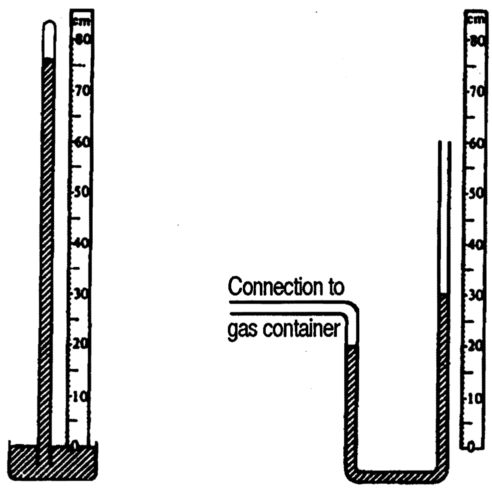


Fig. 1 **Fig. 2**

Mark on the barometer

(a) a point P where the pressure is almost zero,

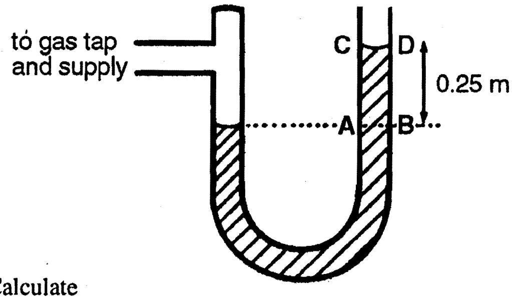
(b) a point Q where the pressure is 20 cm of mercury below atmospheric pressure.

Mark on the manometer

(c) a point R where the pressure is 5 cm of mercury higher than atmospheric pressure.

(d) a point S where the pressure has its maximum value. J80/I/3

27 The diagram shows a manometer with limbs of area of cross-section 0.0012 m^2, and contains liquid which weighs 8000 N/m^3. The manometer is connected to the laboratory gas supply and the tap turned on. As shown in the diagram there is a difference in the liquid levels in the two limbs of 0.25 m.



Calculate

(a) the volume of liquid between the levels AB and CD in the right hand tube, neglecting the meniscus,

(b) the weight of this liquid,

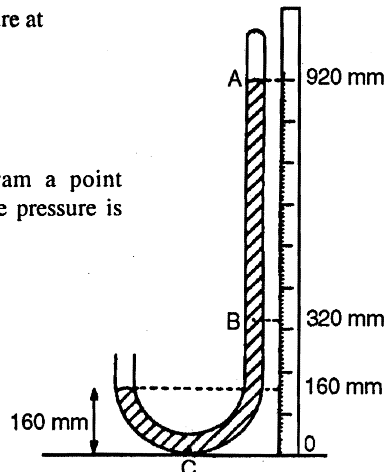
(c) the excess pressure, in N/m^2, of the gas supply above atmospheric. J81/I/3

28 The diagram shows a mercury barometer tube on a day when the atmospheric pressure in the laboratory is 760 mmHg.

Determine the pressure at

(i) A;
(ii) B;
(iii) C.

Mark on the diagram a point labelled D where the pressure is 50 mmHg.

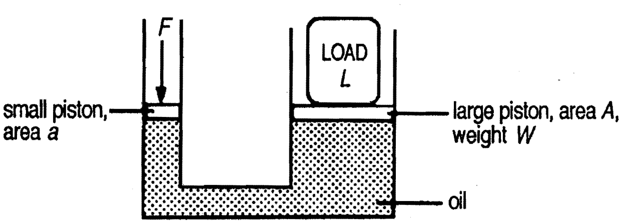


J82/I/2

29 Draw a labelled diagram of a simple mercury barometer. Show clearly on your diagram the height that would be measured to obtain the atmospheric pressure.

State **two** reasons for using mercury in a simple barometer. N82/I/5

30 *(a)* The diagram illustrates a simplified form of a hydraulic press. A force F is applied to the small piston of area a and of negligible weight.



Write expressions for

(i) the pressure exerted on the liquid by the small piston,

(ii) the pressure exerted on the large piston,

(iii) the force exerted by the large piston on the load L.

Indicate what becomes of the energy used in pressing down the small piston. N82/II/7

31 The pressure of the air in a tyre of an empty lorry is 3.0×10^5 Pa (N/m^2) and the volume of the air in the tyre is $0.080\ m^3$. Calculate the volume of the air in the tyre when the lorry is loaded until the pressure of the air in the tyre rises to 3.6×10^5 Pa. (Assume that the air temperature does not change.)

The tyre pressure of a lorry that has been moving for some time is usually greater than the tyre pressure when the lorry has been standing at rest. Why is this so? J83/I/2

32 A vessel with vertical sides and a base of area $0.050\ m^2$ contains liquid of density $1100\ kg/m^3$ and depth 6.0 m.

Calculate

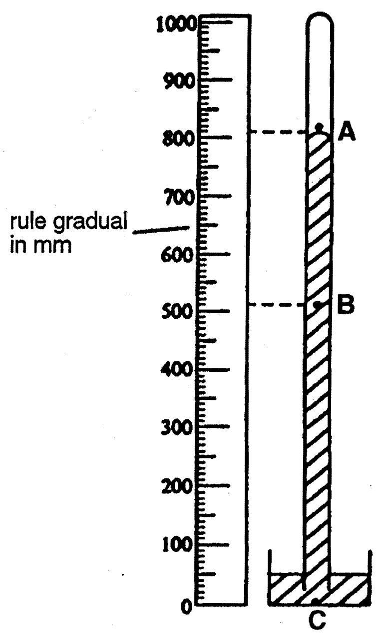
(a) the mass of liquid in the vessel,

(b) the weight of this liquid,

(c) the pressure exerted by the liquid on the base of the vessel.

[Take the weight of 1 kg as 10 N]. N83/I/2

33 The diagram shows a mercury barometer on a day when the atmospheric pressure is 760 mmHg.



(a) What is the pressure

(i) at point A, just above the mercury meniscus,

(ii) at point B in the mercury,

(iii) at point C, on the bottom of the mercury reservoir?

(*b*) On the diagram, draw a line, labelled D, to show the level in the mercury at which the pressure is 400 mmHg. N84/I/5

34 (*a*) What is meant by (i) *pressure*, (ii) *atmospheric pressure*?

Explain in terms of the movement of molecules why the atmospheric pressure at the top of a mountain is less than at sea level.

Draw a labelled diagram of a simple mercury baro-meter. Indicate clearly how the value of atmospheric pressure is read from the barometer.

Explain briefly why the value obtained is the same when the cross-sectional area of the tube is increased.

(*b*) Calculate

(i) the weight of mercury in a tank, given that the area of the base of the tank is 0.5 m^2, that the depth of mercury is 0.3 m and that the density of mercury is 13 600 kg/m^3;

(ii) the pressure that the mercury exerts on the base of the tank.

[Take the weight of 1 kg to be 10 N.] J84/II/7

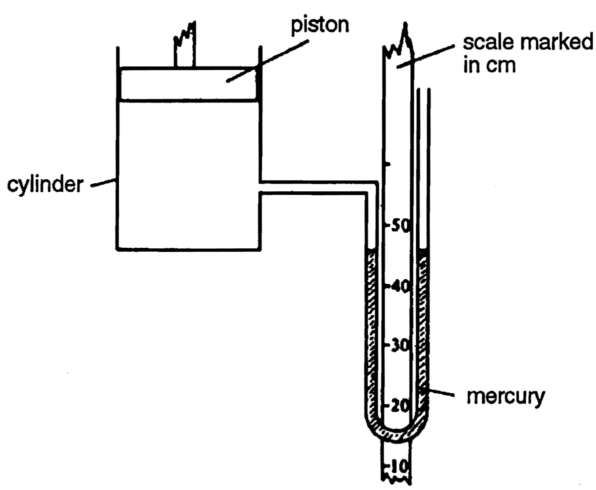
35 The tyres of a car are in contact with the ground over a *total* area 3.0×10^{-2} m^2. The total weight of the car is 6300 N. Calculate the pressure exerted by the tyres on the ground.

Why would you expect the temperature of the tyres to have risen after the car has been in motion for some time? N85/I/4

36 A bubble of air at the bottom of a lake has a volume of 3.0 cm^3 and the pressure on it is equivalent to 4.5 atmospheres. Assuming that the temperature remains constant, calculate the volume of the bubble when it reaches the surface, where the pressure is 1.0 atmosphere.

Suggest, in terms of the forces acting on it, *why* the bubbles rises towards the surface. J86/I/4

37



The diagram shows a cylinder, containing a fixed mass of gas, connected to a mercury manometer. As indicated by the mercury levels, the gas is at atmospheric pressure.

Calculate the pressure of the gas (in atmospheres) when its volume is reduced to two-thirds of the original value. The temperature of the gas is constant throughout the change: the piston is tight-fitting, allowing no gas to escape.

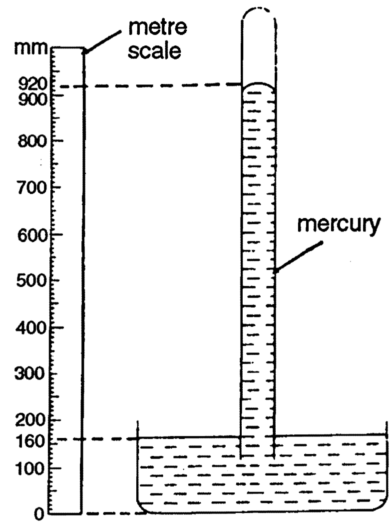
Indicate on the diagram the approximate positions of the mercury surfaces after the gas has been compressed. (Take the pressure of one atmosphere to be equal to that of a 76 cm column of mercury.) J87/I/3

38 The diagram shows a simple mercury barometer and a metre scale set up to measure the atmospheric pressure.

State the atmospheric pressure shown by the barometer.

When air was introduced into the barometer tube, the difference between the mercury levels in the barometer tube and in the reservoir became 746 mm.

Deduce the pressure of the air above the mercury in the barometer tube.



After the air has been introduced, the barometer tube is lowered so that its lower end is immersed more deeply in the reservoir. By considering the air above the mercury in the barometer tube, explain briefly why the difference in mercury levels in the tube and reservoir is now less than 746 mm. N87/I/6

39 Fig. 3.1 below represents a simple mercury barometer on a particular day: the scale alongside the barometer is marked in mm.

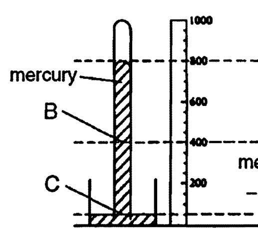


Fig. 3.1

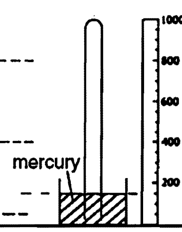


Fig. 3.2

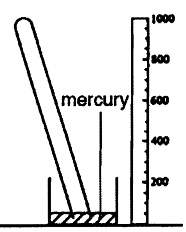


Fig. 3.3

(a) What is the pressure, *inside the tube* in Fig. 3.1,

(i) at point C ....

(ii) at point B? .... [2]

(b) The mercury levels shown inside the tubes in Figs. 3.2 and 3.3 are incorrect.

(i) On Fig. 3.2, show the correct level of mercury *inside the tube* after pouring more mercury into the reservoir until it reaches the level shown by the dotted lines in the diagram.

(ii) On Fig. 3.3, show the correct level of mercury *inside the tube* after tilting the tube from the position shown in Fig. 3.1 into the position shown in Fig. 3.3. [2]

J88/I/3

40 When a block of metal of mass 1.2 kg stands on a horizontal surface, the area of contact between the block and the surface is 8.0 cm^2.

(a) Assuming that the force of gravity acting on a mass of 1 kg is 10 N, calculate the pressure exerted by the block on the surface. [2]

(b) The volume of the block is 150 cm^3. Calculate the density of the metal. [2]

J89/I/1

41 Fig. 4 shows a U-tube manometer connected to a gas cylinder of large volume. The atmospheric pressure is 76 cm of mercury.

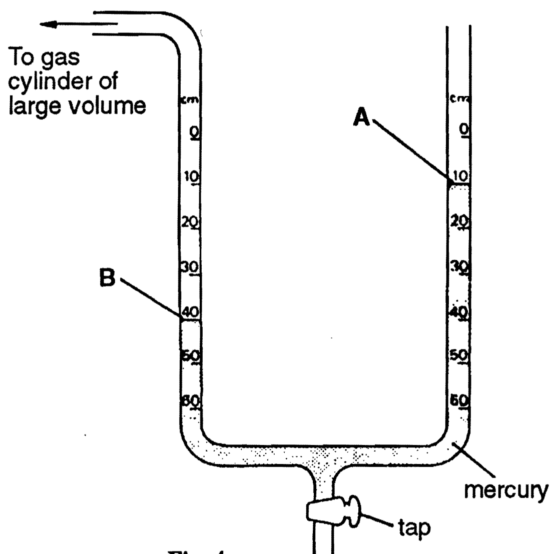


Fig. 4

(a) (i) What is the pressure at point **A** in the right-hand tube? [1]

(ii) What is the pressure at point **B** in the left-hand tube? [1]

(b) The tap is opened and mercury is run out until the level in the left-hand tube drops to the 60 cm mark.

(i) Assuming that the pressure in the gas cylinder remains constant, what is the new position of the level in the right-hand tube?

(ii) Explain how you arrived at your answer. [2]

N89/I/2

42 *(a)* Write down an equation which you could use to calculate the total pressure below the surface of a liquid. State the meaning of each symbol you use.

(b) Use your equation to show that the pressure on a diver increases by one atmospheric pressure for each 10 m the diver descends in a fresh-water lake.

(Atmospheric pressure is 1.0×10^5 Pa; density of fresh water = 1.0×10^3 kg/m^3; g = 10 N/kg) [5]

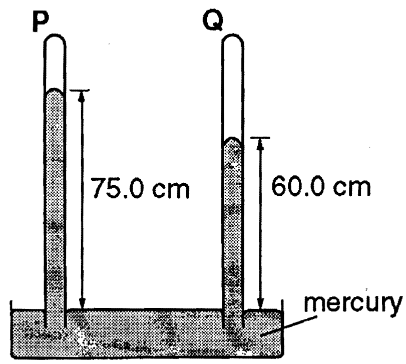
N91/II/3

43 Figure 5 shows two vertical tubes **P** and **Q**, each closed at the upper end. The pressure in the space above the mercury meniscus in tube **P** is negligibly small. There is a small amount of air in this space in the tube **Q**.

The density of mercury is 13.6×10^3 kg/m^3.

The gravitational force on a mass of 1.00 kg is 10 .0 N.

Fig. 5



Using the data given in Fig. 5, determine

(a) the atmospheric pressure, in Pa, at the time, [3]

(b) the pressure, in Pa, exerted by the air in the space at the top of tube **Q**. [3]

J94/II/3

44 A small bubble of air rises to the surface from the bottom of a lake of depth 20.0 m. Atmospheric pressure at the surface of the lake is 1.00×10^5 Pa. The local value of the gravitational force acting on a mass of 1.00 kg is 10.0 N. The density of water is 1.00×10^3 kg/m^3.

(a) Calculate the change of pressure exerted on the bubble as it rises from the bottom of the lake to the surface. [2]

(b) The volume of the bubble when it is at the bottom of the lake is 3 mm^3. Calculate the volume of the bubble as it reaches the surface, assuming that there is no change in temperature. [3]

N96/II/4

45 *(a)* Draw a labelled diagram of a simple mercury barometer. State how such a barometer may be used to obtain a value for atmospheric pressure. [4]

(b) The bottom of the Philippine Trench in the Western Pacific Ocean is 11 km below sea-level. Assuming that the density of sea water is 1.0×10^3 kg/m^3 and that the gravitational force acting on a mass of 1.0 kg is 10 N, estimate the pressure at the bottom of the Trench. [3]

N97/II/4

46 *(a)* Fig. 6 shows a simple mercury barometer that can be used to measure the pressure of the atmosphere.

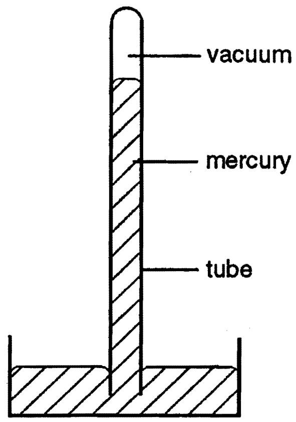


Fig. 6

(i) On Fig. 6, mark a vertical distance that would provide a measurement of atmospheric pressure.

(ii) State and explain what happens to the level of the mercury in the tube when atmospheric pressure increases. [3]

J98/II/3

47 An engineer wishes to check the volume of air inside a pipe and to check that the pipe is not leaking. He connects a syringe to one end of the pipe and a manometer to the other end, as shown in Fig. 7.

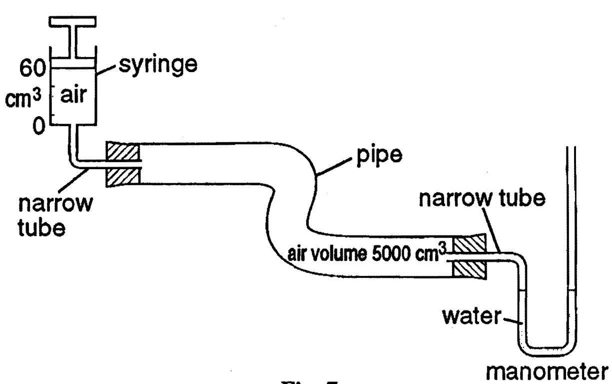


Fig. 7

The syringe initially contains 60 cm^3 of air, and the pipe contains 5000 cm^3 of air. The volume of the narrow tubes may be neglected. All the air is initially at atmospheric pressure, 1.000×10^5 Pa.

The piston is pushed fully down and held steady so that the total volume of air decreases.

(a) Explain, in terms of molecules, why the pressure of the air inside the pipe increases when the piston in the syringe is pushed down. [3]

(b) In this section, assume the pipe does not leak and that the temperature of the air inside remains constant.

When the piston is pushed fully down, calculate

(i) the new pressure of the air in the pipe,

(ii) the difference in pressure between the air inside and the air outside the pipe,

(iii) the depth of water which exerts the same pressure as your value in (ii).

[density of water = 1000 kg/m^3 ; g = 10 N/kg] [7]

(c) (i) If the pipe leaks very slowly, state what happens to the levels of water on each side of the manometer when the piston is pushed down and left down. Draw a diagram of the manometer to illustrate your answer.

(ii) State how the manometer could be altered to give larger differences in liquid level for the same pressure in the pipe. [5]

N99/II/10

48 Fig. 8 shows a piece of glass being lifted by a suction cup.

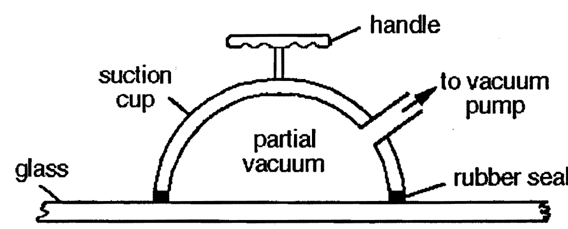


Fig. 8

Air is removed from the cup by a vacuum pump and a partial vacuum is created inside the cup. Atmospheric pressure outside pushes the glass on to the cup.

The area of the glass covered by the cup is 0.0025 m^2. The pressure inside the cup is reduced to 60 000 Pa. Atmospheric pressure outside is 100 000 Pa.

(a) (i) State the formula that relates pressure to force and to area.

(ii) Calculate the greatest weight of glass that can be lifted with this cup. [4]

(b) State two changes that would allow a suction cup to lift a heavier piece of glass. [2]

J2000/II/2

ANSWERS

1. **C**	2. **D**	3. **A**	4. **E**	5. **A**
6. **E**	7. **A**	8. **C**	9. **A**	10. **D**
11. **B**	12. **D**	13. **A**	14. **D**	15. **A**
16. **A**	17. **C**	18. **D**	19. **C**	20. **A**
21. **D**	22. **B**	23. **C**	24. **D**	

25. 860 mm Hg
27. *(a)* 0.003 m^2 *(b)* 2.4 N *(c)* 20 000 N/m^2
28. (i) 0 (ii) 60 mm Hg (iii) 920 mm Hg
31. 0.0667 m^3
32. *(a)* 330 kg *(b)* 3300 N *(c)* 66 000 N/m^2
33. *(a)* (i) 0 (ii) 300 mm Hg (iii) 800 mm Hg
34. *(b)* (i) 24 00 N (ii) 40 800 N/m^2
35. 210 000 N/m^2
36. 13.5 cm^3
37. 1.5 atm; 64 cm
38. 760 mm Hg; 14 mm Hg
39. *(a)* (i) 750 mm Hg; (ii) 400 mm Hg
40. *(a)* 1.5×10^4 N/m^2 *(b)* 8 g/cm^3
41. *(a)* (i) 76 cm Hg (ii) 106 cm Hg
    (b) (i) 30 cm mark
42. *(b)* 1 atm
43. *(a)* 102 000 Pa *(b)* 20 400 Pa
44. *(a)* 2×10^5 Pa *(b)* 9 mm^3
45. *(b)* 1.1×10^8 Pa
47. *(b)* (i) 1.012×10^5 Pa
    (ii) 1200 Pa (iii) 12 cm
48. *(a)* (ii) 100 N