Gas pressure and volume

Worked solutions

GCSE science calculations

This topic online

1 A sealed metal cylinder holds a fixed mass of nitrogen gas. The pressure of the gas is 200 000 Pa and its volume is 0.0015 m^3.

Calculate the value of pressure × volume for the gas.

Give the unit Pa m^3.

(2 marks)

Pressure x volume = constant

$pV = 200\,000 \times 0.0015$

300 Pa m^3

2 Some air is trapped in a sealed container. At a pressure of 120 000 Pa the air has a volume of 0.004 m^3.

A piston squashes the air until its volume is 0.003 m^3. The temperature of the air does not change.

Calculate the new pressure of the air.

(2 marks)

Pressure x volume = constant, so $p1 \times V1 = p2 \times V2$

$120\,000 \times 0.004 = p2 \times 0.003$

$480 = p2 \times 0.003$

Divide both sides by 0.003

$p2 = 480 \div 0.003$

160 000 Pa

3 A plastic storage bag holds 0.05 m^3 of air at a pressure of 90 000 Pa. The bag is sealed and slowly allowed to expand until the volume of the air is 0.06 m^3. The temperature stays the same.

Calculate the new pressure of the air.

(2 marks)

Pressure x volume = constant, so $p1 \times V1 = p2 \times V2$

$90\,000 \times 0.05 = p2 \times 0.06$

$4500 = p2 \times 0.06$

$p2 = 4500 \div 0.06$

75 000 Pa

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4 Chiara seals the end of a syringe containing 30 cm^3 of air at a pressure of 100 kPa. She pushes the plunger in slowly until the volume of the air is 20 cm^3. The temperature of the air does not change.

Calculate the new pressure of the air in pascals.

(3 marks)

Convert kPa to Pa: 1 kPa = 1000 Pa

100 kPa = 100 000 Pa

Both volumes are in cm^3, so leave them in cm^3

Pressure x volume = constant, so p1 x V1 = p2 x V2

100 000 x 30 = p2 x 20

3 000 000 = p2 x 20

p2 = 3 000 000 ÷ 20

150 000 Pa

5 Owen blocks the outlet of a bicycle pump with his finger. The pump contains 250 cm^3 of air at a pressure of 104 000 Pa.

He pushes the handle in until the volume of the air is 0.0001 m^3. The temperature of the air stays the same.

Calculate the new pressure of the air.

(3 marks)

The volumes must be in the same unit: 1 m^3 = 1 000 000 cm^3

V1 = 250 ÷ 1 000 000 = 0.00025 m^3

Pressure x volume = constant, so p1 x V1 = p2 x V2

104 000 x 0.00025 = p2 x 0.0001

26 = p2 x 0.0001

p2 = 26 ÷ 0.0001

260 000 Pa

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6 A small research balloon is released from a field near Aberystwyth. It contains 1.5 m^3 of helium at a pressure of 100 kPa and a temperature of 15 °C.

The balloon rises to a height where the pressure of the helium is 60 kPa. Assume the temperature of the helium stays at 15 °C.

Calculate the new volume of the helium. (3 marks)

The temperature is constant, so 15 °C is not needed

Convert kPa to Pa: 1 kPa = 1000 Pa

$p1 = 100\ kPa = 100\ 000\ Pa$

$p2 = 60\ kPa = 60\ 000\ Pa$

Pressure x volume = constant, so $p1 \times V1 = p2 \times V2$

$100\ 000 \times 1.5 = 60\ 000 \times V2$

$150\ 000 = 60\ 000 \times V2$

$V2 = 150\ 000 \div 60\ 000$

2.5 m^3

7 A machine in a factory compresses a fixed mass of air into a tank. After compression the air has a pressure of 250 000 Pa and a volume of 0.008 m^3.

Before compression the pressure of the air was 100 000 Pa. The temperature did not change.

Calculate the volume of the air before compression. (3 marks)

Pressure x volume = constant, so $p1 \times V1 = p2 \times V2$

$100\ 000 \times V1 = 250\ 000 \times 0.008$

$100\ 000 \times V1 = 2000$

Divide both sides by 100 000

$V1 = 2000 \div 100\ 000$

0.02 m^3

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8 In a science lesson, Mr Adeyemi seals some air inside a syringe at 15 cm^3. He pulls the plunger out slowly until the volume of the air is 45 cm^3. A gauge then reads 34 kPa. The temperature of the air stays the same.

Calculate the pressure of the air before the plunger was pulled out. Give your answer in kPa. (3 marks)

Pressure x volume = constant, so p1 x V1 = p2 x V2

Both volumes in cm^3 and answer wanted in kPa, so keep these units

p1 x 15 = 34 x 45

p1 x 15 = 1530

p1 = 1530 ÷ 15

102 kPa

9 A bubble of gas is released from the mud at the bottom of a garden pond, 1.4 m below the surface.

At the bottom the bubble has a volume of 2.0 cm^3 and the pressure of the gas is 115 000 Pa.

When the bubble reaches the surface, the pressure of the gas is 101 000 Pa. Assume the temperature of the gas does not change.

Calculate the volume of the bubble at the surface.

Give your answer to 2 significant figures. (3 marks)

Both pressures are given, so the depth of 1.4 m is not needed

Pressure x volume = constant, so p1 x V1 = p2 x V2

115 000 x 2.0 = 101 000 x V2

230 000 = 101 000 x V2

V2 = 230 000 ÷ 101 000

V2 = 2.277... cm^3

2.3 cm^3

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10 A foot pump for an airbed has a cylinder holding 400 cm^3 of air at 100 kPa. When the pedal is pressed, the air is squashed. A valve opens and lets air out when the pressure inside the cylinder reaches 320 kPa. Assume the temperature of the air does not change.

a. Calculate the volume of the air in the cylinder when the valve opens.

b. Calculate how much the volume of the air has decreased by when the valve opens. Show your working.

(4 marks)

a)

Pressure x volume = constant, so p1 x V1 = p2 x V2

Both pressures are in kPa, so they can stay in kPa

$100 \times 400 = 320 \times V2$

$40\,000 = 320 \times V2$

$V2 = 40\,000 \div 320$

125 cm^3

b)

Decrease = starting volume - final volume

decrease = 400 - 125

275 cm^3

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11 Amira investigates a fixed mass of air at constant temperature. She changes the pressure and records the volume of the air.

Pressure in kPa	Volume in cm^3
100	40
125	32
160	25
200	20

a. Calculate pressure × volume for the first row of the table. Give your answer in Pa m^3.

b. Predict the volume of the air when the pressure is 250 kPa. Show your working.

(4 marks)

a)

Convert to Pa and m^3: 1 kPa = 1000 Pa, 1 m^3 = 1 000 000 cm^3

$p = 100\ kPa = 100\ 000\ Pa$

$V = 40 \div 1\ 000\ 000 = 0.00004\ m^3$

Pressure × volume = constant

$pV = 100\ 000 \times 0.00004$

4 Pa m^3

b)

p1 × V1 = p2 × V2, keep kPa and cm^3 to match the table

$100 \times 40 = 250 \times V$

$4000 = 250 \times V$

$V = 4000 \div 250$

16 cm^3

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12 A party shop in Leeds has a helium tank with a volume of 0.75 m^3. The helium in the tank is at a pressure of 1.2 MPa.

Helium flows out of the tank into balloons until the pressure in the tank falls to 100 kPa. Each filled balloon holds 0.015 m^3 of helium at 100 kPa. Assume the temperature stays the same.

a. Calculate the volume the helium would take up at a pressure of 100 kPa.

b. Calculate how many balloons can be filled. Show your working.

(5 marks)

a)

Convert to Pa: 1 MPa = 1 000 000 Pa, 1 kPa = 1000 Pa

$p1 = 1.2 \text{ MPa} = 1\,200\,000 \text{ Pa}$

$p2 = 100 \text{ kPa} = 100\,000 \text{ Pa}$

Pressure x volume = constant, so $p1 \times V1 = p2 \times V2$

$1\,200\,000 \times 0.75 = 100\,000 \times V2$

$900\,000 = 100\,000 \times V2$

$V2 = 900\,000 \div 100\,000$

9 m^3

b)

0.75 m^3 of helium stays in the tank, so it does not go into balloons

volume for balloons $= 9 - 0.75 = 8.25 \text{ m}^3$

number of balloons $= 8.25 \div 0.015$

550 balloons

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