PEARSON EDEXCEL INTERNATIONAL GCSE PHYSICS (9–1) | TOPIC 5

FREE SAMPLE

Solids, Liquids and Gases

Free sample: knowledge organiser and Worksheet 1 with answers

4PH1 EDEXCEL SPEC

Density | Density practical | $p = F/A$ | $p = h\rho g$ | Change of state | Specific heat capacity

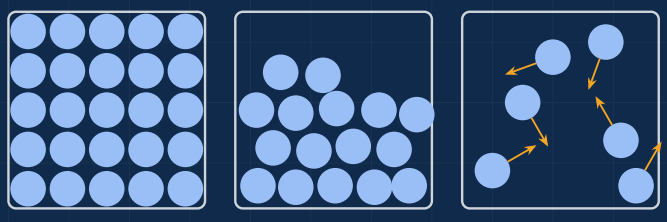
Kelvin scale | Gas laws | Exam-style questions

$$\rho = m / V$$

$$p = h \rho g$$

$$p_1V_1 = p_2V_2$$

$$\Delta Q = m c \Delta T$$



solid liquid gas

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Free sample

Full pack: 4 worksheets, exam paper, answers

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Knowledge organiser

Key words

Density – mass per unit volume, in kg/m^3 or g/cm^3.

Pressure – the force acting at right angles per unit area of a surface.

Pascal (Pa) – the unit of pressure: 1 Pa = 1 N/m^2.

Pressure difference – the extra pressure at a depth h below the surface of a fluid, compared with the surface.

Equations 5.3 5.5 5.7

density = mass ÷ volume $\quad \rho = \frac{m}{V}$

pressure = force ÷ area $\quad p = \frac{F}{A}$

pressure difference = height × density × g

$$p = h \times \rho \times g$$

ρ in kg/m^3, m in kg, V in m^3, p in Pa, F in N, A in m^2, h in m, g = 10 N/kg

Measuring density 5.4

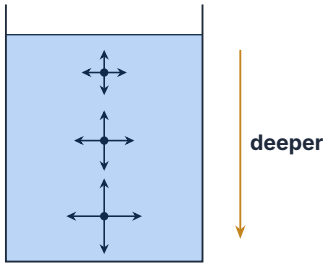
Regular solid: measure length, width and height with a ruler; $V = l \times w \times h$. Find the mass on a balance.

Irregular solid: lower it into a measuring cylinder of water; the rise in the level is its volume.

Liquid: find the mass of an empty measuring cylinder, add a known volume of liquid and find the mass again.

Read the bottom of the meniscus at eye level.

Pressure in a fluid 5.6



At a point in a liquid or gas at rest, the pressure acts **equally in all directions**. It increases with **depth** and with **density**. The width or shape of the container does not matter.

Worked example: density

A stone of mass 52 g raises the water in a measuring cylinder from 40 cm^3 to 60 cm^3.

$V = 60 - 40 = 20$ cm^3

$\rho = m/V = 52 \div 20 = 2.6$ g/cm^3 = 2600 kg/m^3

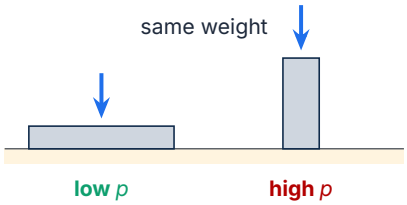
Worked example: pressure difference

Water (ρ = 1000 kg/m^3), 4.0 m below the surface, g = 10 N/kg:

$p = h \times \rho \times g$

$p = 4.0 \times 1000 \times 10 = 40\,000$ Pa (40 kPa)

Force and area 5.5



Large area: snowshoes, tractor tyres, wide foundations.

Small area: knives, needles, drawing pins, studs.

Units and common mistakes

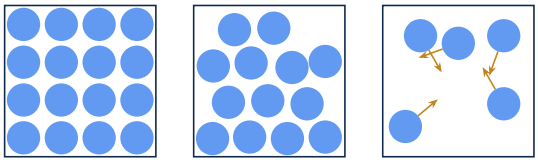
1 g/cm^3 = 1000 kg/m^3

1 m^3 = 1 000 000 cm^3; 1 m^2 = 10 000 cm^2

- Using a mass in kg as the force in $p = F/A$: find the weight, $W = m \times g$.
- Leaving a depth in cm in $p = h \times \rho \times g$.
- A wider tank does not give a bigger pressure: only depth and density matter.

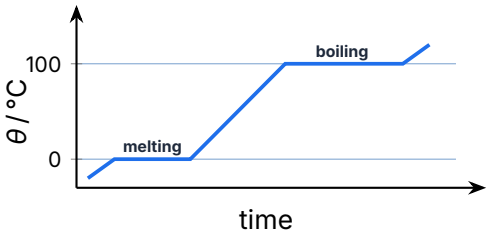
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Particles in the three states PAPER 2 ONLY



Solid: close together, regular pattern, vibrate about fixed positions.
Liquid: close together, irregular, move around each other.
Gas: far apart, random motion at high speed.

Change of state PAPER 2 ONLY



Heating increases the energy stored. Either the temperature rises, or the state changes at a **constant temperature**. **Evaporation** happens at the surface at any temperature; **boiling** happens throughout the liquid at the boiling point.

Specific heat capacity PAPER 2 ONLY

The energy needed to raise the temperature of 1 kg of a substance by 1 °C. Unit: J/kg °C.

$\Delta Q = m \times c \times \Delta T$

ΔQ change in thermal energy (J), m mass (kg), c specific heat capacity (J/kg °C), ΔT change in temperature (°C)

Water: $c = 4200$ J/kg °C. Example: 3.0 kg heated by 20 °C needs $3.0 \times 4200 \times 20 = 252\,000$ J.

Gas molecules 5.15–5.19

Gas molecules move randomly. They collide with the walls and exert a force, so they exert a **pressure**.

Higher temperature → greater average speed.

Absolute zero: −273 °C = 0 K, the lowest possible temperature.

$T\,(\text{K}) = \theta\,(^\circ\text{C}) + 273$

The Kelvin temperature is proportional to the average kinetic energy of the molecules.

Gas laws for a fixed mass of gas 5.20–5.22

Constant temperature: squash the gas into a smaller volume and its pressure increases.

$p_1V_1 = p_2V_2$

Example: 120 kPa, 300 cm^3 → 200 cm^3: $p_2 = 120 \times 300 \div 200 = 180$ kPa

Constant volume: heat the gas and its pressure increases.

$\frac{p_1}{T_1} = \frac{p_2}{T_2}$ **T must be in kelvin**

Example: 100 kPa at 280 K → 350 K: $p_2 = 100 \times 350 \div 280 = 125$ kPa

Common mistakes

- Using Celsius in $p_1/T_1 = p_2/T_2$: always add 273 first. Doubling the Celsius temperature does not double the pressure.
- Using the final temperature instead of the **change** in temperature, ΔT, in $\Delta Q = m \times c \times \Delta T$.
- Leaving a mass in grams in $\Delta Q = m \times c \times \Delta T$: convert to kg.
- Saying the temperature rises while a substance melts or boils: it stays constant until the change of state is complete.
- In $p_1V_1 = p_2V_2$ both volumes (and both pressures) just need the same unit; in $p_1/T_1 = p_2/T_2$ the temperatures must be in kelvin.

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Density

WORKSHEET 1
5.1 5.3 5.4

You will: use $\rho = m/V$ with the correct units, convert between g/cm^3 and kg/m^3, and describe how to measure the density of regular solids, irregular solids and liquids.

5.3 specification statement **PAPER 2 ONLY** Paper 2 only (bold P statements) **CHALLENGE** stretch question

1 5.3 Density is calculated using the equation $\rho = \frac{m}{V}$.

(a) State what each symbol stands for. [2]

ρ _____ m _____ V _____

(b) State the SI unit of density. [1]

unit = _____

2 5.3 Complete the calculations. Show your working. [5]

(a) A block of aluminium has a mass of 540 kg and a volume of 0.20 m^3. Calculate its density.

density = _____

(b) Copper has a density of 8900 kg/m^3. Calculate the mass of 0.0020 m^3 of copper.

mass = _____

(c) Cooking oil has a density of 800 kg/m^3. Calculate the volume of 2.4 kg of oil.

volume = _____

(d) A steel bolt has a mass of 79 g and a volume of 10 cm^3. Calculate its density in g/cm^3.

density = _____

(e) A piece of wood has a mass of 150 g and a volume of 200 cm^3. Calculate its density in g/cm^3.

density = _____

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3 5.1 1 g/cm^3 is equal to 1000 kg/m^3.

(a) Convert 7.9 g/cm^3 to kg/m^3. [1]

density = _____

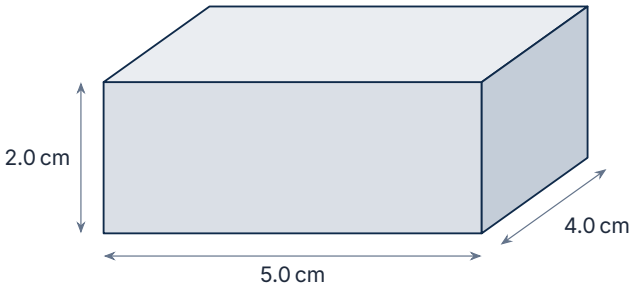
(b) Convert 920 kg/m^3 to g/cm^3. [1]

density = _____

(c) Convert 250 cm^3 to m^3. [1]

volume = _____

4 5.4 A student finds the density of a rectangular block of metal.



mass = 108 g

(a) Name the instruments she uses to measure the lengths and the mass. [2]

.....

.....

(b) Calculate the volume of the block. [1]

volume = _____

(c) Calculate the density of the metal in g/cm^3. [2]

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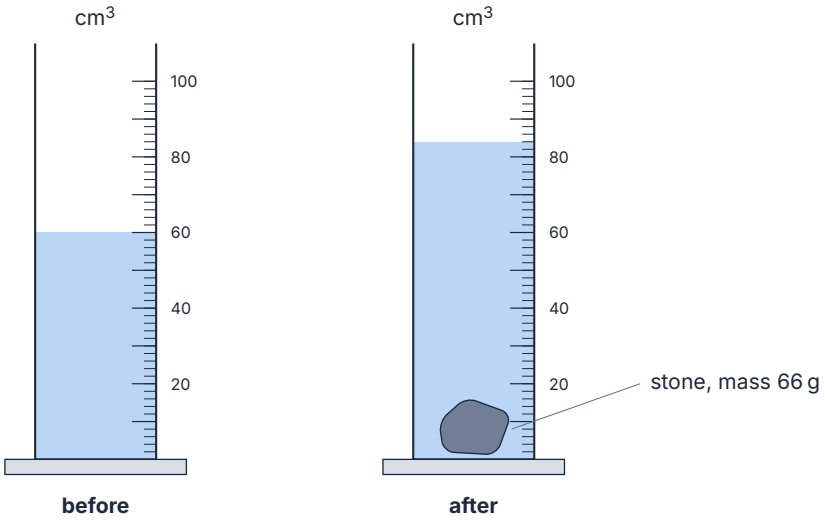
density = _____

(d) Suggest how she could make her value of the volume more accurate. [1]

.....

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5 5.4 A student uses a measuring cylinder to find the volume of a small stone. The diagrams show the water level before and after the stone is lowered in.



(a) Record the two readings. [2]

before _____ cm^3 after _____ cm^3

(b) Calculate the volume of the stone. [1]

volume = _____

(c) Calculate the density of the stone in kg/m^3. [3]

.....

.....

density = _____

(d) State **two** things the student should do to read the measuring cylinder accurately. [2]

.....

.....

6 5.4 Describe how to find the density of cooking oil. You are given a measuring cylinder and a balance. Include the measurements you would take and how you would use them. [4]

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7 5.3 In the experiment in Question 6, a student records these results.

mass of empty measuring cylinder	120.0 g
mass of measuring cylinder + oil	166.0 g
volume of oil	50.0 cm^3

Calculate the density of the oil in g/cm^3. [3]

density = _____

8 5.3 CHALLENGE A crown is said to be made of pure gold. Its mass is 1.02 kg and its volume is 60 cm^3. The density of gold is 19 300 kg/m^3. Use a calculation to decide whether the crown is pure gold. [3]

Exam tip Density is a property of the material, not of the object. Cutting a block in half halves its mass **and** its volume, so the density stays the same.

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Answers: Worksheet 1

Each **(1)** is one mark. Accept answers that round correctly and allow error carried forward from earlier parts. $g = 10$ N/kg and $c_{water} = 4200$ J/kg °C throughout. Accept N/m^2 for Pa.

Worksheet 1 – Density

1 **(a)** ρ density, m mass, V volume: all three **(2)**; two correct **(1)**
(b) **kg/m^3** **(1)**

2 **(a)** $540 \div 0.20 =$ **2700 kg/m^3** **(1)**
(b) $m = \rho V = 8900 \times 0.0020 =$ **17.8 kg** **(1)**
(c) $V = m/\rho = 2.4 \div 800 =$ **0.0030 m^3** **(1)**
(d) $79 \div 10 =$ **7.9 g/cm^3** **(1)**
(e) $150 \div 200 =$ **0.75 g/cm^3** **(1)**

3 **(a)** **7900 kg/m^3** **(1)**
(b) **0.92 g/cm^3** **(1)**
(c) $250 \div 1\,000\,000 =$ **2.5×10^{-4} m^3** ($0.000\,25$ m^3) **(1)**

4 **(a)** ruler (or vernier calipers) **(1)**; (top-pan) balance **(1)**
(b) $5.0 \times 4.0 \times 2.0 =$ **40 cm^3** **(1)**
(c) $108 \div 40$ **(1)** $=$ **2.7 g/cm^3** **(1)**
(d) Measure each length several times (in different places) and use the mean, or use vernier calipers. **(1)**

5 **(a)** before **60 cm^3** **(1)**; after **84 cm^3** **(1)**
(b) $84 - 60 =$ **24 cm^3** **(1)**
(c) $66 \div 24$ **(1)** $= 2.75$ g/cm^3 **(1)** $=$ **2750 kg/m^3** **(1)**
(d) Any two: eye level with the surface **(1)**; read the bottom of the meniscus **(1)**; cylinder on a flat, level surface.

6 Find the mass of the empty measuring cylinder on the balance **(1)**; pour in some oil and read its volume **(1)**; find the mass of the cylinder and oil **(1)**; mass of oil $=$ difference, then density $=$ mass $\div$ volume **(1)**

7 $m = 166.0 - 120.0 = 46.0$ g **(1)**; $\rho = 46.0 \div 50.0$ **(1)** $=$ **0.92 g/cm^3** **(1)**

8 $V = 60$ cm^3 $= 6.0 \times 10^{-5}$ m^3 **(1)**; $\rho = 1.02 \div (6.0 \times 10^{-5}) = 17\,000$ kg/m^3 **(1)**; this is less than 19 300 kg/m^3, so the crown is **not pure gold** **(1)** (or $1020 \div 60 = 17.0$ g/cm^3)

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Get the full pack

You have just used Worksheet 1. The full Topic 5 pack contains:

- **Worksheet 1:** Density
- **Worksheet 2:** Pressure, including $p = h \times \rho \times g$
- **Worksheet 3:** Change of state and specific heat capacity (Paper 2)
- **Worksheet 4:** Ideal gas molecules and the gas laws
- **Multiple-choice practice:** 10 questions
- **Exam-style questions:** a 40-mark paper with a six-mark question
- **Revision checklist** and two-page knowledge organiser

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