5.1 Density pressure and change of state

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

Objective

Build the skills to answer exam questions on **density, pressure and change of state** 、 : $\rho = m/V$, $p = F/A$, pressure in liquids, particles in solids, liquids and gases, specific heat capacity, and melting and boiling.

You must be able to:

- calculate density and pressure
- calculate the pressure difference in a liquid with $p = h\rho g$
- use specific heat capacity, $\Delta Q = mc\Delta T$
- measure the density of a regular and an irregular object

1 Key knowledge and worked examples

Density, pressure and heating

idea	equation or rule
density	$\rho = m \div V$ (kg/m^3 or g/cm^3)
pressure	$p = F \div A$ (Pa = N/m^2)
pressure difference in a liquid	$p = h \times \rho \times g$, with $g = 10$ N/kg
specific heat capacity	$\Delta Q = m \times c \times \Delta T$
change of state	while a substance melts or boils its temperature stays the same; the energy breaks bonds between particles
particles	solid: fixed, close, vibrate; liquid: close, move past each other; gas: far apart, fast, random

Worked example 1: density. A block has mass 540 g and volume 200 cm^3. Find its density.

1. Known: $m = 540$ g; $V = 200$ cm^3.
2. Rule: $\rho = m \div V$.
3. Numbers: $540 \div 200$.
4. Result: 2.7 **g/cm^3**.

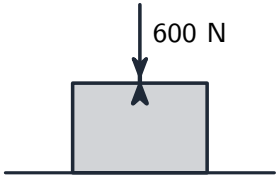
Worked example 2: heating. Find the energy to warm 2.0 kg of oil by 5.0 °C. For oil, $c = 2000$ J/(kg °C).

1. Known: $m = 2.0$ kg; $c = 2000$; $\Delta T = 5.0$.
2. Rule: $\Delta Q = mc\Delta T$.
3. Numbers: $2.0 \times 2000 \times 5.0$.
4. Result: 20 000 **J**.

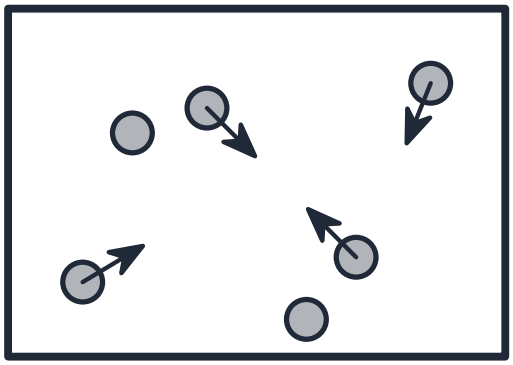
Answer shapes: pressure needs the area in m^2; 1 cm^2 = 0.0001 m^2.

2 Practice

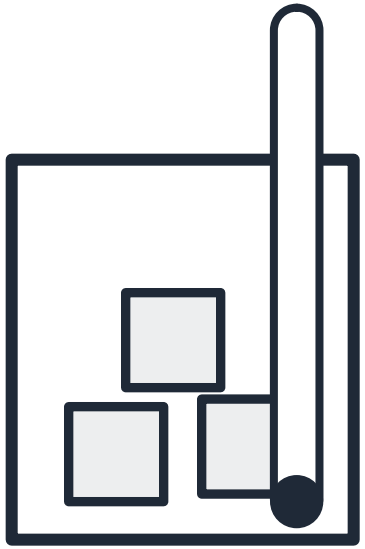
2.1 A box weighs 600 N and rests on an area of 0.20 m^2. Calculate the pressure on the floor. [2]



2.2 Describe the arrangement and movement of particles in a gas. [2]

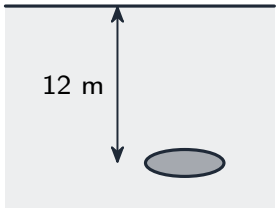


2.3 Explain why the temperature of ice stays at 0 °C while it melts, even though it is being heated. [2]

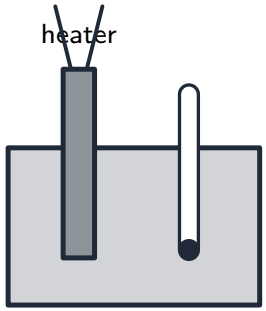


3 Exam-style questions

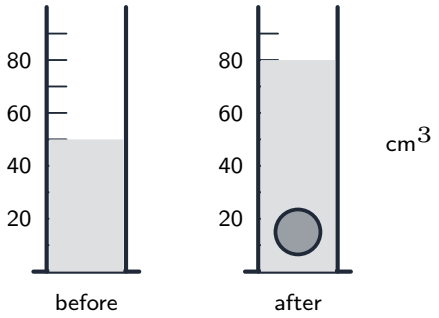
3.1 A diver is 12 m below the surface of the sea. Sea water has density 1030 kg/m^3. Calculate the pressure due to the water on the diver. [3]



3.2 A 1.5 kg aluminium block is heated by a 50 W heater for 300 s. Its temperature rises by 11 °C. Calculate the specific heat capacity of aluminium. [3]



3.3 A student wants to find the density of a small stone. She uses a balance and a measuring cylinder.



(a) The stone has a mass of 78 g. Use the readings to find its volume. [3]

(b) Calculate the density of the stone. [3]

(c) Explain why a cork floats on water but the stone sinks. Water has density 1.0 g/cm^3 and cork about 0.24 g/cm^3. [3]

(d) Describe how the student can measure the density of a regular block and of the stone as accurately as possible. [6]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- $600 \div 0.20$
- **3000** Pa

2.2

- particles are far apart, in a random arrangement
- they move quickly in random directions

2.3

- the energy is used to break the bonds between the particles
- not to make the particles move faster, so the temperature does not rise

3.1

- $p = h\rho g$
- $12 \times 1030 \times 10$
- **123 600** Pa (about 124 kPa)

3.2

- energy $= 50 \times 300 = 15\,000$ J
- $c = 15\,000 \div (1.5 \times 11)$
- **909** J/(kg °C)

3.3

(a) readings 50 cm^3 and 80 cm^3; volume $= 80 - 50 =$ **30** cm^3

(b) $\rho = m \div V$; $78 \div 30 =$ **2.6** g/cm^3

(c) cork is less dense than water; so it floats; the stone, 2.6 g/cm^3, is denser than water, so it sinks

(d) points to include:

- measure the mass of each object on a balance; zero the balance first (K)
- regular block: measure length, width and height with a ruler; $V = l \times w \times h$ (K)
- stone: read the water level, lower the stone in on a thread, read again; the rise is the volume (K)
- or use a displacement can and collect the water in a measuring cylinder (App)
- read the measuring cylinder at eye level, at the bottom of the meniscus (App)
- repeat and find means; use a balance and ruler with small divisions; $\rho = m \div V$ (An)

Levels: **5**–**6** a full, logical answer with correct physics and correct terms; **3**–**4** several correct points, partly linked; **1**–**2** one or two relevant points.