AQA Physics

GCSE Student calculation sheet P6.1

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Density

Specification references:

- P3.1.1 Density of materials
- M1a, M1b, M2a, M3b, M3c, M5c

Aims

In this sheet, you will work through two worked examples designed to allow you to improve your maths skills. The focus is on solving algebraic equations, by substituting numbers into the equation and rearranging if needed. The algebraic equation is the formula for density.

Learning outcomes

After completing this activity, you should be able to:

- determine the volume of rectangular shapes
- convert between g and kg
- convert between litres, millilitres and cm^3
- apply the relationship between density, mass, and volume
- substitute numerical values into algebraic equations using appropriate units
- solve algebraic equations.

Worked examples

1 A student pours out 1 litre of a liquid and finds its mass is 0.7 kg. Calculate the density of the liquid.

Step 1: Write down what you know

Volume = 1 litre, Mass = 0.7 kg, density = ?

Step 2: Convert your units (either into g and cm^3 or kg and m^3)

Volume = 1 litre = 1000 ml (1 litre = 1000 ml)

Volume = 1000 cm^3 (1 ml = 1 cm^3)

Mass = 0.7 kg = 700 g (1 kg = 1000 g)

Step 3: Write the numbers into the equation and calculate

$$\text{Density } (g/cm^3) = \frac{\text{mass (g)}}{\text{volume } (cm^3)} = \frac{700}{1000} = 0.7 \text{ g/cm}^3$$

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2 A block of wood has a density of 0.8 g/cm^3. The block measures 30 cm × 10 cm × 10 cm. Calculate the mass of the block of wood in kg.

Step 1: Write down what you know

Density = 0.8 g/cm^3, length = 30 cm, depth = 10 cm, height = 10 cm, mass = ?

Step 2: Convert your units (either into g and cm^3 or kg and m^3)

Not needed but you do need to find volume in this question.

Step 3: Calculate the volume

Volume = 30 × 10 × 10 = 3000 cm^3 (volume = length × depth × height)

Step 4: Write the numbers into the equation

$$\text{Density } (\text{g/cm}^3) = \frac{\text{mass (g)}}{\text{volume (cm}^3)}$$

$$0.8 = \frac{\text{mass}}{3000}$$

This time the question wants you to calculate the mass. Mass is not the subject of the formula.

Step 5: Rearrange the equation so that mass is the subject of the formula

Multiply both sides of the equation by 3000

0.8 × 3000 = mass

2400 g = mass

Mass in kg = 2.4 kg (1 kg = 1000 g)

Questions

1 Convert the following to cm^3

a 100 ml

..... (*1*)

b 2 litres

..... (*1*)

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2 A tennis ball has a volume of 150 cm^3 and mass of 58 g. Calculate the density of the tennis ball. State the units.

.....

..... (*3*)

3 An ice cube has the dimensions 3 cm × 2 cm × 2 cm. The mass of the ice cube is 10.8 g. Calculate the density of ice.

.....

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..... (*3*)

4 A miner finds a sample of rock and is convinced it contains gold. He looks up the density of gold and discovers gold has a density of 19 g/cm^3, whilst 'fool's gold' has a density of 5 g/cm^3. The mass of his sample is 5.5 kg and the volume of water displaced by it is 300 cm^3.

a Calculate the density of the sample in g/cm^3.

.....

..... (*2*)

b Discuss whether you think the miner had found gold or fool's gold. Explain your answer.

.....

..... (*2*)

5 Molten iron has a density of 7.0 g/cm^3. In its solid state, iron has a density of 8.0 g/cm^3.

a Calculate the volume of 10 kg of molten iron.

.....

..... (*3*)

b Calculate the volume of 10 kg of solid iron.

.....

..... (*3*)

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c Molten iron fills a mould, which has a volume of 200 cm^3. Calculate the volume when the iron cools and solidifies.

.....

.....

..... (*2*)

6 A fish tank with mass 1.0 kg is placed on a shelf. The dimensions are 37 cm × 15 cm × 28 cm. The shelf can hold a mass of 16 kg and the density of the water inside it is 1.0 g/cm^3.

a Calculate the maximum volume of water the fish tank can contain.

..... (*1*)

b Determine whether the shelf is strong enough for the fish tank when it is full of water. Explain your answer

.....

.....

..... (*3*)

7 A hollow plastic ball has volume of 250 cm^3 and a mass of 150 g. To float, the ball must have a density less than 1.0 g/cm^3.

a Calculate the density of the ball.

..... (*1*)

b The ball is floating in water, but it has a small hole and is slowly filling with water. Calculate how much water will flow into it before it sinks.

.....

.....

..... (*3*)

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Answers

8 **a** 100 cm^3 (*1*)

b 2000 cm^3 (*1*)

9 Density = $\frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}} = \frac{58}{150}$ (*1*)

= 0.39 g/cm^3 (*1 mark for answer, 1 for units*)

10 Volume = $l \times d \times h = 3 \times 2 \times 2 = 12\ cm^3$ (*1*)

Density $\frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}} = \frac{10.8}{12}$ (*1*)

= 0.9 g/cm^3 (*1*)

11 **a** Density $(g/cm^3) = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}} = \frac{5500}{300}$ (*1*)

= 18 g/cm^3 (*1*)

b Gold (*1*)

The density of the rock is much closer to that of gold than that of fool's gold (accounting for the fact that the sample is not pure). (*1*)

12 **a** Density $(g/cm^3) = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$ so volume $= \frac{\text{mass}}{\text{density}}$ (*1*)

Volume = $\frac{10000}{7.0}$ (*1*)

= 1400 g/cm^3 (to 2sf) (1429) (*1*)

b Density $(g/cm^3) = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$ so volume $= \frac{\text{mass}}{\text{density}}$ (*1*)

Volume $= \frac{10000}{8.0}$ (*1*)

= 1300 g/cm^3 (to 2 sf) (1250) (*1*)

c Mass of iron = density × volume = 7.0 × 200 = 1400 g (*1*)

Volume $= \frac{\text{mass}}{\text{density}} = \frac{1400}{8.0} = 180 cm^3 (175)$ (*1*)

13 **a** Volume = $l \times d \times h = 37 \times 15 \times 28 = 15\,540$ = 16 000 cm^3 (*1*)

b Mass of water = density × volume = 1 × 15 540 = 15.54 kg (*1*)

Total mass = mass of water + mass of fish tank = 1.0 + 15.54 = 16.54 kg (*1*)

The shelf is not strong enough as the total mass is greater than 16 kg. (*1*)

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14 a Density $= \frac{150}{250} = 0.6$ g/cm^3 (*1*)

b Mass = density × volume = 1 × 250 = 250 g

(*1 mark for rearrangement, 1 mark for realising have to set density = 1*)

Mass of water that can be added = 250 – 150 = 100 g (*1*)