Exercise-5(B)

1. **Define the term density.**
Solution:
The density of a substance is its mass per unit volume, i.e., the density of a substance

$$\Rightarrow \frac{\text{Mass of the substance}}{\text{Volume of the substance}}$$

2. **What are the units of density in (i) C.G.S. and (ii) S.I. system.**
Solution:
The units of density are as follows:
(i) C.G.S = g cm^{-3}
(ii) S.I. system = kg m^{-3}

3. **Express the relationship between the C.G.S. and S.I. units of density.**
Solution:
The units of density are as follows:
- C.G.S = g cm^{-3}
- S.I. system = kg m^{-3}

They are related as follows:
1 g cm^{-3} = 1000 kg m^{-3}

4. **The density of iron is 7800 kg m^{-3}. What do you understand by this statement?**
Solution:
The statement conveys that the mass of 1m^{-3} of iron is 7800kg.

5. **Write the density of water at 4°C in S.I. unit.**
Solution:
The density of water at 4°C in S.I. unit is 1000 kg m^{-3}

6. **How are the (i) mass, (ii) volume, and (iii) density of a metallic piece affected, if at all, with increase in temperature?**
Solution:
With an increase in the temperature, the parameters are affected in the following ways:
(i) Mass – mass is unchanged with an increase in temperature
(ii) Volume – with an increase in the temperature, the volume increases
(iii) Density – with an increase in the temperature, the density of the metallic piece affected decreases.

7. **Water is heated from 0°C to 10°C. How does the density of water change with temperature?**
Solution:
When water is heated from 0°C, the density of water increases up to 4°C and then decreases beyond 4°C

8. Complete the following sentences:

(i) Mass = __________x density

(ii) S.I. unit of density is ____________

(iii) Density of water is_______ kg m^{-3}

(iv) Density in kg m^{-3} = _________x density in g cm^{-3}

Solution:

(i) Volume

(ii) kg m^{-3}

(iii) 1000

(iv) 1000

9. What do you understand by the term relative density of a substance?

Solution:

Relative density of a substance is also defined as the ratio of the mass of a certain volume of a substance to the mass of an equal volume of water at 4°C.

10. What is the unit of relative density?

Solution:

Relative density is no unit.

11. Differentiate between density and relative density of a substance?

Solution:

Density – it is the ratio of mass of a substance to its volume

Relative density – is the ratio of density of a substance to the density of water at 4°C.

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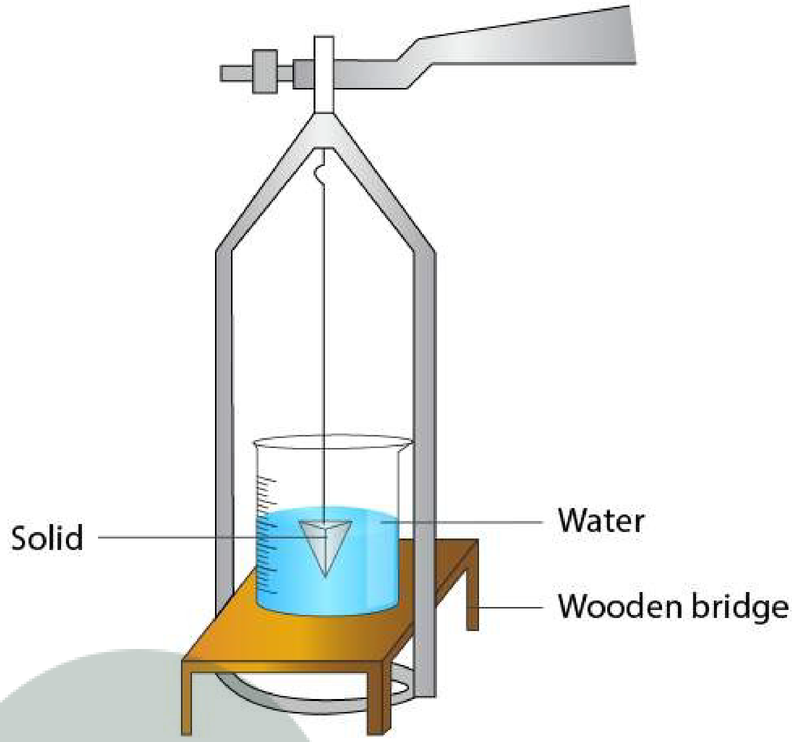
12. With the use of Archimedes' principle, state how you will find relative density of a solid denser than water and insoluble in it. How will you modify your experiment if the solid is soluble in water?

Solution:



The experiment is as follows:
Procedure:
- Find the weight W_1 of the given solid with the help of a physical balance
- Fill a beaker with water and submerge the solid completely in it in a way that it does not touch the base and the walls of the beaker. Now find the weight of the solid in water, W_2

Observation:
- The difference in W_2 and W_1 is equivalent to the loss in weight of the solid when immersed in water, i.e., $(W_2 - W_1)$gf
  Relative density = weight of the solid in air/loss in weight of the solid in water
  $= W_1(W_1 - W_2)$
  If the solid is soluble in water, take a liquid instead of water in which the solid is not soluble and it sinks in the liquid taken.
  Therefore, the relative density = (weight of the solid in air/loss of weight of solid in liquid) x relative density of the liquid

13. A body weighs W gf in air and W_1 gf when it is completely immersed in water. Find: (i) volume of the body, (ii) upthrust on the body, (iii) relative density of material of the body.

Solution:

(i) The volume of the body is given $(W-W_1)$ cm^3
(ii) Upthrust on the body is given by $(W-W_1)$ gf
(iii) Relative density of the material of the body is given by $W/(W-W_1)$

14. Describe an experiment, using Archimedes' principle, to find the relative density of a liquid.

Solution:

Following experiment demonstrates Archimedes' principle to find the relative density of a liquid.

Relative density of a substance is the ratio of the density of that substance to the density of water at 4°C. Archimedes' principle can be used to perform an experiment that measures the weight of the liquid that is displaces by a body and weight of water displaced by the same body

The difference of weight of a body in air and the weight of a body in liquid gives the weight of the liquid displaced by the body.
To find the weight of the body in water displaced by the body, the difference of the weight of the body in air and weight of the body in water should be known

W_1 = weight of the body in air
W_2 = weight of the body when immersed in liquid
W_3 = weight of the body when immersed in water

Hence, using the Archimedes' principle the relative density can be found using the formula:

Relative density of liquid $= \frac{\text{Weight of the body in air – weight of the body in liquid}}{\text{weight of the body in air} - \text{weight of the body in water}} = \frac{W_1 - W_2}{W_1 - W_3}$

15. A body weighs W_1 gf in air and when immersed in a liquid it weighs W_2 gf, while it weighs W_3 gf on immersing it in water. Find: (i) volume of the body (ii) upthrust due to liquid (iii) relative density of the solid and (iv)relative density of the liquid.

Solution:
Given:
W_1 = weight of the body in air
W_2 = weight of the body when immersed in liquid
W_3 = weight of the body when immersed in water
(i) Volume of the body = W_1-W_3 cm^3
(ii) Upthrust due to liquid = W_1-W_2 gf
(iii) relative density of the solid = $\frac{\text{weight of the solid in air}}{\text{weight in air} - \text{weight in water}} = \frac{W_1}{W_1 - W_3}$
(iv) relative density of the liquid = $\frac{W1 - W2}{W_1 - W_3}$

Multiple choice type:

1. **Relative density of a substance is expressed by comparing the density of that substance with the density of:**
   (a) Air
   (b) Mercury
   (c) Water
   (d) Iron
   Solution:
   (d) Water
   Density of water at 4°C is 1g cm^{-3} , is considered as the standard.

2. The unit of relative density is:
(a) g cm^{-3}
(b) kg m^{-3}
(c) m^3 kg^{-1}
(d) no unit
Solution:
(d) no unit
Since, it is a pure ratio, it has no unit.

3. The density of water is:
(a) 1000 g cm^{-3}
(b) 1 kg m^{-3}
(c) 1 g cm^{-3}
(d) None of these
Solution:
(c) 1 g cm^{-3}
Density of water at 4°C is 1g cm^{-3}

Numericals:

1. The density of copper is 8.83 g cm^{-3}. Express it in kg m^{-3}.
Solution:
Expressing density in 8.83 g cm^{-3} in kg m^{-3}
8.83 x 1000 = 8830 kg m^{-3}

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2. The relative density of mercury is 13.6. State its density in (i) C.G.S. unit (ii) S.I. unit.
Solution:
(i) Relative density in C.G.S = density of substance in gcm^{-3}/1.0gcm^{-3}
= 13.6/1 = 13.6 g cm^{-3}
(ii) Relative density in S.I. unit = density of substance in kg m^{-3}/1000 kg m^{-3}
= 13.6/1000 = 13.6 x 10^3 kg m^{-3}

3. The density of iron is 7.8 x 10^3 kg m^{-3}. What is its relative density?
Solution:
We know that R.D = density of substance in kg m^{-3}/1000 kg m^{-3}
= 7.8 x 10^3/1000 kg m^{-3}
= 7.8

4. The relative density of silver is 10.8. Find its density.
Solution:
Given: R.D = 10.8
We know that R.D = density of substance in kg m^{-3}/1000 kg m^{-3}
10.8 = d/1000
⇨ d= 10.8 x 10^3kg m^{-3}

5. Calculate the mass of a body whose volume is $2m^3$ and relative density is 0.52.

Solution:

Given:

The relative density of silver = 0.52

Volume of the body = $2m^3$

Density of the body = 0.52×10^3 kg m^3

To find the mass of the body

Mass = density x volume

= $0.52 \times 10^3 \times 2 = 1040$ kg

6. Calculate the mass of air in a room of dimensions 4.5m x 3.5m x 2.5m if the density of air at N.T.P. is 1.3 kg m^{-3}

Solution:

Given:

Density of air = 1.3 kg m^{-3}

Volume of air = 4.5m x 3.5m x 2.5m = 39.375

We know that mass of air = density x volume

⇨ 1.3 x 39.375 = 51.19kg

7. A piece of stone of mass 113g sinks to the bottom in water contained in a measuring cylinder and water level in cylinder rises from 30ml to 40ml. Calculate R.D. of stone.

Solution:

Given:

Mass of the stone = 113g

Rise in the level of water is equivalent to the volume occupied by the stone

=> 40ml – 30ml=10ml

Therefore, volume of the stone = $10cm^{-3}$

To find the R.D. of the stone

Density of the stone = mass/volume = 113/10 => 11.3 gcm^{-3}

∴ relative density of the stone is 11.3

8. A body of volume $100cm^3$ weighs 1 kgf in air. Find: (i) its weight in water and (ii) its relative density.

Solution:

Given:

Volume of the body = $100cm^3$

Weight of the body in air, W_1= 1kgf or 1000gf

Let Weight of the body in water be W_2

We know that R.D of water is 1 and that of a solid is 10

(i) To find the weight of the body in water

Relative density of the body = $\frac{W1}{W_1 - W_2}$ x relative density of water

$$10 = \frac{1000}{1000 - W_2} \times 1$$

$$10\ (1000 - W_2) = 1000$$

$W_2 = 1000 - 100 = 900$ gf

(ii) To find the relative density of the body

Density of the body = mass/volume

= 1000/100 = 10gf

Relative density is equivalent to density in C.G.S. with no unit, hence R.D. of the body is 10.

9. A body of mass 70kg, when completely immersed in water, displaces 20,000 cm^3 of water. Find: (i) the weight of the body in water and (ii) the relative density of material of the body.

Solution:

Given:

Mass of the body = 70kg

Volume of water displaced = 20,000 cm^3 or 0.02 m^3

(i) To find the weight of the body submerged in water

Mass of the solid immersed in water= mass of the water displaced

= volume of water displaced x density of water

= 0.02 x 1000 = 20kg

Weight of the body, W = mg

Weight of the body in water = (70 x 9.8) – (20 X 9.8) = 50 kgf

(ii) Density in C.G.S = mass/volume = 70 x 1000/ 20000 =3.5 g cm^3

Relative density of the solid = density in C.G.S without unit

= 3.5

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10. A solid weighs 120gf in air and 105 gf when it is completely immersed in water. Calculate the relative density of solid.

Solution:

Given:

Weight of the solid in air = 120gf

Weight of the solid when completely immersed in water = 105gf

Relative density of a solid = $\frac{\text{weight of solid in air}}{\text{weight of the solid in air} - \text{weight of the solid in water}}$ x R.D. of water

$= \frac{120}{120 - 105} \times 1 = 8$

11. A solid weighs 32 gf in air and 28.8 gf in water. Find: (i) the volume of solid, (ii) R.D. of solid, and (iii) the weight of solid in a liquid of density 0.9gcm^{-3}.

Solution:

Given:

weight of the solid in air, W_1 = 32gf

weight of the solid immersed completely in water, W_2 = 28.8gf

density of the liquid = 0.9gcm^{-3}

(i) To find the volume of solid = mass of the solid/density of solid

= 32/10 = 3.2 m^3

(ii) To find the R.D. of the solid

Relative density of the solid = $\frac{W1}{W_1 - W_2}$ x relative density of water

$= \frac{32}{32 - 28.8} \times 1 = 10$

(iii) To find the weight of the solid in a liquid

Let W_3 be the weight of the solid in liquid

We know that, R.D of solid = $\frac{W1}{W_1 - W_3}$ x relative density of liquid

⇨ $10 = \frac{32}{32 - W_3} \times 0.9$

⇨ $W_3 = 29.12$gf

12. A body weighs 20gf in air and 18 gf in water. Calculate relative density of the material of the body.

Solution:

Given:

Weight of the body in air, W_1 = 20gf

Weight of the body in water, W_2 = 18gf

We know that, R.D of solid = $\frac{W1}{W_1 - W_2}$ x relative density of water

$= \frac{20}{20-18} \times 1$ [R.D. of water is 1]

= 10

13. A solid weighs 1.5 kgf in air and 0.9kgf in a liquid of density 1.2 x 10^3 kg m^{-3}. Calculate R.D. of solid.

Solution:

Given:

Weight of the solid in air = 1.5 kgf

Weight of the solid in liquid = 0.9kgf

Density of the liquid = 1.2 x 10^3 kg m^{-3}

Relative density of the liquid = 1.2

We know that, R.D of solid = $\frac{W1}{W_1 - W_2}$ x relative density of liquid

$= \frac{1.5}{1.5-0.9} \times 1.2 = 3$

14. A jeweler claims that he makes ornament of pure gold of relative density 19.3. He sells a bangle weighing 25.25 gf to a person. The clever customer weighs the bangle when immersed in water and finds that it weighs 23.075 gf in water. With the help of suitable calculations find out whether the ornament is made of pure gold or not.

[Hint: Calculate R.D of material of bangle which comes out to be 11.6]

Solution:

Given:

R.D of pure gold = 19.3

W_1 = weight of the bangle in air = 25.25gf

W_2 = weight of the bangle in water = 23.075 gf

We know that, R.D of solid = $\frac{W1}{W_1 - W_2}$ x relative density of water

R.D. of the bangle = $\frac{W1}{W_1 - W_2}$ x relative density of water

$= \frac{25.25}{25.25 - 23.075}$ x 1 [R.D. of water is 1]

= 11.6

But, Relative density of gold is 19.3

Therefore, we can deduce that the bangle is not made of pure gold.

15. A piece of iron weighs 44.5 gf in air. If the density of iron is 8.9 x 10^3 kg m^{-3}, find the weight of the iron piece when immersed in water.

Solution:

Given:

Weight of the iron piece = 44.5 gf

Density of iron = 8.9 x 10^3 kg m^{-3}

We know that density of water = 1000 kg m^{-3}

To find the weight of the iron immersed in water

Weight of iron immersed in water = weight of iron in air x[1 – (density of water/density of iron)]

= 44.5 [1-(1000/8900)]

= 39.5 gm

16. A piece of stone of mass 15.1g is first immersed in a liquid and it weighs 10.9 gf. Then on immersing the piece of stone in water, it weighs 9.7 gf. Calculate:

(a) The weight of the piece of stone in air,

(b) The volume of the piece of stone,

(c) The relative density of stone,

(d) The relative density of the liquid.

Solution:

Given:

(i) Mass of the stone = 15.1g, weight of the stone = 15.1 gf

(ii) Let the weight of the stone in air be W_a

Weight of the stone when immersed in water = 9.7gf

Upthrust on the stone = 15.1 – 9.7 = 5.4 gf

As the density of water is 1gcm^{-3}, volume of the stone = 5.4cm^3

(iii) Weight of the stone in liquid, W_1 = 10.9gf

Weight of the stone in water, W_2 = 9.7 gf

We know that, R.D of stone = $\frac{Wa}{W_a - W_2} = \frac{15.1}{15.1 - 9.7} = 2.8$

(iv) Relative density of liquid = $\frac{Wa - W1}{W_a - W_2}$

$= \frac{15.1 - 10.9}{15.1 - 9.7}$

$= \frac{4.2}{5.4} = 0.78$