CHAPTER 11

Mixture and Alligation

When two or more than two pure substances are mixed in a certain ratio, they create a mixture.

Here, we shall confine ourselves to mostly homogeneous mixtures in view of the question commonly asked.

Mixture

The new product obtained by mixing two or more ingredients in a certain ratio is called a mixture of those particular ingredients.

Mean Price

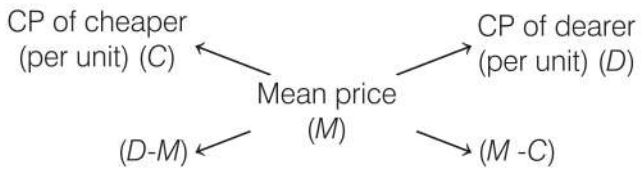
The cost price of a unit quantity of the mixture is called the mean price.

Rules of Mixture or Alligation

- This rule of mixture is used to determine the mean price of the mixture, when the prices of the individual items being mixed together and the proportion in which they are being mixed are given.
- When two ingredients at given prices are known, then the ratio in which these two are mixed to obtain a mixture of known price is given by

$$\frac{\text{Amount of cheaper}}{\text{Amount of dearer}} = \frac{\text{Cost price of dearer} - \text{Mean price}}{\text{Mean price} - \text{Cost price of cheaper}}$$

- It is also known as rule of alligation. It can also be expressed, as



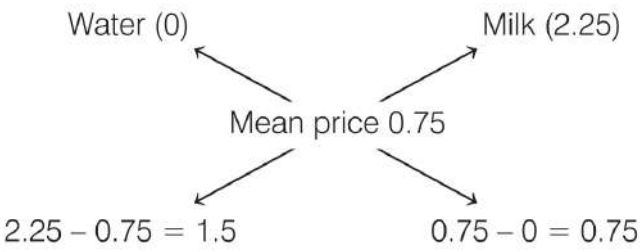
Hence, Amount of cheaper : Amount of dearer

$$= (D - M) : (M - C)$$

Example: A mixture of a certain quantity of milk with 16 L of water is worth ₹ 0.75 per litre.

If pure milk be worth ₹ 2.25 per litre, how much milk is there in the mixture?

Sol. According to the rule of alligation,



$\therefore$ Water : Milk = 1.5 : 0.75 = 2 : 1

$$\text{Clearly, quantity of milk} = \frac{1}{2}$$

$$= \frac{1}{2} \times 16 = 8 \text{ L}$$

Keep in Mind-

- The value of the mixture is always higher than the lowest value and lower than the highest value of the items being mixed.
- Rule of mixture or alligation is applied for rate, ratio, percentage value, speed, prices etc. and not for absolute values.
- In other words, whenever per cent, per hour, per km, per kg etc. are being compared, we can use this method.

Solved Examples:

1. Tea worth ₹126 per kg and ₹135 per kg are mixed with a third variety in the ratio 1: 1: 2. If the mixture is worth ₹ 153 per kg. The price of the third variety per kg will be

(a) ₹ 169.5
(c) ₹ 175.5
(b) ₹ 170.0
(d) ₹ 180.0

Sol. (c) Let the common ratio be x.

Price of 3rd variety of tea $= ₹p$

Now, by given condition,

$$126 \times x + 135 \times x + p \times 2x = 153(x + x + 2x)$$
$$\Rightarrow \quad 126x + 135x + p \times 2x = 153 \times 4x$$
$$\Rightarrow \quad 261x + p \times 2x = 612x$$
$$\Rightarrow \quad p \times 2x = 612x - 261x$$
$$\therefore \quad p = \frac{351x}{2x}$$
$$\Rightarrow \quad p = ₹175.50$$

2. Two vessels A and B contain milk and water mixed in the ratio $8:5$ and $5:2$, respectively. The ratio in which these two mixtures be mixed to get a new mixture containing $69\frac{3}{13}\%$ milk is

(a) $2:7$
(b) $3:5$
(c) $5:2$
(d) $5:7$

Sol. (a) Total ratio of milk in vessel $A = \frac{8}{13}$

Total ratio of milk in vessel $B = \frac{5}{7}$

Ratio of milk in new mixture $= \frac{69\frac{3}{13}}{100}$

$$= \frac{900}{13 \times 100} = \frac{9}{13}$$

Ratio in which they are mixed

$$\frac{8}{13} \searrow \quad \underline{\frac{9}{13}} \quad \swarrow \frac{5}{7}$$
$$\frac{65 - 63}{91} \swarrow \quad \searrow \frac{9}{13} - \frac{8}{13}$$

$$= \frac{2}{91} : \frac{1}{13} = \frac{\overline{91}}{\frac{1}{13}} = \frac{2}{91} \times \frac{13}{1} = \frac{2}{7} = 2:7$$

3. A mixture of milk and water is such that the quantity of milk is $\frac{3}{5}$ that of water. The proportion of milk in the mixture is

(a) $1/8$
(b) $1/2$
(c) $3/8$
(d) $5/8$

Sol. (d) Milk $= \frac{3}{5}$ water $\Rightarrow$ 5 milk $=$ 3 water

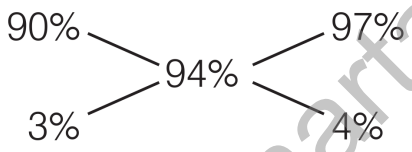
Total mixture $= 5 + 3 = 8$ units

Portion of milk in mixture $= \frac{5}{8}$

4. Two solutions of 90% and 97% purity are mixed, resulting in 21 L of mixture of 94% purity. The quantity of the second solution in the resulting mixture, in litres, is

(a) 15
(b) 12
(c) 9
(d) 6

Sol. (b) By mixture method,



∴ Quantity of second solution in 21L of mixture $= \frac{4}{7} \times 21 = 12$ L

Practice Questions

1. A mixture of 20 kg of spirit and water contains 10% water. After adding a certain amount of water, the weight of the new mixture is 25 kg. What is the percentage of water in the new mixture?

(a) 18
(b) 28
(c) 12.5
(d) 15

2. 60 kg of a certain variety of rice at ₹ 32perkg is mixed with 48 kg of another variety of rice and the mixture is sold at the average price of ₹ 28 per kg. If there be no profit or loss due to the new sale price, then the price of the second variety of rice is

(a) ₹ 25.60 per kg
(b) ₹ 25 per kg
(c) ₹ 23 per kg
(d) ₹ 30 per kg

3. By mixing two different quantities of pulses in the ratio 2: 3 and selling the mixture at the rate of ₹ 22 per kg a shopkeeper makes a profit of 10%. If the cost of the smaller quantity be ₹ 14 per kg, then the cost per kg of the larger quantity is

(a) ₹ 23
(b) ₹ 24
(c) ₹ 25
(d) None of the above

4. A drum contain 20 L of a paint. From this 2 L of paint is taken out and replaced by 2 L of oil. Again 2 L of this mixture is replaced by 2 L of oil. If the operation is performed once again, then final ratio of the paint and the oil in the drum would be

(a) 729: 271
(b) 172: 279
(c) 3: 7
(d) 217: 972

5. Several litres of acid were drawn off a 54 L vessel full of acid and an equal amount of water added. Again the same volume of the mixture was drawn off and replaced by water. As a result, the vessel contained 24 L of pure acid. How much of the acid was draw off initially?

(a) 12 L
(b) 16 L
(c) 18 L
(d) 24 L

6. There are three containers of equal capacity. The ratio of sulphuric acid to water in the first container is 3: 2, that in the second container is 7: 3 and in the third container 11:4. If all the liquids are mixed together, then the ratio of sulphuric acid to water in the mixture will be

(a) 61: 29
(b) 61: 28
(c) 60: 29
(d) 59: 29

7. A container is filled with liquid, 6 part of which are water and 10 part milk. How much of the mixture must be drawn off and replaced with water so that the mixture may be half water and half milk?

(a) $\frac{1}{3}$
(b) $\frac{1}{7}$
(c) $\frac{1}{5}$
(d) $\frac{1}{8}$

8. A man buys milk at a certain price per litre and after mixing it with water sells it again at the same price. How many of water does he mix in every litre of milk if he makes a profit of 25% ?

(a) 250 mL
(b) 200 mL
(c) 150 mL
(d) 30 mL

9. A barrel contains a mixture of wine and water in the ratio 3: 1. How much fraction of the mixture must be drawn off and substituted by water so that the ratio of wine and water in the resultant mixture in the barrel become 1:1?

(a) $\frac{1}{4}$
(b) $\frac{1}{3}$
(c) $\frac{1}{2}$
(d) $\frac{2}{3}$

10. Atul bought 30 kg of rice at ₹ 8.50perkg and 20 kg of rice at ₹ 8.00 per kg. If he has to make a 20% profit, at approximately, what rate per kg should he sell the rice?

(a) ₹ 10.00
(b) ₹ 12.00
(c) ₹ 8.50
(d) ₹ 8.00

11. Raghav buys milk at a certain price and after mixing it with water sells it again at the same price. How many of water he mixes in a litres of milk, if he makes a profit of 20% ?

(a) 200 mL
(b) 250 mL
(c) 150 mL
(d) 20 mL

12. Pure ghee costs ₹ 100 per kg. After adulterating it with vegetable oil costing ₹ 50 per kg. A shopkeeper sells the mixture at ₹ 96 per kg, thereby making a profit of 20%. In what ratio does he mix the two?

(a) 1: 2
(b) 3: 2
(c) 3: 1
(d) 2: 3

13. Two types of oils having the rates of ₹ 4 per kg and ₹5 per kg respectively are mixed in order to produce a mixture having the rate of ₹ 4.60perkg. What should be the amount of the second type of oil if the amount of the first type of oil in the mixture is 40 kg ?

(a) 75 kg
(b) 50 kg
(c) 60 kg
(d) 40 kg

14. 400 students took a mock exam in Delhi 60% of the boys and 80% of the girls cleared the cut off in the examination. If the total percentage of students qualifying is 65%, how many girls appeared in the examination?

(a) 100
(b) 120
(c) 150
(d) 300

ANSWERS

1. (b)	**2.** (c)	**3.** (b)	**4.** (a)	**5.** (c)	**6.** (a)	**7.** (c)	**8.** (a)	**9.** (a)	**10.** (a)
11. (a)	**12.** (b)	**13.** (c)	**14.** (a)						

Hints & Solutions:

1. Quantity of water in mixture of 20 kg = 10% of 20 kg = 2 kg

Weight of new mixture = 25 kg

Quantity of water in new mixture = $25 - (20 - 2)$

$= 25 - 18 = 7$ kg

$\therefore$ Required percentage $= \frac{7 \times 100}{25} = 7 \times 4 = 28\%$

2. Let price of the second variety of rice be ₹ x per kg.

Then, total cost of first variety of rice $= 60 \times 32 = ₹1920$

and total cost of second variety of rice $= 48 \times x = ₹48x$

$\therefore$ Total SP of both varities of rice

$$= (60 + 48) \times 28 = 108 \times 28$$
$$= ₹3024$$

Since, there is neither profit nor loss, therefore,

$$1920 + 48x = 3024$$
$$\Rightarrow 48x = 1104$$
$$\therefore x = 23$$

Thus, price of second variety of rice is ₹ 23 per kg.

3. Let the total quantity of pulses $= 5$ kg

SP of the mixture $= ₹22 \times 5 = ₹110$

$\because$ Profit $= 10\%$

$\therefore$ CP of the mixture $= ₹100$

$\because$ Cost of the first quantity $= 2 \times 14 = ₹28$

Cost of the second quality $= ₹72$

$\therefore$ CP of the second quality $= \frac{72}{3} = ₹24$

4. The quantity of paint $= 18$ L and quantity of oil $= 2$ L Now, 2 L of mixture is taken out and 2 L of oil is mixed.

$\therefore$ Now, the quantity of paint $= 18 - \frac{9}{5} = \frac{81}{5}$ L

and quantity of oil $= 2 + 2 - \frac{1}{5} = \frac{19}{5}$ L

Now, this process is performed again.

Then, the quantity of paint $= \frac{81}{5} - \frac{81}{50} = \frac{729}{50}$ L

and quantity of oil $= \frac{19}{5} - \frac{19}{50} + 2 = \frac{271}{50}$ L

Hence, the ratio of paint and oil $= 729 : 271$

5. Let x L of several litres of acid were drawn off initially

$\therefore$ Remaining acid in the vessel $= (54 - x)$L

and quantity of water in the vessel $= x$ L

Now, x L of mixture is drawn off

$\therefore$ Quantity of acid drawn off $= \left(\frac{54-x}{54} \times x\right)$ L

and quantity of water drawn off $= \frac{x^2}{54}$ L

Now, the quantity of acid $= \left[54 - x - \left(\frac{54-x}{54}\right)x\right]$ L

$$\therefore\ 54 - x - \frac{(54-x)}{54}x = 24$$

$$\Rightarrow\ x^2 - 108x + 1620 = 0$$
$$\Rightarrow\ x = 90,18$$
$$\therefore\ 90 > 54$$

So, $x = 90$ is ruled out

Hence, $x = 18$

6. Amount of Sulphuric acid in the new mixture $= \frac{3}{5} + \frac{7}{10} + \frac{11}{15} = \frac{61}{30}$

and amount of water in the new mixture $= \frac{2}{5} + \frac{3}{10} + \frac{4}{15} = \frac{29}{30}$

Ratio of sulphuric acid and water in the new mixture $= \frac{61}{30} : \frac{29}{30} = 61:29$

7. Let the container initially contains 16 L of liquid.

Let ' a ' L of liquid be replaced with water.

Quantity of water in the new

mixture $= \left(6 - \frac{6a}{16} + a\right)$ L

Quantity of milk in the new

mixture $= \left(10 - \frac{10a}{16}\right)$ L

$$\therefore\ 6 - \frac{6a}{16} + a = 10 - \frac{10a}{16}$$

$96 - 6a + 16a = 160 - 10a$

$\Rightarrow\ 96 + 10a = 160 - 10a$

$\Rightarrow$

$$20a = 64$$
$$a = \frac{64}{20} = \frac{16}{5}$$

$\therefore$ Part of mixture replaced $= \frac{1}{16} \times \frac{16}{5} = \frac{1}{5}$

8. Let 1 L of milk is bought for ₹ 810 .

Let x L of water is added to it, so that $(1 + x)$L of the mixture is sold at ₹ 10 per litre.

$\therefore$ CP of $(1 + x)$L $= ₹10$

and SP of $(1 + x)$L $= ₹10(1 + x)$

Profit per cent:

$\therefore\ 100x = 25 \Rightarrow x = \frac{1}{4}$

$\therefore$ 250 mL of water should be mixed in every litre of milk.

10. $\frac{30}{20} = \frac{x-8}{8.50-x}$

Where, x is the CP of the mix per kg.

$\Rightarrow \quad 25.50 - 3x = 2x - 15$
$\Rightarrow \quad 5x = 25.50 + 16$

$\therefore\ x = \frac{41.50}{5} = ₹8.30$

$\therefore$ SP of mix per kg at 20% profit

$= \frac{8.30 \times 120}{100} = 9.96$
$= ₹10.00$ (approx.)

11. Let the price of milk per litre be ₹ 1 .

∴ SP of adulterated milk per litres = ₹1

∴ CP of adulterated milk per litres $= \frac{1\times100}{(100+20)} = ₹\frac{5}{6}$

$\because \frac{\text{Quantity of water}}{\text{Quantity of milk}} = \frac{1-\frac{5}{6}}{\frac{5}{6}-0} = \frac{\frac{1}{6}}{\frac{5}{6}}$

∴ Quantity of water with 1 L of milk = 200 mL

12. CP of mixture per kg

$= \frac{100\times96}{(100+20)} = ₹80$

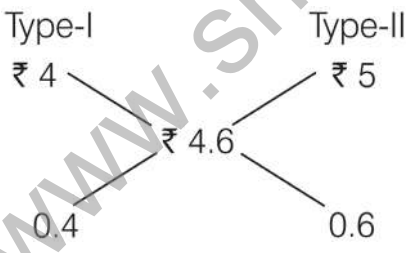
$\frac{\text{Quantity of pure ghee}}{\text{Quantity of vegetable oil}}$

$= \frac{50-80}{80-100}$

∴ Required ratio $= \frac{30}{20} = 3:2$

13. Given, first type of oil in the mixture = 40 kg

By mixture and alligation rule,



∴ Required ratio = 2: 3

Let the quantity of type-I and type-II be $2x$ and $3x$ respectively.

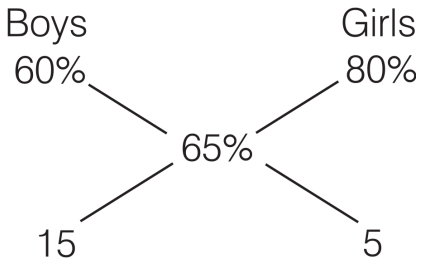
$2x = 40$

$x = 20$

∴ Quantity of second type oil $= 3 \times 20 = 60$ kg

14. Given, total students $= 400$

By mixture and alligation rule,



$\therefore$ Required ratio $= 3:1$

Number of girls appeared in examination $= \frac{1}{4} \times 400 = 100$