Chapter 15

Altering product strength, use of stock solutions, and problem solving by allegation

Part 2

Lecture 6

LECTURER ANAS TARIK NAFEI

Dilution and Fortification of Solids and Semisolids

1. **If 30 g of a 1% hydrocortisone ointment are mixed with 12 g of a non-medicated ointment base, what would be the resulting concentration of hydrocortisone in the mixture?**

30 g x 1% = 0.3 g hydrocortisone

30 g 9hydrocortisone ointment + 12 g ointment base= 42 g mixture

$$\frac{0.3\ \text{g}}{42\ \text{g}} = 0.0071 \times 100 = 0.71\%\ (w/w)$$

Or, Q1 x C1 = Q2 x C2

30 (g) x 1 (%) = 42 (g) x (%) x = 0.71% (w/w)

(2) As a part of a clinical study, a pharmacist is asked to prepare modifications of standard 22 g 2% w/w mupirocin ointments by adding the needed quantities of **either** mupirocin powder **or** a nonmedicated ointment base. **Required for the study** are a 1.75% w/w mupirocin ointment **and** a 2.25% w/w mupirocin ointment. For each modified ointment, **calculate the quantity of component to add to a standard ointment**.

For the 1.75% w/w ointment:

(Dilution with the nonmedicated ointment base is required).

Q1 x C1 = Q2 x C2

22 g x 2% = x g x 1.75 %

X= 25.14 g (of a 1.75% w/w mupirocin ointment may be prepared).

25.14 g – 22 g = 3.14 g (nonmedicated ointment base is required to be added).

Proof: 22 g × 2% w/w= 0.44 g (quantity of mupirocin in the standard ointment).

$$\frac{0.44 \text{ g (mupirocin)}}{25.14 \text{ g (diluted ointment)}} \times 100 = 1.75\% \text{ w/w}$$

For the 2.25% w/w ointment:

(Fortification with mupirocin powder is required).

22 g × 2% w/w = 0.44 g (quantity of mupirocin in the standard ointment).

22 g – 0.44 g = 21.56 g (nonmedicated portion [ointment base] of the standard ointment).

IF fortified ointment may contain 2.25% w/w mupirocin

↓

nonmedicated portion would represent 100% - 2.25% = 97.75%

$Q_1 \times C_1 = Q_2 \times C_2$

21.56 g x 97.75 % = x g x 100 % x= 22.056 g

22.056 g – 21.56 g = 0.496 g total mupirocin in the final product.

0.496 g - 0.44 g = 0.056 g of mupirocin is required to be added

$$\text{Proof}: \frac{0.496\text{ g (mupirocin)}}{22.056\text{ g (fortified ointment)}} \times 100 = 2.249\% \approx 2.25\%\text{ w/w}$$

Allegation

Alligation is an arithmetical method of solving problems that involves the mixing of solutions or mixtures of solids of different percentage strengths.

Alligation Medial. is a method by which the "weighted average" strength of a mixture of two or more substances of known quantity and concentration may be calculated.

Example calculations Using Alligation Medial

1. **What is the percentage of zinc oxide in an ointment prepared by mixing 200 g of 10% ointment, 50 g of 20% ointment, and 100 g of 5% ointment?**

	0.10 X 200 g =	20 g
	0.20 X 50 g =	10 g
	0.05 X 100 g =	5 g
Totals:	350 g	35 g

35 (g) ÷ 350 (g) = 0.10 X 100 = 10% w/w

NOTE: In some problems, the addition of a diluent or vehicle must be considered and treated as zero percentage strength, as in the following example.

2. **What is the percentage strength of alcohol in a mixture of 500 mL of a solution containing 40% v/v alcohol, 400 mL of a second solution containing 21% v/v alcohol, and a sufficient quantity of a nonalcoholic third solution to make a total of 1000 mL?**

0.40 x 500 mL = 200 mL

0.21x 400 mL = 84 mL

0 x 100 mL = 0 mL

Totals: 1000 mL 284 mL

284 (mL) ÷ 1000 (mL) = 0.284 x 100 = 28.4% v/v

3. **A pharmacist–herbalist wishes to consolidate the following assayed batches of *Gingko biloba* leaves: 200 g containing 22% w/w glycosides, 150 g containing 26% w/w glycosides, and 80 g containing 27% w/w glycosides. Calculate the percent of glycosides in the combined mixture.**

0.22 × 200 g = 44 g

0.26 × 150 g = 39 g

0.27 × 80 g = 21.6 g

Totals: 430 g 104.6 g

104.6 (g) ÷ 430 (g) = 0.243 × 100 = 24.3% w/w

Alligation Alternate. **This is a method used to determine the quantities of ingredients of differing strengths needed to make a mixture of a desired strength.**

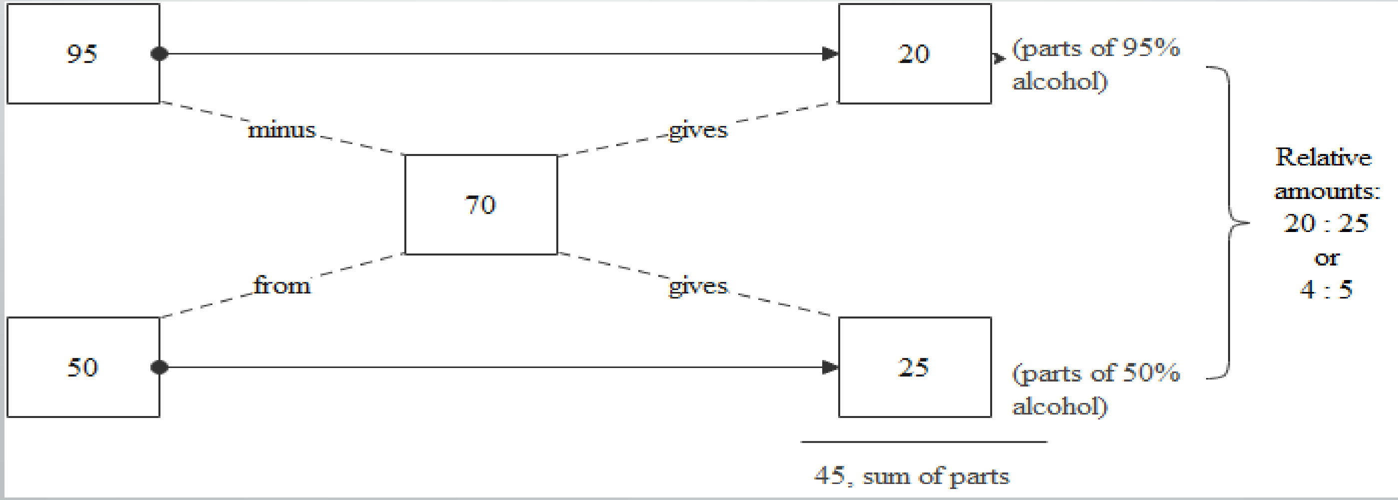
It involves matching pairs of ingredients, one higher in strength and one lower in strength than the desired strength, which lies somewhere in between.

As shown in the example below, the desired strength is placed in the center of the working diagram:

Example Calculations Using Alligation Alternate

(1) In what proportion should alcohols of 95% and 50% strengths be mixed to make 70% alcohol?

Note: the difference between the *strength of the stronger component* (95%) and the *desired strength* (70%) indicates the *number of parts of the weaker* to be used (25 parts), and the difference between the *desired strength* (70%) and the *strength of the weaker component* (50%) indicates the *number of parts of the stronger* to be used (20 parts).



The mathematical validity of this relationship can be demonstrated.

Percent given	Percent desired	Proportional parts required
a		x
	c	
b		y

Given these data, the ratio of x to y may be derived algebraically as follows:

$$ax + by = c(x + y)$$

$$ax + by = cx + cy$$

$$ax - cx = cy - by$$

$$x(a - c) = y(c - b)$$

$$\frac{x}{y} = \frac{c - b}{a - c}$$

Given a = 95%, b = 50%, and c = 70%, we may therefore solve the problems as follows:

$$0.95x + 0.50y = 0.70(x + y)$$

Or

95 x + 50 x = 70 x + 70 x

95 x - 70 x = 70 y - 50 y

x(95 – 70) = y(70 - 50)

$$\frac{x}{y} = \frac{70 - 50}{95 - 70} = \frac{20}{25} = \frac{4\ (parts)}{5\ (parts)}$$

The result can be shown to be correct by *alligation medial*:

95 x 4 = 380

50 x <u>5</u> = <u>250</u>

Total: 9 630

630 / 9 = 70 %

The customary layout of *alligation alternate*, used in the subsequent examples, is a convenient simplification of the preceding diagram.

(2) In what proportion should 20% benzocaine ointment be mixed with an ointment base to produce a 2.5% benzocaine ointment?

NOTE that an "ointment base" has no drug content and thus is represented by a zero in the scheme.

20%		**2.5 parts of 20% ointment**
	2.5%	
0%		**17.5 parts of ointment base**

Relative amounts 2.5: 17.5 or 1:7, answer.

Check 20 x 1 = 20

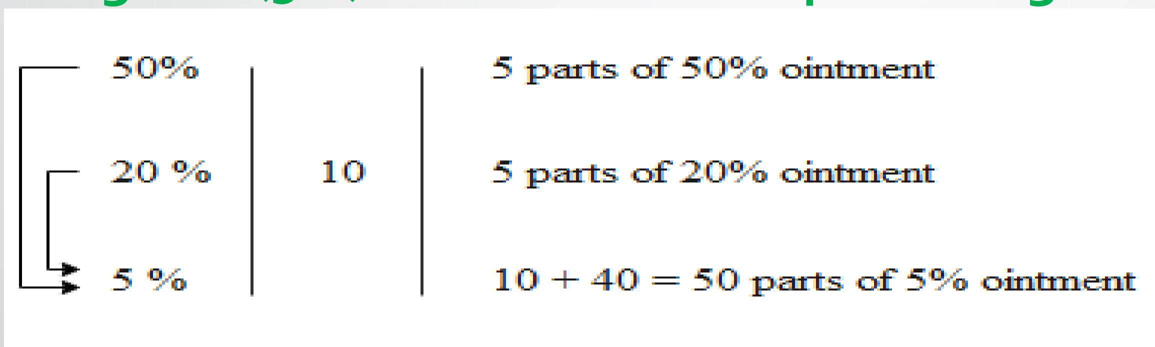
0 x 7 = 0

Total: 8 20

20/8 = 2.5%

(3) A hospital pharmacist wants to use three lots of zinc oxide ointment containing, respectively, 50%, 20%, and 5% of zinc oxide. In what proportion should they be mixed to prepare a 10% zinc oxide ointment?

NOTE The two lots containing more (50% and 20%) than the desired percentage may be separately linked to the lot containing less (5%) than the desired percentage:



Relative amounts: 5:5:50, or 1:1:10, answer.

Check: *50 x 1 = 50*

20 x 1 = 20

5 x <u>10</u> = <u>50</u>

Total: 12 120 = (120/12) = 10%

(4) In what proportions may a manufacturing pharmacist mix 20%, 15%, 5%, and 3% zinc oxide ointments to produce a 10% ointment?

Each of the weaker lots is paired with one of the stronger to give the desired strength, and because we may pair them in two ways, we may get two sets of correct answers

20%		7 parts of 20% ointment
15 %		5 parts of 15% ointment
5 %	10	5 parts of 5% ointment
3 %		10 parts of 3% ointment

Relative amounts: 7:5:5:10, *answer.*

Check

20 x 7 = 140

15 x 5 = 75

5 x 5 = 25

3 x 10 = 30

Total: 27 270 = (270/27) = 10%

Or

20%		5 parts of 20% ointment
15%		7 parts of 15% ointment
	10%	
5%		10 parts of 5% ointment
3%		5 parts of 3% ointment

Relative amounts: 5:7:10:5, *answer.*

Check:

20 x 5 = 100

15 x 7 = 105

5 x 10 = 50

3 x 5 = 15

Totals: 27 270

270 / 27 = 10%

(5) How many milliliters each of a 50% w/v dextrose solution and a 5% w/v dextrose solution is required to prepare 4500 mL of a 10% w/v solution?

50%		5 parts of 50% solution
	10%	
5%		40 parts of 5% solution

There is a *total* of 45 parts to prepare the 4500 mL mixture, or 100 mL per part (4500 mL/45 parts). And the amount of each component may be calculated by:

5 (parts) × 100 mL = 500 mL of the 50% w/v dextrose solution

40 (parts) × 100 mL = 4000 mL of 5% w/v dextrose solution

(6) How many grams of 2.5% w/w hydrocortisone cream should be mixed with 360 g of 0.25% w/w cream to make a 1% w/w hydrocortisone cream?

2.5%		0.75 parts of 2.5% cream
	1%	
0.25%		1.5 parts of 0.25% cream

360 g — 1.5 parts

x g — 1 part

x = 240 g

240 g — 1 part

x g — 0.75 part

x = 180 g the quantity of the 2.5% w/w hydrocortisone cream required.

(7) How many grams of zinc oxide powder should be added to 3200 g of a 5% w/w zinc oxide ointment to prepare a 20% w/w zinc oxide ointment?

NOTE: In the allegation alternate diagram, the zinc oxide powder is 100% zinc oxide.

100%		15 parts of the zinc oxide powder
	20%	
5%		80 parts of the 5% zinc oxide ointment

3200 g   80 part

X g   1 part

x = 40 g/part of the 5% zinc oxide ointment)

40 g × 15 (parts) = 600 g of the zinc oxide powder

Proof : 3200 g × 5% w/w = 160 g zinc oxide content

+ 600 g zinc oxide powder

760 g zinc oxide total

760 g/3800 g (3200 g + 600 g) × 100% = 20% w/w zinc oxide

Specific Gravity of Mixtures

The methods of alligation medial and alligation alternate may be used in solving problems involving the specific gravities of liquids as demonstrated below.

Example Calculations of Specific Gravity Using Alligation

1. **What is the specific gravity of a mixture of 1000 mL of syrup with a specific gravity of 1.300, 400 mL of glycerin with a specific gravity of 1.250, and 1000 mL of an elixir with a specific gravity of 0.950?**

1.300	x	1000	=	1300
1.250	x	400	=	500
0.950	x	1000	=	950
Totals:		2400		2750

2750 / 2400 = 1.146, *answer.*

(2) In what proportion must glycerin with a specific gravity of 1.25 and water be mixed to prepare a liquid having a specific gravity of 1.10?

1.25		0.10 parts of glycerin
	1.10	
1.00		0.15 parts of water

Relative amounts: 0.10:0.15 or 2:3

(3) How many milliliters of each of two liquids with specific gravities of 0.950 and 0.875 should be used to prepare 1500 mL of a liquid having a specific gravity of 0.925?

0.950		0.050, or 50 parts of liquid with specific gravity of 0.95
	0.925	
0.875		0.025, or 25 parts of liquid with specific gravity of 0.875

Relative amounts: 50:25, or 2:1, with a total of three parts:

$$\frac{3\ (\text{parts})}{2\ (\text{parts})} = \frac{1500\ (\text{ml})}{x\ (\text{ml})}$$

x = 1000 mL of liquid with specific gravity of 0.950

$$\frac{3\ (\text{parts})}{2\ (\text{parts})} = \frac{1500\ (\text{ml})}{y\ (\text{ml})}$$

y = 500 mL of liquid with specific gravity of 0.875

Thank you!

TO ALL THE PHRAMACISTS,
THANK YOU FOR
WORKING TO KEEP US
HEALTHY DURING THE
CORONAVIRUS!