EngrD 2190 – Lecture 25

Concept: Graphical Mass Balances with Operating Lines

Context: Osmotic Extraction, Matching Graphical Models
with Absorbers and Strippers

Defining Question: What are the defining features of a
graphical model for an absorber/stripper?

Bring a Straightedge or Ruler to Lecture 26.

Read Chapter 4 pp. 277-289.
Multistage, counter-current flash drums

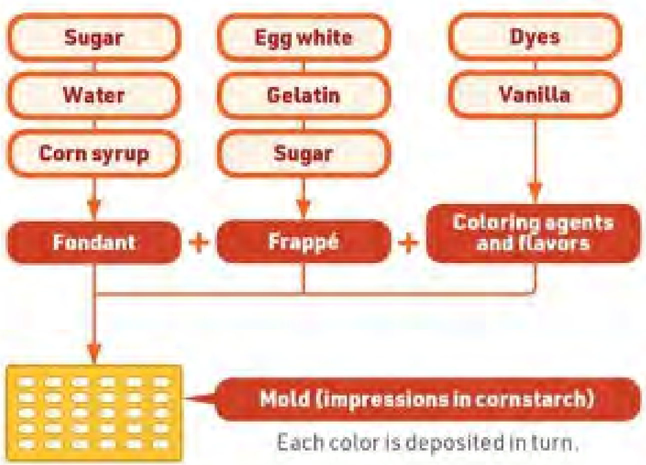
The chemistry of candy corn

PERIODIC GRAPHICS

Confectioners produce around 9 billion pieces of candy corn every year, according to the US National Confectioners Association. Here we look at what candy corn is made of and the chemistry behind its vibrant colors.

How is candy corn made?

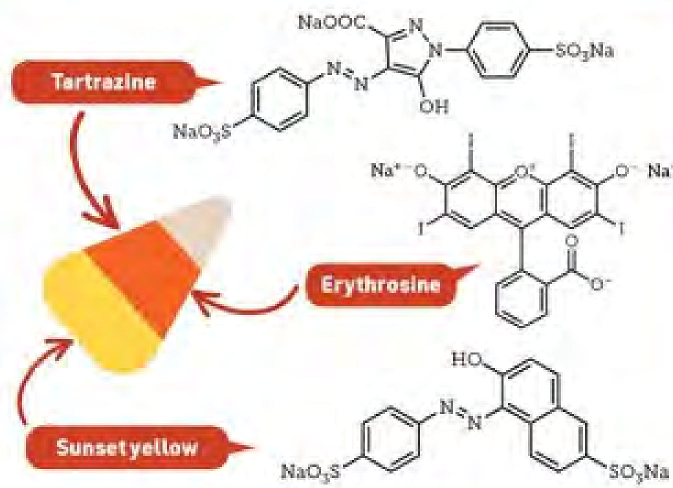
Candy corn is a type of candy called a mallow cream. Manufacturers make candy corn by combining fondant with frappé (a marshmallow-like ingredient), coloring agents, and flavors.



Cornstarch removes moisture from the candies as they dry. Manufacturers then put the dried candy corn into a metal tumbling pan and coat it in shellac wax for a shiny appearance.

The colors of candy corn

Candy corn's colors come from food dyes. These include the azo dyes tartrazine (yellow no. 5) and sunset yellow (yellow no. 6).



Erythrosine (red no. 3) is another dye that candy corn confectioners often use. Manufacturers have also created alternative candy corn, which is colored with turmeric and β-carotene instead of synthetic dyes.

Homework

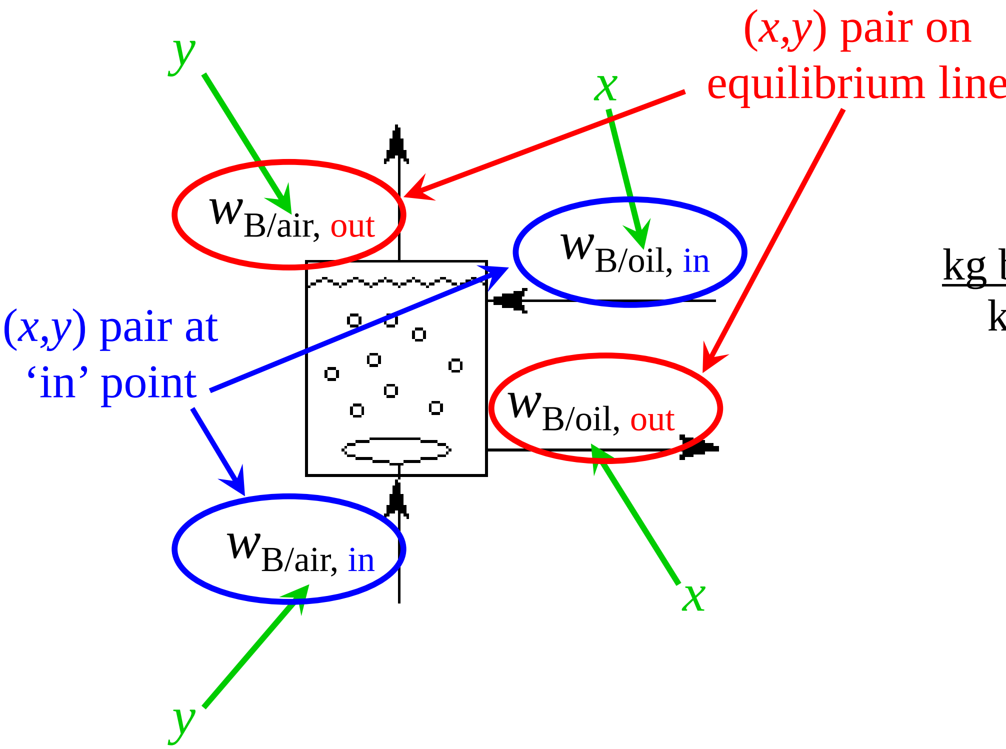
- Homework 7 due Friday 11/7.

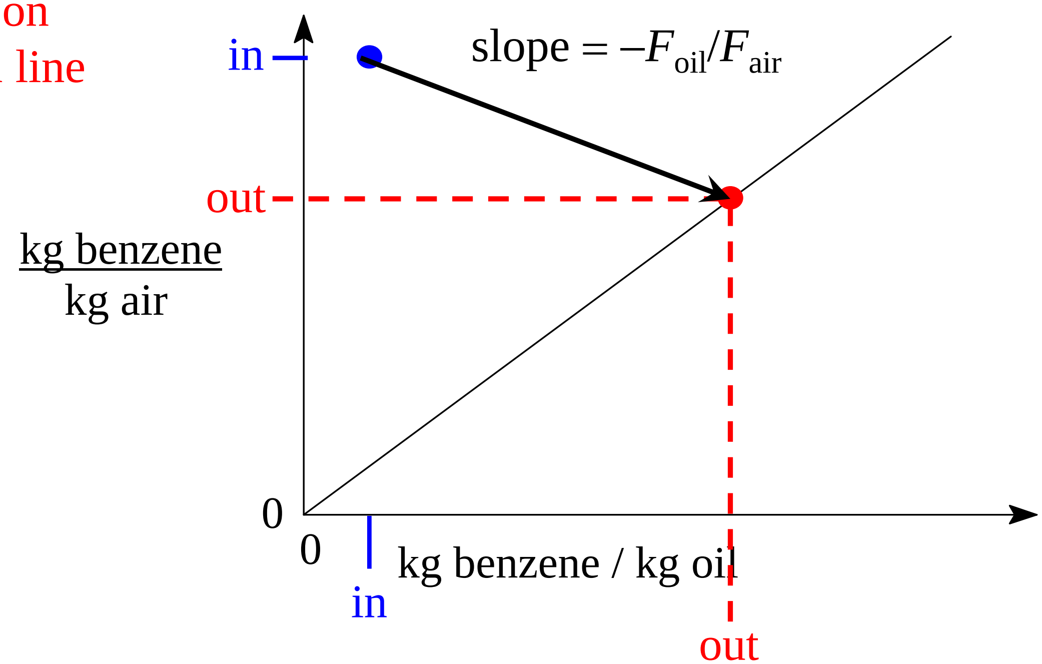
  4.34 mass and energy balances on enthalpy-concentration diagrams.
  4.101 design based on ternary diagrams
  4.46 analysis of multistage absorbers.
  4.104 design with multistage absorbers.

Download blank graphs and phase data from EngrD 2190 homepage:
Textbook→ Textbook Graphs and Figures →
Graphs for Chapter 4 Exercises.

Homework is your chief means of assessing your command of the material.

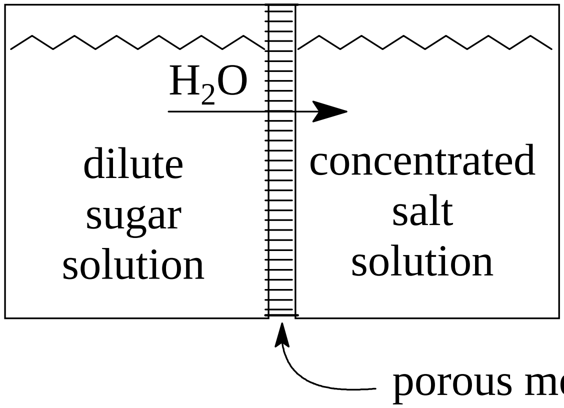
Recap: Graphical Analysis of a Single-Stage Absorber





Key concept: We need two streams -
an oil stream (*x* coordinate) and an air stream (*y* coordinate)
to plot a point.
These two streams are a *plotting pair*.

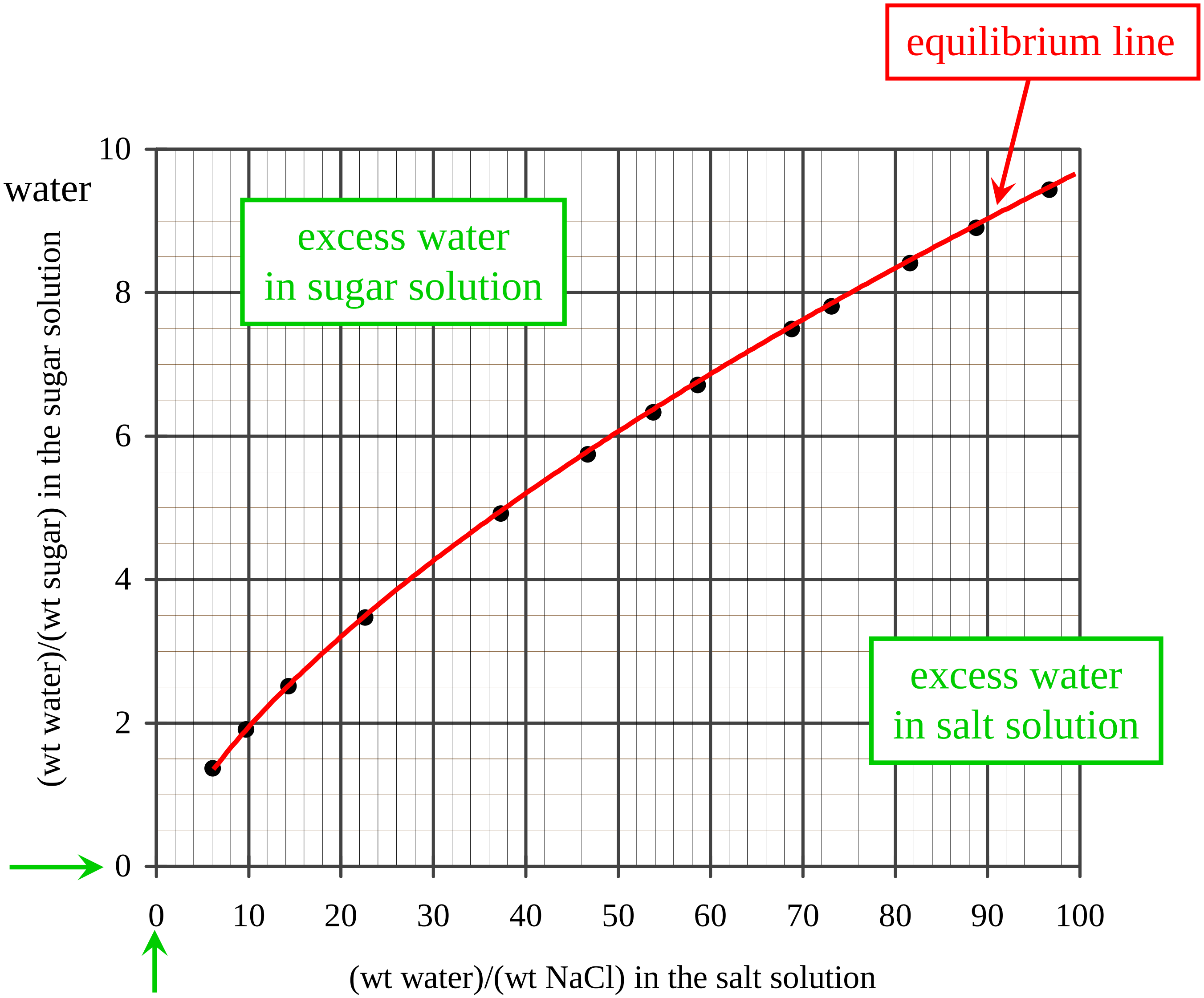
Exercise 4.52 *Solution is posted.*



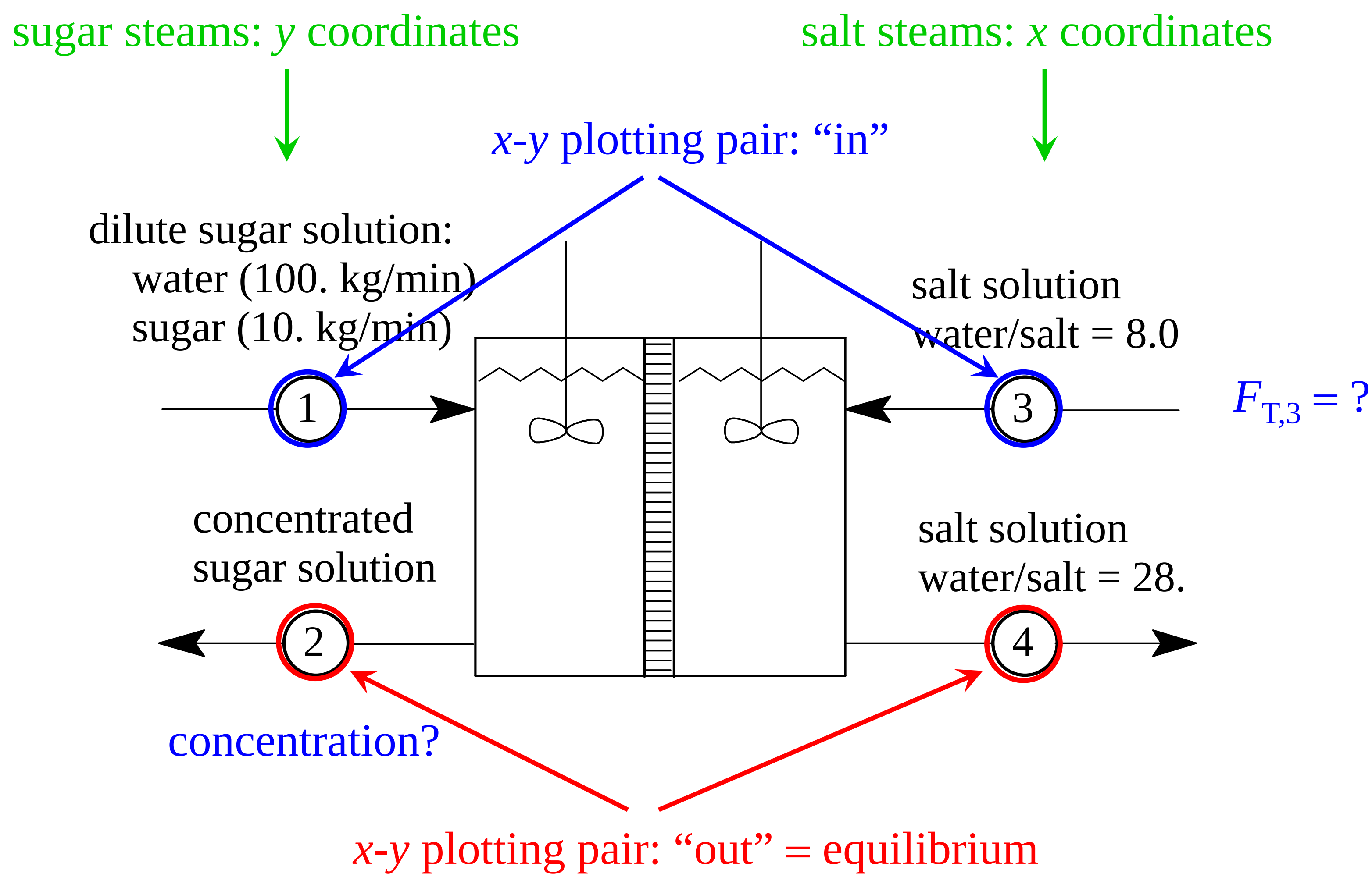
porous membrane
permeable only to water

benzene absorber: *benzene* moves from air to oil.

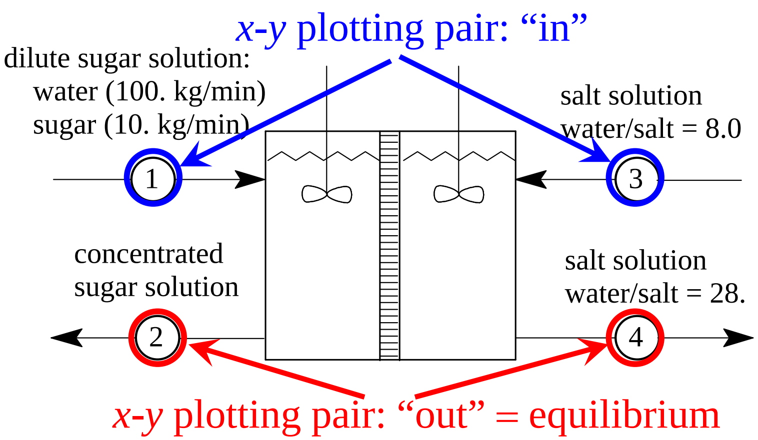
water absorber: *water* moves from sugar solution to salt solution.

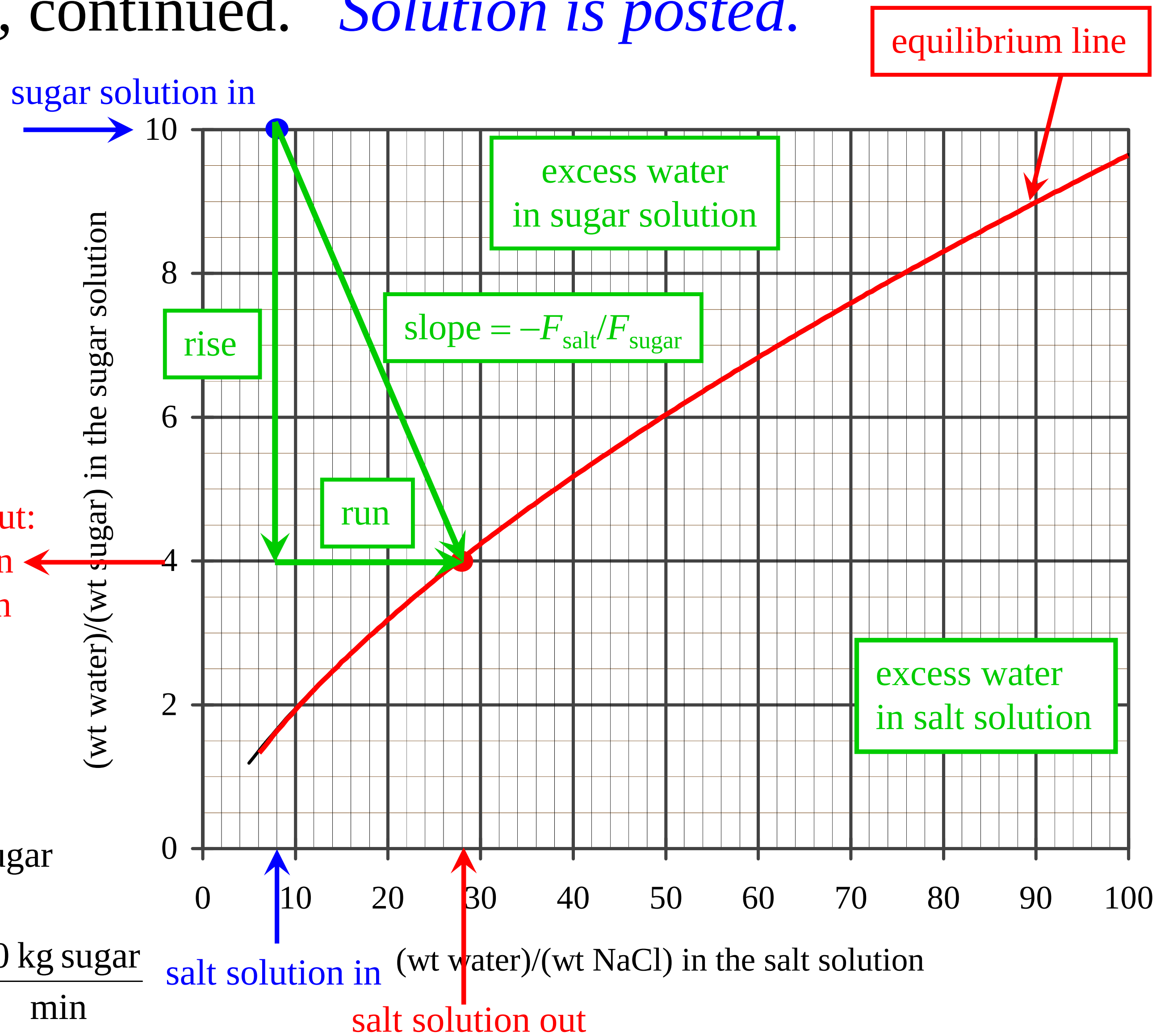


Exercise 4.52, continued. *Solution is posted.*



Exercise 4.52, continued. *Solution is posted.*





$$\text{slope} = -\frac{F_{\text{salt}}}{F_{\text{sugar}}} = \frac{\text{rise}}{\text{run}}$$

$$-\frac{F_{\text{salt}}}{F_{\text{sugar}}} = \frac{4-10\ \text{kg water/kg sugar}}{28-8\ \text{kg water/kg salt}}$$

$$= \frac{-6\ \text{kg salt}}{20\ \text{kg sugar}} = -0.30\ \text{kg salt/kg sugar}$$

$$F_{\text{salt}} = \frac{0.30\ \text{kg salt}}{\text{kg sugar}} F_{\text{sugar}} = \frac{0.30\ \text{kg salt}}{\text{kg sugar}} \times \frac{10\ \text{kg sugar}}{\text{min}}$$

$$= 3.0\ \text{kg salt/min}$$

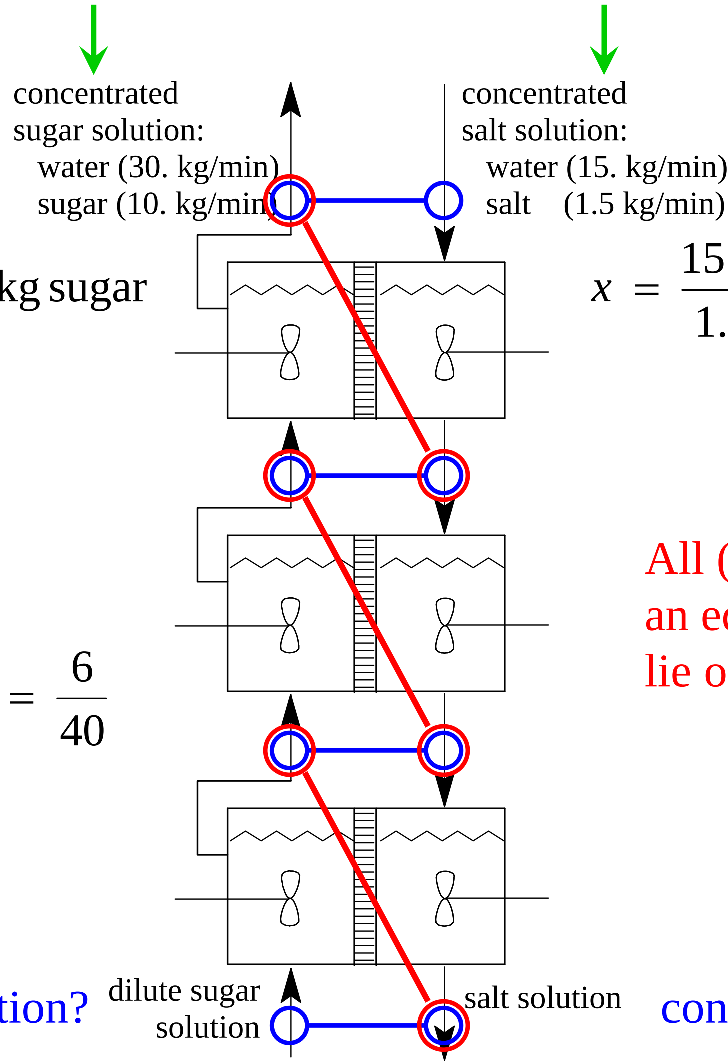
Stream 3: $$\frac{F_{\text{water},3}}{F_{\text{salt},3}} = \frac{8\ \text{kg water}}{\text{kg salt}}$$

$$F_{\text{water},3} = \frac{8\ \text{kg water}}{\text{kg salt}} \times \frac{3\ \text{kg salt}}{\text{min}} = 24\ \text{kg water/min}$$

$$F_{\text{total},3} = F_{\text{salt},3} + F_{\text{water},3} = 27\ \text{kg/min}$$

Exercise 4.52, continued. *Solution is posted.*

sugar steams: *y* coordinates   salt steams: *x* coordinates



$$y = \frac{30 \text{ kg water}}{10 \text{ kg sugar}} = 3 \text{ kg water/kg sugar}$$

$$x = \frac{15 \text{ kg water}}{1.5 \text{ kg salt}} = 10 \text{ kg water/kg salt}$$

An (x, y) pair on the operating line is (10,3)

operating line slope:

$$\frac{F_{salt}}{F_{sugar}} = \frac{1.5 \text{ kg salt/min}}{10 \text{ kg sugar/min}} = \frac{3}{20} = \frac{6}{40}$$

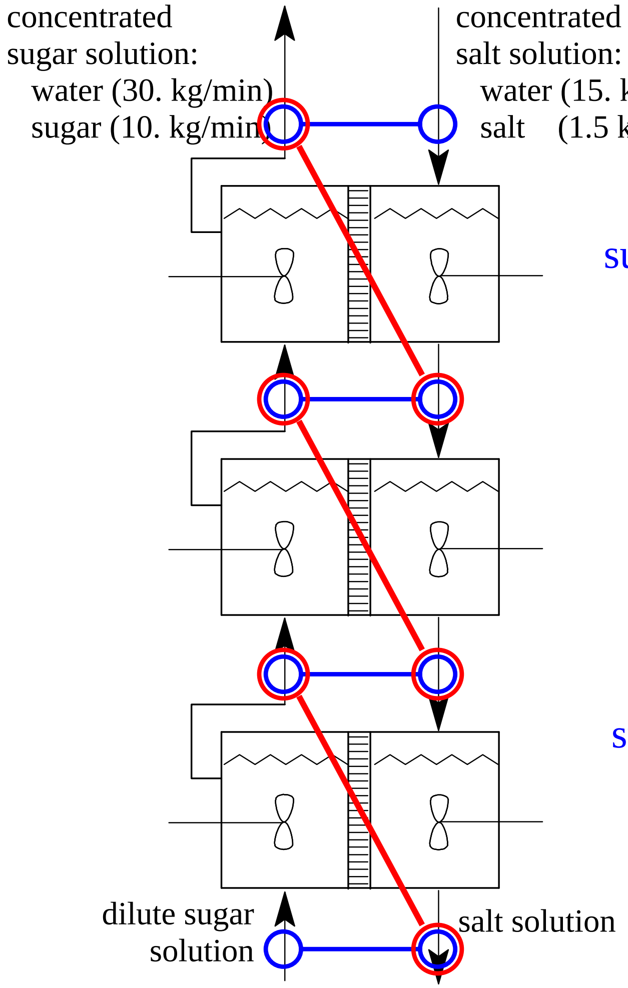
$$\frac{\text{rise}}{\text{run}} = \frac{6}{40} = \frac{9-3}{50-10}$$

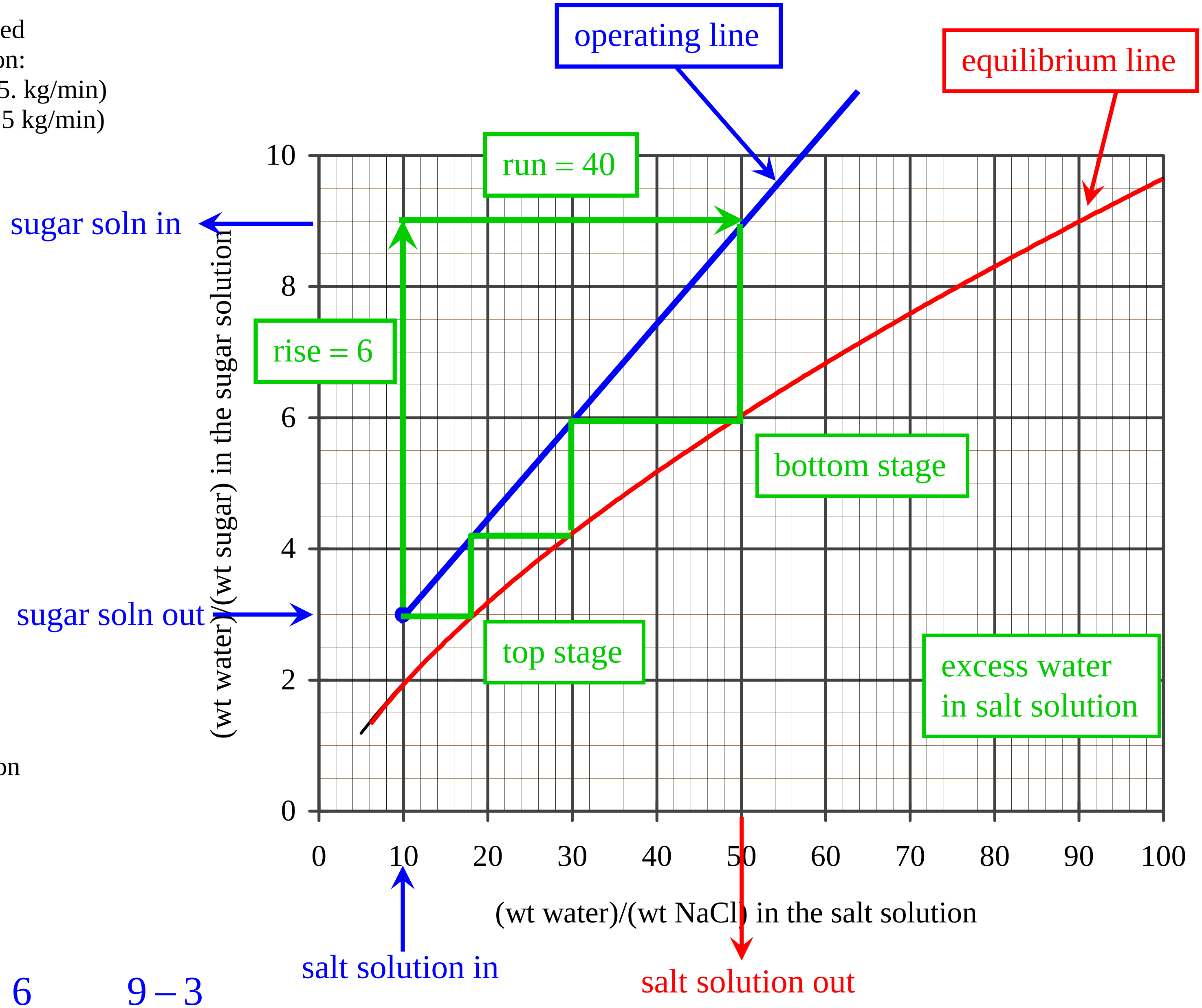
All (x,y) pairs leaving an equilibrium stage lie on the equilibrium line.

concentration?   concentration?

All adjacent (x, y) pairs lie on the operating line: slope = F_{salt}/F_{sugar}.

Exercise 4.52, continued. *Solution is posted.*



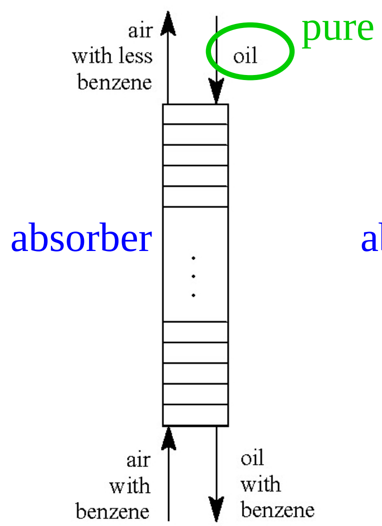


An (x, y) pair on the operating line is (10,3)

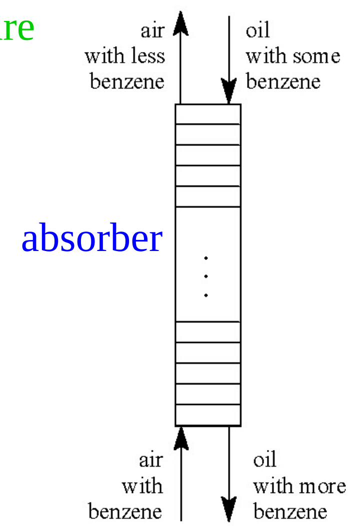
operating line slope: $\dfrac{\text{rise}}{\text{run}} = \dfrac{6}{40} = \dfrac{9-3}{50-10}$

Exercise 4.49 *Solution is posted.*

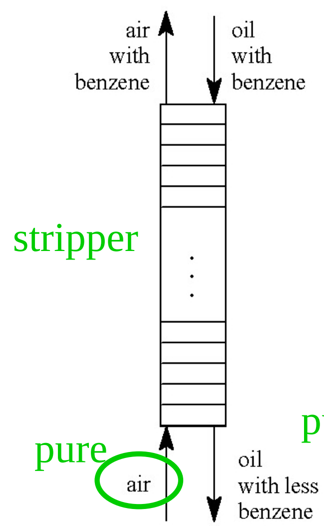
4.49 Match the absorbers and strippers below with the graphical models on the other sheet.



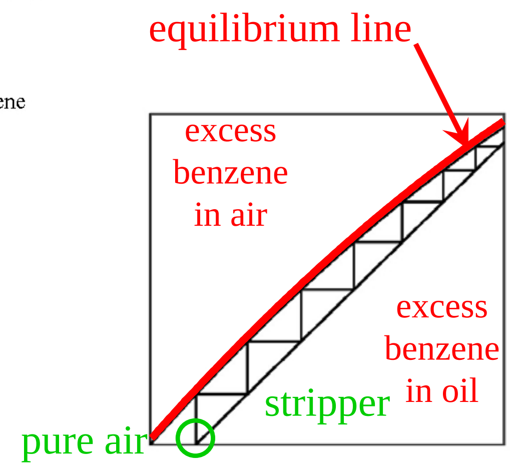
Graphical Model **B**



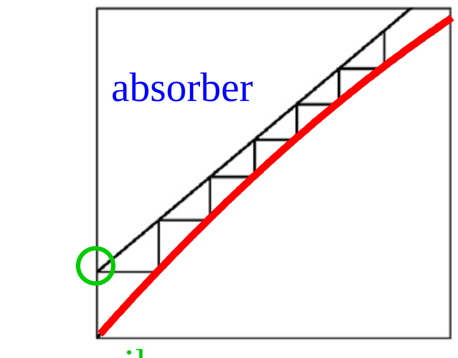
Graphical Model **C**



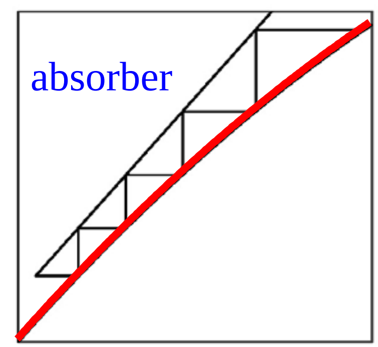
Graphical Model **A**



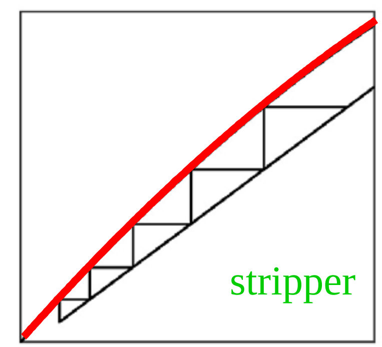
Graphical Model A



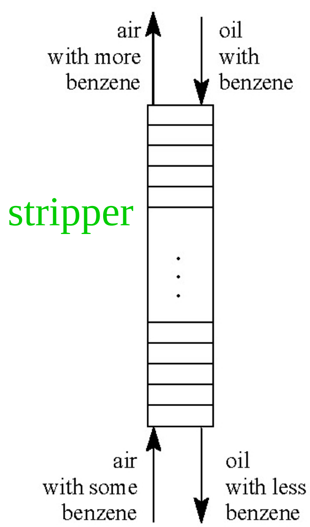
Graphical Model B



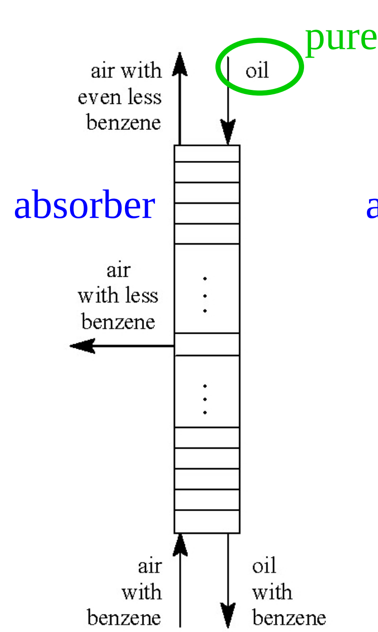
Graphical Model C



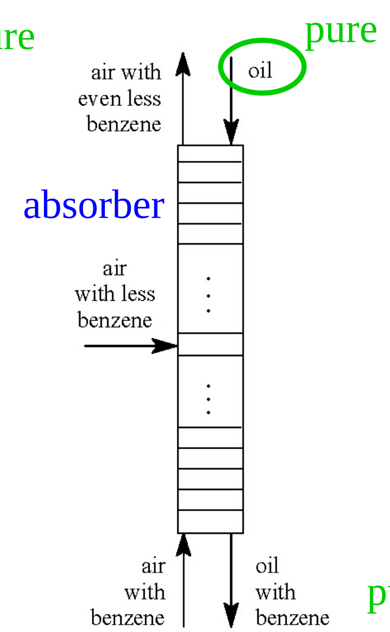
Graphical Model D



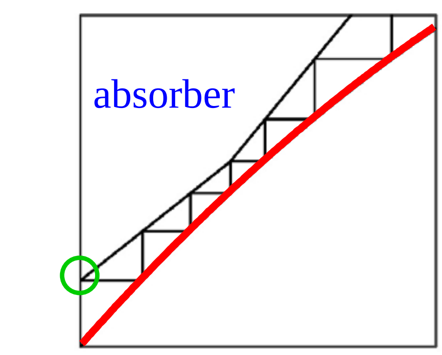
Graphical Model **D**



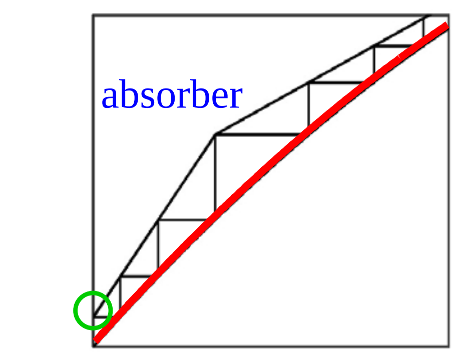
Graphical Model ___



Graphical Model ___

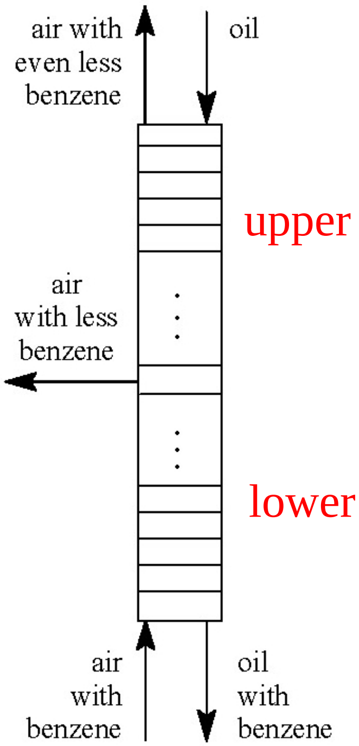


Graphical Model E

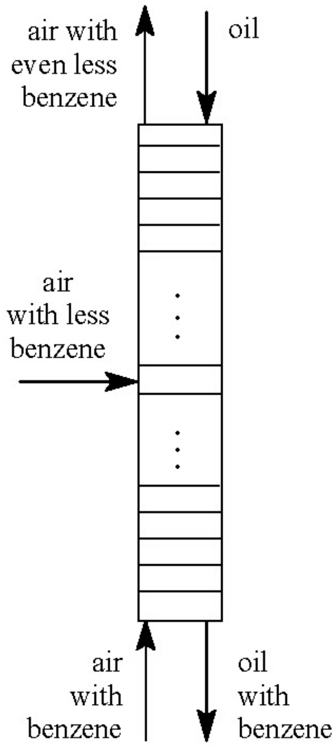


Graphical Model F

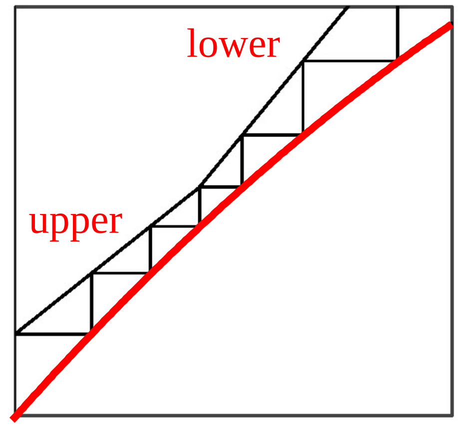
Exercise 4.49, continued.



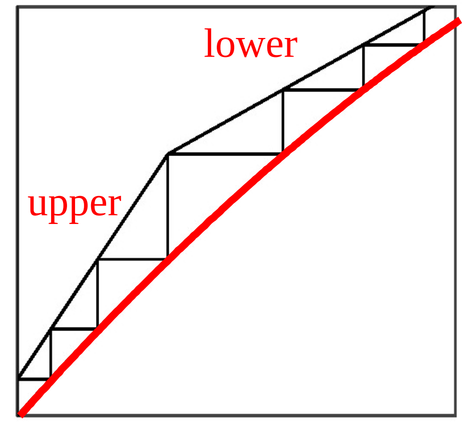
Graphical Model F



Graphical Model E



Graphical Model E



Graphical Model F

$$\left(\frac{F_{\text{oil}}}{F_{\text{air}}}\right)_{\text{upper}} < \left(\frac{F_{\text{oil}}}{F_{\text{air}}}\right)_{\text{lower}} \qquad \left(\frac{F_{\text{oil}}}{F_{\text{air}}}\right)_{\text{upper}} > \left(\frac{F_{\text{oil}}}{F_{\text{air}}}\right)_{\text{lower}}$$

$$F_{\text{oil, upper}} = F_{\text{oil, lower}}$$

$$F_{\text{air, upper}} < F_{\text{air, lower}}$$

$$\left(\frac{F_{\text{oil}}}{F_{\text{air}}}\right)_{\text{upper}} > \left(\frac{F_{\text{oil}}}{F_{\text{air}}}\right)_{\text{lower}}$$