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VCE Chemistry ½
Principles of Chromatography [1.10]
Workbook

Outline:

Learning Objectives:

- ☐ **CH12 [1.10.1]** - Identify which substances would dissolve one another based on miscibility and polarity
- ☐ **CH12 [1.10.2]** - Apply the concepts of adsorption and desorption to stationary and mobile phases
- ☐ **CH12 [1.10.3]** - Apply chromatography principles to Thin Layer Chromatography (TLC)
- ☐ **CH12 [1.10.4]** - Calculate Retardation factor (R_f) values for components on a TLC plate

Section A: Miscibility

Sub-Section: Miscibility Principles

Active Recall: What is a solvent?

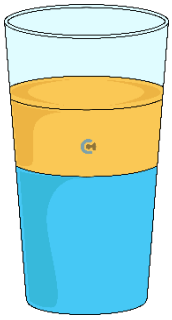
liquid

Context

- So far, we've been looking at solid solutes dissolving in liquid solvents.
- However, solubility can be extended to whether solvent will dissolve in other solvents.

Exploration: Introduction to Miscibility

- If we think about cooking:
  - Is any alcoholic drink (such as wine) made of 100% alcohol? [Yes] / [No] 12%
  - What is the other major liquid that alcohol mixes with?
- What happens if we pour oil into a beaker of water?
  - They [mix evenly] / [form separate layers].
  - Here's a picture of water mixing with oil:



- As such, water is said to be miscible with ethanol but immiscible with oil.

Miscibility

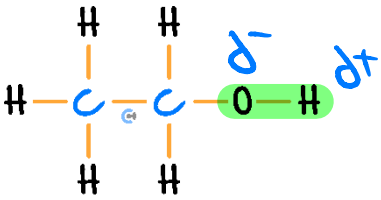
- **Definition:**
  - Two liquids are considered to be miscible if they can mix together to form one **homogeneous/uniform** solution.

NOTE: The terms soluble and miscible essentially mean the same thing - however, soluble refers to a solid being able to dissolve in a liquid whereas miscible means a liquid being able to dissolve in another liquid.

How do we know whether two liquids will be miscible or immiscible?

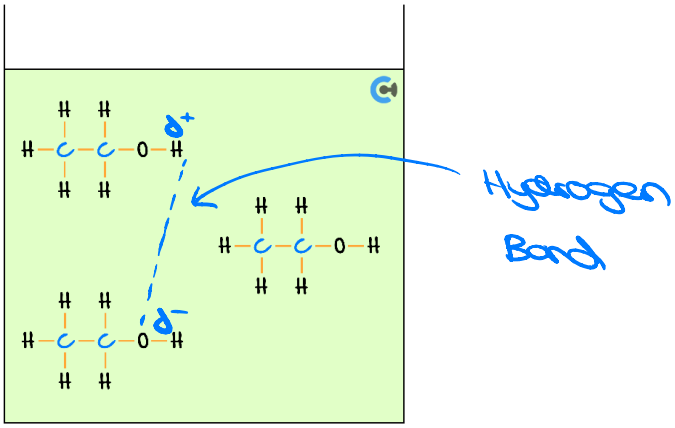
Exploration: Polar Miscibility

- Let's consider an ethanol molecule:

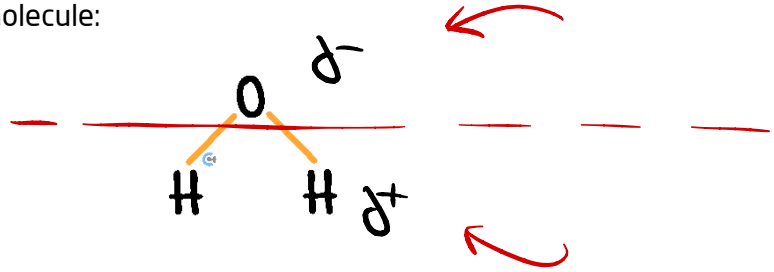


  - Is ethanol [polar] / [non-polar]?

- If we consider a beaker of liquid ethanol ($C_2H_5OH(l)$):
  - What is the strongest type of intermolecular bonding it can undergo with itself? *(Label Below)*



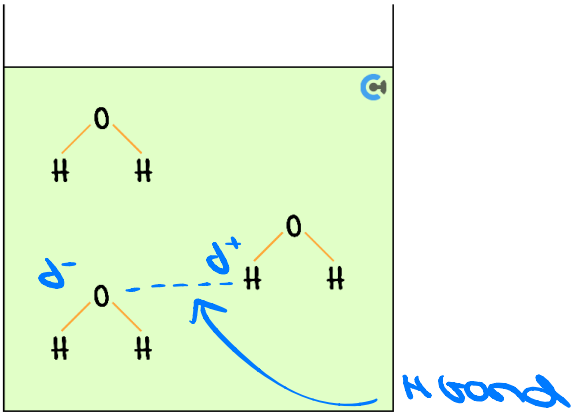
- Let's now consider a water molecule:



  - Is water [polar] / [non-polar]?

- If we consider of beaker of water:

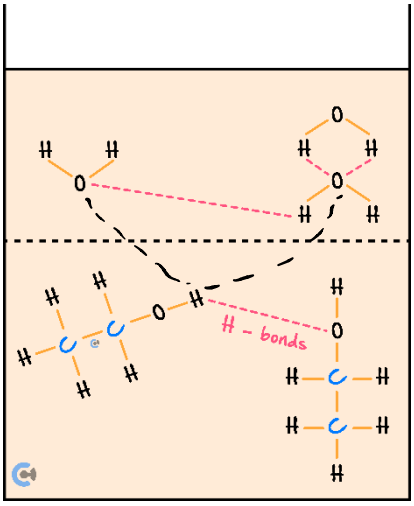
  - What is the strongest type of intermolecular bonding it can undergo with itself? *(Label Below)*



- We see that **both** water and ethanol form hydrogen bonds with itself.

- If we mix the two liquids together:

  - What type of bonds will they form with each other? *(Label Below)*

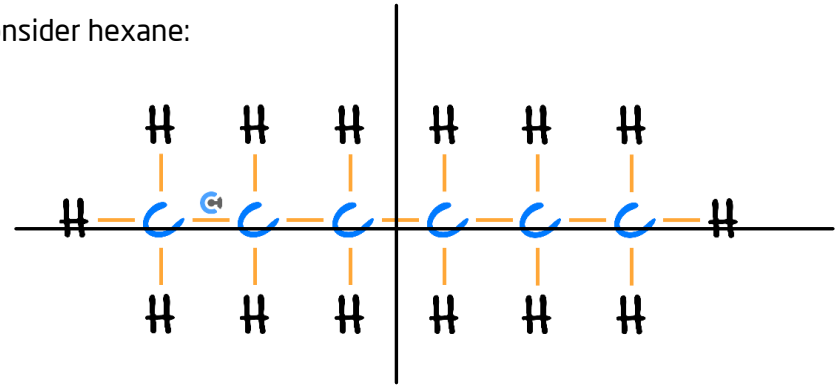


  - Water and ethanol are miscible

Let's look at a similar scenario but with another compound instead!

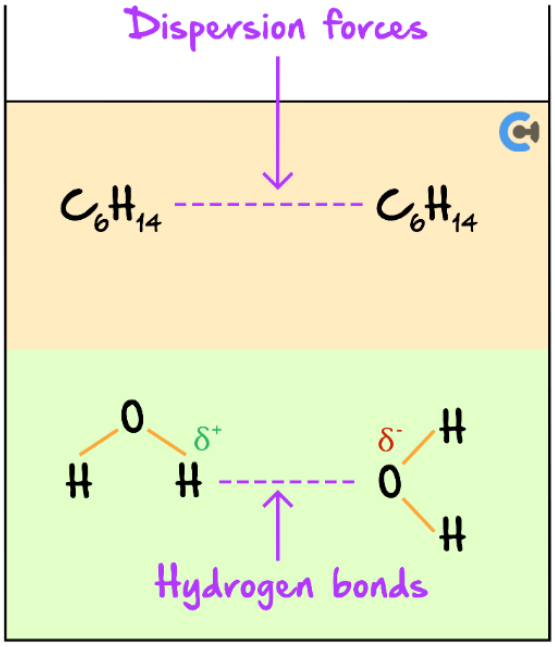
Exploration: Immiscibility

- However, if we consider hexane:



  - Is hexane [polar] / [non-polar]?
  - Strongest intermolecular bonding: dispersion forces

- When hexane and water are mixed together:

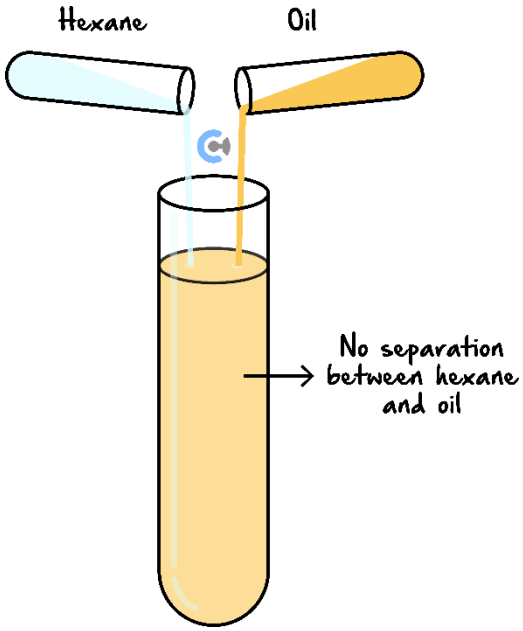


  - Water and hexane's intermolecular bonds are [same] / [different].
  - Water and hexane will form [one] / [two] layers.
  - Water and hexane are [miscible] / [immiscible].

What about two non-polar molecules?

Exploration: Non-polar Miscibility

- If we consider hexane (C_6H_{14}) and oil:

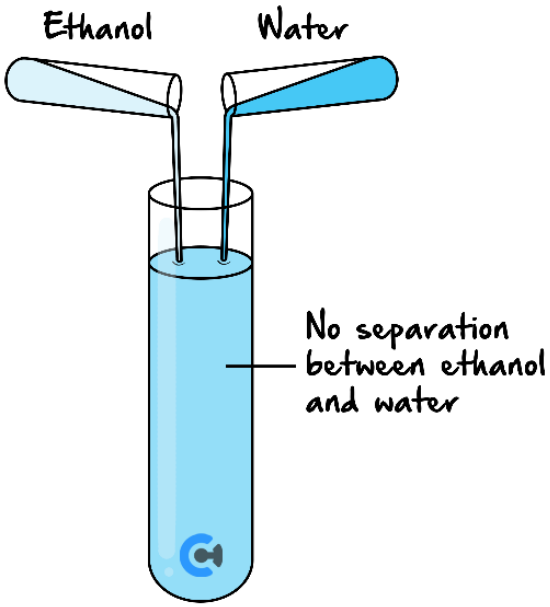


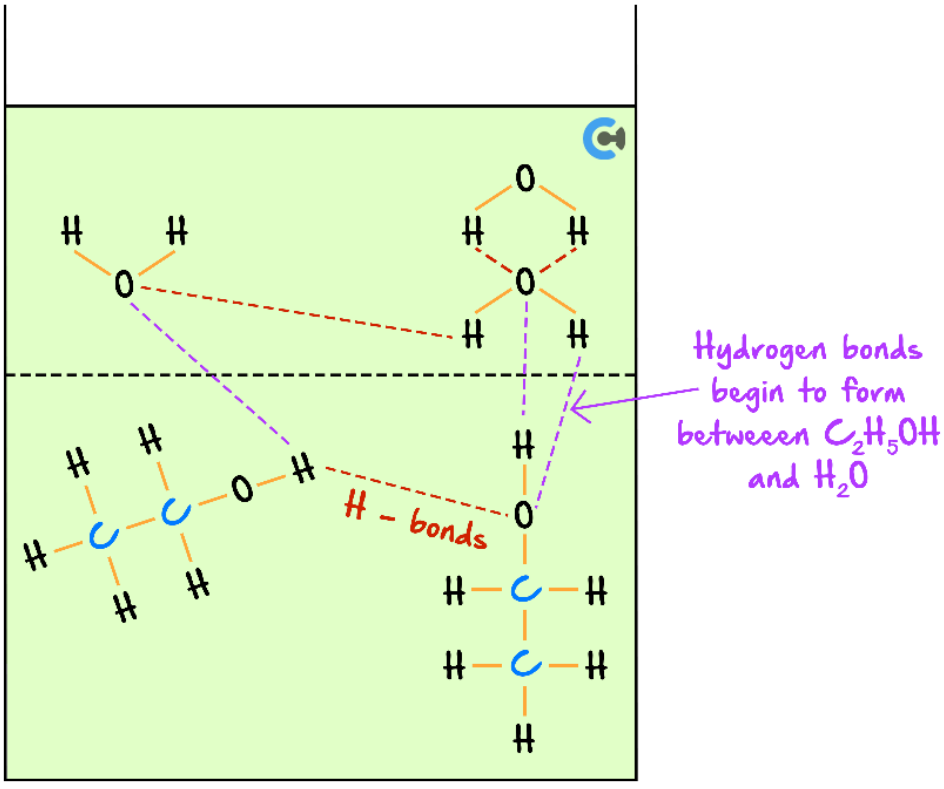
- They are both **non-polar** and thus undergo dispersion forces with themselves.
- Hexane and oil will form [one] / [two] layers.
- Water and hexane are [miscible] / [immiscible].

Space for Personal Notes

Miscibility vs Immiscibility

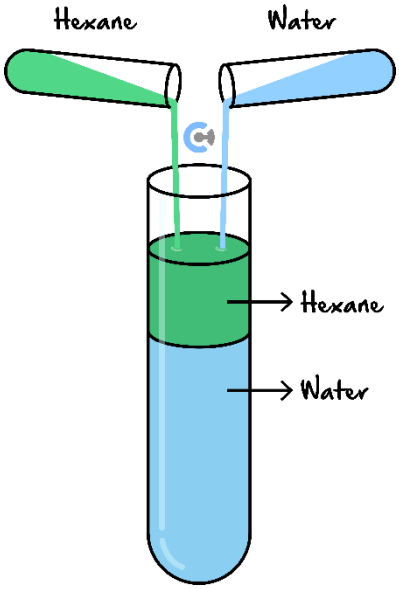
- Polar and polar will dissolve as they are able to form **dipole-dipole/hydrogen bonds** with one another, allowing them to form one homogenous layer.





- Non-polar and non-polar molecules **will dissolve**.
- They **both undergo dispersion forces** with each other.

- Polar and non-polar molecules **will not dissolve.**



- One undergoes **dispersion forces only.**
- The other undergoes **stronger dipole-dipole/hydrogen bonding** with itself.

TIP: Just remember: **Like dissolves with like**.

Let's look at a question together!

Question 1 (3 marks) **Walkthrough.**

Explain whether nitrogen gas (N_2) is soluble or insoluble in water.

- N_2 is non-polar ∴ only has dispersion forces
- H_2O is polar ∴ has hydrogen bonds.
- Thus immiscible → no common bonding.

: N≡N :

Sample Response: Miscibility

- Compound X is polar/non-polar and can therefore exhibit: *insert type of intermolecular bonding*

- Compound Y is also polar/non-polar and can exhibit: *insert type of intermolecular bonding*

- As they undergo the same type of intermolecular bonding, they will mix to form one homogenous layer.

- Therefore, they are miscible.

Recall!

Active Recall: What is the main rule to remember for miscibility?

like dissolves like

Space for Personal Notes

Your Turn!

Question 2

Classify whether the following will be miscible or immiscible **in water**.

a. Ethane (C_2H_6)

[miscible] / [immiscible]

b. Ammonia (NH_3)

[miscible] / [immiscible]

c. CCl_4

[miscible] / [immiscible]

d. Methanol (CH_3OH)

[miscible] / [immiscible]

Question 3

Classify whether the following will be miscible or immiscible in **hexane** (C_6H_{14}).

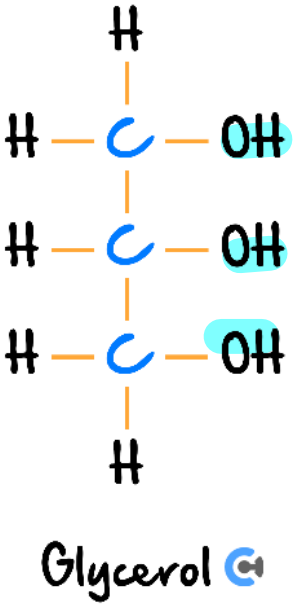
a. Tetrachloromethane (CCl_4)

[miscible] / [immiscible]

b. Ethanol (C_2H_5OH)

[miscible] / [immiscible]

c. Glycerol ($C_3H_5(OH)_3$)



[miscible] / [immiscible]

Question 4 Additonal Question.

Predict the miscibility of carbon dioxide (CO_2) in water. Justify your answer.

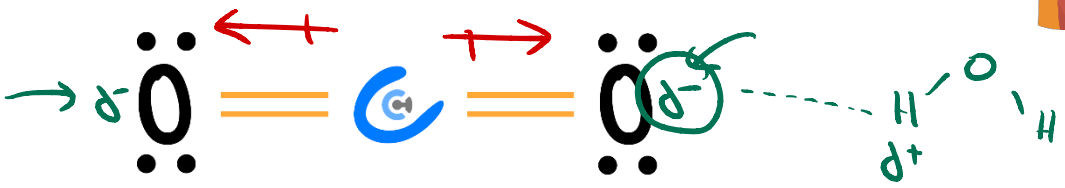
Miscible while carbon dioxide is non-polar overall, but it contain polar bonds. Water can actually form dipole-diople polar bonds with the polar regions of the carbon dioxide.

Space for Personal Notes

Sub-Section: Miscibility Exceptions

Discussion: How do soft drinks get fizzy?

Exploration: CO_2 in Water



- Carbon dioxide is non-polar and water is polar so they in theory should be immiscible
  - However, while carbon dioxide is non-polar overall, does it contain polar bonds?
  - Water can actually form dipole-dipole bonds with the **polar regions** of the carbon dioxide.
  - Water and CO_2 are actually **miscible.**

NOTE: These exceptions are rarely covered in VCE so don't worry about them too much!

Extension: Soft Drinks

- Soft drinks are fizzy due to the **carbonic acid** in the carbonated drinks (H_2CO_3) which can readily form from dissolved carbon dioxide $CO_2(aq)$.
- When there is a **pressure change** (such as opening the can/bottle) or if it is shaken, the dissolved $CO_2(aq)$ can undissolve, turning back into $CO_2(g)$ which is released as bubbles.

Space for Personal Notes

Recall!

Active Recall: How do ionic compounds dissolve in water?

Dissociation / ionisation

Try some more questions!

Question 5

Methanol (CH_3OH) and hydrogen chloride (HCl) are both placed in water by Dan.

Are the following statements true for methanol only, hydrogen chloride only, both, or neither?

a. The compound dissolves in water.

[Methanol only] / [Hydrogen chloride only] / [Both] / [Neither]

b. Ion-dipole forces of attraction exist in the solution of the dissolved compound.

[Methanol only] / [Hydrogen chloride only] / [Both] / [Neither]

c. The only forces of attraction between the particles of the compound and water in solution are dispersion forces.

[Methanol only] / [Hydrogen chloride only] / [Both] / [Neither]

d. Hydrogen bonds are formed when the compound dissolves in water.

[Methanol only] / [Hydrogen chloride only] / [Both] / [Neither]

e. Atoms within the molecules are separated from each other during the dissolving process.

[Methanol only] / [Hydrogen chloride only] / [Both] / [Neither]

Space for Personal Notes

Question 6

Methanol (CH_3OH) like ethanol, will dissolve in water without ionising.

Write a chemical equation to represent the dissolution process for the compound in water.

$CH_3OH(l) \xrightarrow{H_2O(l)} CH_3OH(aq)$

Question 7 Additional Question.

Nitric acid (HNO_3), like HCl, will ionise when it dissolves in water.

Write a chemical equation to represent the dissolution process for the compound in water.

$$HNO_{3(aq)} \rightarrow H^+_{(aq)} + NO_3^-{}_{(aq)}$$

Space for Personal Notes

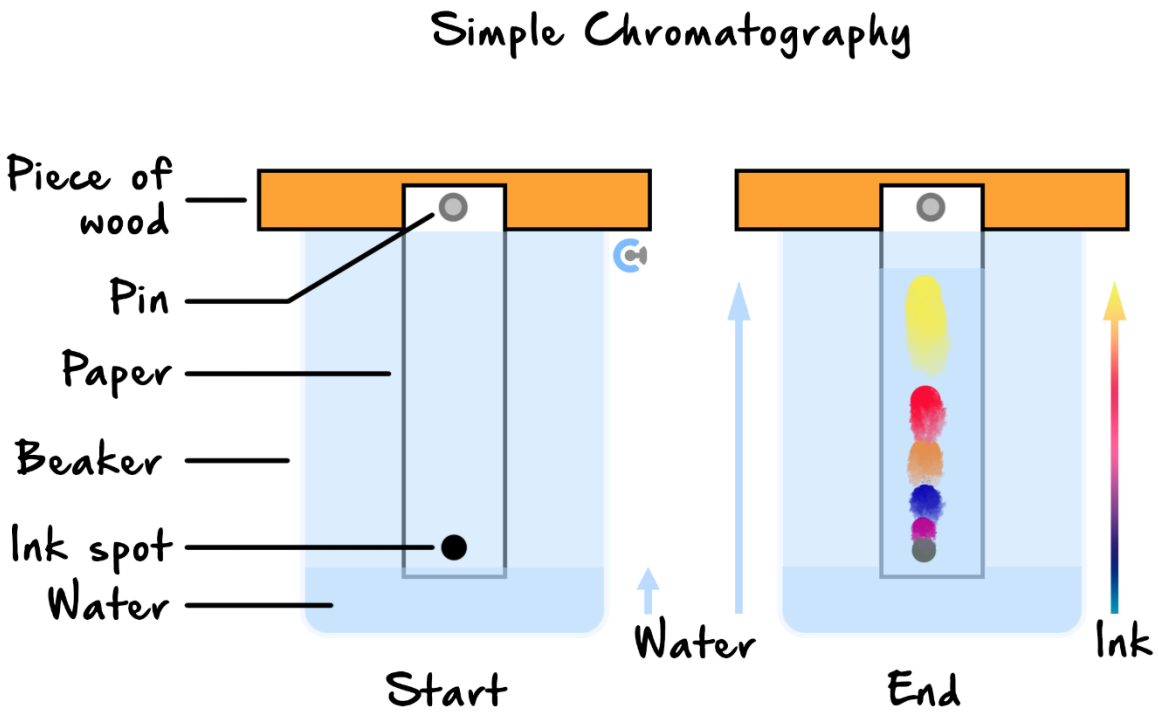
Section B: Chromatography Principles

Sub-Section: Stationary Phase and Mobile Phase

Let's have a look at chromatography now!

Context

- Chromatography is used to separate mixtures of substances into their components.



- Watch the first video here:
  - https://www.youtube.com/playlist?list=PLnm-faSGdwIyj4GKMSJA4SWyyIWk-r4g-
  - Skip to $0:25$ and watch at $2x$ speed.
- All forms of chromatography work on the same principle.
  - They all have a stationary phase and a mobile phase.

Misconception

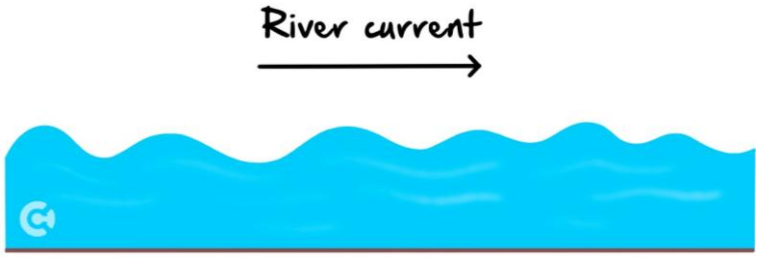
"Phase means 'period of time', and thus the stationary and mobile phase are two time periods which occur separately."

TRUTH:

- The stationary phase (SP) and mobile phase (MP) **do not refer to time periods.**
- 'Phase', in this case, actually refers to the different physical components of chromatography.
- There is a physical component which is stationary (SP), and a component which moves (MP).

Exploration: Principles of Chromatography

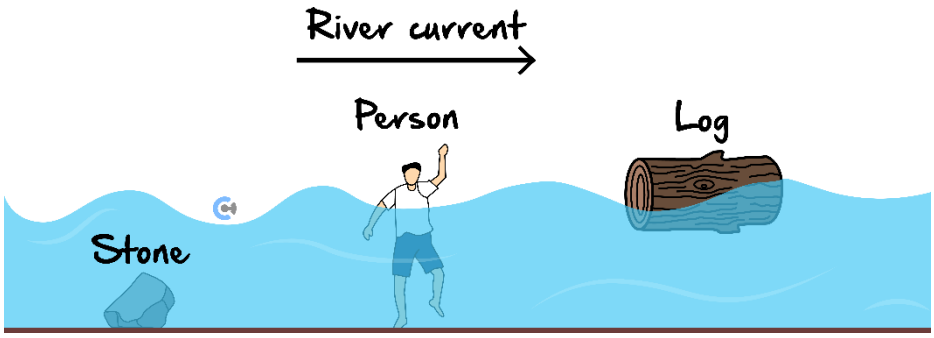
- We can think of chromatography as a river:



Mobile Phase (component which moves)	Stationary Phase (component which stays still)
water	river bed

- The mobile phase flows through the stationary phase.
- It can carry components along it!

- Consider that the river has a person, a stone and a log:



Travels Slowest & Shortest Distance	Travels Fastest & Farthest Distance
Object: stone	Object: log
Has [greater]/[weaker] attraction with the stationary phase.	Has [greater]/[weaker] attraction with the stationary phase.

- As substances travel at different rates, the mixture will be separated!

Mobile Phase & Stationary Phase

Stationary Phase	Mobile Phase
Component which [stays still] / [moves].	Component which [stays still] / [moves].
More attracted to this phase → substance travels a [shorter] / [longer] distance.	More attracted to this phase → substance travels a [shorter] / [longer] distance.

Space for Personal Notes

Recall!

Active Recall: What are the two phases in every chromatography setup?

stationary

mobile

Your Turn!

Question 8 (2 marks)

Jason is investigating two substances, object P and object Q which have different strengths of attraction to the different phases of a chromatogram.

a. If object P is more attracted to the mobile phase, state whether it has a quicker or slower rate of travel. (1 mark)

fast

b. If object Q is more attracted to the stationary phase, state whether it has a quicker or slower rate of travel. (1 mark)

slow

Space for Personal Notes

Sub-Section: Adsorption and Desorption

How are the chemicals physically attached to the phases?

Adsorption or Adsorb

- **Definition:**
  - The process whereby a liquid/gas/solute is attached or stuck onto a solid material (the stationary phase).
  - **Alternate definition:** Adsorption can be thought of as substances sticking on to a solid surface.

Desorption or Desorb

- **Definition:**
  - The release of an adsorbed substance from a solid surface.
  - **Alternate definition:** This can be thought of as the **opposite of adsorption**.

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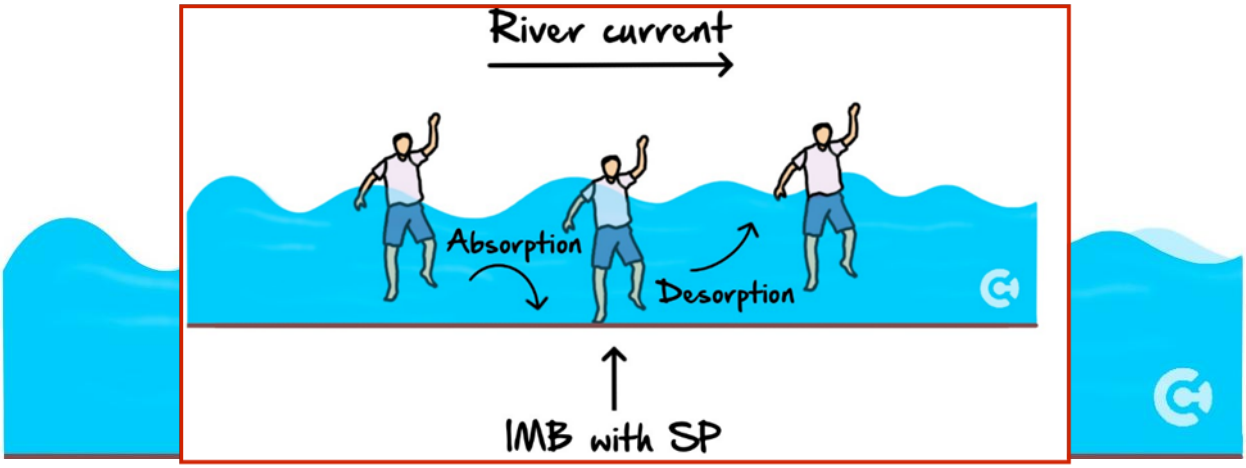
Exploration: Adsorption vs Desorption

- Think about a person trying to **resist** the flow of the current.
- What process takes place when they try to stand on the river bed? *(Label Below)*
- What process takes place when the water carries them forward? *(Label Below)*

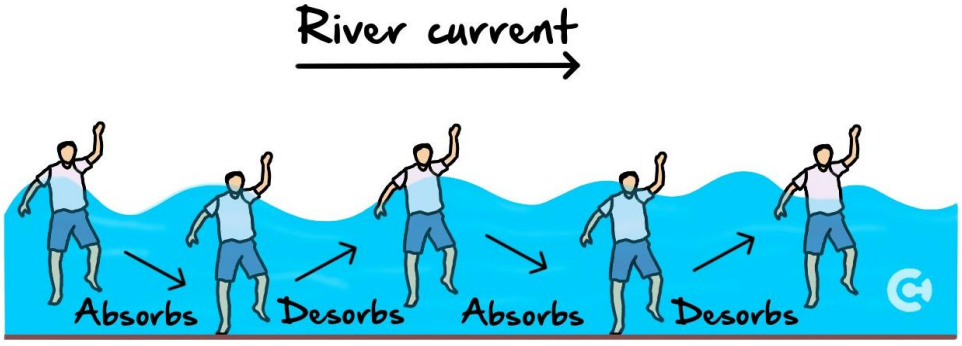


- We see that the substance adsorbs/desorbs to the following phases:

Adsorbs	Desorbs
[Stationary] / [Mobile] phase.	[Stationary] / [Mobile] phase.

Adsorption & Desorption

- Substances always adsorb to the stationary phase and desorb back into the mobile phase.
- Particles keep undergoing this cycle!



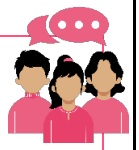
Recall!

Active Recall: What phase do substances stick onto, and what is that process called?

stationary → adsorption

Active Recall: What phase do substances release into, and what is that process called?

mobile → desorption



Discussion: What affects the strength of adsorption and desorption?

POLARITY

Recall!

Active Recall: What is the rule for miscibility?

like - dissolves - like

Space for Personal Notes

Try some questions!

Question 9

State whether each of the following is polar (P) or non-polar (N):

a. Nitrogen gas (N_2)

NP

b. Methane (CH_4)

NP

c. Hydrochloric acid (HCl)

P

d. Water (H_2O)

P

Question 10 Additional Question.

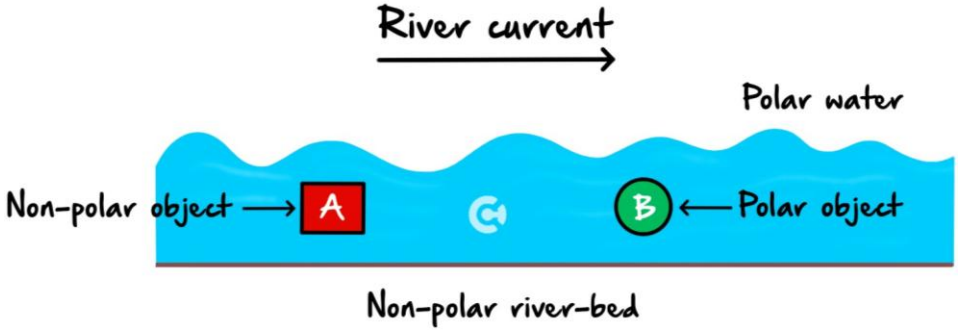
State a suitable solvent for hexane to be miscible with.

Any non-polar solvent such as oil.

Let's investigate what factors affect how strongly a substance adsorbs/desorbs!

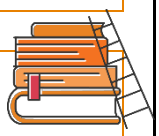
Exploration: Strength of Adsorption and Desorption

- If we consider a polar mobile phase (water) and a non-polar stationary phase (river-bed):



- If there are two objects, object A which is non-polar and object B which is polar, how will they be attracted to the different phases?

Object A (Non-Polar)	Object B (Polar)
Attracted to [polar] / [non-polar] [stationary] / [mobile] phase.	Attracted to [polar]/[non-polar] [stationary] / [mobile] phase.
Will have a [quicker] / [slower] rate of travel.	Will have a [quicker] / [slower] rate of travel.
Will travel a [farther] / [shorter] distance. .	Will travel a [farther] / [shorter] distance.



Extension: Types of Chromatography

- There are two types of chromatography:
  - Normal phase chromatography - The **stationary phase** is polar, and the **mobile phase** is non-polar.
  - Reverse phase chromatography- The **stationary phase** is non-polar, and the **mobile phase** is polar.
- The question will **always tell** which phase is polar and non-polar if that information is needed, so don't bother about memorising what normal and reverse phase is!

NOTE: VCAA never expects you to know which is the normal phase and which is the reverse phase!

ALSO NOTE: Whatever the polarity of the stationary phase, the mobile phase will be the opposite polarity!

Space for Personal Notes

Principle of Separation

- Chromatography separates particles apart based on polarity
- Polar molecules will be attracted to other polar molecules.
- Non-polar molecules will have an affinity for other non-polar substances.

Recall!

Active Recall: Will substances attracted to the stationary phase travel a farther or shorter distance along a chromatogram?

shorter distance

Space for Personal Notes

Let's have a look at a question together!

Question 11 (4 marks) **Walkthrough.**

A particular chromatogram has a polar solvent (MP) and a non-polar stationary phase (SP). Hydrofluoric acid (HF) is passed through the chromatogram.

a. Which phase will the HF be attracted more to? Justify your reasoning. (2 marks)

- HF → very polar
- ∴ HF will be more attracted to the polar mobile phase.

b. Hence or otherwise, explain whether HF is expected to move a short or large distance. (2 marks)

- HF → far distance
- HF is readily absorbed ∴ moves far.

NOTE: Sometimes the word term 'solvent' is used instead of mobile phase, as the mobile phase is usually the solvent!

Space for Personal Notes

Your turn!

Question 12

Consider the following about a chromatogram that uses a polar solvent and a non-polar stationary phase.

Statement I - Polar molecules in the solution will be attracted to the solvent particles by dipole-dipole attraction.

Statement II - Non-polar molecules in the solution will be attracted to the stationary phase by dispersion forces.

Statement III - Polar molecules in the solution will travel through the chromatogram more rapidly than non-polar molecules.

Which of these statements are true?

A. I and II only.

B. I and III only.

C. II and III only.

D. I, II and III.

Question 13

An HPLC column is being used to separate a mixture. It has a polar stationary phase.

The **most suitable solvent** for separating the mixture is:

A. Carbon tetrachloride, CCl_4.

B. Methanol, CH_3OH.

C. Octanol, $C_8H_{17}OH$.

D. Dichloromethane, CH_2Cl_2.

Space for Personal Notes

Question 14 (4 marks)

POLAR

During paper chromatography, water is used as the solvent and a non-polar stationary phase is used. A mixture which consists of fluorine gas, hydrogen chloride and hydrogen fluoride is being separated:

a. State which substance is expected to travel the farthest distance, giving justification for your reasoning. (2 marks)

• HF → most polar
most adsorbed to the polar mobile phase ∴ move furthest.

b. State which substance is expected to travel the shortest distance, giving justification for your reasoning. (2 marks)

• F_2 → non-polar
most adsorbed to the non-polar stationary ∴ least movement

Question 15 Additional Question.

If water is used as the mobile phase for a chromatography setup, state the likely polarity of the stationary phase. Justify your reasoning.

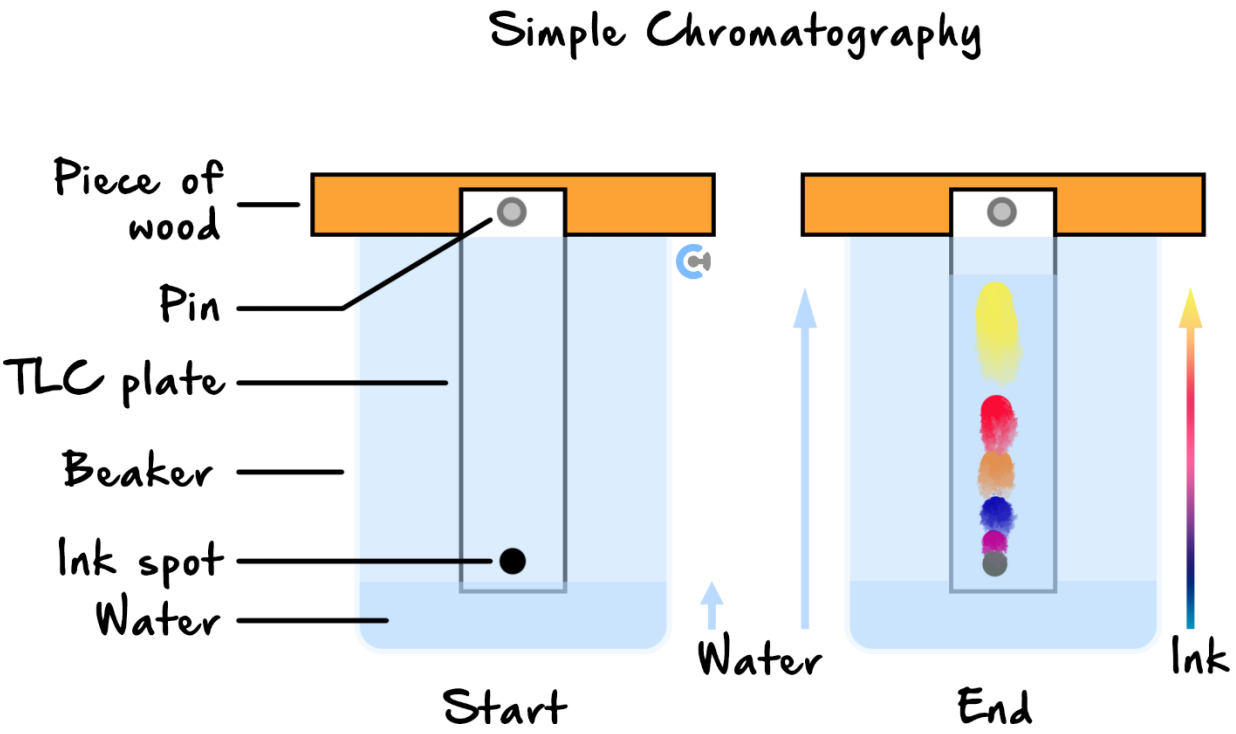
Non-polar → Generate the best separation.

Space for Personal Notes

Section C: Thin Layer Chromatography (TLC)

Sub-Section: Principles of TLC

Context: Paper chromatography works in the same way as TLC



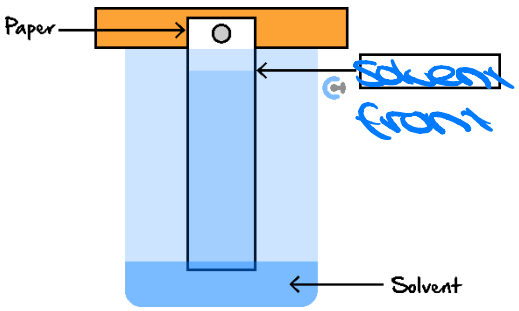
Discussion: How does water climb up the paper against the force of gravity?

Space for Personal Notes

Exploration: Capillary Action

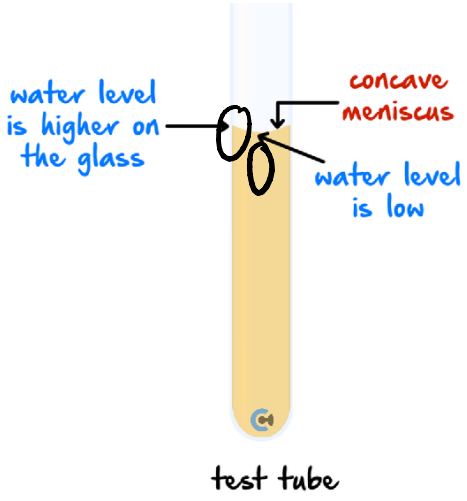
- Consider a test tube filled with water:
  - How does the water level look? *(Label Below)*
  - What is the meniscus? *(Label Below)*
  - What do we notice? *(Label Below)*

  - This is called meniscus.
- A similar thing happens with paper.
  - Paper is made up of a bunch of small holes, and thus, we say it is porous
  - These holes act as capillaries, allowing water to flow into them.
- If we place the paper upright in a container with a shallow level of solvent:
  - As the water needs to fight against gravity, it will **not** rise forever and will stop at a certain point.
  - This point is called the solvent front, which is the highest the water will flow. *(Label Below)*



Capillary Action

- In a test tube, see that water will be higher up on the sides, which is because it is **more strongly attracted** to the glass of the test tube, than to itself.
- That is, the adhesive force is greater than the cohesive force.
  - Adhesive Force - force between unlike molecules; in this case, the force between the water and the glass.
  - Cohesive Force - force between like molecules; in this case, the force between the water molecules themselves.



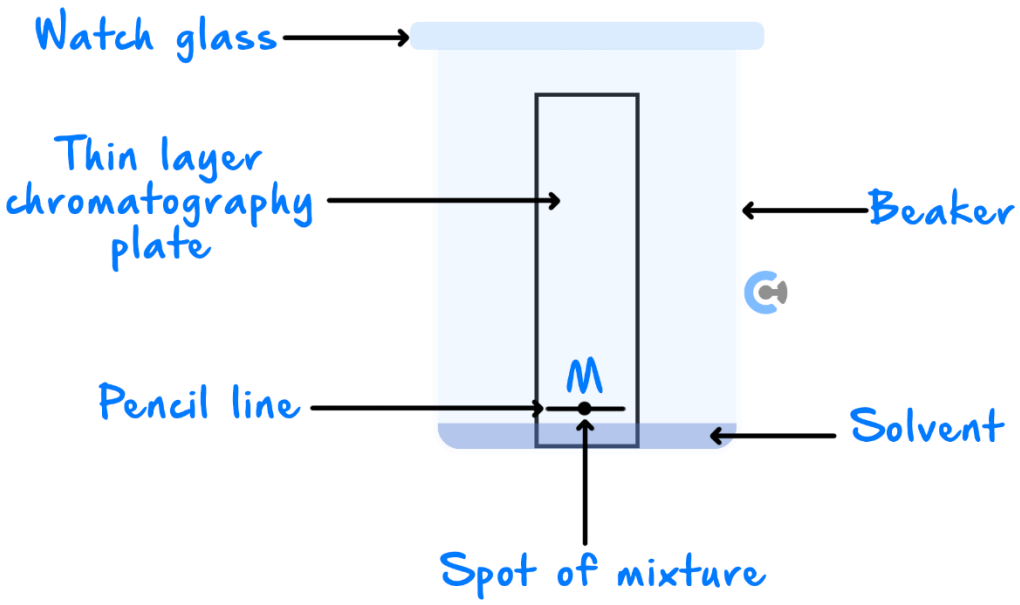
NOTE: How far up the solvent front depends on multiple variables such as the solvent, paper material, adhesiveness of solvent with paper material, temperature, pressure, etc.

ALSO NOTE: You will not be asked about these factors typically.

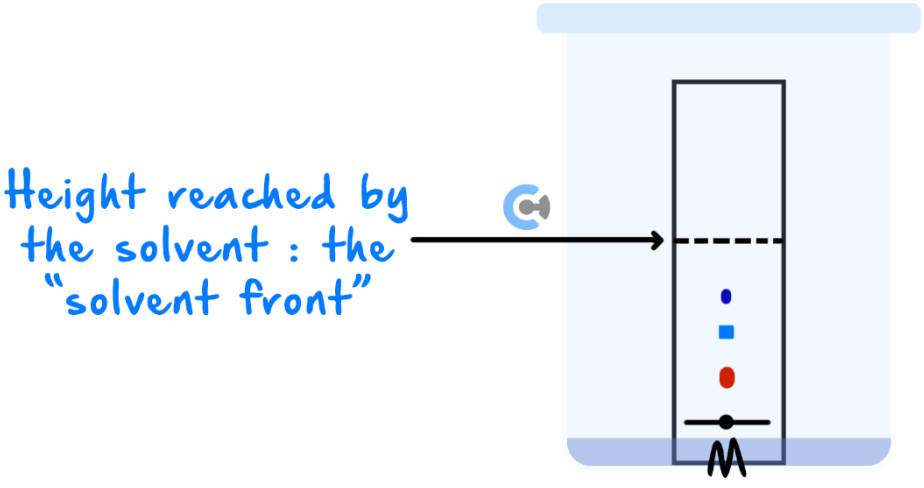
Exploration: Paper/Thin Layer Chromatography Setup

Paper Chromatography	Thin Layer Chromatography (TLC)
Uses paper as the stationary phase.	Uses a thin, uniform layer of silica or alumina coated onto a piece of glass, metal, or rigid plastic as the stationary phase.
The mobile phase is a suitable liquid solvent or mixture of solvents.	

- Let's say we were trying to prove that a particular dye is, in fact, a mixture of simpler dyes.



- A pencil line is drawn near the bottom of the plate, and a drop of the dye is placed onto it.
- The plate is in a shallow layer of solvent in a covered beaker.
  - The solvent must be [below] the level of the line with the spot on it.
- The beaker is covered so that the atmosphere in the beaker is saturated with solvent vapour.

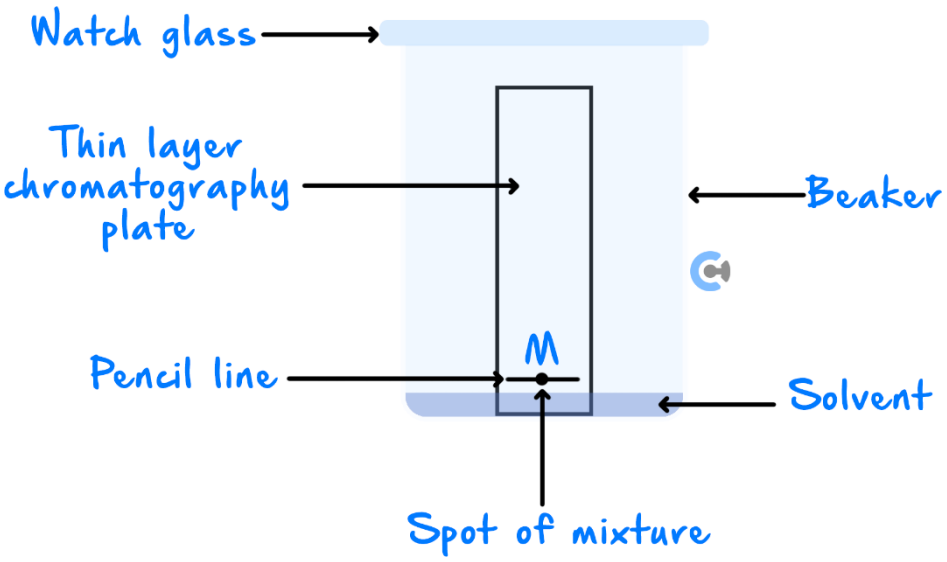


- As the solvent slowly travels up the plate, the different components of the dye mixture travel at [same] / [different] rates and the mixture is [separated] into different coloured spots.

Space for Personal Notes

Thin Layer Chromatography (TLC)

- **Definition:** TLC Stands for thin layer Chromatography, as it involves a glass plate being covered in a thin layer of silica gel or alumina.
  - Silica gel is porous due to its structure.



- A pencil line is drawn near the bottom of the plate, and a drop of the sample is placed onto it.
- Over time, the solvent will rise up, carrying the components of the sample along with it, creating **separation.**

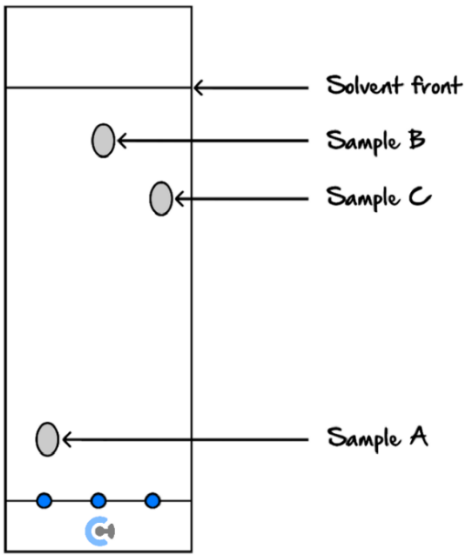
NOTE: You do not need to understand the structure of silica gel.

Space for Personal Notes

Let's look at a question together!

Question 16 Walkthrough.

The thin layer chromatography plate shown below has a polar stationary phase. It was developed using hexane as the solvent.

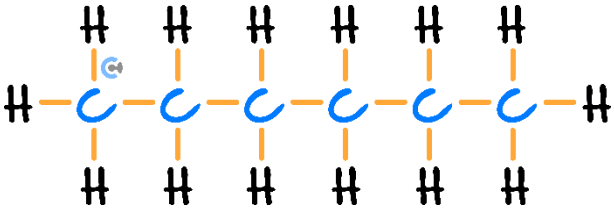


a. Which substance has travelled the shortest distance?

sample A

b.

i. Given the structure of hexane below, state its likely polarity.



non - polar

ii. Hence or otherwise, rank the three substances in terms of increasing polarity.

B, C, A

Recall!

Active Recall: What is the stationary phase used in TLC?

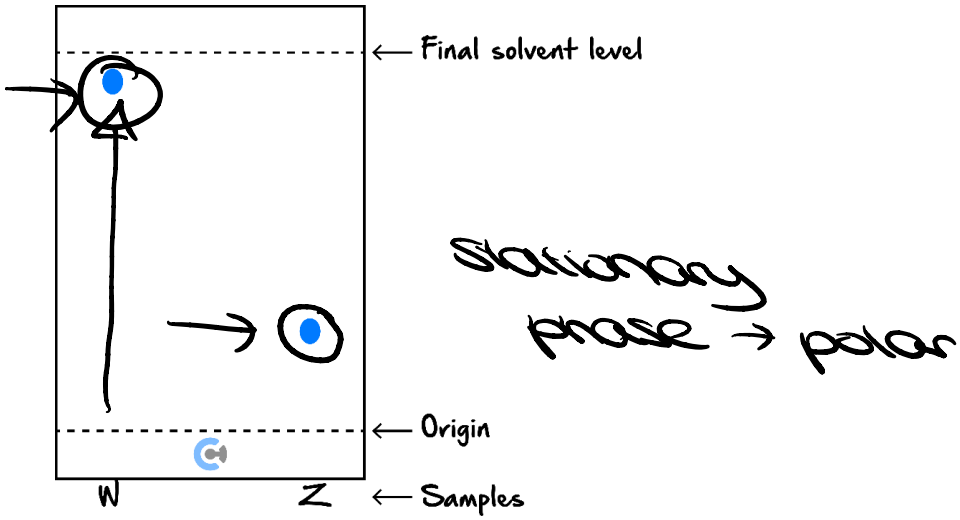
Silica

alumina

Your turn!

Question 17 (1 mark)

Two different food dye samples, W and Z, were compared using thin-layer chromatography, as shown below.



Which of the following is **not** correct?

A. Z is more strongly adsorbed than W.

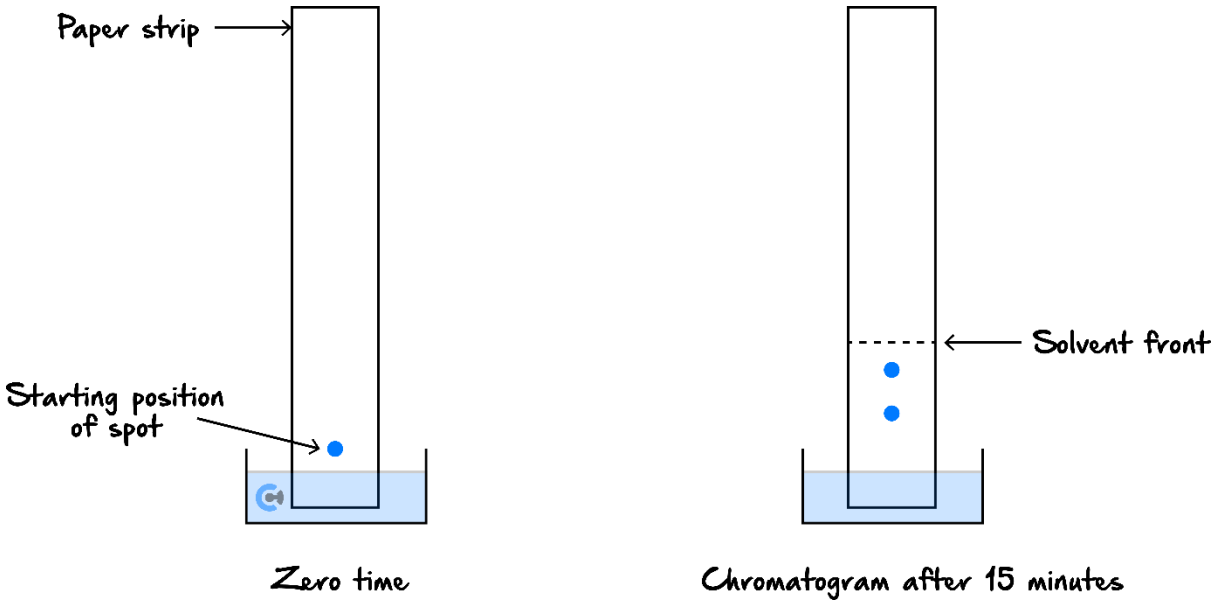
B. Z is more polar than W.

C. W desorbs more readily into the solvent than Z.

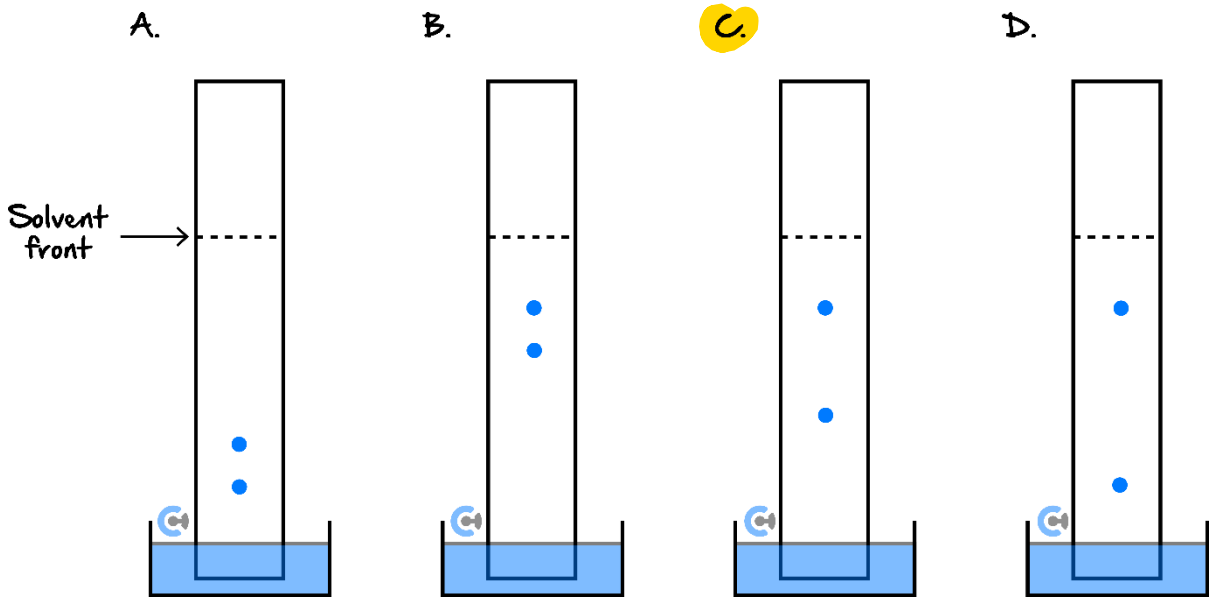
D. W is likely to form more dipole-dipole bonds than molecules of Z.

Question 18 (1 mark) **Additional Question.**

Some students used paper chromatography to separate the pigments in purple ink. They set up a chromatogram, and after 15 minutes the colours had separated as shown in the diagram.



Which one of the following diagrams is most likely to indicate the appearance of the chromatogram after a further 30 minutes?



Space for Personal Notes

Sub-Section: Retardation Factor (R_f) Value

Context

- If we just wanted to know **how many** different types of dyes made up the mixture, we could stop there.
- However, measurements of the plate can also help us **identify** the compounds present.

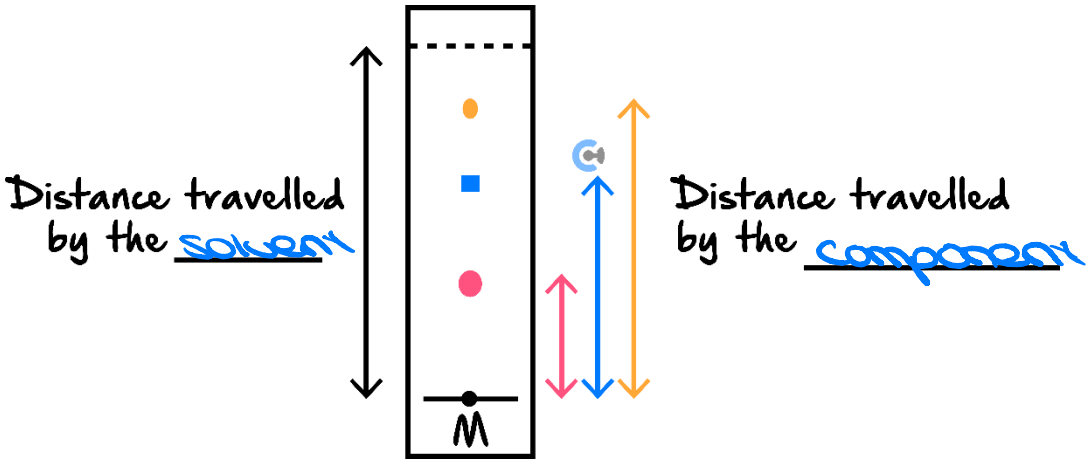
What if we calculate how far each component travels up the TLC plate?

Exploration: Measuring Retardation Factor (R_f) Values

- The Retardation Factor (R_f) value of each dye is then worked out using the following formula:

$$R_f = \frac{\textit{distance travelled by component}}{\textit{distance travelled by solvent}}$$

- What will this look like on a chromatogram? *(Label Below)*



Space for Personal Notes

R_f Value

$$R_f = \frac{distance\ travelled\ by\ component}{distance\ travelled\ by\ solvent}$$

- Substances which are more strongly **adsorbed** to the stationary phase will have a low R_f value.
- Substances which are more strongly **desorbed** to the mobile phase will have a high R_f value.
- As the solvent will always travel the longest distance, the R_f value will always be less than one.

Discussion: What are the units for the R_f value of a component?

N/A.

Recall!

Active Recall: What is the R_f formula?

R_f = distance travelled by component/distance travelled by the solvent.

Space for Personal Notes

Let's have a look at a question together!

Question 19 Walkthrough.

The red component for a particular chromatogram travelled 1.7 cm from the origin, whereas the solvent had travelled 5.0 cm. What is the R_f value for the red dye?

R_f (red dye) $= \frac{1.7}{5} = 0.34$.

REMINDER: Don't forget R_f values are a ratio and, as such, do not have a unit!

Your turn!

Question 20

Calculate the R_f value for a green component which has moved 16 mm from the start line, given that the distance from the start line to the solvent front is 46 mm.

R_f (green) $= 16/46 = 0.35$

Space for Personal Notes

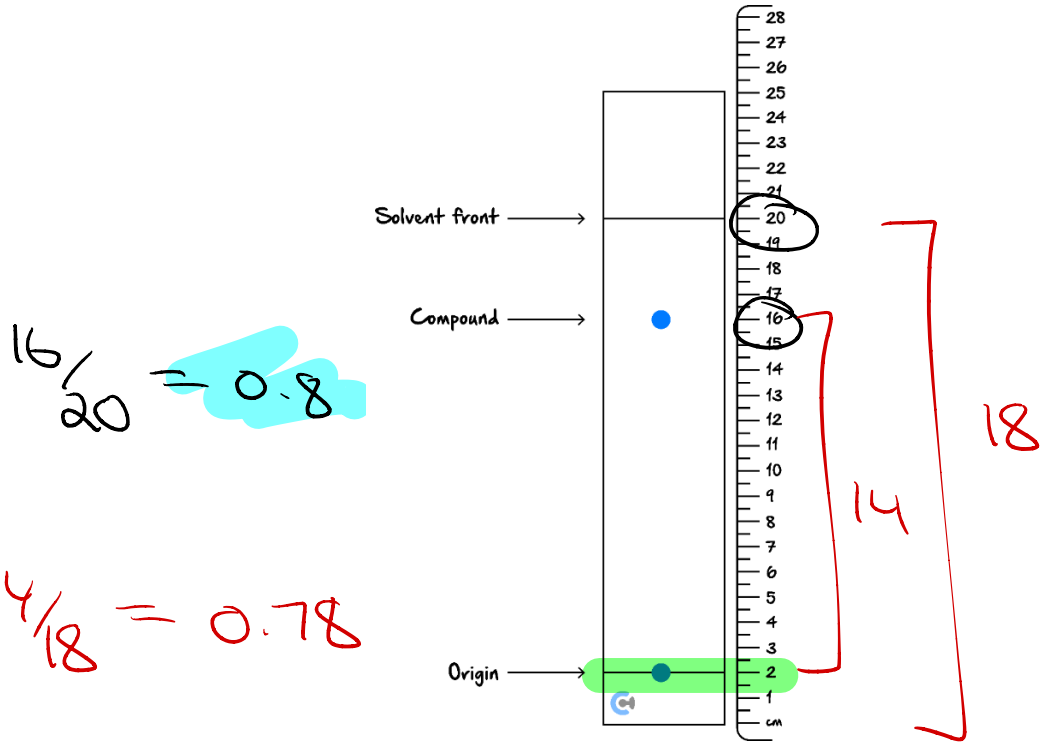
Question 21

Another substance running through a TLC has the solvent front measured to be at 83 cm. Given that the substance has travelled a distance of 38 cm, find the R_f value.

$R_f = 38/83 = 0.46$

Question 22 (1 mark)

A thin layer chromatography (TLC) plate was set up with a non-polar solvent, hexane, and a polar stationary phase, silica gel. The chromatogram below was obtained. A ruler was then placed next to the plate.



The R_f value for the compound would be:

A. 0.80

B. 0.78

C. 0.64

D. 0.61

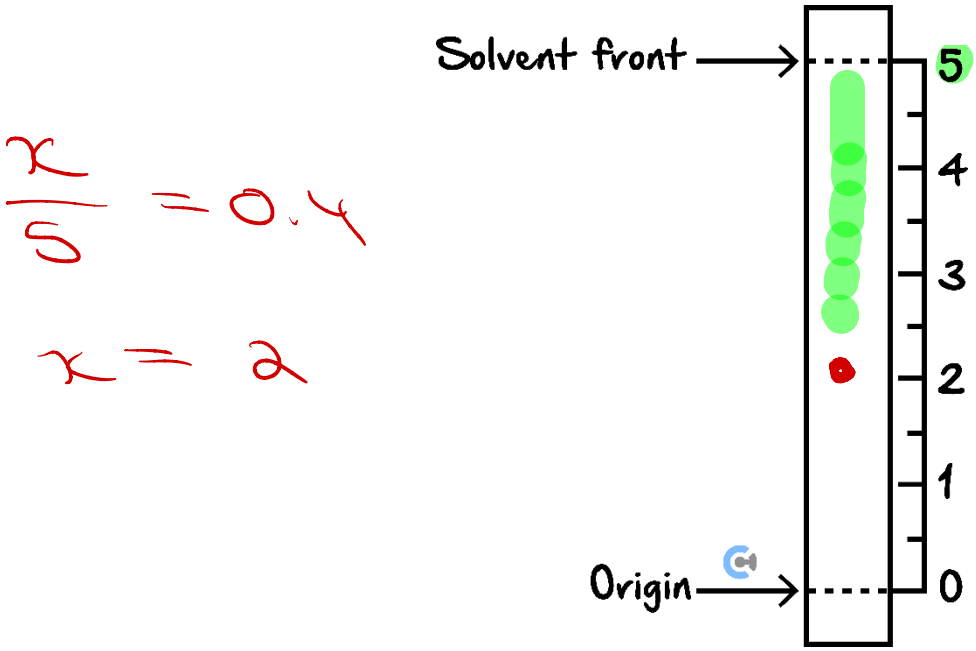
NOTE: Make sure that you measure the distance that each substance has travelled from the origin!

Question 23 (2 marks)

Inspired from VCAA Chemistry Exam 2008
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2008chem1-web.pdf#page=16

A student uses thin-layer chromatography (TLC) to analyse the products of this preparation of paracetamol. For the stationary and mobile phases used for this analysis, the R_f of paracetamol is 0.4.

a. On the diagram of a TLC plate below, use a horizontal line to mark the spot where paracetamol would appear in such an analysis. (1 mark)



$\frac{x}{5} = 0.4$

$x = 2$

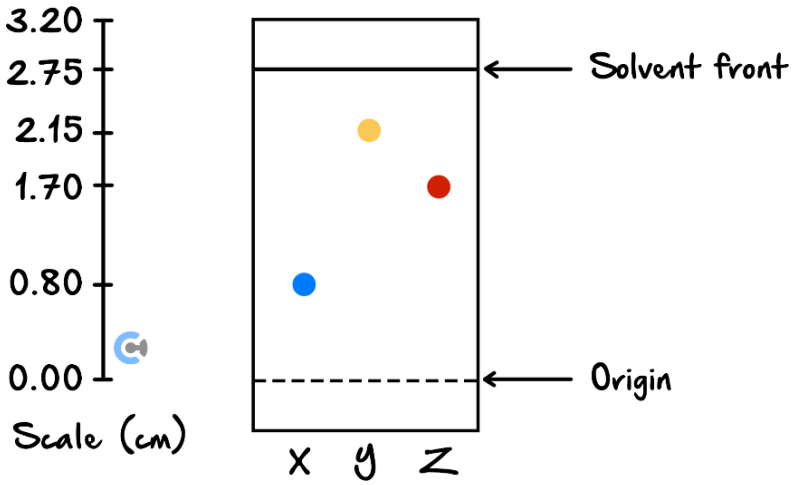
b. 4-aminophenol adsorbs less strongly than paracetamol onto the stationary phase of this TLC plate. Predict whether the R_f value of 4-aminophenol in this analysis is greater or smaller than that of paracetamol, giving a reason for your choice. (1 mark)

Higher Rf → more dissolved in the mobile phase.

Space for Personal Notes

Question 24 (1 mark) **Additional Question.**

Consider the following TLC plate of compounds X, Y and Z developed using a suitable mobile phase on a polar stationary phase:



The R_f value of the most polar component in this TLC separation is:

A. 0.29

B. 0.62

C. 0.78

D. 0.80

Question 25 (1 mark) **Additional Question.**

A student used paper chromatography to separate two components, I and II, in a solution. A spot of the solution was initially placed at the origin.

When the spot corresponding to the component I ($R_f = 0.50$) had advanced 4.0 cm, the spot corresponding to component II was 1.0 cm behind.

The R_f value of component II is closest to:

A. 0.68

B. 0.38

C. 0.25

D. 0.13

Contour Checklist

☐ Learning Objective: [1.10.1] - Identify which substances would dissolve one another based on miscibility and polarity

Study Design

"Polar and non-polar character with reference to the solubility of polar solutes dissolving in polar solvents, and non-polar solutes dissolving in non-polar solvents."

Key Takeaways

- ☐ Polar objects will attract more to the [polar] / [non-polar] phase as they form [dispersion forces] / [dipole-dipole bonds].
- ☐ Non-polar objects will attract more to the [polar] / [non-polar] phase as they form [dispersion forces] / [dipole-dipole bonds].

☐ Learning Objective: [1.10.2] - Apply the concepts of adsorption and desorption to stationary and mobile phases

Study Design

"Experimental application of chromatography as a technique to determine the composition and purity of different types of substances, including calculation of R_f values."

Key Takeaways

Stationary Phase	Mobile Phase
Component which [stays still] / [moves].	Component which [stays still] / [moves].
Substances [adsorb] / [desorb] to this phase.	Substances [adsorb] / [desorb] to this phase.
More attracted to this phase → substance travels a [shorter] / [longer] distance & has a [quicker] / [slower] rate of travel.	More attracted to this phase → substance travels a [shorter] / [longer] distance & has a [slower] / [quicker] rate of travel.

☐ Learning Objective: [1.10.3] – Apply chromatography principles to Thin Layer Chromatography (TLC)

Study Design

"Experimental application of chromatography as a technique to determine the composition and purity of different types of substances, including calculation of R_f values."

Key Takeaways

- ☐ Chromatography is used to separate mixtures.
- ☐ It does so based on each component's polarity
- ☐ TLC stands for thin layer chromatography
- ☐ TLC involves a glass plate being covered in a thin layer of silica.
- ☐ Silica gel is [polar] / [non-polar].
- ☐ Consequently, the solvent used in TLC is typically [polar] / [non-polar].

Learning Objective: [1.10.4] – Calculate Retardation Factor (R_f) values for components on a TLC plate

Study Design

"Experimental application of chromatography as a technique to determine the composition and purity of different types of substances, including calculation of R_f values."

Key Takeaways

$$R_f = \frac{\textit{distance travelled by component}}{\textit{distance travelled by solvent}}$$

- Substances which are more strongly adsorbed to the stationary phase will have a [higher] / [lower] R_f value.
- Substances which are more strongly desorbed to the mobile phase will have a [higher] / [lower] R_f value.
- As the solvent will always travel the longest distance, the R_f value will always be less than one.
- The units for an R_f value are N/A, as the R_f value is merely a ratio

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