**ANSWER KEY.**

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# 3.9 Separation of Solutions and Mixtures

AP Chemistry | ANSWER KEY

Justify answers using intermolecular forces (IMFs). Show your work for calculations.

**1.** Choose the best method (filtration, chromatography, or distillation) to separate each mixture, and explain your choice.

(a) chalk powder that has settled in water

(b) acetone (boiling point 56 °C) dissolved in water

(c) the colored pigments in a spinach leaf extract

(d) A student pours NaCl(aq) through filter paper. Explain why the salt is not removed.

**(a) Filtration. Chalk does not dissolve, so the filter paper catches it and the water passes through.**

**(b) Distillation. It is a solution, and acetone has weaker IMFs and a lower boiling point, so it boils off first.**

**(c) Chromatography. The dissolved pigments have different polarities, so they are attracted differently to the two phases.**

**(d) The $Na^+$ and $Cl^-$ ions are dissolved. They are far smaller than the holes in the paper, so they pass through with the water.**

**2.** In a paper chromatography experiment, the solvent front moved 9.0 cm from the start line. Spot X moved 6.3 cm and spot Y moved 1.8 cm.

(a) Calculate the $R_f$ value of each spot.

(b) Which spot is more strongly attracted to the paper (the stationary phase)? Explain.

**(a) X: $R_f$ = 6.3 cm ÷ 9.0 cm = 0.70. Y: $R_f$ = 1.8 cm ÷ 9.0 cm = 0.20 (no units)**

**(b) Spot Y. It has the lower $R_f$, so it stayed closer to the start line, held back by the paper.**

**3.** A dye has an $R_f$ of 0.45. The solvent traveled 7.6 cm. How far did the dye travel from the start line?

**distance spot traveled = $R_f$ × distance solvent traveled = 0.45 × 7.6 cm = 3.4 cm**

**4.** Give one reason for each lab detail in paper chromatography.

(a) The start line is drawn in pencil, not pen.

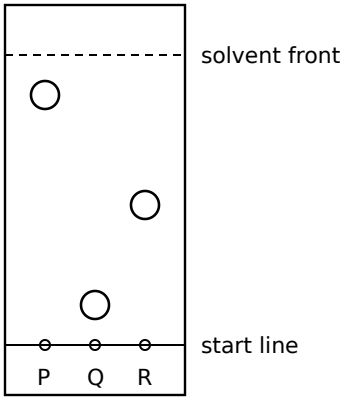
(b) The solvent level must be below the start line.

**(a) Pen ink is a mixture of dyes, so it would separate too. Pencil (graphite) does not dissolve and move.**

**(b) Otherwise the sample dissolves into the solvent in the beaker instead of traveling up the paper.**


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**5.** Three dyes, P, Q, and R, were separated on polar paper using a nonpolar solvent. The chromatogram is shown.




(a) Rank the dyes from least polar to most polar.

(b) Justify the position of dye Q using intermolecular forces.

(c) The same dyes are run on a TLC plate with a nonpolar coating, using water as the solvent. Which dye would travel the farthest? Explain.

**(a) P < R < Q (least polar to most polar)**

**(b) Q traveled the shortest distance, so it has the strongest attraction to the polar paper, through dipole-dipole forces or hydrogen bonding. It is least attracted to the nonpolar solvent.**

**(c) Q. Now the mobile phase (water) is polar, so the most polar dye is most attracted to the mobile phase and travels farthest. Like attracts like.**

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**6.** A mixture of acetone ($CH_3COCH_3$) and water is distilled. Acetone is polar, but it has no H atom bonded to O, N, or F.

(a) Which liquid collects first in the receiving flask? Justify your answer using intermolecular forces.

(b) The thermometer at the top of the flask reads about 56 °C for several minutes, then rises toward 100 °C. What does this tell the student?

**(a) Acetone collects first. Acetone molecules are attracted to each other by dipole-dipole forces (and LDFs) but cannot hydrogen bond to each other. Water molecules hydrogen bond to each other. Acetone has weaker IMFs, so it has a higher vapor pressure and a lower boiling point.**

**(b) The vapor leaving the flask at 56 °C is mostly acetone. When the temperature rises toward 100 °C, the acetone is mostly gone and water is now distilling, so the student should change receiving flasks.**


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