Lesson Title	Basic Radial Chromatography
Length of Lesson	90 minutes
Created By	David Wilson
Subject	Chemistry / Physical Science
Grade Level	9-12th Grade
State Standards	2a, 2f / 4b
DOK Level	DOK1 / DOK2
DOK Application	Describe, Classify, Compare / Explain
National Standards	9-12: B: Physical Science
Graduate Research Element	Chromatography is essential to all areas of chemistry research.

Student Learning Goal:

State Standards: (Chemistry)

2) Demonstrate an understanding of the atomic model of matter by explaining atomic structure and chemical bonding.

a. Describe and classify matter based on physical and chemical properties and interactions between molecules or atoms. (DOK1)

f. Compare different types of intermolecular forces and explain the relationship between intermolecular forces, boiling points, and vapor pressure when comparing differences in properties of pure substances. (DOK1)

State Standards: (Physical Science)

4) Develop an understanding of the atom.

a. Explain the difference between chemical and physical changes and demonstrate how these changes can be used to separate mixtures and compounds into their component parts. (DOK2)

National Science Standards: (9-12)

B: Physical Science: Structure and Properties of Matter

- The physical properties of compounds reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.

Materials Needed (supplies, hand-outs, resources):

[Quantities of supplies listed are per each group.] One black pen, one purple pen [Note: purple dyes are typically composed of a single compound not a mixture. Be sure this is the case for your purple pen.], three other pens of varied colors, 5 pieces of LARGE (as large as a pie pan) round filter paper, ~100 milliliters of water, ~100 milliliters of alcohol, one pie pan, one plastic cup cut to the height of the pie pan, one pencil, and scissors.

Lesson Performance Task/Assessment:

1) Students will be able to determine the R_f values of the components of the pen dye for each solvent. / Lab performance assessment and unit exam.
2) Students will be able to use chromatography to recreate a radial given radial pattern with the pens provided. / Lab performance assessment.
3) Students will be able to explain the process of chromatography using the terms solvent, mixture, mobile phase, and stationary phase.
4) Students will be able to extrapolate an understanding of and explain how column chromatography works. / Lab performance assessment and unit exam.

Lesson Relevance to Performance Task and Students:
This activity will familiarize students with a ubiquitous and fundamental scientific technique based on the principles of chemistry.

Anticipatory Set/Capture Interest:
Present the class with a black pen and ask them, "What color drawing could I make with this pen?" They will probably say black and white at some point. Then, show the class a very bright, colorful chromatogram which was produced by that pen to begin a discussion of chromatography, the separation of mixtures, and the appearance of homogeneous mixtures.

Guided Practice:
The instructor will lead the students in a discussion of the purpose, practical applications, and theory governing chromatography. Then the instructor will instruct the students in setting up their chromatography apparatus and go over the directions for performing the lab.

Independent Practice:
After the initial lab activity, the students will be presented with a completed chromatogram with no other information. The teacher will instruct the students to recreate that given chromatogram exactly with the supplies they have available. (One of the sheets of filter paper given to them will be used to practice and investigate how to repeat the given chromatogram. The other sheet will be used to recreate the given chromatogram. The alcohol and water solvents both may be used in the investigation.)

Remediation and/or Enrichment:
Remediation: Individual IEP.
Enrichment: Students will be asked to brainstorm and come up with five ideas describing how chromatography might be used in forensics, environmental research, pharmaceuticals, and two other scientific fields they can relate it to. The students will write down their ideas in their groups.

Check(s) for Understanding:

A comparison between the chromatogram they created and the one they were asked to create will indicate their understanding of *how* to use chromatography. Verbal questioning during the activity and questions answered on the unit exam will indicate their understanding of the terminology associated with chromatography.

Closure:
The teacher will lead a final discussion of the enrichment topic ideas generated by students involving how chromatography is used in a variety of fields.

Possible Alternate Subject Integrations:
This lesson would integrate well with biology since chlorophyll can be separated into component compounds as well. In fact, the separation of chlorophyll was the first experiment in chromotagraphy.
This lesson also integrates well with middle school mathematics since the calculation of the R_f value is a ratio calculation.

Teacher Notes:
1) See the attached worksheet.
2) In order for the students to complete "Part B – Independent Practice," the teacher must create a chromatogram before class. The students will attempt to recreate that chromatogram after practicing. The students will have to determine the pens used, length of time the solvent was allowed to run across the filter paper, and the solvent used (alcohol, water, or a mixture of both) in order to be able to complete this part.
3) In addition, this lesson can be done on T-shirts instead of filter paper. In fact, asking students to recreate a specific tie-dye pattern on a T-shirt can easily be done, and the students can be allowed to continue the lesson with their own personal pens as the enrichment. In order to do this lesson on T-shirts, the shirt should be stretched over a mason jar or some open container. The shirt must be secured tightly like a drum with a rubber band or tie. An ink drop can be made in the center of the jar, and a drop of alcohol onto the ink spot will act to cause the tie-dye pattern.