GHARDA FOUNDATION

GIT GHARDA INSTITUTE OF TECHNOLOGY

GHARDA INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CHEMICAL ENGINEERING

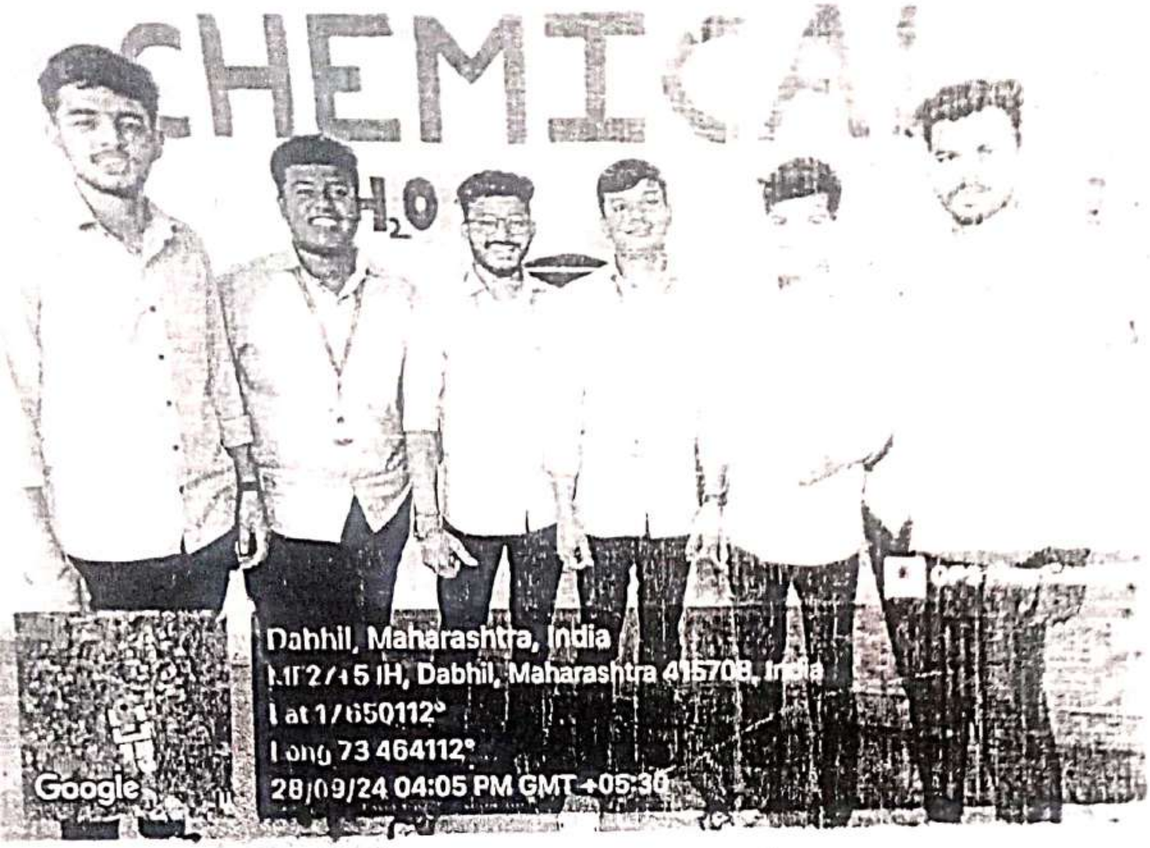
Experiential learning Methodologies
Subject: Mass Transfer Operations-I

Activity 1: Calculation of diffusion coefficient of acetone in open beaker at ambient temperature(Completed on 28.09.2024)

The diffusion of acetone in air involves the process by which acetone molecules spread out and mix with air molecules. Here are some key points about this process:

1. **Molecular Properties**: Acetone (C_3H_6O) is a small, volatile organic compound. Its low molecular weight and relatively high vapor pressure facilitate its diffusion in air.
2. **Concentration Gradient**: Diffusion occurs due to differences in concentration. Acetone will move from areas of higher concentration (e.g., near a spill) to areas of lower concentration until equilibrium is reached.
3. **Temperature Influence**: Higher temperatures increase the kinetic energy of the molecules, enhancing diffusion rates. Acetone evaporates more quickly in warmer environments.
4. **Factors Affecting Diffusion Rate**:
   - **Temperature**: Higher temperatures increase diffusion speed.
   - **Molecular Weight**: Lighter molecules diffuse faster.
   - **Air Movement**: Wind or ventilation can enhance diffusion by dispersing acetone more rapidly.

Procedure: Students are asked to take the difference in weight of acetone after 10 minutes intervals in different conditions of atmosphere. The loss in weight converted into flux and Mass Transfer coefficient is calculated and compared.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Long 73.464283°
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Experiment No. Experintial Learning Date :

Activity - 1

Observation Table :-

Time	Inner Acetone wt	Outer Aceton
0	62.25	61.450
10	61.097	57.686
20	60.309	53.945
30	59.380	50.246
40	58.343	45.521
50	57.265	41.124

Calculation :-

$P_A = 39.997$ kPa T = 303K Pt = 101.325

molecular wat = 58.08 $A = 133.51 \times 10^{-4}$ m²

*for inner

1) $N_A = \frac{\text{moles}}{\text{area} \times \text{Time}}$

$N_A = \frac{62.25 - 61.097}{133.51 \times 10^{-4} \times 58.08 \times 600} = 2.47 \times 10^{-3} \frac{mo}{sec}$

$N_A = \frac{62.25 - 59.350}{0.775 - 1600} = 2.05 \times 10^{-3} \frac{mol}{sec.m^2}$

$N_A = \frac{62.25 - 58.343}{0.775 \times 2405} = 2.03 \times 10^{-3}$

Result :- for Inner (in lab)

N_A (flux) $\frac{mol}{m^2.s}$	KG $\left(\frac{mol}{m^2.s.kpa}\right)$	Ky $\left(\frac{mol}{m^2 sec}\right)$	KC = m/s
2.47×10^{-3}	5.17×10^{-5}	6.25×10^{-3}	0.156
2.08×10^{-3}	5.2×10^{-5}	5.26×10^{-3}	0.131
2.05×10^{-3}	5.12×10^{-5}	5.19×10^{-3}	0.129
2.09×10^{-3}	5.22×10^{-5}	5.29×10^{-3}	0.132
2.142×10	5.35×10^{-5}	5.426×10^{-3}	0.135

for Outer (In corridor)

N_A (flux) $\frac{mol}{m^2.s}$	KG $\left(\frac{mol}{m^2.s.Kpa}\right)$	Ky $\left(\frac{mol}{m^2-sec}\right)$	K_G = m/s
8.09×10^{-3}	2.02×10^{-4}	0.020	0.512
8.06×10^{-3}	2.015×10^{-4}	0.0204	0.510
8.03×10^{-3}	2×10^{-4}	0.0203	0.508
8.39×10^{-3}	2.09×10^{-4}	0.0212	0.531
8.72×10^{-3}	2.18×10^{-4}	0.022	0.5518

Conclusion :-

In this ~~experimental~~ experiential learning activity we calculated molar flux & mass Transfer coefficient in this we can see that molar flux is greater in corridor.

Page No:

Virtual Lab BCE.

ChemReaX™ a chemical reaction modeling and simulation app from ScienceBySimulation

General Reactions | Acid Base Titrations | User Guide | FAQ | Tutorials | Exercises

Quick steps: • Click "Reaction Selector" to choose a pre-defined titration reaction or choose your own titrand and titrant • Enter the titrand and titrant concentrations, the initial volume of the titrand, and the total amount (volume) of titrant added • Click "Run the Reaction" to simulate the titration

Select Reactants	Search/select species using dropdown lists or choose a pre-defined reaction from [Reaction Selector]	Type	Initial Volume (L)	Total Amount Added (L)	Concentration (moles/L)	Equilibrium Constant, K
Analyte/Titrand	HCl	Strong Acid	0.5		0.5	100000
Reagent/Titrant	NaOH	Strong Base		0.5	0.5	100000

[Run the Reaction] [Clear All]

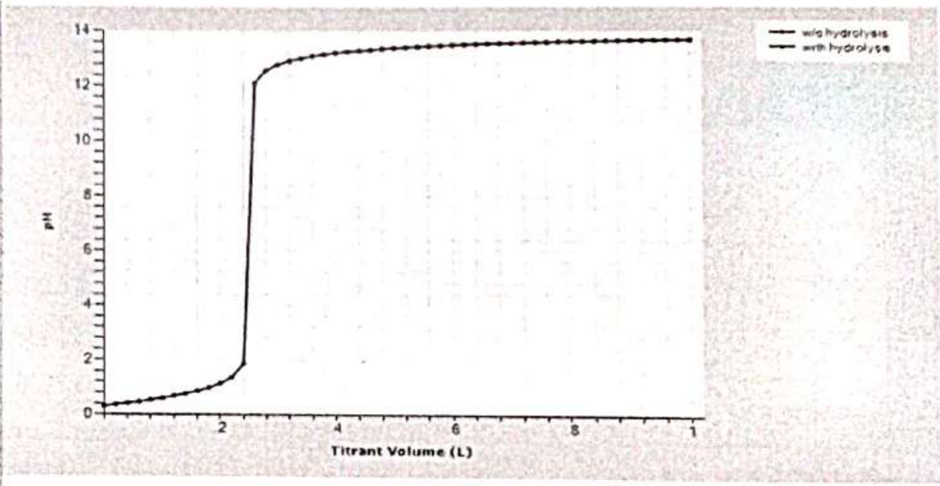
Reactions:

Titrand 1st ionization	HCl (aq)	+	<-->	H(+) (aq)	+	Cl(-) (aq)
Titrand 2nd ionization	n/a	+	<-->		+	
Titrant ionization	NaOH (aq)	+	--->	Na(+) (aq)	+	OH(-) (aq)
Water autoionization	H2O (liquid)	+	<-->	H(+) (aq)	+	OH(-) (aq)
Hydrolysis	n/a	+	<-->		+	
Hydrolysis	n/a	+	<-->		+	

[illegible] CRC Handbook of Chemistry and Physics

Simulated Titration: (@ T = 298.15K)

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]



Innovative Experiment

Subject: Basic Chemical Engineering Lab

S.E. Chemical Engineering

Semester-III

Year:2024-25

Freezing Point Depression

Introduction: (Initial Observation)

In a hot summer day the ice-cream street vendor was making ice-cream, right in the street in a steel pot without a freezer or electricity. How could he produce such a cold environment to freeze milk and make ice-cream under the hot sun using some crushed ice?

Adding salt to ice to make it colder. Why does salt make the ice colder? Can other chemicals do the same?

Knowing how chemicals can modify freezing point or boiling point of liquids, can help us control the conditions or produce products that otherwise we would not be able to produce.

In this work you will study the effects of various solutes on the freezing points of water. Find out what property of a solute is effective in reducing the freezing point. Does freezing point depression have any thing to do with the amount of solute?

Information Gathering:

Study about the physical and chemical properties of salt and water. Find out how salt can reduce the freezing point of water. Read books, magazines or ask professionals who might know in order to learn about the relation between freezing point depression and other properties of solutes and solvents. Learn about mole, molal solutions and molar solutions. Keep track of where you got your information from.

Following are samples of information that you may find.

Mole is the amount equivalent to the atomic or molecular weight of the atom or

molecule in grams.

One mole sodium is 23 grams sodium. One mole water is 18 grams water. One mole Sodium Hydroxide is 40 grams sodium hydroxide.

A molality is the number of moles of solute dissolved in one kilogram of solvent.

To make a one molal solution of sodium chloride (NaCl) , measure out one kilogram of water and add one mole of the solute, NaCl to it. The atomic weight of sodium is 23 and the atomic weight of chlorine is 35. Therefore the formula weight for NaCl is 58, and 58 grams of NaCl dissolved in 1kg water would result in a 1 molal solution of NaCl.

Molarity is the number of moles of a solute dissolved in a liter of solution.

A molar solution of sodium chloride is made by placing 1 mole of a solute into a 1-liter volumetric flask. (Taking data from the example above we will use 58 grams of sodium chloride). Water is then added to the volumetric flask up to the one liter line. The result is a one molar solution of sodium chloride.`

Question/ Purpose:

What do you want to find out? Write a statement that describes what you want to do. Use your observations and questions to write the statement.

The purpose of this project is to compare different solutes for their effects on reducing the freezing point of water.

* I want to know which substance is a better anti-freeze for water? Water soluble substances have different chemical and physical properties. For example they are solids and liquids; They have different molecular weights, different densities, and different freezing points. I want to know which specific property of a substance causes a reduction in the freezing point of water.

Identify Variables:

When you think you know what variables may be involved, think about ways to change one at a time. If you change more than one at a time, you will not know what variable is causing your observation. Sometimes variables are linked and work together to cause something. At first, try to choose variables that you think act independently of each other.

The independent variable (manipulated variable) is the type of solute.

Dependent variable is the freezing point of the solution.

Constants are the mass water, mass of solute, and experiment procedures.

Hypothesis:

Based on your gathered information, make an educated guess about what types of things affect the system you are working with. Identifying variables is necessary before you can make a hypothesis.

Experiment Design:

Design an experiment to test each hypothesis. Make a step-by-step list of what you will do to answer each question. This list is called an experimental procedure. For an experiment to give answers you can trust, it must have a "control." A control is an additional experimental trial or run. It is a separate experiment, done exactly like the others. The only difference is that no experimental variables are changed. A control is a neutral "reference point" for comparison that allows you to see what changing a variable does by comparing it to not changing anything. Dependable controls are sometimes very hard to develop. They can be the hardest part of a project. Without a control you cannot be sure that changing the variable causes your observations. A series of experiments that includes a control is called a "controlled experiment."

Experiment 1: Compare the freezing point depression of water with same mass of different solutes.

Introduction: In this experiment same amounts of various solutes are added to water and the resultant freezing points of the solutions are determined.

Material:

Ice

Sugar (Sucrose, $C_{12}H_{22}O_{11}$)

Salt (NaCl)

ethylene glycol (commercial automotive antifreeze)

Other water soluble substance that you may want to test. For example you may want to add urea (a well known fertilizer), Isopropyl alcohol, or glycerin, to the list of material that you test.

Equipment:

test tubes

thermometer

400-mL beaker (or a 10 ounce Styrofoam cup)

100-mL graduated cylinder

stirring rod

Preparation of Ice Bath:

1. Fill the large beaker 3/4 full with ice.
2. Cover the ice with 1/4 to 1/2 inches of table salt.
3. Stir this ice-salt mixture with a stirring rod and make sure the temperature drops to at least -10°C.

Procedure:

1. Prepare a solution of NaCl by adding 10 grams of NaCl to 100 mL of water. Mix until all crystals dissolve.
2. Prepare a solution of sugar by adding 10 grams of sugar to 100 mL of water. Mix until all crystals dissolve.
3. Prepare a solution of ethylene glycol by adding 10 grams of antifreeze to 100 mL of water. Mix until all crystals dissolve.
4. Place a test tube that is 1/2 full of water in the ice bath.
5. Stir the water in the test tube gently with a thermometer while keeping track of the temperature.
6. When the first ice crystals appear on the inside wall of the test tube, record the temperature. This should be the freezing point of the liquid. (In this step water is the pure solvent).
7. Repeat steps 4-6 with the prepared NaCl, sugar and ethylene glycol solutions.
8. Record your results in your results table

Your results table may look like this:

Solute	Water (mL)	Solute (grams)	Freezing Point

None (pure Water)	100	0	
NaCl	100	10	
Sugar	100	10	
Ethylene Glycol	100	10	

Which substance is a better anti-freeze?

Experiment 2: Compare the freezing point depression of water with same moles of different solutes.

Introduction: In this experiment same number of moles (molecule grams) of various solutes are added to water and the resultant freezing points of the solutions are determined. In this way all solutions will have the same number of solute molecules. This experiment is based on the following information:

One mole of any substance consists of 6.022×10^{23} molecules of that substance. The number 6.02 times 10 to the 23rd is known as Avogadro's number.
For example:

- 18 grams of water contains 6.022×10^{23} water molecules.
- 58 grams of NaCl contains 6.022×10^{23} NaCl molecules.
- 342 grams of sucrose consists of 6.022×10^{23} molecules of sucrose.

To make a one mole solution of NaCl, you place one molecule gram of NaCl in a beaker and then add water to that to bring the volume to 1 liter. Molecular mass of NaCl is 58, so one molecule gram of NaCl is 58 grams of NaCl. To Calculate the molecular weight of any substance, you can add the atomic weights of the atoms that form one molecule of that substance. So the molecular weight of NaCl is calculated by adding the molecular weight of Sodium (23) and Molecular weight of Chlorine (35).

Material:

Ice

Sugar (Sucrose, $C_{12}H_{22}O_{11}$)

Salt (NaCl)

ethylene glycol (commercial automotive antifreeze, $C_2H_6O_2$)

Other water soluble substance that you may want to test. For example you may want to add urea (a well known fertilizer), Isopropyl alcohol, or glycerin, to the list of material that you test.

Equipment:

test tubes

thermometer

400-mL beaker (or a 10 ounce Styrofoam cup)

100-mL graduated cylinder

stirring rod

Preparation of Ice Bath:

1. Fill the large beaker 3/4 full with ice.
2. Cover the ice with 1/4 to 1/2 inches of table salt.
3. Stir this ice-salt mixture with a stirring rod and make sure the temperature drops to at least -10°C.

Procedure:

1. Prepare a solution of NaCl by adding 5.8 grams of NaCl to 100 mL of water. Mix until all crystals dissolve.
2. Prepare a solution of sugar by adding 34 grams of sugar to 100 mL of water. Mix until all crystals dissolve.
3. Prepare a solution of ethylene glycol by adding 6.2 grams of ethylene glycol to 100 mL of water. Mix until all crystals dissolve.
4. Place a test tube that is 1/2 full of water in the ice bath.
5. Stir the water in the test tube gently with a thermometer while keeping track of the temperature.
6. When the first ice crystals appear on the inside wall of the test tube, record the temperature. This should be the freezing point of the liquid. (In this step water is the pure

solvent).

7. Repeat steps 4-6 with the prepared NaCl, sugar and ethylene glycol solutions.

8. Record your results in your results table

Your results table may look like this:

Solute	Water (mL)	Solute (grams)	Freezing Point
None (pure water)	100	0	
NaCl	100	5.8	
Sugar	100	34	
Ethylene Glycol	100	6.2	

Which substance is a better anti-freeze when added at a ratio of 1 molecule gram to each Liter of water?

Experiment 3: (Optional)

I developed this experiment after observing the results of the previous experiment and gathering some more information. I learned that most solutions made by dissolving one mole solute in one liter of water have the same freezing point. In other words the freezing point depression of water is the same with one mole of any solute. The exceptions are the solutes that are very volatile and the solutes that ionize. The freezing point of water reduces by 1.86°C for each mole of a substance in 1 Kg of water. This ratio can be written as $\Delta T = (1.86)(m)$.

ΔT is the freezing point depression.

m is the molality of solution (the number of moles of solute added to 1 kg of water)

This is a very important piece of information because it can be used to determine the molecular mass (mole) of unknown substances. Often chemists try to identify an unknown substance. Knowing the molecular mass of an unknown can be very helpful in such identifications.

<u>Molecular Mass Determination From Freezing Point Depression</u>

1. Dissolve 10 grams of Urea in 100 mL of water.

2. Freeze this solution in the same manner as in the previous experiment. Be sure to record

the freezing point temperature.

3. Calculate the molecular mass of this solute based on the freezing point depression.
   $\Delta T = (1.86)(m)$
   $\Delta T = (1.86)[(\text{grams of solute} \div \text{Molecular mass}) \div \text{kg of water}]$
   Molecular mass of solute = $[(1.86)(\text{grams of solute})] \div [(\Delta T)(\text{kg of solvent})]$
   Since we used 10 grams of solute in 0.1 kg of water, we can write:
   Molecular mass of solute = $186 \div \Delta T$

Cleanup:

All solutions may be flushed down the drain with plenty of water.

Molecular mass of solute = $186 \div \Delta T$

Materials and Equipment:

Material:

ice

Sugar (Sucrose, $C_{12}H_{22}O_{11}$)

Salt (NaCl)

ethylene glycol (commercial automotive antifreeze)

Equipment:

test tubes

thermometer

400-mL beaker (or a 10 ounce Styrofoam cup)

100-mL graduated cylinder

stirring rod

Since commercial antifreeze is primarily ethylene glycol, it is highly toxic and should not be ingested. The ice used in the experiment could become contaminated with antifreeze by accident; students should be warned not to eat the ice. Goggles must be worn throughout the experiment.

Results of Experiment (Observation):

Experiments are often done in series. A series of experiments can be done by changing one variable a different amount each time. A series of experiments is made up of separate experimental "runs." During each run you make a measurement of how much the variable affected the system under study. For each run, a different amount of change in the variable is used. This produces a different amount of response in the system. You measure this response, or record data, in a table for this purpose. This is considered "raw data" since it has not been processed or interpreted yet. When raw data gets processed mathematically, for example, it becomes results.

Results table:

Solute	Water (mL)	Solute (grams)	Freezing Point
None (pure water)	100	0	
NaCl	100	5.8	
Sugar	100	34	
Ethylene Glycol	100	6.2	

Following is a sample of some additional results from similar experiments and observations.

Note that the electrolyte molecules break down to ions, resulting an increase in the number of particles. That is why in the temperature depression formula suggested below, another variable (i) is added.

The freezing point of solutions depend upon the concentration of solute particles. The freezing points of water solutions are always lower than that of pure water. The change in freezing point caused by the presence of a solute dissolved in water can be calculated from the equation,

$\Delta T = (1.86)(m)(i)$,

where 1.86 is the molal freezing point depression constant for water, m is the molality of the solution, and i is the number of particles produced per formula unit.

Molality = moles of solute/kg solvent

Since freezing point depression depends upon the number of particles in solution, a one molal solution of an electrolyte (NaCl), which dissociates in water, lowers the freezing point more than a one molal solution of a non-electrolyte (sucrose). The freezing point of a one molal solution of NaCl is actually -3.37°C, only 1.81 times that of a non-electrolyte, not the -3.62°C that would be expected if NaCl molecules were completely dissociated. This difference is believed to be due to the inter-ionic attractions that prevent the ions from behaving as totally independent particles. The activity or effective concentration of the ions is less than what we expect from the actual concentration. Some of the ions may exist as solvated units called ion pairs. The more dilute the solution of an electrolyte, the more widely separated are the ions, and less are the interionic attractions,. Consequently, the effective ion concentration closely approaches the actual ion concentration.

Calculations:
Write your calculations in this section of your report.

Summary of Results:
Summarize what happened. This can be in the form of a table of processed numerical data, or graphs. It could also be a written statement of what occurred during experiments.

It is from calculations using recorded data that tables and graphs are made. Studying tables and graphs, we can see trends that tell us how different variables cause our observations. Based on these trends, we can draw conclusions about the system under study. These conclusions help us confirm or deny our original hypothesis. Often, mathematical equations can be made from graphs. These equations allow us to predict how a change will affect the system without the need to do additional experiments. Advanced levels of experimental science rely heavily on graphical and mathematical analysis of data. At this level, science becomes even more interesting and powerful.

Conclusion:
Using the trends in your experimental data and your experimental observations, try to answer your original questions. Is your hypothesis correct? Now is the time to pull together what happened, and assess the experiments you did.

Related Questions & Answers:
What you have learned may allow you to answer other questions. Many questions are related. Several new questions may have occurred to you while doing experiments. You may now be able to understand or verify things that you discovered when gathering information for the project. Questions lead to more questions, which lead to additional hypothesis that need to be tested.

Possible Errors:
If you did not observe anything different than what happened with your control, the variable you

changed may not affect the system you are investigating. If you did not observe a consistent, reproducible trend in your series of experimental runs there may be experimental errors affecting your results. The first thing to check is how you are making your measurements. Is the measurement method questionable or unreliable? Maybe you are reading a scale incorrectly, or maybe the measuring instrument is working erratically.

If you determine that experimental errors are influencing your results, carefully rethink the design of your experiments. Review each step of the procedure to find sources of potential errors. If possible, have a scientist review the procedure with you. Sometimes the designer of an experiment can miss the obvious.

References:

Holtzclaw, H.F., Robinson, W.R., and Nebergall, W.H.,*College Chemistry with Qualitative Analysis*, D. C. Heath and Company, Lexington, MA, 1984, p. 359. This work discusses colligative properties.

http://www.oswego.edu/wscp/fp-s.htm

Molarity, Molality and Normality
http://genchem.rutgers.edu/mw5exp.html
Demonstrating molar mass determination
http://genchem.rutgers.edu/mwfp.html
http://wwwchem.csustan.edu/chem1112/mwfpdep.htm
Molecular weight by freezing point depression

https://www.scienceproject.com/projects/intro/Senior/SC029.asp