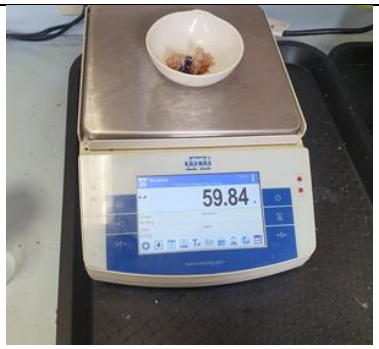
Solutions to the “Blue berry muffin investigation”

2. Calculate the percent, by mass, of oil in the muffin.

i. Construct a table of data.

Item	Mass (g)
Evaporating dish	 55.07
Evaporating dish + muffin sample	 59.84
Muffin sample tested.	59.84 – 55.07 = 4.77
Evaporating dish + oil	
Oil collected.	55.548 -55.07 = 0.478

ii. Show all calculations

Percentage by mass of oil in the muffin
= (mass of oil / mass of muffin) X 100
= (0.478 / 4.77) X 100
= 10.0%

2. Consider the image on the right. It is a pre-packed muffin sold at a convenience store. Calculate the mass, in grams, of oil present in the muffin shown on the right.

The total mass of muffin is 120 g (as stated on the label)
Mass of oil present is 10.0% of the total mass
=> (10.0 /100) X 120 = 12.0 grams of oil

3. Using some or all the terms listed below, explain some of the observed physical properties of the food dye.

- hydrophobic.

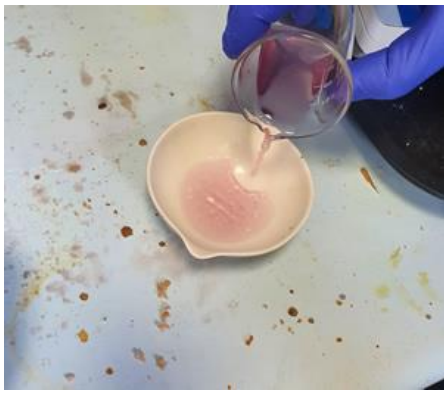
- dipole-dipole.

- polar

- non-polar

- intermolecular

- Just like oil, it is soluble in acetone and can be separated from the muffin, as shown on the right. It is however, insoluble in a hydrophobic solvent, such as oil, as can be seen by the video. This may lead us to suggest that the dye is a polar molecule that may have intermolecular bonds that include either or both dipole-dipole and/or hydrogen bonding.



4. The procedure shown above attempted to isolate the oil from a given mass of muffin.

i Suggest two possible errors with the procedure given above and explain the impact it would have on the final result of the percentage, by mass, of oil content.

- the presence of food colouring will give an inflated mass of the oil leading to an inflated percentage, by mass, of oil present in the muffin.

- beaker was not rinsed with acetone. This will give an underestimation of the percentage, by mass, of oil in the muffin.

Any other plausible error is accepted with the right impact on the overall result suggested.

ii. Offer two ways to improve the procedure.

Any two of the below or any other plausible improvement

- Rinsing the beaker with acetone will wash all the oil out of the beaker and into the evaporating dish.

- Removing the food colouring by mixing the oil and food colouring mixture with water and then separating the pure oil layer using a separating funnel.

- Greater number of trials.

- Test many different muffins of the same type and from the same company. In other words increase the sample size to get more reliable resultws.

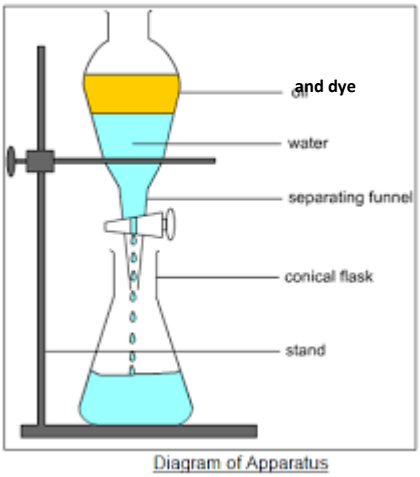


Diagram of Apparatus

5. Consider the label on the right.

a. Identify 3 risks associated with the use of acetone.

- flammable

- Skin irritant

- Eye irritant

- Proper storage

Any of the above plus any other plausible safety risks.

b. For each safety risk, suggest one way to mitigate the risk.

- Keep away from flame or heat sources (sparks, electrical)

- Wear goggles

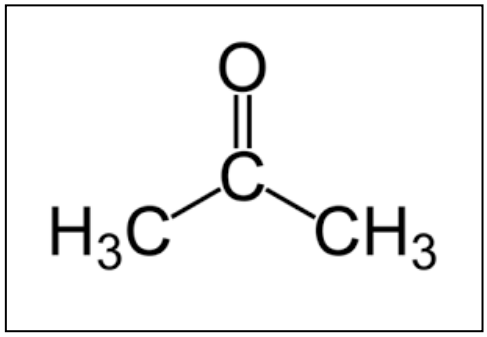
- wear gloves

- Work in a well ventilated laboratory or fume cupboard.

- Store in a well ventilated, fireproof, locked cupboard.

6. With reference to the chemical structure of acetone explain how acetone is a solvent for both hydrophobic and hydrophilic substances.

Acetone has two non-polar methyl groups which can interact with the hydrophobic substances but also has a polar, carbonyl group (C=O), that interacts with the polar water molecule.



7. With reference to the safety data given in question 5. above acetone is a volatile substance that must be handled in a well ventilated laboratory.

i. Compare the flash points of propane and acetone. Explain your reasoning.

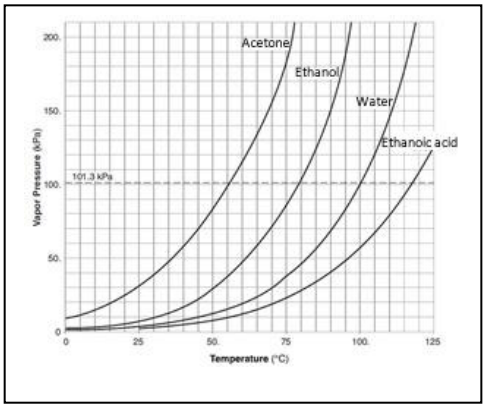
Flash point is a physical property that is directly linked to the strength of intermolecular bonds. Propane, being a hydrocarbon and hence non-polar, has intermolecular bonding comprising of relatively weak dispersion forces. Acetone, being a polar molecule, has intermolecular bonding that is composed of dispersion forces and also dipole-dipole bonding. Acetone having stronger intermolecular bonding will have a higher flash point.

ii. Compare the solubilities in water of acetone and propane. Explain your reasoning.

Acetone being polar will be soluble in water while propane being non-polar will be relatively insoluble in water.

8. Vapour pressure is the pressure exerted by molecules leaving the liquid and entering the gaseous state. Vapour pressure depends only on the temperature of the liquid and not on the volume of the container or the amount of substance.

i. Given the following liquids acetone, ethanol, ethanoic acid (vinegar) and water explain the trend in vapour pressure shown by the graph on the right.



Vapour pressure is dependent on the number of gas molecules present at a given temperature. Strength of intermolecular bonds determines how easily the molecules transition from the liquid phase into the gaseous phase. Strong intermolecular bonds will impede molecules moving from liquid state into the gas state. Hence, the vapour pressure of a substance with strong intermolecular bonds will be lower than the vapour pressure of a substance with weaker intermolecular bonds.

Acetone has the lowest vapour pressure of the four molecules at any given temperature. Intermolecular bonds of acetone include dispersion and dipole-dipole.

Ethanol has intermolecular bonds composed of relatively strong hydrogen bonding and dispersion forces.

Water is the smallest molecule out of the four but has two hydrogens that can form hydrogen bonds. So the intermolecular bonds for water include dispersion forces and relatively stronger hydrogen bonding than ethanol.

Acetic acid has the strongest intermolecular bonds of the four molecules. It is a larger molecule hence the dispersion forces will be greater while the COOH group allows it to form hydrogen bonding.

ii. A pure 5.00 g sample of acetone (58.0 g/mol) is placed in a sealed 1.00 litre vessel at 75 °C. Will there be liquid acetone left in the container after 2 hours? Justify your answer with a calculation.

Step 1 – calculate the amount, in mol, of acetone in the gas state using the ideal gas equation
PV=nRT.
=> PV/RT = n
=> P = 180 kPa (obtained from the graph), V = 1.00 L, R = 8.31, T = 348°K
=> n = 180 X 1.00 / (8.31 X 348) = 0.06224 mol
Step 2 – calculate the mass of acetone gas.
=> 0.06224 X 58.0 = 3.61 grams.

Step 3 Calculate the amount of liquid acetone remaining.
=> 5.00 – 3.61 = 1.39 grams.

9. Consider the image of the lipid isolated from the muffin. Is a saturated or unsaturated fatty acid used in the making of these muffins? Explain.

The lipid is an unsaturated fatty acid. It is a liquid at room temperature indicating the presence of carbon-to-carbon double bonds. Fatty acids with C=C are kinked and hence can not pack tightly together resulting in weak intermolecular bonds leading to the lipid being a liquid at room temperature.

10. The table on the right indicates the results achieved by four groups conducting the investigation on different days, following the same procedure but using different, scales.

Answer the following questions and justify your answer.

i. Are the results from group1 precise?
Precision is a measure of the range of results obtained. Group 1 has results that can be described as precise.

ii. Are the results valid?

Since we are also measuring the mass of food colouring as well as the amount of oil the results are not valid. Other additives may have been dissolved by the acetone and come through int eh filtrate. The aim of the investigation is to calculate the percentage, by mass, of oil int eh muffin.

iii. Are the results obtained reliable?

Reliability is the extent to which the results can be reproduced when the investigation is repeated using the same procedure but with different equipment and by different researchers. In this case the reproducibility of the results is very low. Repeatability and/or reproducibility demonstrate that individual measurements are consistent within a certain acceptable range.