PHYSICAL SCIENCES

Practical Booklet

GRADE 11 TERM 2

TECHNICAL INSTRUCTIONS

Grade 11 Chemistry Practical: Intermolecular forces

Intermolecular forces

TECHNICAL INSTRUCTIONS

Aim: To investigate and explain intermolecular forces and the effects of intermolecular forces on evaporation, surface tension, solubility in water, boiling points and capillarity.

Background information:

The liquids which we will work with are ethanol, water, acetone (nail polish remover), methylated spirits, glycerine and cooking oil. Here is table showing the types of intermolecular forces between their molecules.

Substance	Type of molecule	van der Waals forces	Hydrogen bonds
Ethanol	Polar	✓ dipole-dipole	✓
Water	Polar	✓ dipole-dipole	✓
Acetone	Polar (can also dissolve in non-polar substances)	✓ London forces and dipole-dipole forces	
Methylated spirits	Polar	✓ dipole-dipole	✓
Glycerine	Polar	✓ dipole-dipole	✓
Cooking oil	Non-polar	✓ London forces	
Chloroform	Slightly polar	✓ dipole-dipole	

Apparatus:

Part 1: Evaporation rate: ethanol, water, acetone, methylated spirits
4 evaporating dishes
4 mass meters (electronic mass meters work best)
4 x measuring cylinders or syringes (to measure 20ml)

Part 2: Surface tension: water, cooking oil, glycerine, acetone, methylated spirits
5 x small glass measuring cylinders
5 x stirring rods
1 microscope glass sheet
5 x measuring cylinders or syringes (to measure 50ml)

Part 3: Solubility: **Solvents:** water, ethanol, chloroform
Solutes: sodium chloride, iodine, potassium permanganate
9 x 100 ml beakers
3 spatulas
3 stirring rods
3 x 10 ml test tubes
3 x 50 ml syringes (or 100 ml measuring cylinders)
Masking tape (to label the beakers)
A fine-line permanent marker

Part 4: Boiling points: glycerine, acetone, methylated spirits
3 x boiling (test) tubes
3 x 30 ml syringes
1 large beaker
Hot plate or burner with tripod and gauze mat
Access to water

Intermolecular forces

Investigating the effects of intermolecular forces

The following four experiments investigate the effect of various physical properties (evaporation, surface tension, solubility, boiling point and capillarity) of substances and determine how the intermolecular forces between the molecules relate to these properties. Each experiment looks at a different property.

Part 1: Evaporation rate

Aim:

To investigate evaporation and to determine the relation between evaporation rate and intermolecular forces.

Substances: ethanol, water, acetone, methylated spirits

Method:

1. Place an evaporating dish onto each of four electronic mass meters placed in the same warm spot in the laboratory.
2. Zero each balance (so that it will only read the mass of the substance placed in the dish).
3. Measure 20 ml of each substance into each of the evaporating dishes.
4. Measure the mass of 20 ml of each substance.
5. After 6 minutes, measure the mass of each substance.

Part 2: Surface tension

Aim:

To investigate surface tension and to determine the relation between surface tension and intermolecular forces

Substances: water, cooking oil, glycerin, acetone, methylated spirits

Method:

1. Place about 50 ml of each substance into separate small measuring cylinders.
2. Observe the shape of the meniscus. (This is the level of the liquid). Note what happens at the edges where the liquid touches the glass. (You can place a few drops of food colouring in each substance to help you see the meniscus more clearly.)
3. Now place a drop of the substance on a small piece of glass. Observe the shape of the drop.

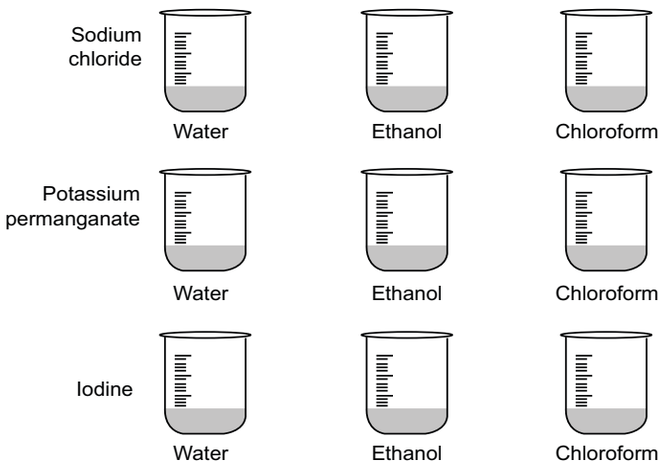
Part 3: Solubility

Aim:

To investigate solubility and to determine the relation between solubility and intermolecular forces.

Precaution:

Chloroform is a volatile solvent. Its fumes cause drowsiness. It is unsafe to allow these fumes to be inhaled by anyone for even short periods of time. Work with chloroform in a well-ventilated space e.g. outdoors, or in a protected space such as a fume cupboard.



Method:

1. Place 50 ml of each solvent given into three separate beakers.
2. Arrange the beakers as shown in the diagram.
3. Into the first set of beakers add about 2 g of sodium chloride.
4. Into the second set of beakers add two or three crystals of potassium permanganate.
5. Into the third set of beakers add one or two pieces (or crystals) of iodine.
6. Stir the contents of each beaker four times (using a clean stirring rod each time).
7. Wait about a minute then observe what happens to the contents of each beaker.

Part 4: Boiling point

Aim:

To investigate boiling point and to determine the relation between boiling point and intermolecular forces

Warning:

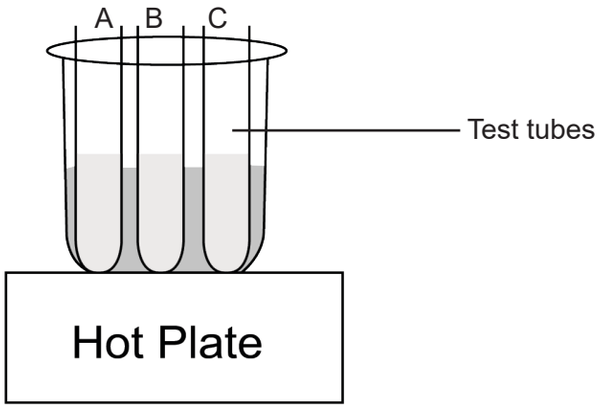
Methylated spirits and acetone are highly flammable. They will easily catch fire if left near an open flame. For this reason, they must be heated in a water bath. This experiment MUST be performed in a well-ventilated room. The fumes from methylated spirits and acetone are toxic.

Note:

1. Cooking oil produces smoke from its surface long before it boils. It is therefore difficult to establish the boiling point of cooking oil. We have therefore left cooking oil out of this experiment.
2. Since we are using a water bath to heat the substances, we can measure (or compare) the temperature at which water boils. Therefore, we are testing three liquids: acetone, ethanol and glycerine.
3. The water bath can be heated using a hot plate, or by using a burner, tripod and gauze mat.
4. If you have access to a digital thermometer, place the probe in the water bath so that you can read the approximate temperature at which each substance (A, B and/or C) begins to boil.

Method:

The boiling points these liquids are easy to look up on the internet or other media, so we are turning this investigation around a little, and identifying the liquids according to their boiling points. You will start with 20 ml of three liquids in separate test tubes labelled A, B and C.



1. Half-fill the beaker with water and place it on the hot plate (or gauze mat).
2. Place the three test tubes in the beaker.
3. Observe the order in which each substance begins to boil.
4. If a substance does not boil by the time the water boils, record its boiling point as “above the boiling point of water”.

In the investigation shown in the video the liquids were as follows:

A. acetone
B. ethanol
C. glycerine

PRACTICAL INVESTIGATION

Grade 11 Chemistry Practical:
Intermolecular forces

Intermolecular forces

PRACTICAL INVESTIGATION 62 MARKS

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Part 4: Boiling points: glycerine, acetone, methylated spirits
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1 large beaker
Hot plate or burner with tripod and gauze mat
Access to water

Intermolecular forces

Investigating the effects of intermolecular forces

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Part 1: Evaporation rate

Aim:

To investigate evaporation and to determine the relation between evaporation rate and intermolecular forces.

Substances: ethanol, water, acetone, methylated spirits

Method:

1. Place an evaporating dish onto each of four electronic mass meters placed in the same warm spot in the laboratory.
2. Zero each balance (so that it will only read the mass of the substance placed in the dish).
3. Measure 20 ml of each substance into each of the evaporating dishes.
4. Measure the mass of 20 ml of each substance.
5. After 6 minutes, measure the mass of each substance.

Results:

Substance	Mass before (g)	Mass after 6 minutes (g)	Change in mass (g)	%Change in mass (%)	Ranking of evaporation rate (1 = fastest; 4 = slowest)
Ethanol					
Water					
Acetone					
Methylated spirits					

(12)

Conclusion: **(4)**

Part 2: Surface tension

Aim:

To investigate surface tension and to determine the relation between surface tension and intermolecular forces

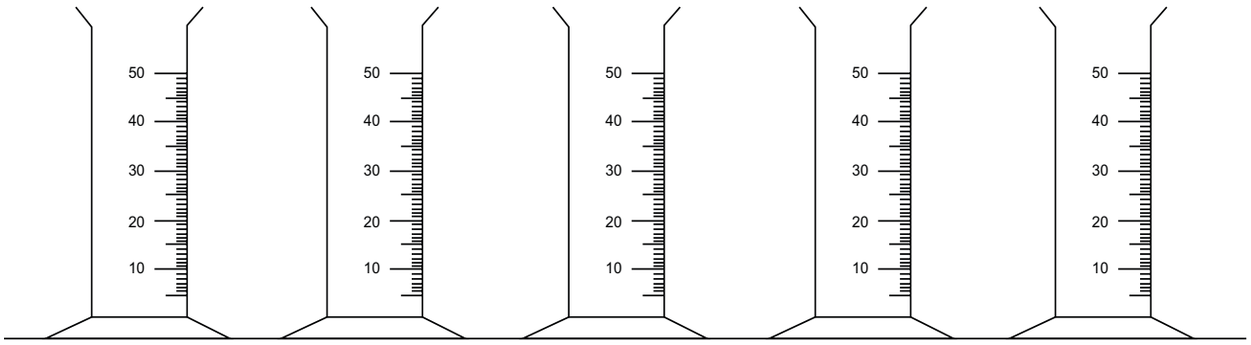
Substances: water, cooking oil, glycerin, acetone, methylated spirits

Method: Place about 50 ml of each substance into separate small measuring cylinders.

1. Observe the shape of the meniscus. (This is the level of the liquid). Note what happens at the edges where the liquid touches the glass. (You can place a few drops of food colouring in each substance to help you see the meniscus more clearly.)
2. Now place a drop of the substance on a small piece of glass. Observe the shape of the drop.

Results:

For each substance draw the shape of the meniscus. **(5)**



Water Cooking oil Glycerine Acetone Methylated spirits

For each substance draw the shape of the droplet, and the side view of the droplet's shape.

SHAPE

Water	**Cooking oil**	**Glycerine**	**Acetone**	**Methylated spirits**

SIDE VIEW **(10)**

Background information: Glass is a polar substance.

2.1 Which substance is most strongly attracted to glass? Justify your answer with reference to the observations. **(4)**

2.2 Rank the substances **in increasing order** of surface tension. Justify your answer. **(4)**

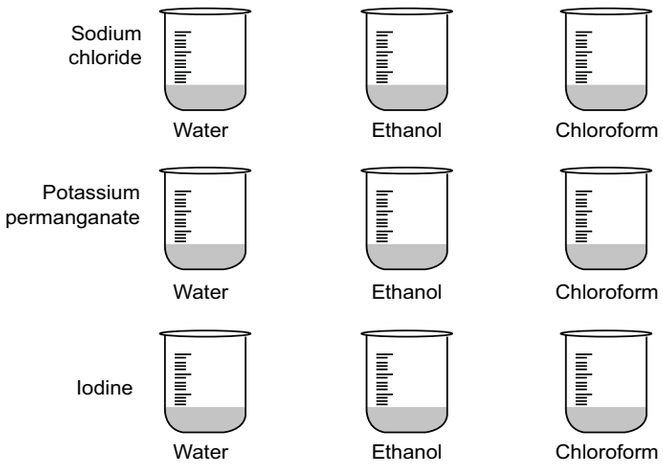
Part 3: Solubility

Aim:

To investigate solubility and to determine the relation between solubility and intermolecular forces.

Precaution:

Chloroform is a volatile solvent. Its fumes cause drowsiness. It is unsafe to allow these fumes to be inhaled by anyone for even short periods of time. Work with chloroform in a well-ventilated space e.g. outdoors, or in a protected space such as a fume cupboard.



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3. Into the first set of beakers add about 2 g of sodium chloride.
4. Into the second set of beakers add two or three crystals of potassium permanganate.
5. Into the third set of beakers add one or two pieces (or crystals) of iodine.
6. Stir the contents of each beaker four times (using a clean stirring rod each time).
7. Wait about a minute then observe what happens to the contents of each beaker.

Results:

Record your results in the table below. If you observe only a small amount of the solid dissolving, then write that very little solid dissolved. If the entire solid dissolves, then write that all the solid dissolved. **(9)**

Substance	Water	Ethanol	Chloroform
Sodium chloride			
Potassium permanganate			
Iodine			

3.1 Classify the solutes as ionic or molecular, and polar or non-polar. **(2)**

Substance	Ionic or molecular	Polar or non-polar
Sodium chloride		
Potassium permanganate		
Iodine		

Conclusion: **(3)**

Part 4: Boiling point

Aim:

To investigate boiling point and to determine the relation between boiling point and intermolecular forces

Warning:

Methylated spirits and acetone are highly flammable. They will easily catch fire if left near an open flame. For this reason, they must be heated in a water bath. This experiment MUST be performed in a well-ventilated room. The fumes from methylated spirits and acetone are toxic.

Note:

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2. Since we are using a water bath to heat the substances, we can measure (or compare) the temperature at which water boils. Therefore, we are testing three liquids: acetone, ethanol and glycerine.

3. The water bath can be heated using a hot plate, or by using a burner, tripod and gauze mat.
4. If you have access to a digital thermometer, place the probe in the water bath so that you can read the approximate temperature at which each substance (A, B and/or C) begins to boil.

Method:

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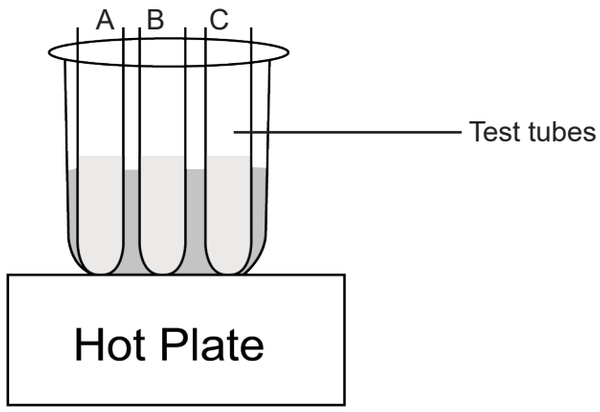

1. Half-fill the beaker with water and place it on the hot plate (or gauze mat).
2. Place the three test tubes in the beaker.
3. Observe the order in which each substance begins to boil.
4. If a substance does not boil by the time the water boils, record its boiling point as “above the boiling point of water”.

Results:

4.1 Write down the boiling points of these liquids.

Glycerin …….. Acetone ……. Ethanol ……. **(1)**

4.2 In which order did the liquids boil? Write down the labels A, B or C.

1st ……. 2nd …… 3rd …….. **(2)**

4.3 Identity the substances.

A ……..…

B ……..

C …….. **(2)**

4.4 How are the intermolecular forces inside a substance related to its boiling point? Justify your answer.

_____

_____

_____

_____ (4)

PRACTICAL INVESTIGATION MEMORANDUM

Grade 11 Chemistry Practical: Intermolecular forces

62 Marks

PRACTICAL INVESTIGATION MEMORANDUM 62 MARKS

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Part 1: Evaporation rate

Aim:

To investigate evaporation and to determine the relation between evaporation rate and intermolecular forces

Results:

Substance	Mass before (g)	Mass after 6 minutes (g)	Change in mass (g)	%Change in mass (%)	Ranking of evaporation rate (1 = fastest; 4 = slowest)
Ethanol	15,4	14,2	1,2✓	7,8✓	2✓
Water	19,3	19,0	0,3✓	1,6✓	4✓
Acetone	15,1	11,6	3,5✓	23,2✓	1✓
Methylated spirits	16,2	15,0	1,2✓	7,4✓	3✓

(12)

Conclusion: **(4)**

- The intermolecular forces between the molecules of acetone are the weakest. ✓
- At the same temperature more acetone molecules were able to break free (evaporate) from the surface of the liquid. ✓
- The other three substances (liquids) each have strong hydrogen bonds ✓ between their molecules, so it takes more energy for molecules to break free of the liquid surface. ✓

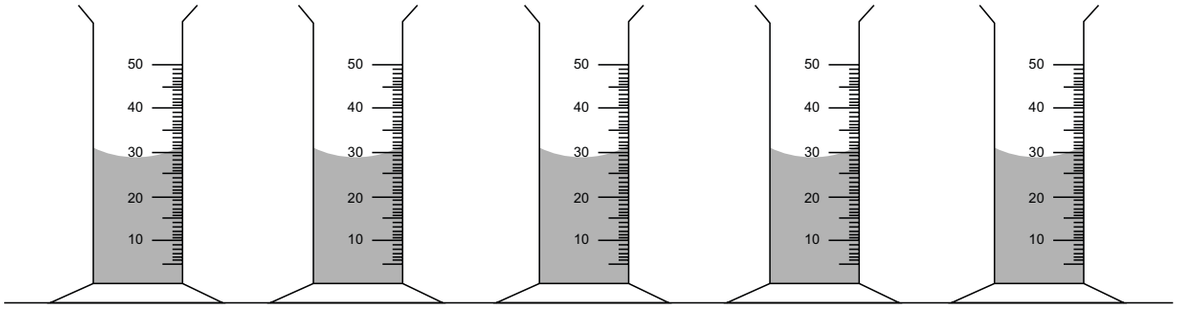
Part 2: Surface tension

Aim:

To investigate surface tension and to determine the relation between surface tension and intermolecular forces

Results:

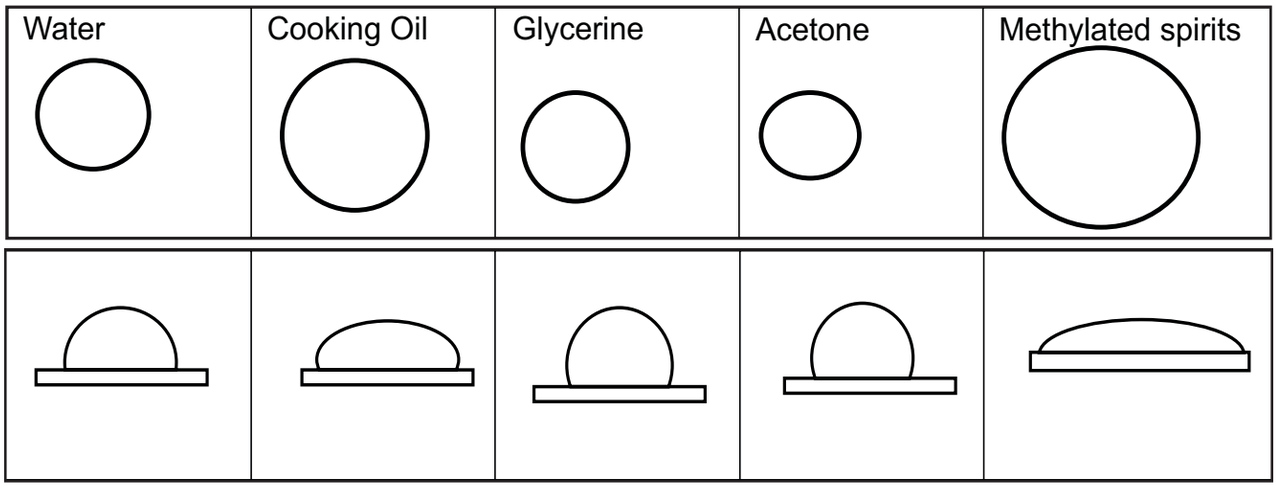
For each substance draw the shape of the meniscus. **(5)**



Water Cooking oil Glycerine Acetone Methylated spirits

For each substance draw the shape of the droplet, and the side view of the droplet's shape.

SHAPE [One ✓ each]



SIDE VIEW [One ✓ each] **(10)**

Background information: Glass is a polar substance.

2.1 Which substance is most strongly attracted to glass? Justify your answer with reference to the observations. **(4)**

Water ✓ is most strongly attracted to glass because it has the **most concave meniscus** ✓ and one **of the flattest water droplets**. ✓ Because water is **a polar solvent and glass is also a polar substance**, ✓they are strongly attracted to each other.

2.2 Rank the substances **in increasing order** of surface tension. Justify your answer. **(4)**

Cooking oil ✓
Acetone✓
Glycerine
Methylated spirits
Water ✓

Cooking oil is a non-polar substance with the weakest intermolecular (or cohesive) forces between its molecules. ✓ [The learners could discuss the shape of cooking oils droplets to prove that oil is non-polar].

Part 3: Solubility

Aim:

To investigate solubility and to determine the relation between solubility and intermolecular forces.

Results:

[One ✓ each; Some learners may record colour and appearance of mixture – that's fine. They MUST state whether the solute dissolved or not as shown in these answers to gain the mark.] **(9)**

Substance	**Water**	**Ethanol**	**Chloroform**
Sodium chloride	All the solid dissolved	Very little solid dissolved (OR also accept) No solid dissolved	No solid dissolved
Potassium permanganate	All the solid dissolved	Very little solid dissolved	No solid dissolved
Iodine	No solid dissolved	Some solid dissolved to form a yellow brown solution	Some solid dissolved to form a purple (pink) solution

3.1 Classify the solutes as ionic or molecular, and polar or non-polar. **(2)**

Substance	**Ionic or molecular** [✓ all correct]	**Polar or non-polar** [✓ all correct]
Sodium chloride	ionic	polar
Potassium permanganate	ionic	polar
Iodine	molecular	non-polar

Conclusion: **(3)**

Ionic solutes dissolve in water because these are both polar substances. ✓

Ethanol can act as a polar and a non-polar solvent because it dissolves both polar and non-polar substances. ✓

Chloroform acts as a non-polar solvent even though it has a slightly polar molecule.✓

Part 4: Boiling point

Aim:

To investigate boiling point and to determine the relation between boiling point and intermolecular forces.

Results:

4.1 Write down the boiling points of these liquids.

Glycerine: 290oC Acetone: 57oC Ethanol: 79oC ✓ **(1)**

4.2 In which order did the liquids boil? Write down the labels A, B or C.

1st A ✓ 2nd B 3rd C ✓ **(2)**

[Any two in correct order]

4.3 Identity the substances.

A Acetone ✓

B Ethanol

C Glycerine ✓

[Any two in correct order c.o.e. from 4.2] **(2)**

4.4 How are the intermolecular forces inside a substance related to its boiling point? Justify your answer.

The stronger the intermolecular forces ✓ the higher the boiling point of the liquid. ✓

Acetone has the weakest intermolecular forces✓ and it has the lowest boiling point. ✓ **(4)**