Teacher Resource Bank

GCE Chemistry

PSA5: AS Physical Chemistry

- Determine the M_r of a Volatile Liquid

AS Physical Chemistry

PSA5 Determine the M_r of a volatile liquid

TECHNICAL SHEET

To determine the M_r of a volatile liquid

Whenever possible, students should work individually.
If it is essential to work in a pair or in a small group, because of the availability of apparatus, supervisors must be satisfied that they are able to assess the contribution from each student to the practical activity.

Requirements

- tall beaker (500 cm^3) as a water bath
- gas syringe with self-sealing cap
- hypodermic syringe
- thermometer (- 10 ^oC to 110 ^oC)
- hexane (b.p. 69 ^oC)
- tripod, gauze and Bunsen burner
- balance (preferably to a precision of at least 2 d.p.)

The hypodermic syringes should have a plastic cover for safety and students need to be advised about the need for care in handling them.

Centres are expected to carry out and be responsible for their own safety risk assessments.

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Student Sheet

It is the responsibility of the student to carry out and be responsible for their own safety risk assessment before carrying out this experiment. Wear safety glasses at all times. Assume that all of the reagents and liquids are toxic, corrosive and flammable.

The relative molecular mass of a volatile liquid can be determined by measuring the volume of vapour produced from a measured mass of the volatile liquid under known conditions of temperature and pressure.

Experiment

a) Draw approximately 5 cm^3 of air into a gas syringe so that the initial volume reading corresponds to the first division on its barrel.
b) Put the rubber self-sealing cap over the nozzle and ensure that the plunger of the syringe is unable to move in or out.
c) Immerse the sealed gas syringe in a hot water bath. Record the temperature of the water bath and measure the volume of the trapped air at that temperature. (Check the boiling point of the volatile liquid and ensure that the temperature of the water bath is at least 10 ^oC higher)
d) Weigh a hypodermic syringe containing a small volume of the volatile liquid (approximately 1 cm^3), together with its cover.
e) Lift the gas syringe out of the water bath and carefully inject approximately 0.2 cm^3 of the volatile liquid through the rubber self-sealing cap into the air space in the gas syringe.
f) Reweigh the hypodermic syringe and its cover. Record this mass and calculate the mass of volatile liquid used.
g) Return the gas syringe to the water bath and allow it to equilibrate in the water bath at the known temperature and record the new total volume. Subtract the volume of air from this total volume to obtain the volume of vapour formed.
h) Flush out the vapour and air from the syringe and repeat the experiment to obtain a second set of results.
i) Make certain that you produce a clear and organised set of results, before proceeding to the next stage. Give due regard to units and to the precision of the readings.
j) For both sets of results, calculate the M_r of the volatile liquid.

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Analysing the data

You should be familiar with the ideal gas equation

$$pV = nRT$$

- Calculate the mass of volatile liquid vaporised (m) in grams
- Measure atmospheric pressure if you are able, but otherwise, assume that atmospheric pressure is 100 kPa
- Convert the temperature to Kelvins by calculating $T = (T\,^{o}C + 273)$ K
- The gas constant, $R = 8.31$ J K^{-1} mol^{-1}
- Convert the volume of vapour formed in the gas syringe into m^3 by calculating ($cm^3 \times 10^{-6}$)

Use these data to calculate the number of moles of vapour

We know that $pV = nRT$

and the number of moles is given by $n = m/M_r$

Therefore $pV = mRT/M_r$

When this relationship is rearranged, it can be used to calculate the relative molecular mass of the volatile liquid.

$$M_r = mRT/pV$$

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TEACHER NOTES AND MARKING GUIDANCE

The specific marking guidance in the specification is as follows

2 marks: All areas of the task are carried out competently.
The apparatus is weighed precisely and handled carefully.
The transfer of liquid or gas is carried out safely and with due care.
The apparatus is equilibrated and all necessary measurements taken.

1 mark: One of the areas of the task is performed poorly.
The apparatus is weighed imprecisely or handled without due care **OR**
The transfer of liquid or gas is not carried out safely or with due care **OR**
The apparatus has not equilibrated or some measurements are not taken.

0 marks: At least two of the areas of the task are performed poorly.
The apparatus is weighed imprecisely or handled without due care.
The transfer of liquid or gas is not carried out safely or with due care.
The apparatus has not equilibrated or some measurements are not taken.

Guidance for Teachers and Students

Teachers are expected to exercise professional judgement in assessing the competence of their candidates in following the instructions.

Candidates should have been given guidance in the correct use of equipment and this guidance **can continue during the practical session** for which this PSA forms a part.

If, however, the guidance required is fundamental or frequent, then the student should **not** be awarded 2 marks.

Judgement of 2 marks, 1 mark or 0 marks will depend on whether the candidate has carried out the activity safely, particularly with regard to handling the gas syringe and the hypodermic syringe.

Students should not be judged on their ability to apply the ideal gas equation nor on their ability to calculate values for the relative molecular mass of hexane. They should be judged on their ability to follow the instructions and to carry out the practical task which leads to the production of a valid set of results. It is unlikely that the results are very reliable but this provides a useful opportunity to discuss the limitations in the technique and how it might be improved.

It is important to remember when marking these practical exercises that PSA is about student competence and that for a student to score full marks on this exercise **perfection is neither expected nor required**.