REAL GASES AND CRITICAL POINT

EXPERIMENT PROCEDURE

- **Observing sulphur hexafluoride in both the liquid and gaseous states.**
- **Plotting isotherms in a *p-V* diagram and a *pV-p* diagram.**
- **Observing how the behaviour of real gases deviates from that for the ideal gas state.**
- **Determining the critical point.**
- **Plotting pressure curves for a saturated vapour.**

OBJECTIVE

Quantitative analysis of a real gas and determining its critical point.

SUMMARY

Sulphur hexafluoride (SF_6) serves as a real gas and is examined in a measurement cell with only a minimal dead volume. Sulphur hexafluoride is especially suitable for this experiment, as its critical temperature (T_C = 319 *K*) and its critical pressure (p_C = 37.6 bar) are both relatively low. It is also non-toxic and is quite safe for use in teaching and in practical classes.

REQUIRED APPARATUS

Quantity	Description	Number
1	Critical Point Apparatus	**1002670**
1	Immersion/Circulation Thermostat (230 V; 50/60 Hz)	**1008654** or
	Immersion/Circulation Thermostat (115 V; 50/60 Hz)	**1008653**
1	Digital Quick Response Pocket Thermometer	**1002803**
1	K-Type NiCr-Ni Immersion Sensor, -65°C – 550°C	**1002804**
2	Tubings, Silicone 6 mm	**1002622**

Additionally required:
Sulphur hexafluoride (SF_6)

NOTE

In accordance with the principles of good laboratory practice, it is recommended that the gas connections should be made by rigid metal pipework, especially if the critical point apparatus is to be used regularly. For connecting to an appropriate gas cylinder, use the 1/8“ (SW 11) threaded pipe connector that is supplied.

BASIC PRINCIPLES

The critical point of a real gas is characterised by the critical temperature T_C, the critical pressure p_C, and the critical density ρ_C. Below the critical temperature, the substance is gaseous at large volumes and liquid at small volumes. At intermediate volumes it can exist as a liquid-gas mixture, in which changing the volume under isothermal conditions causes a change of state: the gaseous fraction increases as the volume is increased, while the pressure of the mixture remains constant. As the liquid and the vapour have different densities, they are separated by the gravitational field. As the temperature rises, the density of the liquid decreases and that of the gas increases until the two densities converge at the value of the critical density. Above the critical temperature, the gas can no longer be liquefied. However, under isothermal conditions the gas does not obey Boyle's Law until the temperature is raised considerably above the critical temperature.

Sulphur hexafluoride (SF_6) is especially suitable for investigating the properties of real gases, as its critical temperature (T_C = 319 *K*) and its critical pressure (p_C = 37.6 bar) are both relatively low. It is also non-toxic and is quite safe for use in teaching and in practical classes.

The apparatus for investigating the critical point consists of a transparent measurement cell, which has very thick walls and can withstand high pressures. The internal volume of the cell can be changed by turning a handwheel, which allows one to make fine adjustments and can be read with a precision down to 1/1000 of the maximum volume. Pressure is applied by a hydraulic system using castor oil of pharmacological quality. The hydraulic system is separated from the cell by a conical rubber seal, which rolls up when the volume is changed. This form of construction ensures that the pressure difference between the measurement cell and the oil space is practically negligible. Therefore, instead of measuring the gas pressure directly, a manometer measures the oil pressure, which avoids having a dead volume in the gas space. The measurement cell is enclosed within a transparent water jacket. During the experiment a thermostatic water bath maintains a precisely controlled and adjustable constant temperature, which is measured by a digital thermometer.

During observations of the transition from the gaseous to the liquid phase and the reverse process, the fact that there is very little dead volume makes it possible to observe the formation of the first drop of liquid or the disappearance of the last bubble of gas.

EVALUATION

The pressure as a function of the volume is measured point-by-point at constant temperature, and the results are plotted as a *p-V* diagram (Clapeyron diagram) and as a *pV-p* diagram (Amegat diagram). The deviation from the behaviour of an ideal gas is immediately obvious and striking.

From the diagrams, the parameters of the critical point can easily be determined, and it is possible to obtain a clear experimental verification of the behaviour of a real gas.

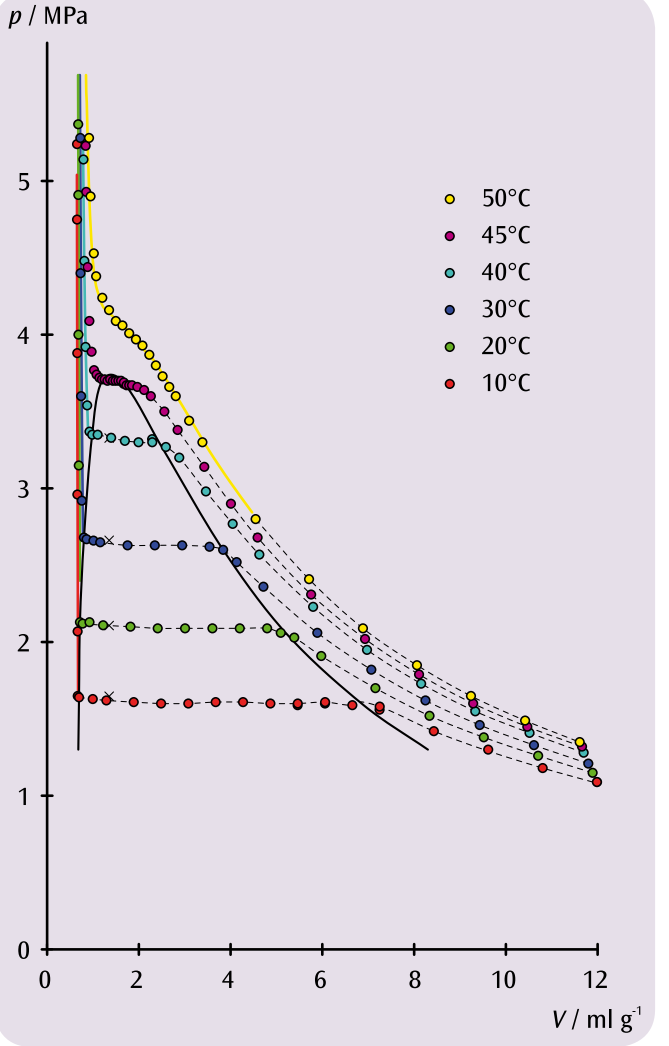

Fig. 1: *p-V* diagram of sulphur hexafluoride