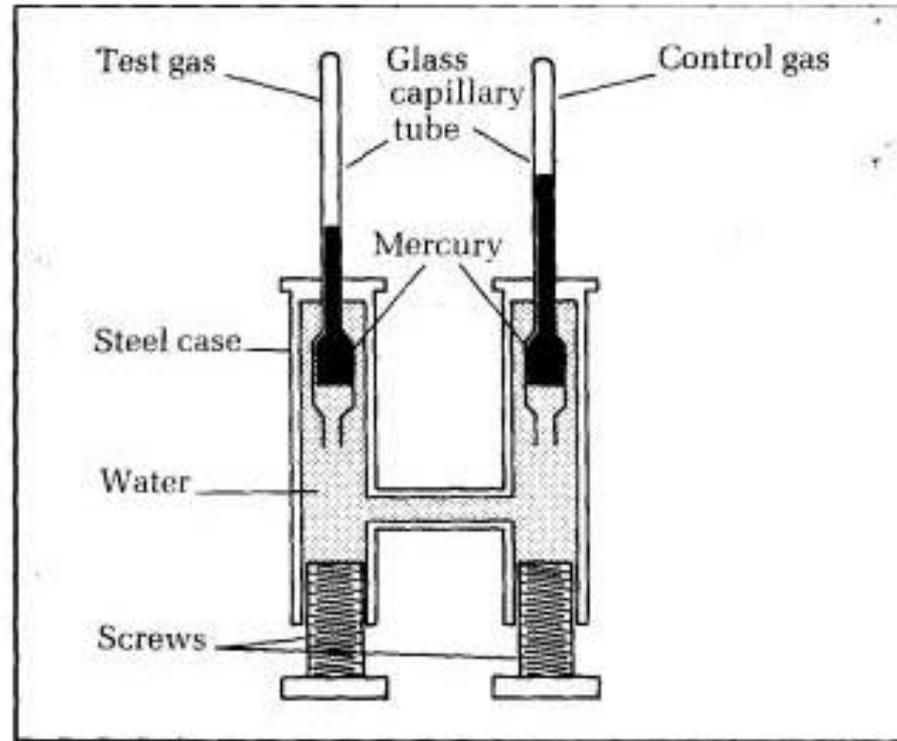


Andrews' experiments

- Liquefaction of gases was investigated by Thomas Andrews in 1863
- Devised apparatus

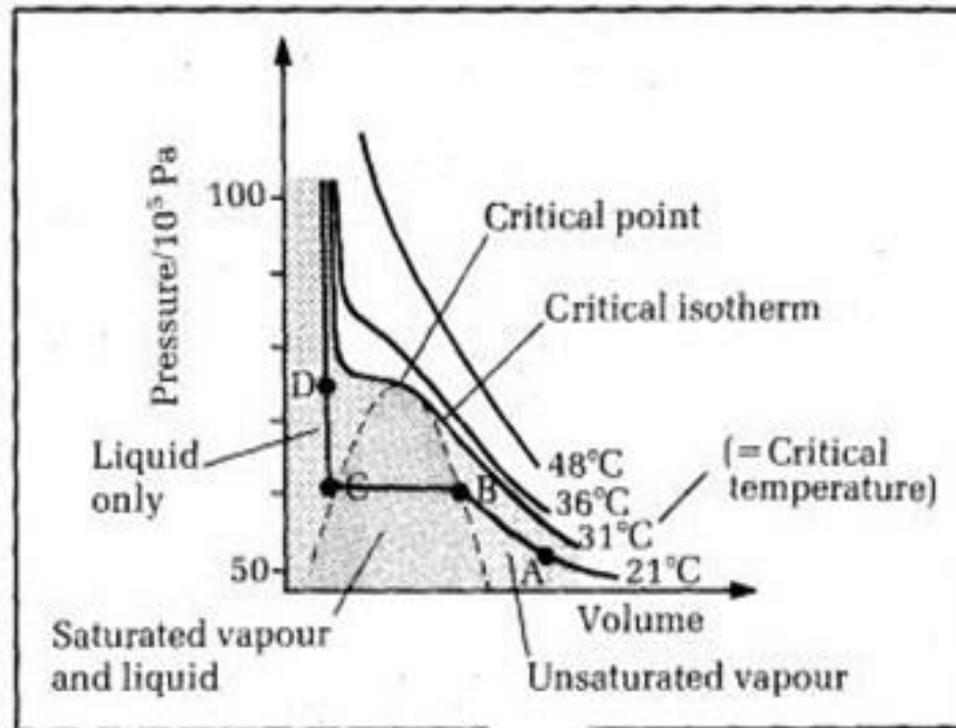


- Two capillary tubes sealed at the upper ends project vertically from a steel casing

- Top part of one of the tubes contained gas carbon dioxide trapped by a thread of mercury
- Top of the other tube contained dry air
- Mercury in each tube was held in by the water pressure in the casing
- The pressure could be increased by turning the screws
- Each tube was in its own water bath, the control bath at room temperature and the carbon dioxide bath at a temperature which could be changed
- Volume of gas per mm length was measured before installing the tubes in the casing
- With CO_2 gas at constant temperature, the pressure was increased in steps

- At each step, the length of each gas column was measured and the volume of each gas could be determined
 - Since air obeys Boyle's law, its pressure could be calculated from its volume
 - Because CO_2 was at the same pressure as the control gas at each step, its pressure was calculated
- Using Boyle's law
- So Andrews was able to obtain readings of pressure and volume at different constant temperatures for a fixed mass of test gas

- Figure shows **isotherms** of p against V
- The state of the CO_2 depends on its pressure, volume and temperature.
- The liquid state can only exist at or below the critical temperature



- *The critical temperature T* is the temperature above which no liquid can form, no matter how great the pressure of the gas is
- *The critical isotherm* is the isotherm at the critical temperature.
- Isotherms below the critical temperature are flat over a range of volume
- At A, the CO_2 is an unsaturated vapour since no liquid is present
- If the volume is now reduced, the pressure rises to point B

- At B, the CO_2 vapour is just saturated
- Further reduction of the volume causes the saturated vapour to liquefy
- At C, the CO_2 , is entirely liquid and the pressure rises sharply from C to D
- Above the critical isotherm, no liquid is present so there are no flat parts on the curves.