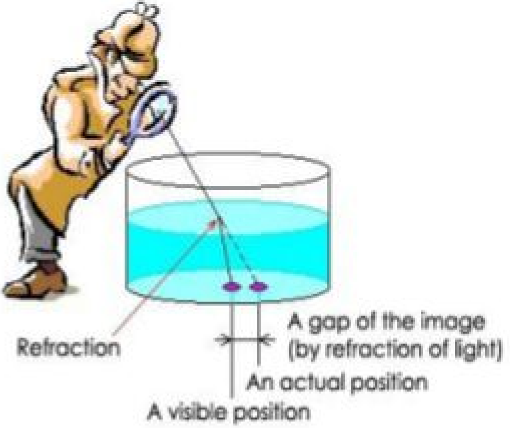

Liquid State

Refractive index ???

- The refractive index or index of refraction of a substance is a measure of the speed of light in that substance. It is expressed as a ratio of the speed of light in vacuum relative to that in the considered medium.



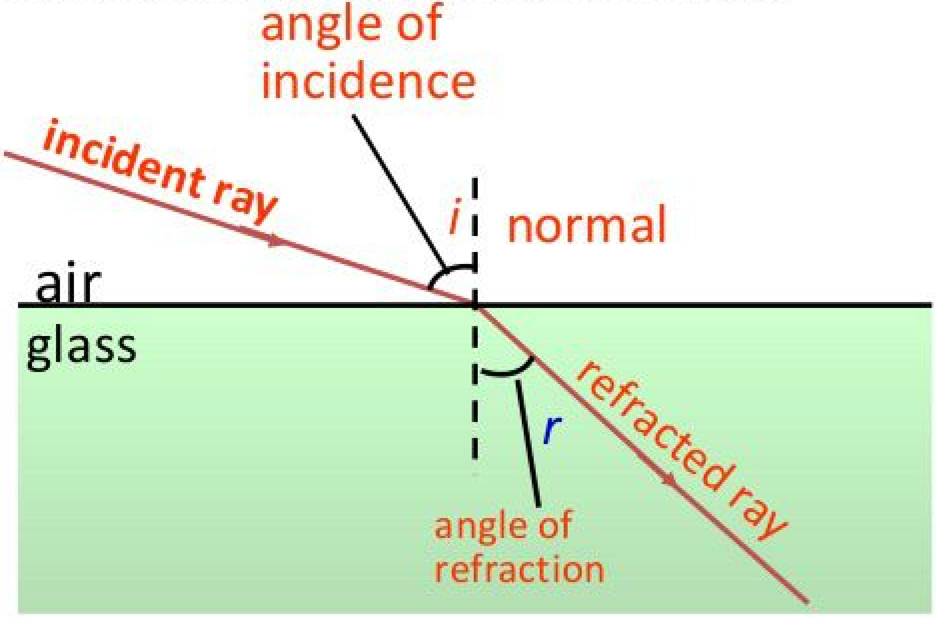
A simplified, mathematical description of refractive index is:

n = velocity of light in a vacuum / velocity of light in medium

Hence, the refractive index of water is 1.33, meaning that light travels 1.33 times as fast in a vacuum than it does in water.

Refraction is the bending of light when the light passes from one medium to another

Useful words to describe refraction of light



Refractive index

- refractive index $n = \dfrac{\sin i}{\sin r}$

  - e.g. for glass, $_{a}n_{g} = \dfrac{\sin \theta_a}{\sin \theta_g}$

  where

  a:air

  g: glass

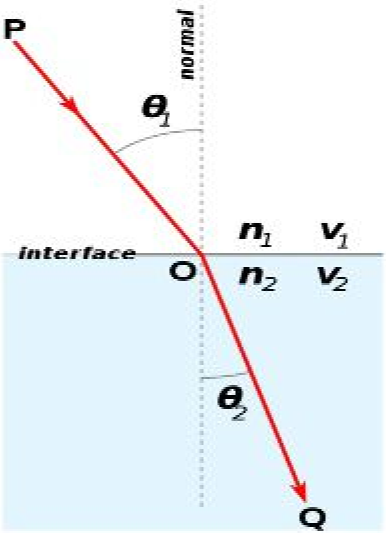
Laws of refraction

When the ratio of the sin i to sin r is constant.

i.e. $$\frac{\sin i}{\sin r} = \text{constant}$$

– This is called **Snell's law**.

Snell's law states that the ratio of the sines of the angles of incidence and refraction is equivalent to the ratio of velocities in the two media, or equivalent to the opposite ratio of the indices of refraction.



$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1}$$

v = velocity, SI units are m/s

n = refractive index, which is unitless

In general,

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

the law is used in ray tracing to compute the angles of incidence or refraction, and in experimental optics and gemology to find the refractive index of a material

Refractive indices of various liquids

Liquid	Refractive index
Glycerine	1.47
Paraffin oil	1.43
Turpentine	1.47
Water	1.34
Ethyl alcohol	1.35
Carbon tetrachloride	1.46
Petrol	1.44
Chloroform	1.43
Benzene	1.50

Instrumentation

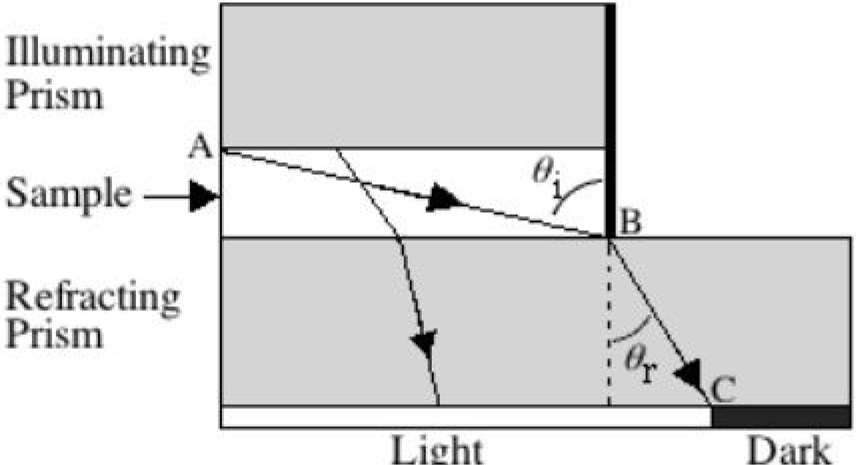
The instrument used to measure refractive index called Refractometer. There are four main types of refractometers:

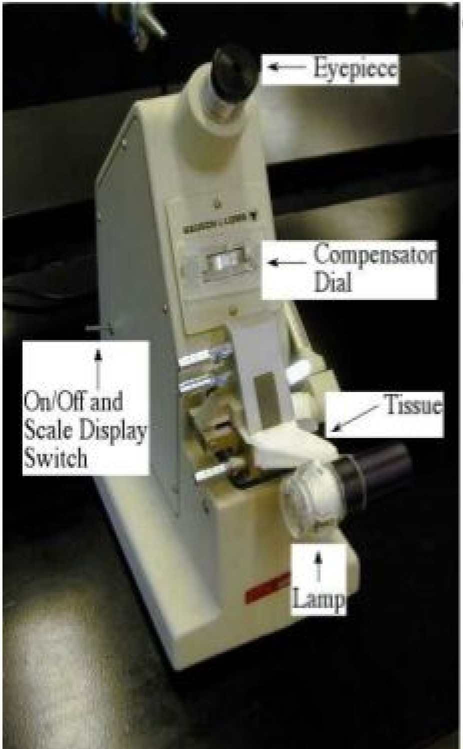
- laboratory or **Abbe refractometers**
- traditional handheld refractometers,
- digital handheld refractometers,
- inline process refractometers.

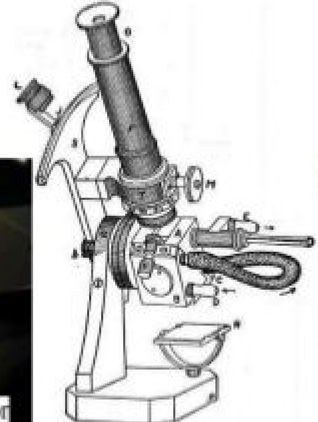
Most common instrument is the Abbe Refractometer having following advantages.

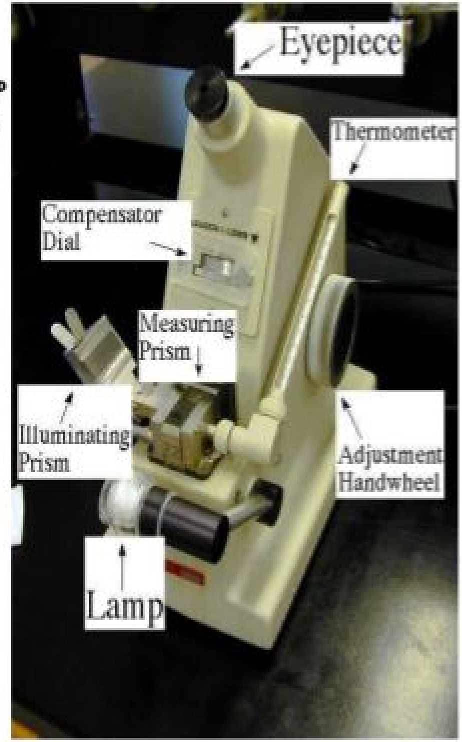
1. The index of refraction obtained is actually that for sodium D line.
2. The prisms can be temperature controlled.
3. Only a small sample is required (a few drop of liquid)

- In the Abbe' Refractometer the liquid sample is sandwiched into a thin layer between an illuminating prism and a refracting prism (Figure). The refracting prism is made of a glass with a high refractive index (e.g., 1.75) and the refractometer is designed to be used with samples having a refractive index smaller than that of the refracting prism.




Eyepiece
Compensator Dial
On/Off and Scale Display Switch
Tissue
Lamp




Eyepiece
Thermometer
Compensator Dial
Measuring Prism
Illuminating Prism
Adjustment Handwheel
Lamp

Traditional Abbe Refractometer

User obtains reading by lining up crosshairs, and reading graduations in the view. Note the external thermometer and the ports for circulating water.

Digital Display Abbe Refractometer

User still has to line up the crosshairs in the eyepiece, but the reading is displayed on the digital readout. Thermometer is now internal, but waterbath is still required for accurate measurements.

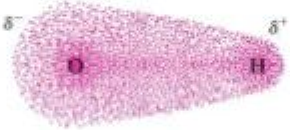
Why Refractive index is Important ?

- The refractive index of a material medium is an important optical parameter since it exhibits the **optical properties** of the material.
- Its values are often required to interpret various types of **spectroscopic data**. Such as DOAS, ES, RPFTS, IRRS,PWMS.
- It is used to calculate the focusing **power of lenses**, and the dispersive **power of prisms.**
- The refractive index coefficients are important parameters in the design of a **solid state laser**.
- The **adulteration** problem is increasing day by day and hence simple, automatic and accurate measurement of the refractive index of materials is of great importance these days.

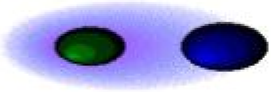
- **Refractive Index (RI) Detector** is designed for high-performance liquid chromatography (HPLC) applications. It provides sensitivity, stability, and reproducibility for the analysis of components with limited or no UV absorption

- Various methods and techniques for the measurement of refractive indices of liquids, solids and gases. Sensitive determination of the refractive indices of certain materials is very important in many fields of research such as material analysis and environmental pollution monitoring.

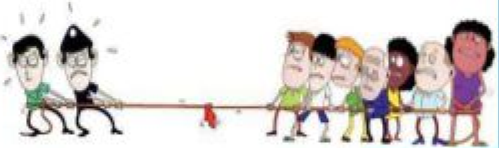
- Refractometric measurements are used for **qualitative analysis** for different type of packaging material like glass, plastics, rubber, silk etc.



DIPOLE MOMENT
AND
APPLICATION OF DIPOLE MOMENTS IN STUDY OF SIMPLE MOLECULE

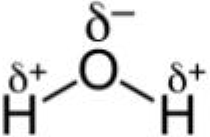


What is Polar molecule?

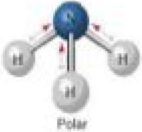


- A Polar Covalent Bond is *unequal* sharing of electrons between two atoms
- Polar bonds are form when there is a **different** between the **electronegativity** values of the atoms participating in a bond
- Electron density is distributed asymmetrically throughout the molecule

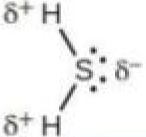
EXAMPLES :



NH3



H2S

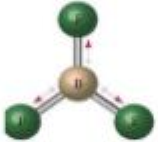


What is Non Polar molecule?

- A Polar covalent is ***EQUAL sharing of electrons between two atoms***
- Polar bonds are form when there is a **similar** the **electronegativity** values of the atoms participating in a bond.
- Electron density is distributed symmetrically within the molecule
- **EXAMPLE :**
- **H2** **Cl2** **BF3**
-

H–H

Cl—Cl



Classification of Bonds

You can determine the type of bond between two atoms by calculating the difference in electronegativity values between the elements

The bigger the electronegativity difference the more polar the bond.

Type of Bond	Electronegativity Difference
Nonpolar Covalent	0 → 0.4
Polar Covalent	0.5 → 1.9
Ionic	2.0 → 4.0

- A dipole moment is a quantity that describes two opposite charges separated by a distance

OR

The product of magnitude of negative or positive charge(q) and the distance between the centres of the positive and negative charges is called **dipole moment.**

It is usually donated by **μ.**

- Dipole moment is a vector quantity i.e. it has magnitude as well as direction.

- If a molecule has a dipole moment,then we call it "polar".

DRAW DIPOLE MOMENT

Dipole moment is a vector quantity and is represented by a small arrow with tail at the positive center and head pointing towards a negative center.

For example,

the dipole moment of HCl molecule is 1.03 D and the dipole of HCl may be represented as:

FORMULA

- A quantitative measures of the polarity of a bond its dipole moment. μ which is the product of the charge Q and the r is distance between the charges

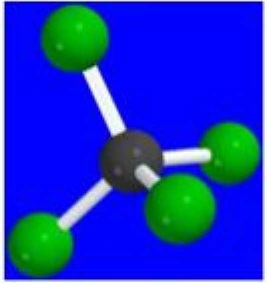
- $\mu = Q \times r$

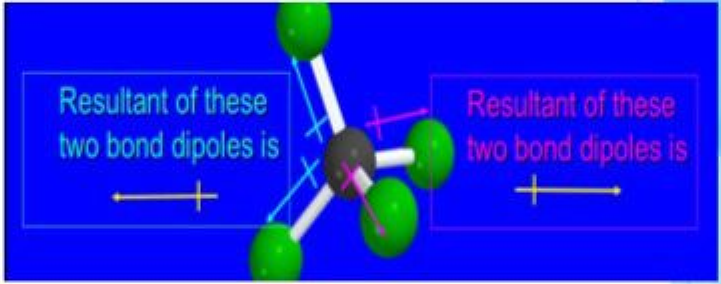
Q is charge of electron = $1.60217662 \times 10^{-19}$ coulombs

r is a distance

$1\ D = 3.335 \times 10^{-30}$ C m (SI units)

EXAMPLE

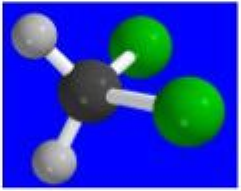


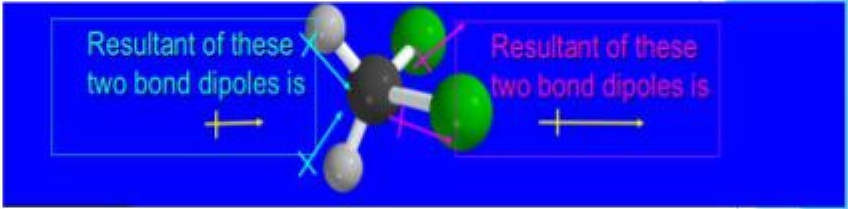


Carbon tetrachloride

μ = 0 D

Carbon tetrachloride has no dipole moment because all of the individual bond dipoles cancel.





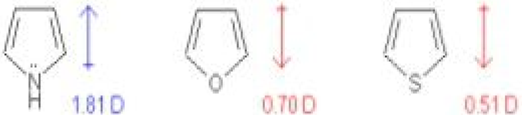
μ = 1.62 D

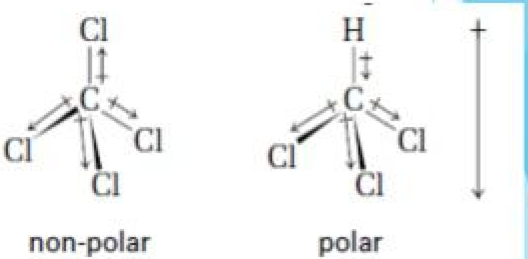
The individual bond dipoles do not cancel in dichloromethane; it has a dipole moment.

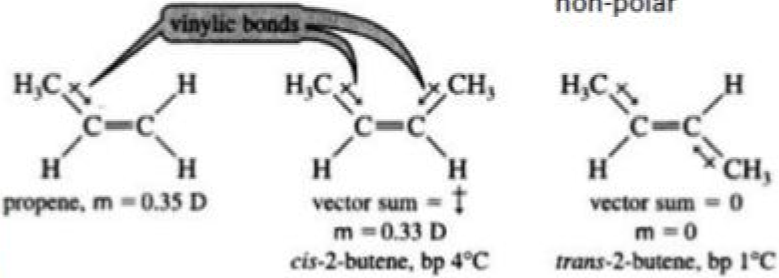
Greater the electronegativity difference between the bonded atom, greater if the dipole moment.

Dipole moment of hydrogen halides are in the order :

H-F > H-Cl > H-Br > H-I







APPLICATION

1) In determining the polarity of bonds :

Greater is the magnitude of *dipole moment,higher* will be the *polarity of the bond.*
This is applicable to molecules containing only one polar bond.
In case of non-polar molecules like H_2 , O_2, N_2 etc, the dipole moment is found to be zero .
This is because there is no charge separation in these molecules.

2) In determining the symmetry of the molecules

If any molecule possesses *two or more polar bonds* ,it will not be symmetrical if it possesses some molecular dipole moment.

Water μ= 1.84 D
H_2S μ = 0.95 D
NH_3 μ=1.47 D

If a molecule contains a number of similar atoms linked to the central atom and the overall dipole moment of the molecule is found to be zero ,this will imply that the molecule is symmetrical.

For Ex: BF_3 , CH_4 , CCl_4

4) To distinguish between cis and trans isomer

Cis isomer usually has *higher dipole* moment than trans isomer

5)To distinguish between Ortho, meta and para isomers

The *dipole moment of para isomer is zero* and that of ortho is greater than that of meta.

Questn 2

From the following identify the dipole molecules?

PF_5

CCl_4

CO

SCl_4

SCl_6

BF_3

NF_3

dipoles:

CO, NF_3, SCl_4

No dipoles:

PF_5, SCl_6, CCl_4, BF_3

Viscosity

Viscosity η is the resistance of liquid to flow under stress

Types

- Absolute (Dynamic) Viscosity
- Kinematic Viscosity

Viscosity

- Viscosity is the measure of the internal friction of a fluid.
- This friction becomes apparent when a layer of fluid is made to move in relation to another layer.
- The greater the friction, the greater the amount of force required to cause this movement, which is called sheer.
- Shearing occurs whenever the fluid is physically moved or distributed, as in pouring, spreading, spraying, mixing, etc.
- Highly viscous fluids, therefore, require more force to move than less viscous materials.

Terminologies

- *Shear: is the movement of material relative to parallel layer.*
- *Shear stress (F) is the force applied per unit* Area to make liquid flow (Force/Area)
- *Shear rate (G) difference in velocity dv,* between two planes of liquids separated by distance dr (i.e. dv/dr)

$$G = \frac{dv}{dr}$$

Absolute (dynamic) viscosity

$$Viscosity(\eta) = \frac{F}{G}$$

- The fundamental unit of viscosity measurement is the *poise*.
- *Shear force required to produce a velocity of 1 cm/sec between two parallel planes of liquid each 1cm^2 in area and separated by 1cm*

- Fluidity; it is the reciprocal of viscosity $Ø = 1/\eta$

its unit *is* inverse poise.

Kinematic Viscosity

It is the absolute viscosity divided by the density of liquid at a specified temperature

$$Kinematic\ Viscosity = \frac{\eta}{\rho}$$

Where ρ is the density of the liquid

The unit is Stock (s) or centistock (cs)

EXPERIMENT:

TO DETERMINE THE VICOSITY OF A LIQUID USING OSTWALD VISCOMETER.

APPARATUS:

Ostwald viscometer, 10ml Pipette, Stop watch, Analytical balance.

PROCEDORE:

- First of all, wash and dry viscometer and other apparatus.
- Take empty gravity bottle and weight it.
- Fill the gravity bottle with water and then with ethanol.
- Weight the filled gravity bottle and calculate densities of water and ethanol.
- Take 20ml water and put it in viscometer, suck water up to the upper mark and then note time (t_w) taken by water to reach the lower mark of viscometer.
- Take 20ml of ethanol in viscometer and note the time (t_l) taken as for water.
- Use the following formula to calculate the viscosity of ethanol.

$$\eta_l = \frac{d_l t_l}{d_w t_w} \times \eta w$$

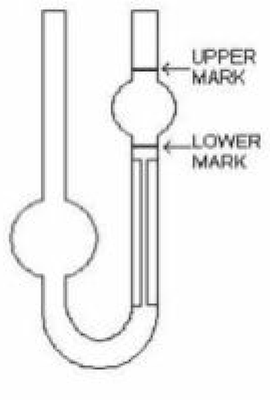


Fig: Ostwald viscometer.

CALCULATIONS:

For density of ethanol (d_l):

Mass of empty gravity bottle (m_1) = 17.9g

Mass of filled gravity bottle (m_2) = 60.08g

Mass of ethanol (m) = m_2-m_1 = 42.18g

Volume of ethanol (v) = 50ml

Density of ethanol (dl) = m/v = 0.8404g/ml

Time taken by ethanol (t_l) = 131.55s

For density of water (d_w):

Mass of empty gravity bottle (m_1) = 18.25g

Mass of filled gravity bottle (m_2) = 69.85g

Mass of water (m) = m_2-m_1 = 51.6g

Volume of water (v) = 50ml

Density of water (dw) = m/v = 1.032g/ml

Time taken by water (t_w) = 57.5s

η_w (20°C) = 1.003 N.s/m^2

Now viscosity of ethanol:

$$\eta_l = \frac{d_l t_l}{d_w t_w} \times \eta w$$

$$\eta_l = \frac{0.8404 \times 131.5 \times 1.003}{1.032 \times 57.5}$$

$$\eta_l = 1.867 \text{ N.s/m}^2$$

PRECATIONS:

- All readings must be taken carefully.
- Same viscometer must be used for both liquids.
- Temperature must be constant during experiment.

OSTWLAD VISCOMETER:- I

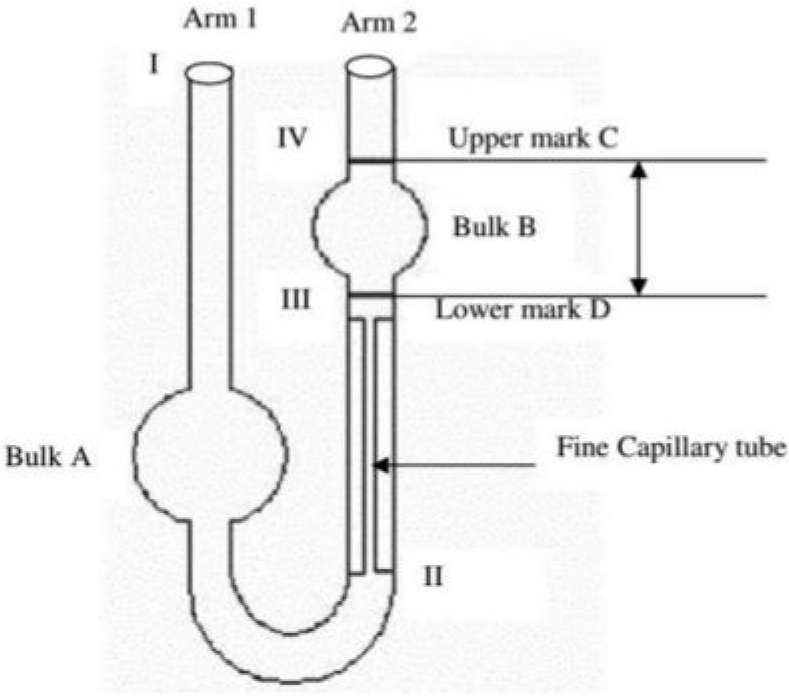


Fig. 1:- Ostwald Viscometer