Topic 3B - The Gas Laws
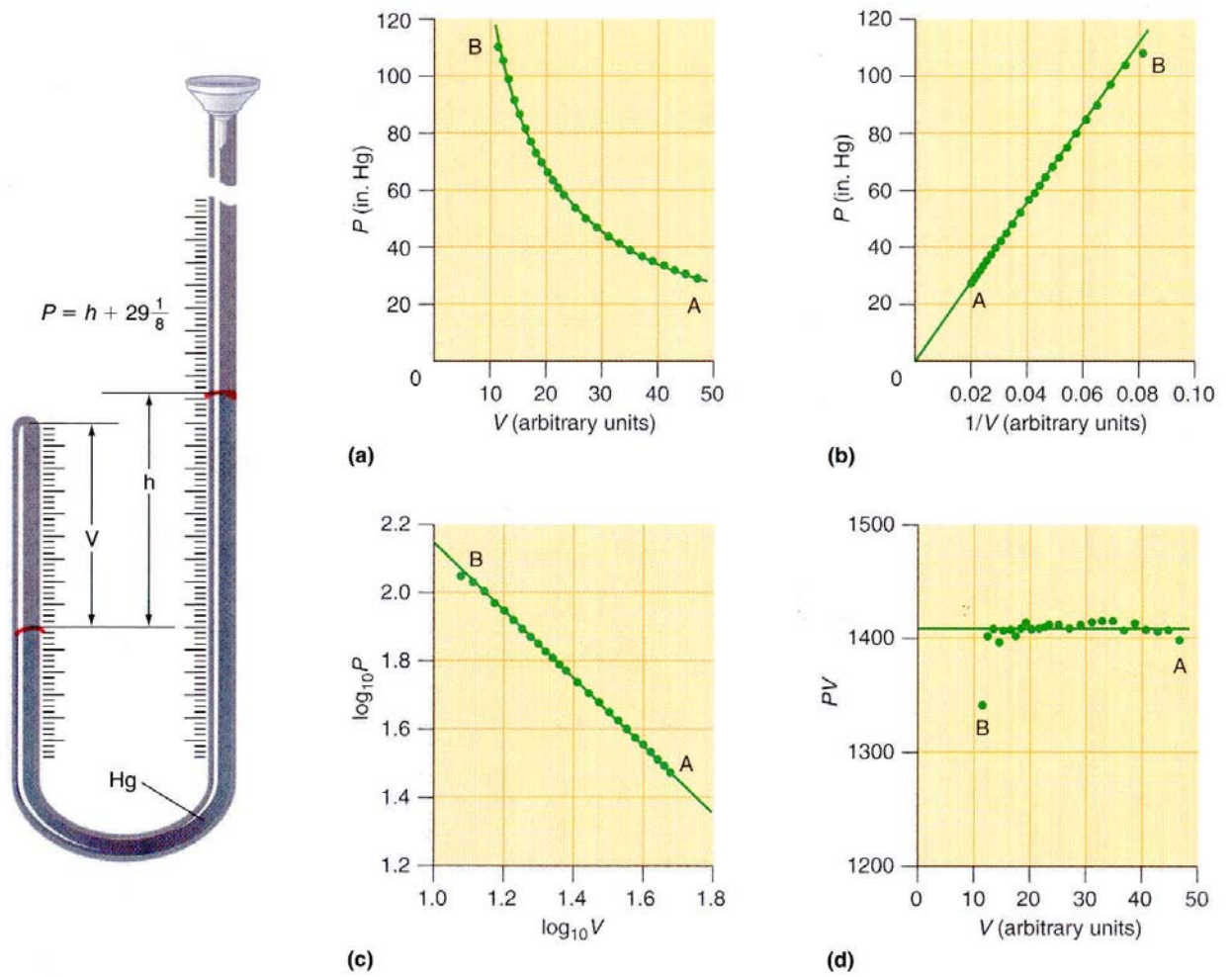
Figure 9.3: Robert Boyle's J-tube
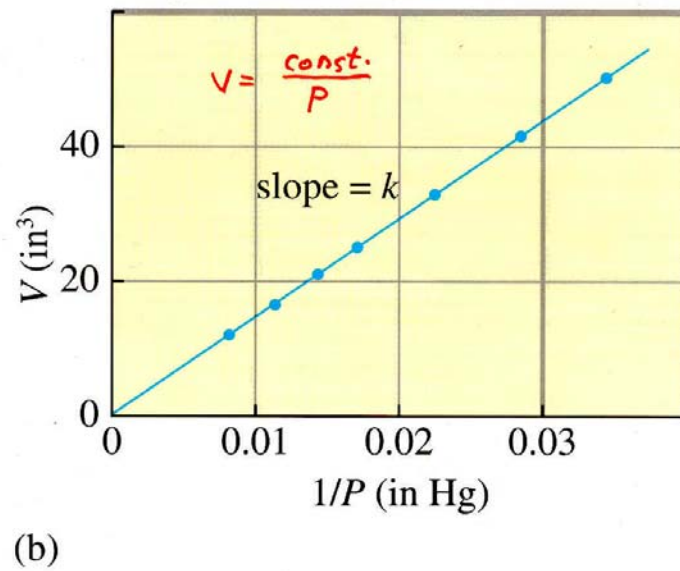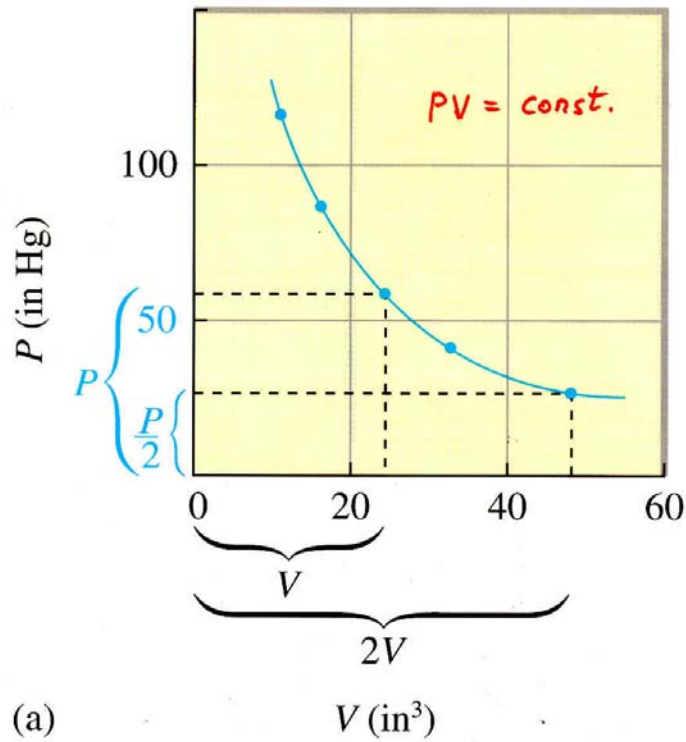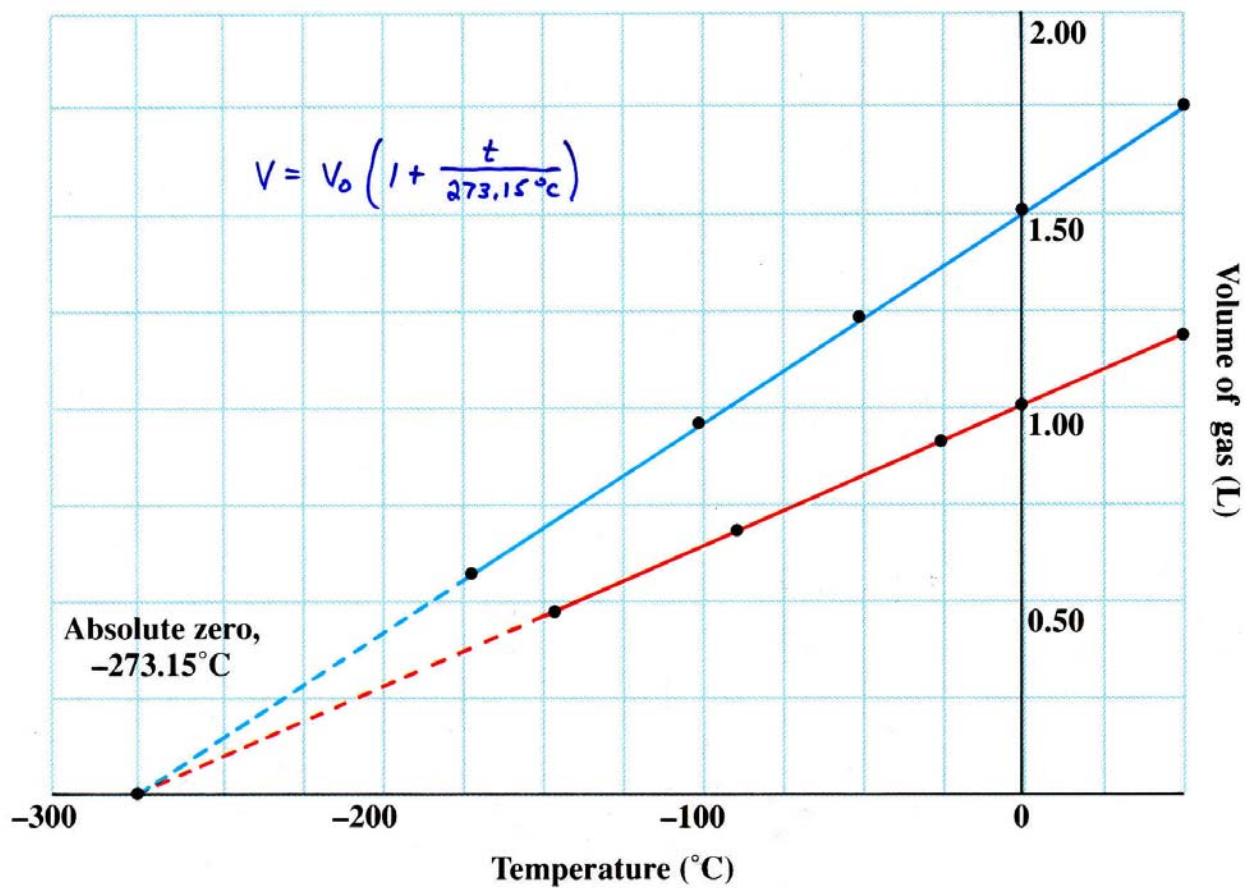
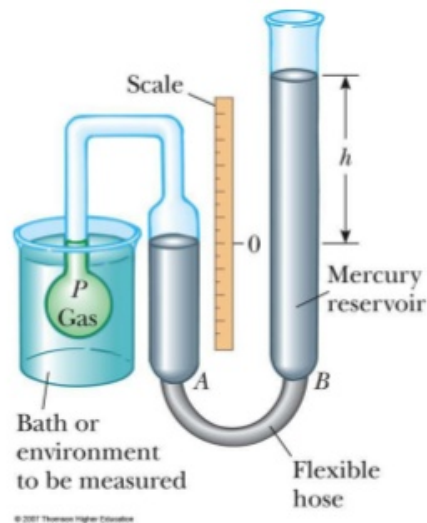$$P = h + 29\tfrac{1}{8}$$

(a)

(b)

Figure 5.5
Plotting Boyle's data

Constant-Volume Gas Thermometer

- The physical change exploited is the variation of pressure of a fixed volume gas as its temperature changes

- The volume of the gas is kept constant by raising or lowering the reservoir B to keep the mercury level at A constant

$$V = V_0 \left(1 + \frac{t}{273.15\,^{\circ}C}\right)$$

GASES - EMPIRICAL OBSERVATIONS

Boyle's Law: At constant temperature, the volume occupied by an ideal gas is inversely proportional to its pressure:

$$V = \frac{const.}{P}$$

Charles' Law: At constant pressure, the volume of an ideal gas is directly proportional to its absolute temperature:

$$V = T \times const.$$

Avogadro's Principle: Equal numbers of moles of ideal gases occupy equal volumes at the same temperature and pressure

Ideal Gas Law:
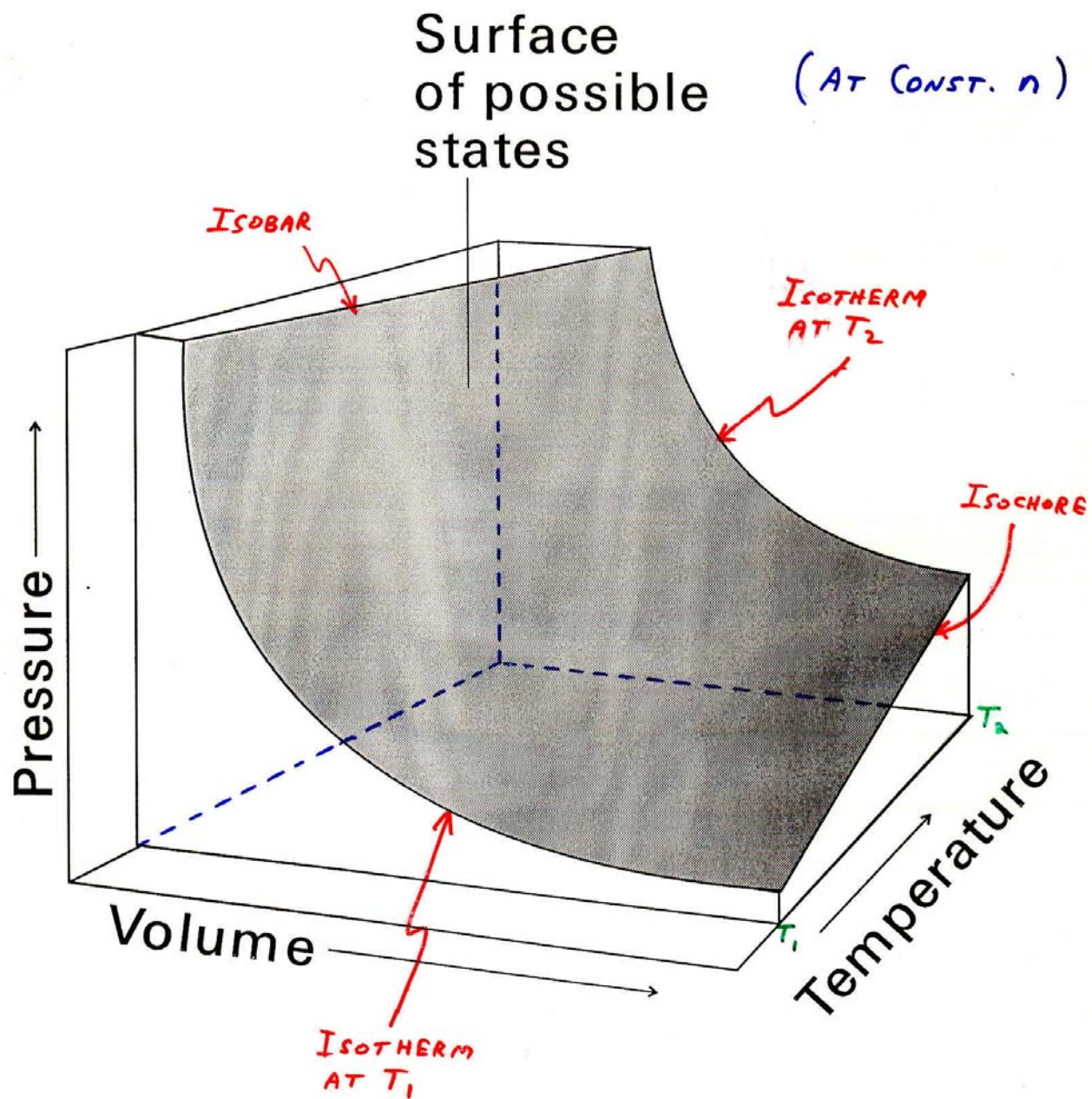
Since $V \propto \dfrac{1}{P}$ and $V \propto T$ and $V \propto n$, then

$V \propto \dfrac{nT}{P} \implies PV = nRT$ (an "equation of state"),

where

$R = 8.314\ \text{J-mol}^{-1}\text{-K}^{-1} = 0.082\ \text{L-atm-mol}^{-1}\text{K}^{-1}$

Surface
of possible
states

(AT CONST. n)

ISOBAR

ISOTHERM
AT T_2

ISOCHORE

Pressure

Volume

ISOTHERM
AT T_1

T_2

T_1

Temperature

P-V-T Surface (n = constant)

$$P_f = P_i \frac{T_f}{T_i}$$

Isochores

$$P_f = \frac{P_i v_i}{v_f}$$

Isotherms

Pressure P

Temperature T

Pressure P

Volume v

Pressure P

Volume v

Temperature T

— Constant volume
— Constant temperature
— Constant pressure

$$v_f = v_i \frac{T_f}{T_i}$$

Isobars

Volume v

Temperature T