$$\left(P + \frac{n^2 a}{v^2}\right)(V - nb) = nRT$$

Table 11.3. The van der Waals constants for real gases

	a (L^2 atm/mol^2)	b (L/mol)
He	0.034	0.0237
O_2	1.36	0.0318
NH_3	4.17	0.0371
H_2O	5.46	0.0305
CH_4	2.25	0.0428
C_2H_6	5.489	0.06380
CH_3OH	9.523	0.06702
C_2H_5OH	12.02	0.08407

Table 11.2. Vapor pressure of water as a function of temperature

Temp. (°C)	Pressure (torr)	Temp. (°C)	Pressure (torr)	Temp. (°C)	Pressure (torr)
0	4.6	18	15.5	40	55.3
1	4.9	19	16.5	45	71.9
2	5.3	20	17.5	50	92.5
3	5.7	21	18.7	55	118.0
4	6.1	22	19.8	60	149.4
5	6.5	23	21.1	65	187.5
6	7.0	24	22.4	70	233.7
7	7.5	25	23.8	75	289.1
8	8.0	26	25.2	80	355.1
9	8.6	27	26.7	85	433.6
10	9.2	28	28.3	90	525.8
11	9.8	29	30.0	95	634.1
12	10.5	30	31.8	96	657.6
13	11.2	31	33.7	97	682.1
14	12.0	32	35.7	98	707.3
15	12.8	33	37.7	99	733.2
16	13.6	34	39.9	100	760.0
17	14.5	35	42.2	101	787.6

(11.23) 1. A sample of SO_2 occupies 1.45 L at 2.75 atm. If we assume no temperature change, how many liters will this gas occupy at 800 torr?

$$\frac{P_1 V_1}{\cancel{T_1}} = \frac{P_2 V_2}{\cancel{T_2}}$$

$$(2.75 \, atm)(1.45 L) = (1.0526 \, atm)(V_2)$$

$$\frac{3.988 \, L \cdot atm}{1.0526 \, atm} = V_2 \qquad \boxed{V_2 = 3.79 \, L}$$

(11.49) 2. Calculate the pressure, in torr and atmospheres, that would be exerted by 25.0 kg of steam (H_2O) in a 1000-L boiler at 200°C if we assume ideal gas behavior.

$$PV = nRT$$

$$P = \frac{nRT}{V} = \frac{\left(\frac{25000}{18.0 \, g/n}\right)(0.08205)(473 K)}{1000 L} = \frac{(1388.9)(0.08205)(473 K)}{1000 L}$$

$$P = \frac{53902 \, L \cdot atm}{1000 L} = \boxed{53.9 \, atm}$$

$$\boxed{41000 \, torr}$$

(11.63) 3. An important reaction in the production of nitrogen fertilizers is the oxidation of ammonia

$$4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(g)}$$

How many liters of O_2, measured at 25°C and 0.895 atm, must be used to produce 100 liters of NO at 500°C and 750 torr?

$$100\,L\,NO\left(\frac{5\,O_2}{4\,NO}\right) = 125\,L\,O_2 \text{ @ } 500°C, 750\,torr$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(0.9868\,atm)(125\,L)}{773\,k} = \frac{(0.895\,atm)(V_2)}{298\,k}$$

$$0.1596 = \frac{(0.895)(V_2)}{298}$$

$$\boxed{V_2 = 53.1\,L}$$

(11.70) 4. A gas is collected by the displacement of water until the total pressure inside a 100 mL flask is 70 torr at 25°C. How many milliliters would the dry gas occupy at STP?

with TYPO 70 ≠ 700

$$P_g + P_{H_2O} = 70\,torr$$

$$P_g + 23.8 = 70\,torr$$

$$P_g = 46.2\,Torr \text{ @ } 25°$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(46.2)(100mL)}{298°} = \frac{(760)(V_2)}{273}$$

$$15.50 = \frac{760\,V_2}{273}$$

$$\boxed{V_2 = 5.5\,mL}$$

(11.50) 5. The density of a gas was found to be 1.81 g/L at 30°C and 760 torr. What is its molecular mass?

$$\frac{1.81g}{1L} \qquad \frac{(760)(1L)}{303} = \frac{(760)\,V_2}{273} \quad V_2 = 0.9010\,L$$

So. at STP $\quad \dfrac{1.81g}{0.9010\,L}\left(\dfrac{22.4L}{1\,mole}\right)$ at STP. $\boxed{45.0\,g/mole}$

or

$$n = \frac{PV}{RT} = \frac{(760)(1L)}{(60.4)(303°)}$$

$$n = 0.04020$$

$$\frac{1.81}{0.04020} = \boxed{45.0\,g/n}$$

(11.96)

6. Use the van der Waals equation to calculate the pressure, in atm, exerted by 1.000 moles of He at 0.00°C in volume of 22.400 L. Use R = 0.082057 L atm/mol K. Compare this to the pressure an ideal gas would exert under these same conditions.

$$K = C + 273.15$$

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$

$$P = \frac{nRT}{V - nb} - \frac{n^2 a}{V^2}$$

$$P = \left(\frac{(1)(0.082057)(273.15)}{(22.400 L) - (1.000)(0.0237)}\right) - \left(\frac{(1.000)^2 \, 0.034}{(22.400 L)^2}\right)$$

$$P = \left(\frac{22.4139}{22.3763}\right) - \left(\frac{0.034}{501.76}\right)$$

$$P = 1.00168 - 0.00006776 \quad \boxed{P = 1.0016 \text{ atm}}$$

$$P = \frac{nRT}{V}$$

$$P = \frac{(1)(0.08206)(273.15)}{22.4}$$

$$\boxed{P = 1.00 \text{ atm}}$$

(11.95)

7. Why did van der Waals subtract a correction from the measured volume? Why did he add a correction to the measured pressure?

Because of Volume occupied by Particles of gas really is not Available volume and the ideal Gas eq. assumes it is. ∴ must be Subtracted to get "real" volume. Volume measured for real gas will always be Larger than ideal Volume

$$V_{ideal} = V_{meas.} - nb$$

or

$$V_{meas} = V_{ideal} + nb$$

Ideal assumes no interaction to slow particles or change their paths. and so is unaccounted For. Must be added back in since lower collision Frequency will decrease pressure measured for real gas.

$$P_{ideal} = P_{meas} + \frac{n^2 a}{V^2}$$