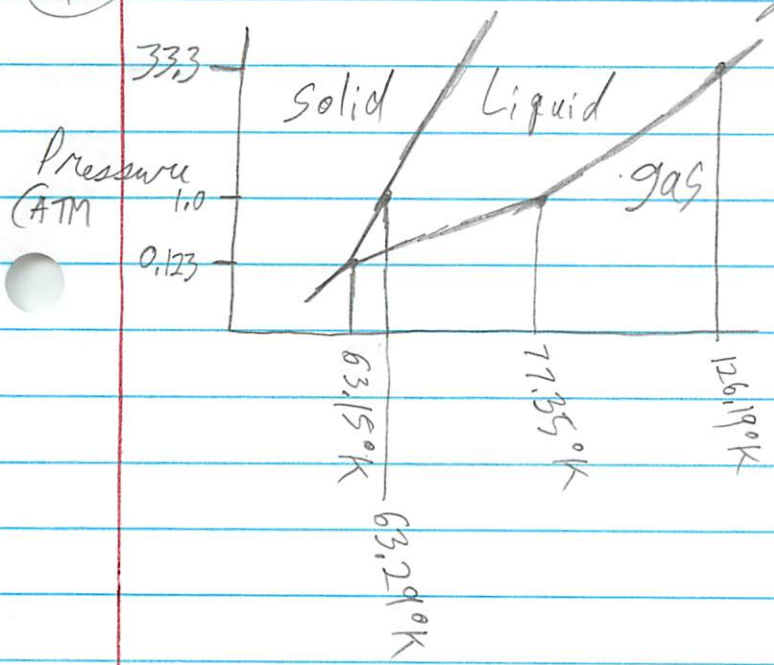
HW #9

Book: 40, 46, 50, 54, 58, 62 Ch 10

(40) Pressure Cooker: heated P: 4.0 ATM
Use Fig 10.23c to estimate T of Water

~420°K

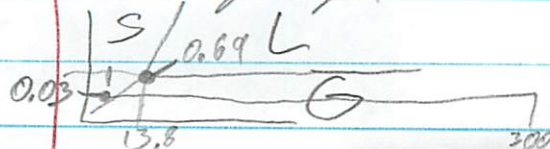
(46) Create a Phase Diagram for N_2



(50) Tripple Point of H is at 13.8°K pressure 0.069 ATM

A) What is the vapor pressure of solid hydrogen at 13.8°K? VP = 0.069 ATM

B. Solid hydrogen held at 0.030 ATM heated 5-300°K



Solid to gas, sublimation

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$1h \cdot 60 min \cdot 60 sec = 3600 s$

D = diffusion const.

(54) Mean-square displacement Time interval $= 6D\Delta t$

Calculate the rms at 25°C after 1h

A. Oxygen in Air = $D = 2.1 \times 10^{-5} m^2 s^{-1}$

$$\sqrt{6 \cdot (2.1 \times 10^{-5} m^2 s^{-1}) \cdot 3600 s} = \boxed{0.673 m}$$

B. Molecule in water = $D = 2.26 \times 10^{-9} m^2 s^{-1}$

$$\sqrt{6 \cdot (2.26 \times 10^{-9} m^2 s^{-1}) 3600 s} = \boxed{0.007 m}$$

C. Atom in Sodium = $D = 5.8 \times 10^{-13} m^2 s^{-1}$

$$\sqrt{6 \cdot (5.8 \times 10^{-13} m^2 s^{-1}) 3600 s} = \boxed{1.12 \times 10^{-4} m}$$

(58) Heat H_2O from 0.0°C to 4°C density increases from 0.99987 to 1.00 g/cm^{-3}

What can you conclude about the thermal expansion coefficient?

$$\alpha = \frac{\Delta V}{V \Delta T}$$

In this range, the α is negative.

Normally in solid → liquid interactions display positive α.

$R = 0.08206\ L\ atm\ mol^{-1} K^{-1}$

(62) Air over a liquid is vapor saturated at 0.98 ATM at 25°C. = 298.15°K

6.0L of the vapor is captured, and cooled to Condense, = 223.15°K

Pure air occupies 3.75L at −50°C 1 ATM

Calculate the vapor pressure of the unknown liquid at 25°C = 298.15°K

$PV = nRT \qquad n = \frac{PV}{RT}$

$$n = \frac{(1\ ATM)(3.75L)}{(0.08206\ L \cdot ATM \cdot Mol^{-1} \cdot K^{-1})(223.15\ °K)}$$

$n = 0.205\ Mol\ Air$

$$P_{Air} = \frac{nRT}{V} = \frac{(0.205\ mol)(0.08206\ L \cdot ATM \cdot Mol^{-1} K^{-1})(298.15°K)}{(6.0L)}$$

$P_{Air} = 0.8359$

$P_{Total} - P_{Air} = P_{unknown}$

$0.98\ ATM - 0.8359\ ATM = \boxed{0.1441\ ATM_{unknown}}$

Other Problems

(1) Van der Waals

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

Ideal

$$PV = nRT$$

If $V \to \infty$ $\quad \infty >>> nb$

$$(P + 0)(\infty - 0) = nRT \qquad P \cdot \infty = nRT$$

$$(P \cdot \infty = nRT) = (P \cdot \infty = nRT)$$

(2) Atomic Radii

He = 0.49 Å = 10^{-10} M = 10^{-8} cm

Ar = 0.88 Å

Xe = 1.24 Å

Vander Waals b constant

0.02370 L/mol

0.03219 L/mol

0.0510 L/mol

$1\,cm^3 = 1\,mL$

$$V_{sphere} = \frac{4}{3}\pi r^3$$

$$He_{Vol/molecule} = \frac{4}{3} \cdot \pi (0.49 \times 10^{-8}\,cm)^3 = 4.93 \times 10^{-25}\,cm^3/atom$$

$$Ar = \frac{4}{3} \cdot \pi (0.88 \times 10^{-8}\,cm)^3 = 2.85 \times 10^{-24}\,cm^3/atom$$

$$Xe = \frac{4}{3} \cdot \pi (1.24 \times 10^{-8}\,cm)^3 = 7.99 \times 10^{-24}\,cm^3/atom$$

$cm^3 = 1\,ml \qquad 1\,mL = \frac{L}{1000\,mL}$

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He: $\left(4.93\times10^{-25}\ \frac{mL}{atom}\right)\left(\frac{1L}{1000mL}\right)\left(\frac{6.022\times10^{23}\ atom}{mol}\right) = 2.97\times10^{-4}\ \frac{L}{mol}$

Ar: $\left(2.85\times10^{-23}\ \frac{mL}{atom}\right)\left(\frac{1L}{1000mL}\right)\left(\frac{6.022\times10^{23}\ atom}{mol}\right) = 0.0017\ \frac{L}{mol}$

Xe: $\left(7.99\times10^{-24}\ \frac{mL}{atom}\right)\left(\frac{1L}{1000mL}\right)\left(\frac{6.022\times10^{23}\ atom}{mol}\right) = 0.0048\ \frac{L}{mol}$

$Atom: \frac{Calculated}{Tabulated}$

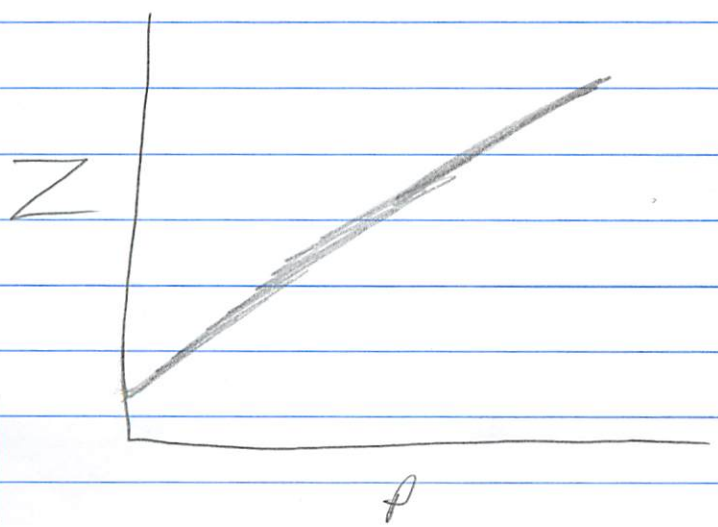
He: $\frac{2.97\times10^{-4}\ L/mol}{0.02370\ L/mol} = 0.0125 \approx 1.2\%$ of Tabulated value

Ar: $\frac{0.0017\ L/mol}{0.03219\ L/mol} = 0.0528 \approx 5.3\%$ of Tabulated value

Xe: $\frac{0.0048\ L/mol}{0.0510} = 0.094 \approx 9.4\%$ of Tabulated value

(3) $P(V-nb) = nRT$ find Z for this gas
Sketch Z as a function of P

$Z = \frac{PV}{nRT}$ Set $Z = \frac{P(V-nb)}{nRT}$



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(4) Expansion Coefficient of iron is $3.54 \times 10^{-5} K^{-1}$

1L Bar of Fe 0°C to 30°C

273.15°K 303.15°K

$3.54 \times 10^{-5} K^{-1} = \frac{\Delta V}{V \cdot \Delta T} = 3.54 \times 10^{-5} K^{-1} = \frac{\Delta V}{1L \cdot 30°}$

$3.54 \times 10^{-5} K^{-1} \cdot 1L \cdot 30°K = \boxed{0.0011\ L}$

10000 cm 10 cm 10 cm

$V = 1{,}000{,}000\ cm^3 = 1 \times 10^6\ mL = 1000L_{Total\ V}$

$3.54 \times 10^{-5} K^{-1} = \frac{\Delta V}{1000L \cdot 30°K} =$

$3.54 \cdot 10^{-5} K^{-1} \cdot 1000L \cdot 30°K = 1.062L = \Delta V$

Proportional Change

$1\ cm^3 = 1\ mL$

$1.062\ L = 1062\ mL$

$\sqrt[3]{1062\ cm^3} = 10.2\ cm$

$\boxed{X = 1{,}020\ cm \text{ length increase}}$

assuming all sides increase the same amount 10.2 cm

10.2 cm for 100 cm sides.

$\frac{1020\ cm}{10{,}000\ cm} = \frac{10.2\ cm}{100\ cm}$ $\frac{1.02\ cm}{10\ cm} = \frac{10.2\ cm}{100\ cm}$

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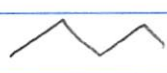
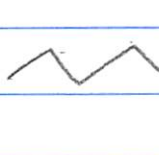
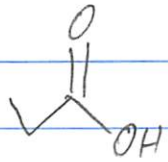
HB is F, O, N

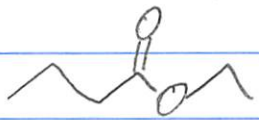
(5) Butanol  hydrogen Bonding

Pentanal  no HB

Propanoic acid  HB

Diethyl Ether  no HB

Butyl amine  HB

ethyl Butanoate  no HB

(6) As the vapor pressure of a liquid becomes higher than the ambient pressure bubbles form as the liquid changes phase to a gas.

(7) EXO = Energy to surroundings

melting – Endo solid → liq
deposition – Exo gas → solid
condensation – Exo gas → liq
vaporization – Endo liq → gas
sublimation – Endo solid → gas
freezing – Exo liq → solid