Today

Dalton's Law of Partial ✓
STP ✓

Skip Chapters 9, 11, 12

Do parts of Chapter 10 Energy
Chapter 13 Equilibrium } today

Tomorrow Chapter 14 acid/base

Dalton's Law of Partial Pressures

The pressure of a system is the sum of all of the partial pressures.

$$P_T = \underbrace{P_1 + P_2 + P_3 + \ldots + P_n}_{\text{Partial Pressures}}$$

Ex What is the pressure in a system with 0.62 atm of H_2 and 0.92 atm of N_2?

$$P_T = P_{H_2} + P_{N_2} = 0.62\,\text{atm} + 0.92\,\text{atm}$$

$$= \boxed{1.54\text{ atm total}}$$

$$P_T = \boxed{P_1 + P_2 + \dots + P_n}$$

Same Container
Same Volume
Same Temp

$PV = nRT$

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

$$P_T = \frac{n_1RT}{V} + \frac{n_2RT}{V} + \dots + \frac{n_nRT}{V}$$

sum of moles

$$P_T = \frac{(n_1 + n_2 + \dots + n_n)RT}{V}$$

Ex

What is the pressure in a container with a volume of 10.0 L filled with 1.62 g N_2 and 30.7 g H_2 if the temp is 25 °C?

$P = ?$
$V = 10.0 L$
$n = 30.7 g\ H_2$ & $1.62 g\ N_2$
$T = 25\ °C + 273.15 = 298.15\ K$
$R = 0.0821 \frac{L\ atm}{mol\ K}$

$H_2 = 2.016\ g/mole$
$N_2 = 28.02\ g/mole$

$$n_{H_2} = \overset{3}{30.7 g\ H_2} \times \frac{1\ mole\ H_2}{\underset{4}{2.016 g\ H_2}} = 15.228174$$

$$n_{N_2} = \overset{3}{1.62 g\ N_2} \times \frac{1\ mole\ N_2}{\underset{4}{28.02 g\ N_2}} = 0.05781 5845$$

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

Dalton's Law

$$P = \frac{nRT}{V} = \frac{(n_{H_2} + n_{N_2})RT}{V}$$

$$P = \frac{(15.2 \text{ moles} + 0.0578 \text{ moles})(0.0821 \frac{L\,atm}{moles\,K})(298.15\,K)}{(10.0\,L)}$$

$= 37.348218$ atm $= \boxed{37.3 \text{ atm}}$

Standard Temperature & Pressure

STP Conditions

Standard temp = 273.15 K or 0 °C

Standard pressure = 1.00 atm

Ex

What is the volume of 3.62 moles of gas at STP?

$P = 1.00$ atm

$T = 273.15$ K

$n = 3.62$ mole

$V = ?$

$R = 0.0821 \frac{L\,atm}{mole\,K}$

$PV = nRT$

$$V = \frac{nRT}{P} = \frac{(\overset{3}{3.62\text{ moles}})(\overset{3}{0.0821}\ \frac{L\,atm}{mol\,K})(\overset{5}{273.15K})}{\underset{3}{1.00\text{ atm}}}$$

$= 81.180726\ L$

$$\boxed{= 81.2\ L}$$

Ex

what is the volume of 1.00 mole gas at STP?

$PV = nRT$

$$V = \frac{nRT}{P} = \frac{(\overset{3}{1.00\text{ mole}})(\overset{3}{0.0821}\ \frac{L\,atm}{mol\,K})(\overset{5}{273.15K})}{(\underset{3}{1.00\text{ atm}})}$$

$= 22.425615\ L$

Equality

$$\boxed{1 \text{ mole gas @ STP} = 22.4\ L}$$

Ex What is the volume of 32.6g CH_4 at STP?

Road Map 1

12.01
4.016
16.026 g/mole

$P = 1.00$ atm
$V = ?$
$n = 32.6\,g\,CH_4 \times \frac{1\text{ mole }CH_4}{16.026\,g\,CH_4}$
$T = 273.15\,K$
$R = 0.0821\,\frac{L\,atm}{mol\,K}$

$PV = nRT$

Road Map 2   1 mole gas = 22.4 L @ STP

$g\,CH_4 \longrightarrow \text{mole } CH_4 \longrightarrow L\,CH_4$

$\overset{3}{32.6}\,g\,CH_4 \times \frac{1\text{ mole }CH_4}{\underset{5}{16.026}\,g\,CH_4} \times \frac{\overset{3}{22.4}\,L\,CH_4}{1\text{ mole }CH_4} = 45.565955\,L$

$\boxed{= 45.6\,L}$

$$\underset{6.72\,\text{mole}}{3\,H_2} + \underset{\text{excess}}{N_2} \rightarrow \underset{L}{2\,NH_3}$$

Ex

6.72 mole H_2 are reacted with excess N_2 at STP. How many Liters of NH_3 are formed in the reaction?

Road Map

$$\text{mole } H_2 \longrightarrow \text{mole } NH_3 \xrightarrow{1\text{ mole} = 22.4\text{ @STP}} L\ NH_3$$

$$\overset{3}{6.72\text{ mole } H_2} \times \frac{\overset{\text{Exact}}{2\text{ mole } NH_3}}{3\text{ mole } H_2} \times \frac{\overset{3}{22.4\text{ L}}}{1\text{ mole } NH_3} = 100.352\text{ L } NH_3$$

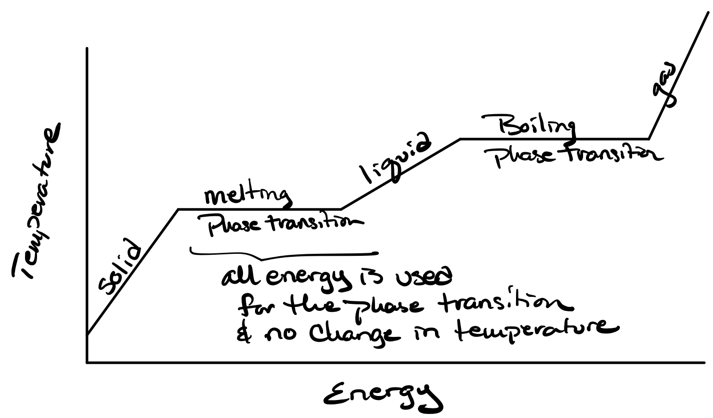
$$\boxed{= 100.\text{ L } NH_3}$$

Chapter 10

Energy of transitions (Phase Transitions)

$$\text{Solid} \underset{}{\overset{?}{\rightleftharpoons}} \text{liquid} \qquad \text{liquid} \overset{?}{\rightleftharpoons} \text{gas}$$

Phase transitions



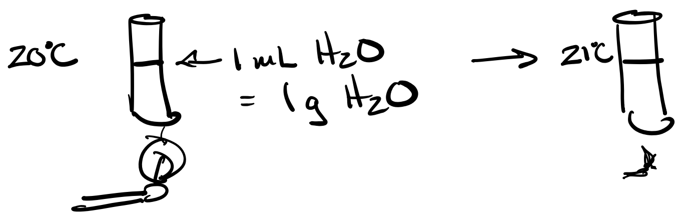
How do we calculate the energy required to change the temp of an object or the temp change for a given energy amount?

Specific Heat $= C = \frac{cal}{g\,°C}$

The amount of energy required to increase the temp of 1 g material by 1°C

Energy units

cal = calorie = The amount of energy required to raise 1g H_2O by 1°C



1g raised 1°C = 1 cal

$$\boxed{4.186 \text{ Joule} = 1 \text{ cal}}$$

Food calorie = 1 Cal = 1 kcal

1 Food calorie = 1 Cal = 1 kcal = 1000 cal

Specific Heat $C = \frac{cal}{g°C}$

$H_2O_{(l)}$ = 1.01 cal/g°C

$H_2O_{(s)}$ = 0.4897 cal/g°C

$Cu_{(s)}$ = 0.09197 cal/g°C

$$\text{Energy} = mc\Delta T = (\cancel{g})\left(\frac{cal}{\cancel{g}\cdot\cancel{°C}}\right)(\cancel{°C})$$

m = mass (g)

c = cal/g°C

ΔT = Change in temperature
$(T_f - T_i)$

Ex

How much energy would be required to heat a 300. mL cup of tea from 25°C to 100.°C if the $d_{H_2O} = 1.00$ g/mL and $C_{H_2O} = 1.01$ cal/g°C?

$$\mathcal{E} = mc\Delta T$$

$\mathcal{E}$ = ?

$m = 300.\ mL \times \frac{1.00\ g}{1\ mL} = 300.\ g$

$c = 1.01$ cal/g°C

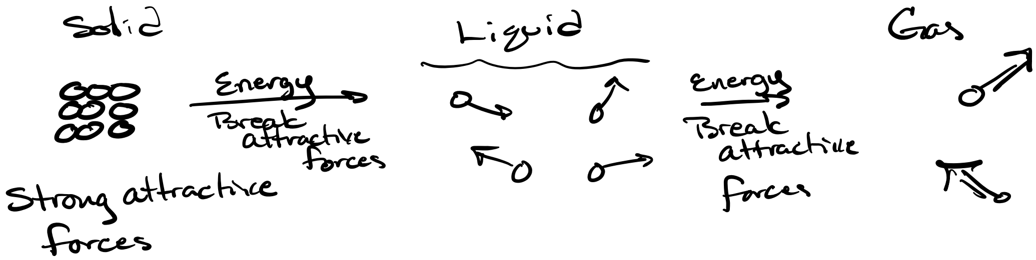
$\Delta T = T_f - T_i = 100.°C - 25°C = 75°C$

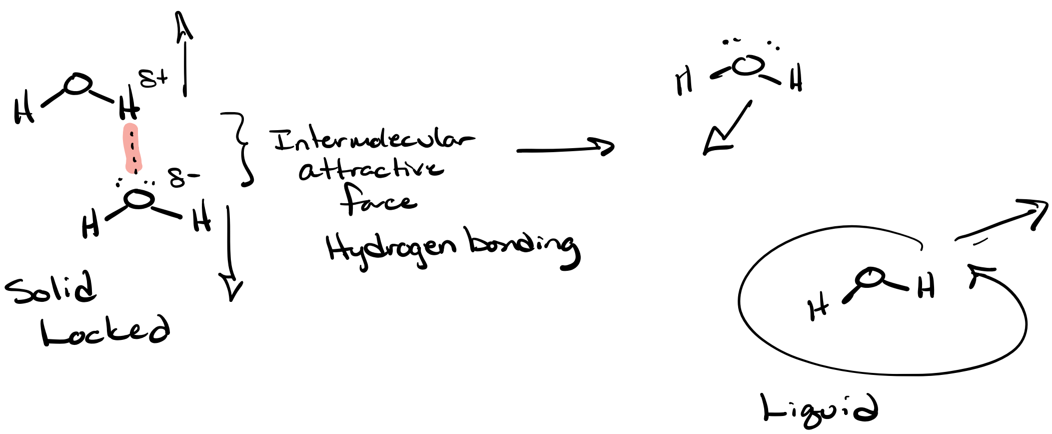
$$\mathcal{E} = (\overset{3}{300.}\ \cancel{g})\left(\frac{\overset{3}{1.01}\ cal}{\cancel{g}\ \cancel{°C}}\right)(\underset{2}{75}\ \cancel{°C})$$

$= 22725$ cal

$$\boxed{= 23000 \text{ cal} = 23 \text{ kcal}}$$

2.3×10^4 cal





Phase Transition Constants

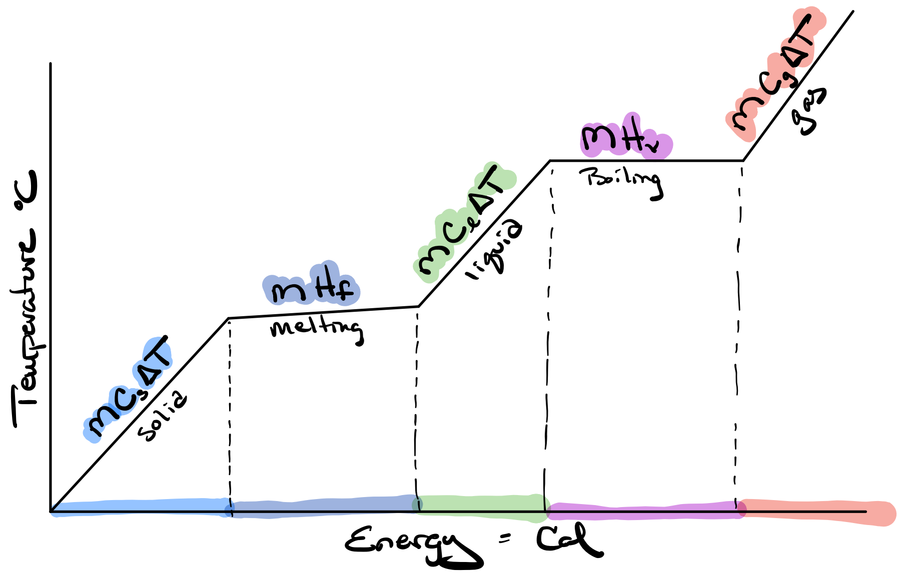
__Units__

Cal/g $\quad H_f \quad$ Heat of fusion $\quad$ melting or freezing

$$\text{solid} \underset{\text{freezing}}{\overset{\text{melting}}{\rightleftharpoons}} \text{liquid}$$

Cal/g $\quad H_v \quad$ Heat of Vaporization $\quad$ Boiling or Condensing

$$\text{liquid} \underset{\text{Condensing}}{\overset{\text{Boiling}}{\rightleftharpoons}} \text{gas}$$

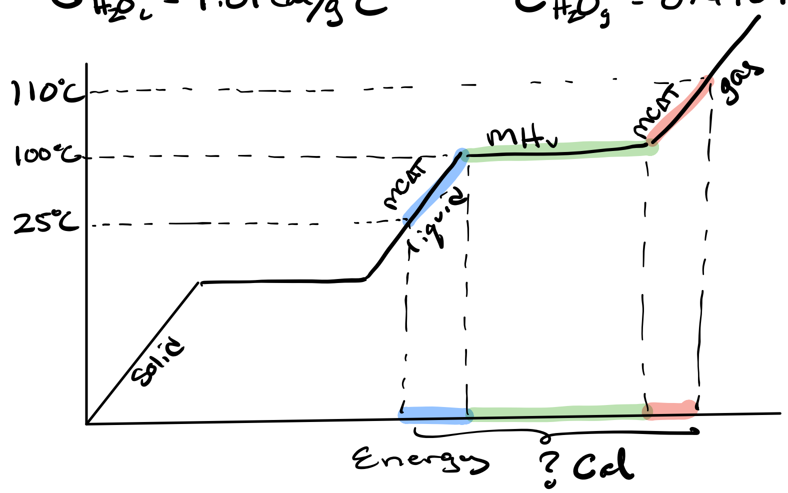


Ex

How much energy is required to change the temperature of 150.mL H_2O from liquid at 25°C to steam at 110°C.

The H_f = 79.7 cal/g H_v = 540 cal/g

$C_{H_2O_\ell}$ = 1.01 cal/g°C $C_{H_2O_g}$ = 0.4969 cal/g°C



$$E_T = mC\Delta T_l + mH_v + mC\Delta T_g$$

$m = 150.\,g$

$C_l = 1.01\ cal/g^\circ C$

$\Delta T_l = 100. - 25 = 75\ ^\circ C$

$m = 150.\,g$

$H_v = 540.\ cal/g$

$m = 150.\,g$

$C_g = 0.4969\ cal/g^\circ C$

$\Delta T_g = 110. - 100. = 10.\ ^\circ C$

$$\overset{3}{}\ \overset{3}{}\ \overset{2}{}\ \overset{3}{}\ \overset{3}{}\ \overset{3}{}\ \overset{4}{}\ \overset{2}{}$$

$$E = (150\,\cancel{g})(1.01\,cal/\cancel{g}\,\cancel{^\circ C})(75\,\cancel{^\circ C}) + (150\,\cancel{g})(540\,cal/\cancel{g}) + (150\,\cancel{g})(0.4969\,cal/\cancel{g}\,\cancel{^\circ C})(10.\,\cancel{^\circ C})$$

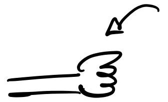
sig figs ?

$= 93|107.85\ cal$

liquid	11|362.5	cal
Boiling	81|000	cal
Steam +	|745.35	cal
	93|107.85	cal

$$\boxed{= 93000\ cal \quad \text{or} \quad 9.3 \times 10^4\ cal}$$

Burn from 1 mL H_2O @ 100 °C



1 mL 100 °C

$\downarrow$ $75\,°C = \Delta T$

25 °C

Energy imparted to hand

$$E = mc\Delta T = (1.00\,g)(1.01\,cal/g\,°C)(75\,°C)$$

$$= 75.75\,cal = 76\,cal$$

Burn

1.00 g Steam 100 °C

$\downarrow$ mH_v

liquid 100 °C

$\downarrow$ $mc\Delta T$

25 °C

$$E = mc\Delta T_L + mH_v$$

$$= (1.00\,g)(1.01\,cal/g\,°C)(75\,°C) + (1.00\,g)(540\,cal/g)$$

$$= 75.75 + 540.\,cal$$

$$= 615.75\,cal$$

$$= \boxed{616\,cal}$$

Burn from same amount of Steam.