CH.2

Naming

first steps look at the cation

Ionic

[metal + non-metal]

عامودي

هي عناصر العواميد
في الجدول الدوري

لا نهتم لشحنة
ال metal

transition metals

يهمني شحنة
ال metal

Steps:

1] نسمي ال [cation] مثل وهو في periodic Table
دون أي إضافة

2] إذا كان العنصر الثاني mono-atomic
رح نضيف (ide) على نهايته.

3] إذا كان poly-atomic فهو محفظ
من الجدول

نهتم بالشحنة في حالات معينة

(Molecular covalent)

[non-metal , non-metal]

steps:-

1] نسمي العنصر الأول مثل وهو بال
periodic table
ما بنحطله mono
وإذا كان أكثر من واحد نضع له
مثل di , Tri ...

2] العنصر الثاني عادي نضيف له
mono , di ....
وبآخر اسمه ide

نهتم بالأرقام الصغيرة
بجانب العناصر

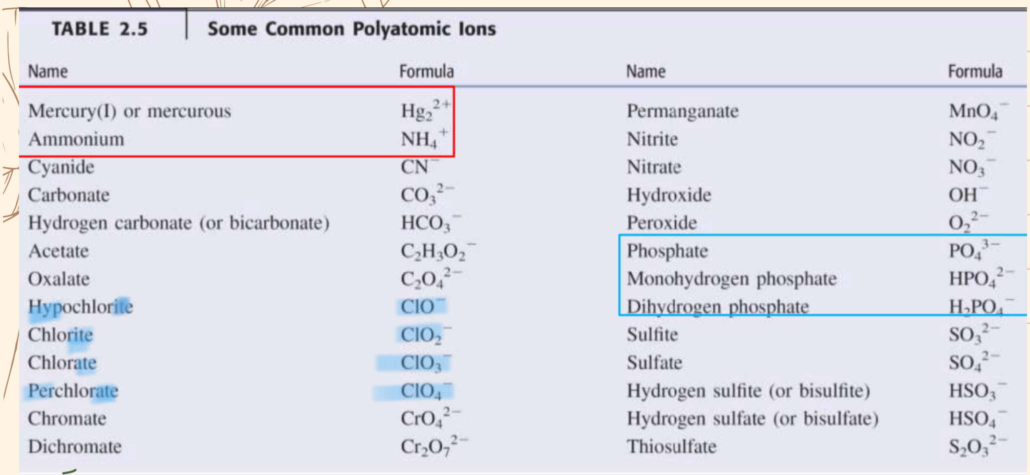


TABLE 2.5 **Some Common Polyatomic Ions**

Name	Formula	Name	Formula
Mercury(I) or mercurous	Hg_2^{2+}	Permanganate	MnO_4^-
Ammonium	NH_4^+	Nitrite	NO_2^-
Cyanide	CN^-	Nitrate	NO_3^-
Carbonate	CO_3^{2-}	Hydroxide	OH^-
Hydrogen carbonate (or bicarbonate)	HCO_3^-	Peroxide	O_2^{2-}
Acetate	$C_2H_3O_2^-$	Phosphate	PO_4^{3-}
Oxalate	$C_2O_4^{2-}$	Monohydrogen phosphate	HPO_4^{2-}
Hypochlorite	ClO^-	Dihydrogen phosphate	$H_2PO_4^-$
Chlorite	ClO_2^-	Sulfite	SO_3^{2-}
Chlorate	ClO_3^-	Sulfate	SO_4^{2-}
Perchlorate	ClO_4^-	Hydrogen sulfite (or bisulfite)	HSO_3^-
Chromate	CrO_4^{2-}	Hydrogen sulfate (or bisulfate)	HSO_4^-
Dichromate	$Cr_2O_7^{2-}$	Thiosulfate	$S_2O_3^{2-}$

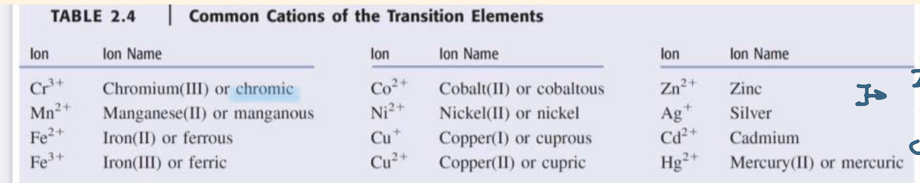


TABLE 2.4 | **Common Cations of the Transition Elements**

Ion	Ion Name	Ion	Ion Name	Ion	Ion Name
Cr^{3+}	Chromium(III) or chromic	Co^{2+}	Cobalt(II) or cobaltous	Zn^{2+}	Zinc
Mn^{2+}	Manganese(II) or manganous	Ni^{2+}	Nickel(II) or nickel	Ag^{+}	Silver
Fe^{2+}	Iron(II) or ferrous	Cu^{+}	Copper(I) or cuprous	Cd^{2+}	Cadmium
Fe^{3+}	Iron(III) or ferric	Cu^{2+}	Copper(II) or cupric	Hg^{2+}	Mercury(II) or mercuric

← لا تكتب له شحنة أبدًا. كما هو في الجدول فقط

NH_3	ammonia	SiH_4	Silane	NO	nitric oxide
N_2H_2	Hydrazine	B_2H_6	Diborane		
PH_3	phosphine	CH_4	Methane	H_2S	hydrogen sulfide
Cl	Chlorine				

Cl_2O_7 → dichlorine heptoxide not heptaoxide

BrO_3^- → Bromate

$LiBrO_2$ → Lithium Bromite

CH.3 Calculations with chemical Formula.

1. Calculating the Formula weight From the Formula

$CHCl_3 \rightarrow 12 \times 1 + 1 \times 1 + 35.45 \times 3 = 119.4$ amu

For any element → atomic mass (amu) = molar mass (grams)

2. 1 mole of a substance = 6.022×10^{23} units → Avogadro's number

3. when the Question asks us about " How many atoms How many molecules"

we use $n = \frac{m}{Mr} \rightarrow n$ ✓ 1mole → 6022×10^{23}

$n \rightarrow \boxed{x} \leftarrow$ وهو المطلوب

4. what is the mass in grams of one Chlorine atom, Cl?

1mole → 6.022×10^{23} atom

n → atom

↳ $n = \frac{m}{Mr}$

5. grams of the compound → moles of compound → moles of the element → atoms of the element.

How many hydrogen atoms are present in 25.6g of urece $(NH_2)_2CO_2$?

6. percentage composition → percent by mass = $\frac{m\ element}{m\ sample} * 100\%$

$= \frac{Mr\ of\ element * \text{number of atoms}}{Mr\ of\ sample} * 100\%$

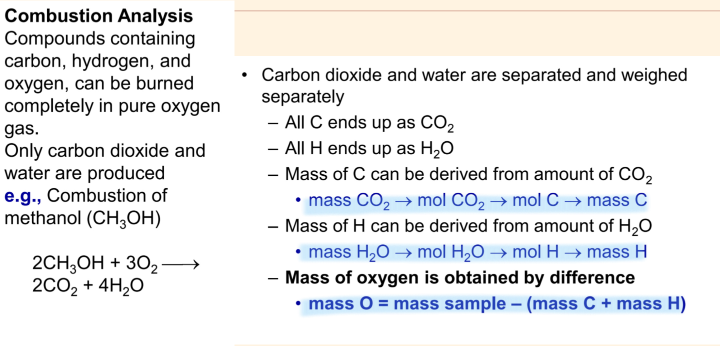
7. mass percentage of element * mass of sample = grams of the element

8. Empirical formula → 1. calculate moles of each substance
2. select the smallest number of moles
3. Divide all numbers of moles by the smallest one.

* إذا طلع معك 1.33 لا تقربها لواحد

إنما نضربها ب Factor حتى يصير integer

obtained From experimental analysis of compound



Combustion Analysis
Compounds containing carbon, hydrogen, and oxygen, can be burned completely in pure oxygen gas.
Only carbon dioxide and water are produced
e.g., Combustion of methanol (CH_3OH)

$$2CH_3OH + 3O_2 \longrightarrow 2CO_2 + 4H_2O$$

- Carbon dioxide and water are separated and weighed separately
  - All C ends up as CO_2
  - All H ends up as H_2O
  - Mass of C can be derived from amount of CO_2
    - mass CO_2 → mol CO_2 → mol C → mass C
  - Mass of H can be derived from amount of H_2O
    - mass H_2O → mol H_2O → mol H → mass H
  - **Mass of oxygen is obtained by difference**
    - **mass O = mass sample – (mass C + mass H)**

9. Molecular Formula From Empirical Formula

1] calculate Mr For the compound on its Empirical Formula from periodic Table

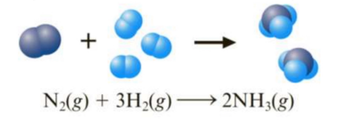
2] divide → molecular mass يلي انا حسبتها = رقم

يلي أنا حسبتها

↳ بجربه بال empirical Formula.

10.

Molar Interpretation of a Chemical Equation



$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

11. Limiting reactant → نعمل علاقة بين كل مادة متفاعلة و الناتج المطلوب يلي ينتج عدد أقل يكون هو ال L.R

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

IF 0.3 mol Zn is add to a solution containing 0.52mol HCl How many moles of H_2 are produced

1 Zn → 1 H_2 2 HCl → 1 H_2

0.3 → x 0.52 → x

x = 0.3 x = 0.26 ∴ HCl → L.R

→ هذه الكمية الناتجة من H_2

و Zn كم يتفاعل منه؟
0.26 ليه لانه
هو excess فقط
يتفاعل منه مع HCl
كمية ال HCl نفسها

وإذا أعطى كل التفاعلات نحولهم لمولات ونعمل نفس الخطوات.

12. mass = Molar mass x compound عددها بال
Avogadro's number

experimently ←

percentage yield = $\dfrac{\text{actual yield}}{\text{theoretical yield}}$ * 100%

↳ From equations

grams تعبر عن عدد

Actual ≤ theoretical

The actual yield given by the Question

& It will asks us about the Theoretical yield → which is the same as Limiting reactant.

1. بعد منحدد ال L.R بنحسب عدد مولات الناتج يلي هو طالبي أسئلة ال p.y

بعدين بنحسب (mass) ← grame إله وهي نفسها ال Theoretical yield

2. ☐ mixed with ☐ → ☐ ← نفسها تطلب ال actual yield

---

1 mole of oxygen atoms (O) = 6.022×10^{23} (O) atoms

" " " " molecules (O_2) = 6.022×10^{23} (O_2) molecules

= $2 \times 6.02 \times 10^{23}$ (O) atoms

---

1 mole of sodium carbonate (Na_2CO_3) = 6.02×10^{23} Na_2CO_3 units ,

= $2 \times 6.02 \times 10^{23}$ Na^+ ions + $1 \times 6.02 \times 10^{23}$ CO_3^{-2} ions.

The total number of atoms in 0.1 mol of N_2O_5 is :-

عندما يطلب منا عدد ال atoms ننظر للمركب كم يحتوي على ذرات ومن ثم نحول عدد مولات المركب أذا اعطاني داخل عدد مولات ذراته ونضرب كل منهم بعدد أفوكادرو

1 mole → $7 \times 6.022 \times 10^{23}$ atoms

0.1 → x

x = 4.2×10^{23} atoms.

CH.4

pure H_2O does not contain ions → not conductive

An aqueous solution of ions (aq) is conductive

- Ionic compounds (salt) in water → Dissociation
  separated ions → Hydrated
  conduct electricity
- Molecular compounds → solute particles are surrounded by water
  ↳ molecules do not dissociate
  Generally molecular compounds don't conduct electricity
- electrolyte → is a substance that dissolve in H_2O to give an electrically conducting solution

1. strong electrolyte
   - * electrolyte that dissociates 100% in H_2O
   - * yield aqueous solution that conducts electricity
   - * Ionic compounds, $NaCl$, KNO_3
   - * stronge acids, bases

2. Weak electrolyte
   - * When dissolved in H_2O a small percentage of molecules ionized
   - * weakly conduct electricity
   - * weak acids & bases

   Acetic Acid CH_3COOH, Amonia: NH_3

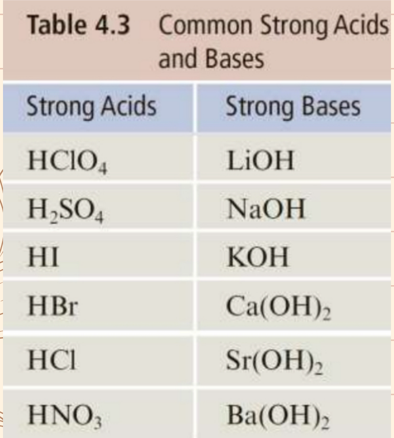


Table 4.3 Common Strong Acids and Bases

Strong Acids	Strong Bases
$HClO_4$	$LiOH$
H_2SO_4	$NaOH$
HI	KOH
HBr	$Ca(OH)_2$
HCl	$Sr(OH)_2$
HNO_3	$Ba(OH)_2$

. None - electrolyte :

a substaut that dissolve in H_2O to give a non conducting or very poorly conducting solution.

- molecules remain intact in solution ex. sugers (lucose sucrose)
- Alcohol (Methanol, Ethanol) , Urea

- Solubility rules For Ionic compounds

* Not all electrolytes are ionic substances
* polyatomic ions remain intact

ex. $KIO_3 \rightarrow K^+ + IO_3^-$

* $HgCl_2$ soluble but Hg_2Cl_2 insoluble

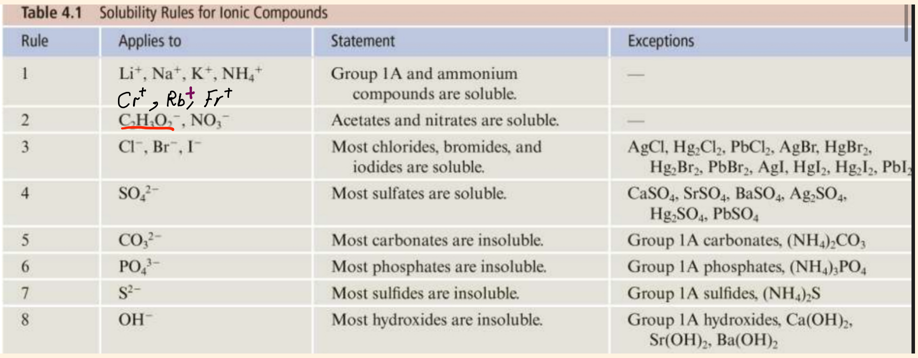


Table 4.1 Solubility Rules for Ionic Compounds

Rule	Applies to	Statement	Exceptions
1	Li^+, Na^+, K^+, NH_4^+ Cr^+, Rb^+, Fr^+	Group 1A and ammonium compounds are soluble.	—
2	$C_2H_3O_2^-$, NO_3^-	Acetates and nitrates are soluble.	—
3	Cl^-, Br^-, I^-	Most chlorides, bromides, and iodides are soluble.	$AgCl$, Hg_2Cl_2, $PbCl_2$, $AgBr$, $HgBr_2$, Hg_2Br_2, $PbBr_2$, AgI, HgI_2, Hg_2I_2, PbI_2
4	SO_4^{2-}	Most sulfates are soluble.	$CaSO_4$, $SrSO_4$, $BaSO_4$, Ag_2SO_4, Hg_2SO_4, $PbSO_4$
5	CO_3^{2-}	Most carbonates are insoluble.	Group 1A carbonates, $(NH_4)_2CO_3$
6	PO_4^{3-}	Most phosphates are insoluble.	Group 1A phosphates, $(NH_4)_3PO_4$
7	S^{2-}	Most sulfides are insoluble.	Group 1A sulfides, $(NH_4)_2S$
8	OH^-	Most hydroxides are insoluble.	Group 1A hydroxides, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$

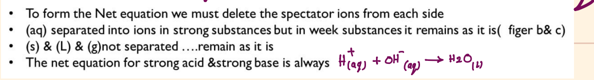
* most alcohols are soluble but they can not be electrolytes like CH_3OH
* Benzen (C_6H_6) and hexane (C_6H_{14}) are insoluble

→ How many ions Form on the dissociation of

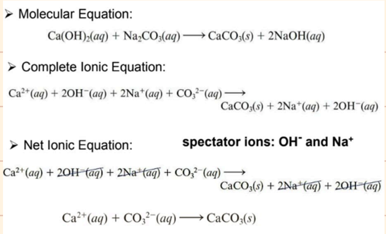
Na_3PO_4 ? 4 , $Al_2(SO_4)_3$? 5

$Pb(ClO_3)_2 \rightarrow$ soluble

- Molecular equations & Ionic equations



- To form the Net equation we must delete the spectator ions from each side
- (aq) separated into ions in strong substances but in week substances it remains as it is(figer b& c)
- (s) & (L) & (g)not separated ….remain as it is
- The net equation for strong acid &strong base is always $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$



➢ Molecular Equation:

$$Ca(OH)_2(aq) + Na_2CO_3(aq) \longrightarrow CaCO_3(s) + 2NaOH(aq)$$

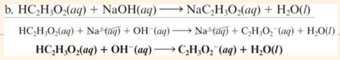
➢ Complete Ionic Equation:

$$Ca^{2+}(aq) + 2OH^-(aq) + 2Na^+(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s) + 2Na^+(aq) + 2OH^-(aq)$$

➢ Net Ionic Equation: **spectator ions: OH⁻ and Na⁺**

$$Ca^{2+}(aq) + \cancel{2OH^-(aq)} + \cancel{2Na^+(aq)} + CO_3^{2-}(aq) \longrightarrow CaCO_3(s) + \cancel{2Na^+(aq)} + \cancel{2OH^-(aq)}$$

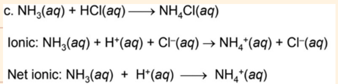
$$Ca^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$$



b. $HC_2H_3O_2(aq) + NaOH(aq) \longrightarrow NaC_2H_3O_2(aq) + H_2O(l)$

$HC_2H_3O_2(aq) + \cancel{Na^+(aq)} + OH^-(aq) \longrightarrow \cancel{Na^+(aq)} + C_2H_3O_2^-(aq) + H_2O(l)$

$HC_2H_3O_2(aq) + OH^-(aq) \longrightarrow C_2H_3O_2^-(aq) + H_2O(l)$



c. $NH_3(aq) + HCl(aq) \longrightarrow NH_4Cl(aq)$

Ionic: $NH_3(aq) + H^+(aq) + Cl^-(aq) \rightarrow NH_4^+(aq) + Cl^-(aq)$

Net ionic: $NH_3(aq) + H^+(aq) \longrightarrow NH_4^+(aq)$

لمّا يسألني سؤال reaction يلي صار لازم أحدد

الي يذوب في الماء ويلي ما يذوب بحرم أعمل exchange

ال anions ← بجي يلي soluble ← نفككه وهو يعطيني ال

ال ← spectator ions

← ويلي insoluble ← لا نفككه وهو يعطيني

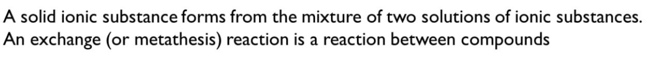
ال net-ionic equation

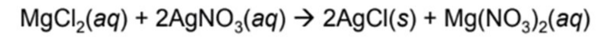
ex. $BaCl_2 + ZnSO_4 \rightarrow \underset{\text{insoluble}}{BaSO_4} + \underset{\text{soluble}}{ZnCl_2}$

net ionic eq. → $Ba^{+2} + SO_4^{-2} \rightarrow BaSO_4$

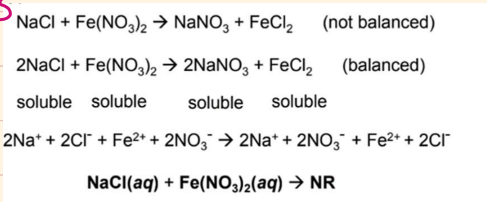
There are many types of reactions

1. precipitation reaction


A solid ionic substance forms from the mixture of two solutions of ionic substances.
An exchange (or metathesis) reaction is a reaction between compounds


$MgCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Mg(NO_3)_2(aq)$

IF the precipitate (solid) does not appear then the reaction does not happen even IF the reactant exchange their anions


$NaCl + Fe(NO_3)_2 \rightarrow NaNO_3 + FeCl_2$ (not balanced)

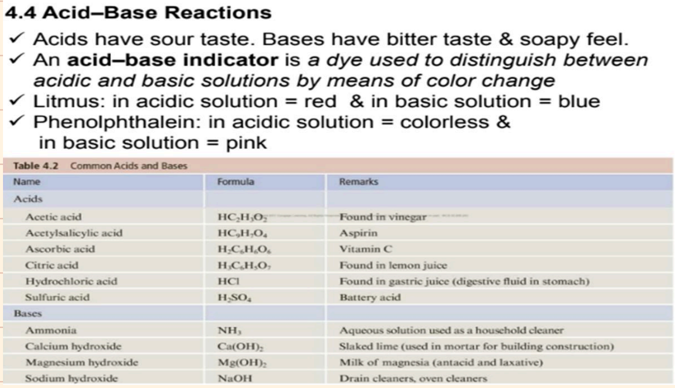
$2NaCl + Fe(NO_3)_2 \rightarrow 2NaNO_3 + FeCl_2$ (balanced)

soluble soluble soluble soluble

$2Na^+ + 2Cl^- + Fe^{2+} + 2NO_3^- \rightarrow 2Na^+ + 2NO_3^- + Fe^{2+} + 2Cl^-$

$\mathbf{NaCl(aq) + Fe(NO_3)_2(aq) \rightarrow NR}$

2. Acid base Reaction

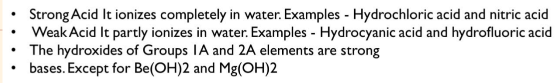


4.4 Acid–Base Reactions

- ✓ Acids have sour taste. Bases have bitter taste & soapy feel.
- ✓ An **acid–base indicator** is *a dye used to distinguish between acidic and basic solutions by means of color change*
- ✓ Litmus: in acidic solution = red & in basic solution = blue
- ✓ Phenolphthalein: in acidic solution = colorless & in basic solution = pink

Table 4.2 Common Acids and Bases

Name	Formula	Remarks
Acids		
Acetic acid	$HC_2H_3O_2$	Found in vinegar
Acetylsalicylic acid	$HC_9H_7O_4$	Aspirin
Ascorbic acid	$H_2C_6H_6O_6$	Vitamin C
Citric acid	$H_3C_6H_5O_7$	Found in lemon juice
Hydrochloric acid	HCl	Found in gastric juice (digestive fluid in stomach)
Sulfuric acid	H_2SO_4	Battery acid
Bases		
Ammonia	NH_3	Aqueous solution used as a household cleaner
Calcium hydroxide	$Ca(OH)_2$	Slaked lime (used in mortar for building construction)
Magnesium hydroxide	$Mg(OH)_2$	Milk of magnesia (antacid and laxative)
Sodium hydroxide	$NaOH$	Drain cleaners, oven cleaners

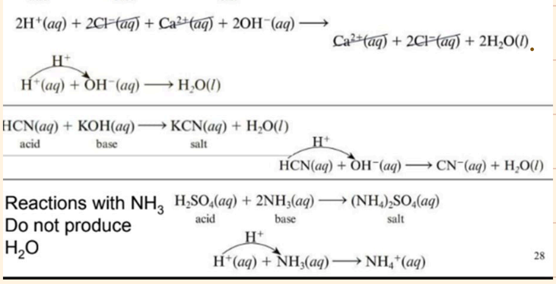

- Strong Acid It ionizes completely in water. Examples - Hydrochloric acid and nitric acid
- Weak Acid It partly ionizes in water. Examples - Hydrocyanic acid and hydrofluoric acid
- The hydroxides of Groups 1A and 2A elements are strong
- bases. Except for Be(OH)2 and Mg(OH)2

Definitions of acid and base
according to Bronsted and Lowry
An acid is the species (molecule or ion) that donates a proton to another species in a proton-transfer reaction.
A base is the species (molecule or ion) that accepts a proton from another species in a proton-transfer reaction.

An acid produces hydrogen ions when dissolved
in water.
HNO, (aq) ->H*(aq) + NO, (aq)
A base produces hydroxide ions when dissolved in
water.
NaOH(s) >Na*(aq) + OH (aq)

- **Neutralization reaction**

A reaction of an acid and base that results in an ionic compound and possibly water



$2HCl(aq) + Ca(OH)_2(aq) \longrightarrow CaCl_2(aq) + 2H_2O(l)$ Driving force of reaction

acid base salt

$2H^+(aq) + \cancel{2Cl^-(aq)} + \cancel{Ca^{2+}(aq)} + 2OH^-(aq) \longrightarrow \cancel{Ca^{2+}(aq)} + \cancel{2Cl^-(aq)} + 2H_2O(l)$.

H^+

$H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$

$HCN(aq) + KOH(aq) \longrightarrow KCN(aq) + H_2O(l)$

acid base salt

H^+

$HCN(aq) + OH^-(aq) \longrightarrow CN^-(aq) + H_2O(l)$

Reactions with NH_3
Do not produce
H_2O

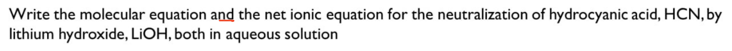
$H_2SO_4(aq) + 2NH_3(aq) \longrightarrow (NH_4)_2SO_4(aq)$

acid base salt

H^+

$H^+(aq) + NH_3(aq) \longrightarrow NH_4^+(aq)$

28



Write the molecular equation and the net ionic equation for the neutralization of hydrocyanic acid, HCN, by lithium hydroxide, LiOH, both in aqueous solution

$HCN + LiOH \rightarrow LiCN + H_2O$

$HCN + \cancel{Li^+} + OH^- \rightarrow \cancel{Li^+} + CN^- + H_2O$

$HCN + OH^- \rightarrow CN^- + H_2O$

- **Acid-Base Reactions with gasc formation**

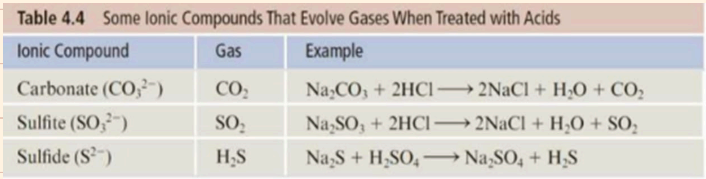
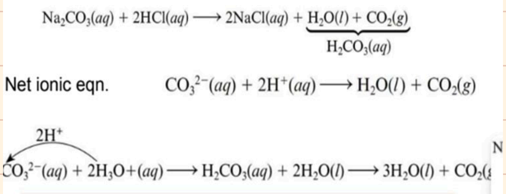


Table 4.4 Some Ionic Compounds That Evolve Gases When Treated with Acids

Ionic Compound	Gas	Example
Carbonate (CO_3^{2-})	CO_2	$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$
Sulfite (SO_3^{2-})	SO_2	$Na_2SO_3 + 2HCl \longrightarrow 2NaCl + H_2O + SO_2$
Sulfide (S^{2-})	H_2S	$Na_2S + H_2SO_4 \longrightarrow Na_2SO_4 + H_2S$



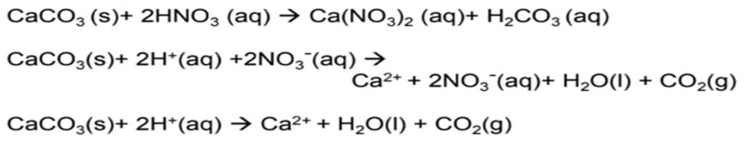
$$Na_2CO_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + \underbrace{H_2O(l) + CO_2(g)}_{H_2CO_3(aq)}$$

Net ionic eqn. $CO_3^{2-}(aq) + 2H^+(aq) \longrightarrow H_2O(l) + CO_2(g)$

$2H^+$

$CO_3^{2-}(aq) + 2H_3O+(aq) \longrightarrow H_2CO_3(aq) + 2H_2O(l) \longrightarrow 3H_2O(l) + CO_2($

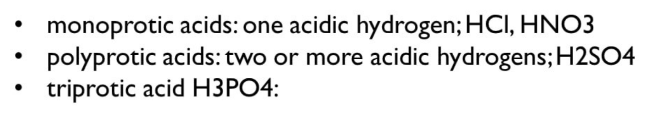
N



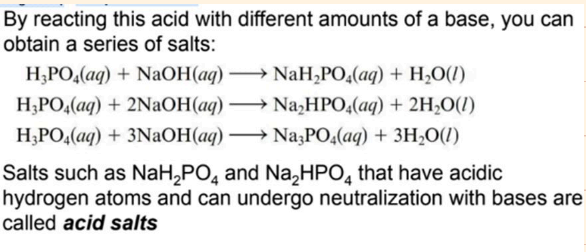
$CaCO_3\ (s) + 2HNO_3\ (aq) \rightarrow Ca(NO_3)_2\ (aq) + H_2CO_3\ (aq)$

$CaCO_3(s) + 2H^+(aq) + 2NO_3^-(aq) \rightarrow Ca^{2+} + 2NO_3^-(aq) + H_2O(l) + CO_2(g)$

$CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+} + H_2O(l) + CO_2(g)$



- monoprotic acids: one acidic hydrogen; HCl, HNO3
- polyprotic acids: two or more acidic hydrogens; H2SO4
- triprotic acid H3PO4:



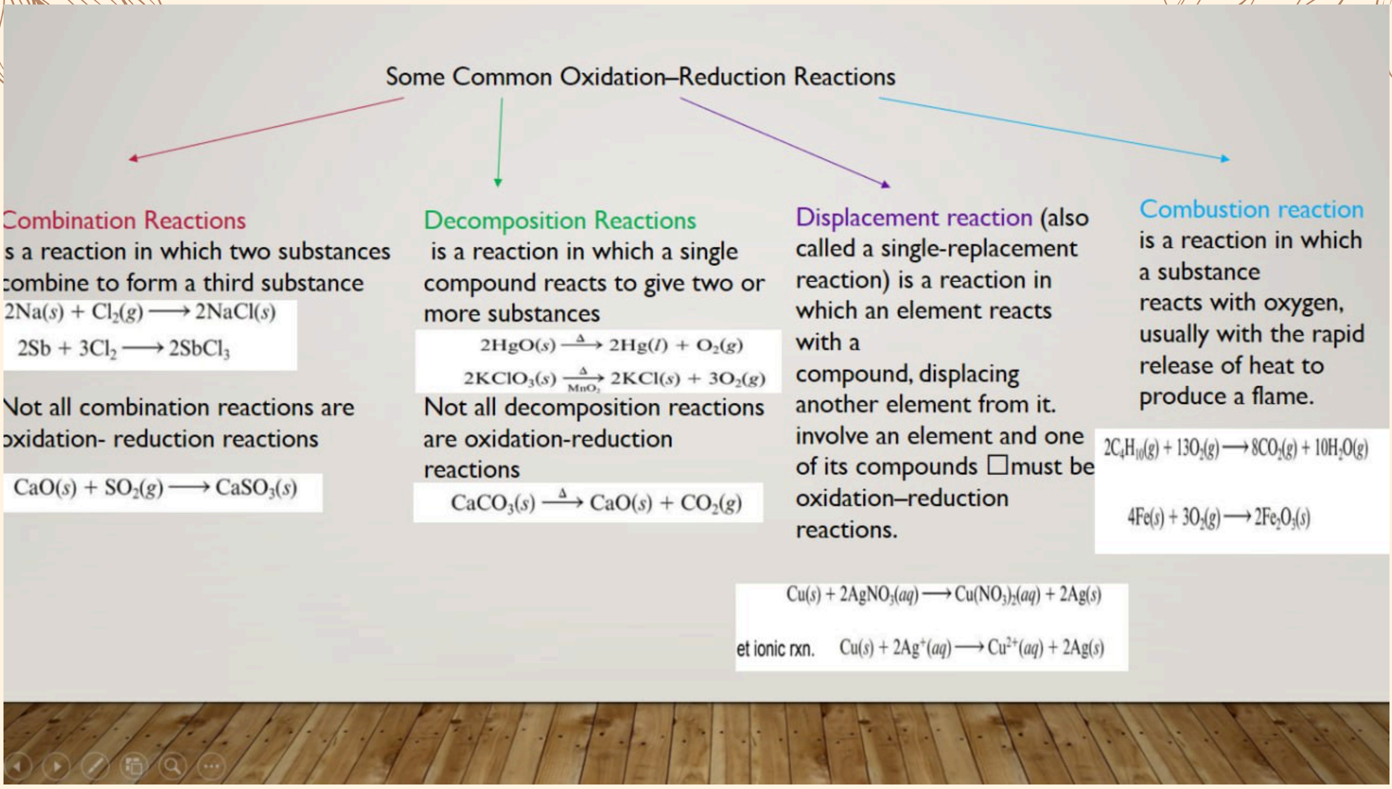
By reacting this acid with different amounts of a base, you can obtain a series of salts:

$H_3PO_4(aq) + NaOH(aq) \longrightarrow NaH_2PO_4(aq) + H_2O(l)$

$H_3PO_4(aq) + 2NaOH(aq) \longrightarrow Na_2HPO_4(aq) + 2H_2O(l)$

$H_3PO_4(aq) + 3NaOH(aq) \longrightarrow Na_3PO_4(aq) + 3H_2O(l)$

Salts such as NaH_2PO_4 and Na_2HPO_4 that have acidic hydrogen atoms and can undergo neutralization with bases are called ***acid salts***



Some Common Oxidation–Reduction Reactions

Combination Reactions

s a reaction in which two substances combine to form a third substance

$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$

$2Sb + 3Cl_2 \longrightarrow 2SbCl_3$

Not all combination reactions are oxidation- reduction reactions

$CaO(s) + SO_2(g) \longrightarrow CaSO_3(s)$

Decomposition Reactions

is a reaction in which a single compound reacts to give two or more substances

$2HgO(s) \xrightarrow{\Delta} 2Hg(l) + O_2(g)$

$2KClO_3(s) \xrightarrow[MnO_2]{\Delta} 2KCl(s) + 3O_2(g)$

Not all decomposition reactions are oxidation-reduction reactions

$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$

Displacement reaction (also called a single-replacement reaction) is a reaction in which an element reacts with a compound, displacing another element from it. involve an element and one of its compounds □must be oxidation–reduction reactions.

$Cu(s) + 2AgNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2Ag(s)$

et ionic rxn. $Cu(s) + 2Ag^+(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$

Combustion reaction is a reaction in which a substance reacts with oxygen, usually with the rapid release of heat to produce a flame.

$2C_4H_{10}(g) + 13O_2(g) \longrightarrow 8CO_2(g) + 10H_2O(g)$

$4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(s)$

What is the final concentration of HCl in a solution prepared by addition of 922 ml of 4.73 M HCl to 549 ml of 2.03 M HCl ?

sec(1) → $n = 922 \times 10^{-3} \times 4.73 = 4.4$

sec(2) → $n = 2.03 \times 10^{-3} \times 549 = 1.11$

Total moles → $4.4 + 1.11 = 5.5$

Total volume → $(922 + 549) \times 10^{-3} = 1.47$

$$\frac{n}{v} = M$$

$$\frac{5.5}{1.47}$$

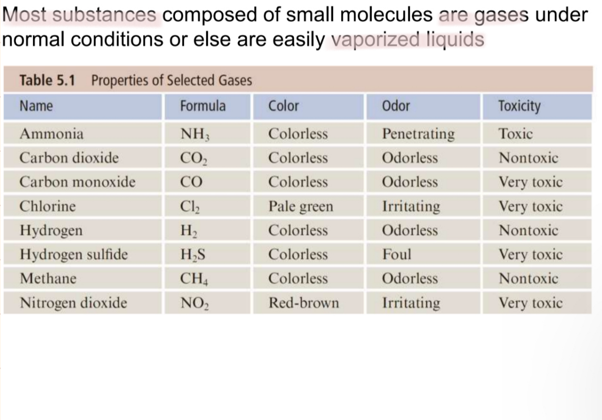
$$\boxed{M = 3.7}$$

what is the mass in grams of hydrogen atoms present in 5 molecules of water?

$$n = \frac{\text{number of atoms or molecules}}{\text{Avogadro's number}} \rightarrow$$ المطلوب

$$\frac{2 \times 5}{6.022 \times 10^{23}} = 1.67 \times 10^{-23}$$

CH . 5 Gaseous state



Most substances composed of small molecules are gases under normal conditions or else are easily vaporized liquids

Table 5.1 Properties of Selected Gases

Name	Formula	Color	Odor	Toxicity
Ammonia	NH_3	Colorless	Penetrating	Toxic
Carbon dioxide	CO_2	Colorless	Odorless	Nontoxic
Carbon monoxide	CO	Colorless	Odorless	Very toxic
Chlorine	Cl_2	Pale green	Irritating	Very toxic
Hydrogen	H_2	Colorless	Odorless	Nontoxic
Hydrogen sulfide	H_2S	Colorless	Foul	Very toxic
Methane	CH_4	Colorless	Odorless	Nontoxic
Nitrogen dioxide	NO_2	Red-brown	Irritating	Very toxic

Gas pressure and its Measurement

pressure → The force exerted per unit area of surface → $kg/m.s^2$ → pascal (pa)

$F = m g$

pressure of coin (9.3 mm in radius and 2.5g)

$F = \text{mass} \times g$

$\text{Area} = \pi r^2$

$\left.\right] \rightarrow p = \frac{F}{A}$

The general relationship between the pressure (p) and hight (h) of a liquid column in a barometer or manometer is $p = gdh$

A barometer is a device for measuring the pressure of the atmosphere.

A manometer is a device that measures the pressure of a gas or liquid in a vessel.

The pressure of a gas in a flask is measured to be 797.7 mm Hg. What is this pressure in pascal and atmosphere?

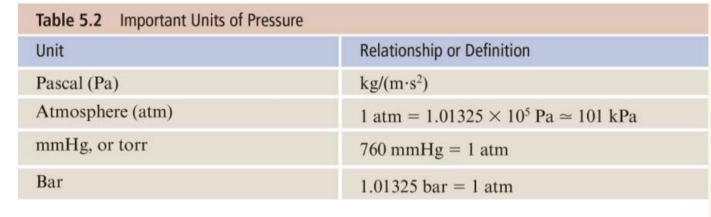


Table 5.2 Important Units of Pressure

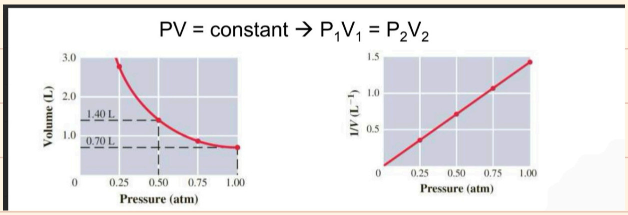
Unit	Relationship or Definition
Pascal (Pa)	$kg/(m \cdot s^2)$
Atmosphere (atm)	1 atm = 1.01325×10^5 Pa ≃ 101 kPa
mmHg, or torr	760 mmHg = 1 atm
Bar	1.01325 bar = 1 atm

Empirical Gas laws

Boyle's law → $PV =$ constant → For given amount of gas at fixed Temperature.

The volume of a sample of gas at a given temperature varies inversely with the applied pressure $V \propto \frac{1}{P}$

PV = constant → $P_1V_1 = P_2V_2$



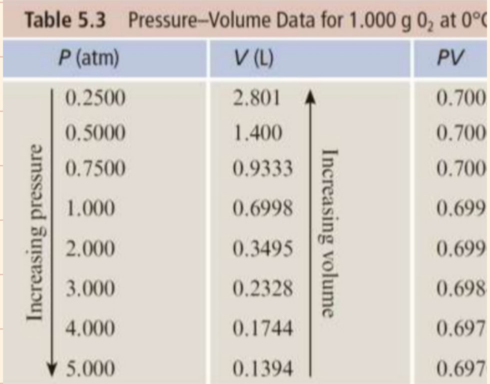


Table 5.3 Pressure–Volume Data for 1.000 g 0_2 at 0°

P (atm)	V (L)	PV
0.2500	2.801	0.700
0.5000	1.400	0.700
0.7500	0.9333	0.700
1.000	0.6998	0.699
2.000	0.3495	0.699
3.000	0.2328	0.698
4.000	0.1744	0.697
5.000	0.1394	0.697

Increasing pressure

Increasing volume

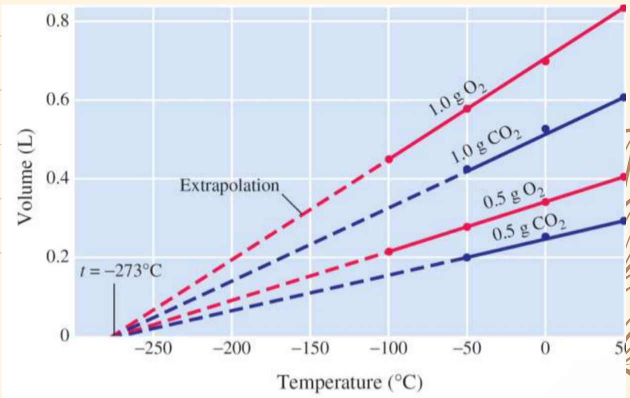
ممكن يجيب هذا الجدول ويسأل اذا زدنا الضغط كم يصير الحجم ← فلازم تعرفي العلاقة بينهم

$dm^3 = L$

Charles's law → $\frac{V}{T} =$ constant → For given amount of gas at a fixed pressure

$\frac{V_f}{T_f} = \frac{V_i}{T_i}$ → First convert $T = °C + 273 = K$

Absolute zero is the point in which a straight-line graph of V versus T (K) intersects the origin.





Boyles's law & charles's law can be combined to:

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

A 39.8 mg sample of caffeine gives 10.1 cm^3 of N_2 gas at 23°C and 746 mmHg. What is the volume of N_2 at 0°C and 760 mmHg?

↳ The Question gives us the mass just to tell us that the amount of gas is constant → we dont have to use it.

Avogadro's law: → temperature / molar concentration / pressure طالما ثابتين

1. French chemist Joseph Louis Gay Luassac concluded from experaments on gas reactions → The law of combining volumes.
2. Equal volumes of any two gases at the same temperature and pressure contain the same number of molecules.
3. STP → standard Temperature & pressure (0°c & 1atm)
4. Means that one mole of that gas equals 22.4L

Avogadro's law → V_m = specific constant = 22.4 L/mol at STP

The Ideal Gas law ⇒ $pv = nRT$ → $k = °C + 273$

atm ← p

v → L

n → moles

R → = 0.082

↳ But in questions that consiste energy we put it → R = 8.314

Gas Density → $PM_m = dRT$

Molecular weight Determination (Mr) (g/mol)

d is the density of the gas in g/L

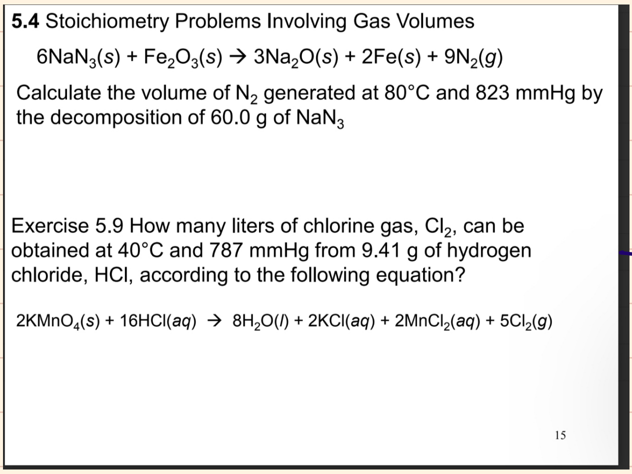
The gas that has the greatest density has the greatest Mr


Whenever the question sayes oxygen
it is O_2 so Mr = 32 not 16

Calculate the volum of 7.4g NH_3 at STP → $V = \frac{nRT}{P}$

OR → Calculate the number of moles then ...
by using avogadro.

1 mole → 22.4
0.44 " → x



5.4 Stoichiometry Problems Involving Gas Volumes

$6NaN_3(s) + Fe_2O_3(s) \rightarrow 3Na_2O(s) + 2Fe(s) + 9N_2(g)$

Calculate the volume of N_2 generated at 80°C and 823 mmHg by the decomposition of 60.0 g of NaN_3

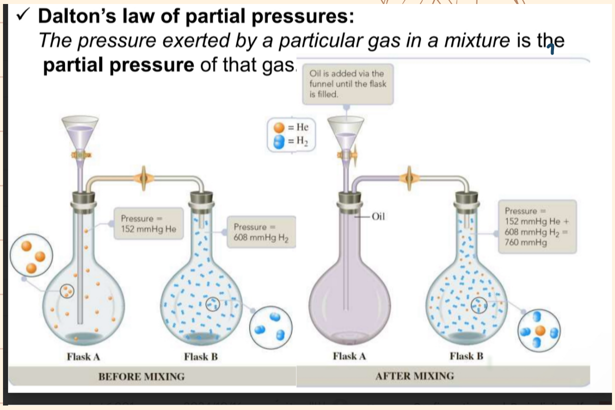
Exercise 5.9 How many liters of chlorine gas, Cl_2, can be obtained at 40°C and 787 mmHg from 9.41 g of hydrogen chloride, HCl, according to the following equation?

$2KMnO_4(s) + 16HCl(aq) \rightarrow 8H_2O(l) + 2KCl(aq) + 2MnCl_2(aq) + 5Cl_2(g)$

→ imp

Gas Mixtures : law partial pressures

The pressure exerted by a particular gas in a mixture is the partial pressure of that gas



✓ **Dalton's law of partial pressures:**
The pressure exerted by a particular gas in a mixture is the **partial pressure** of that gas.

The individual partial pressures follow the Ideal gas law

→ For component A → $P_A V = n_A RT$

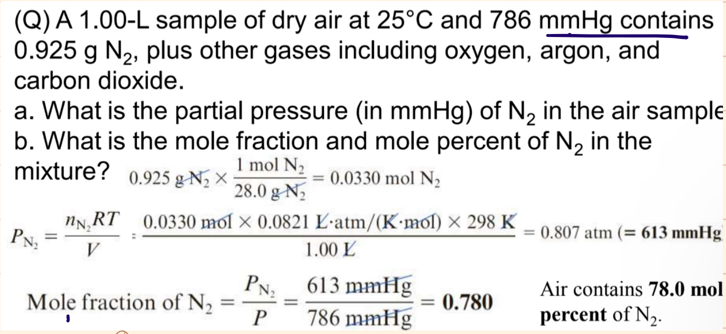
$P_{Total} = n \quad TR / V$

sum of moles for the whole sample

Dalton's law of partial pressures :-

$P = P_A + P_B + P_C$

Mole fraction of A $= \frac{n_A}{n} = \frac{P_A}{P}$



(Q) A 1.00-L sample of dry air at 25°C and 786 mmHg contains 0.925 g N_2, plus other gases including oxygen, argon, and carbon dioxide.
a. What is the partial pressure (in mmHg) of N_2 in the air sample
b. What is the mole fraction and mole percent of N_2 in the mixture?

$0.925 \text{ g } \cancel{N_2} \times \frac{1 \text{ mol } N_2}{28.0 \text{ g } \cancel{N_2}} = 0.0330 \text{ mol } N_2$

$P_{N_2} = \frac{n_{N_2}RT}{V} = \frac{0.0330 \cancel{\text{mol}} \times 0.0821 \cancel{\text{L}}\cdot\text{atm}/(\cancel{\text{K}}\cdot\cancel{\text{mol}}) \times 298 \cancel{\text{K}}}{1.00 \cancel{\text{L}}} = 0.807 \text{ atm } (= \mathbf{613 \text{ mmHg}}$

Mole fraction of $N_2 = \frac{P_{N_2}}{P} = \frac{613 \cancel{\text{mmHg}}}{786 \cancel{\text{mmHg}}} = \mathbf{0.780}$

Air contains **78.0 mol percent** of N_2.

$\frac{P_i V_i}{T_i} = \frac{P_F V_F}{T_F}$

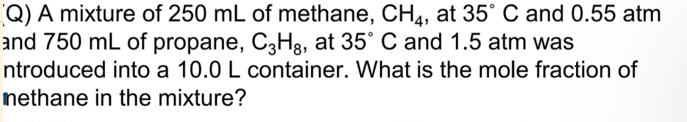
$\frac{0.55\,(0.25)}{35 + \cancel{273}} = \frac{P_F \quad (10)}{35 + \cancel{273}}$

1] $\boxed{P_{F\,CH_4} = 0.0138}$

بنفس الطريقة تحسب بقية الغازات

2] $P_{C_3H_8} = 0.112$

mole fraction $= \frac{P_{CH_4}}{P_{Total}} = \frac{0.0138}{0.0138 + 0.112} = 0.1$



(Q) A mixture of 250 mL of methane, CH_4, at 35˚ C and 0.55 atm and 750 mL of propane, C_3H_8, at 35˚ C and 1.5 atm was introduced into a 10.0 L container. What is the mole fraction of methane in the mixture?

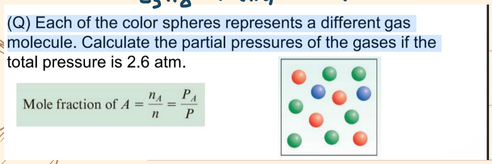
A. 0.50 0.55 atm × 0.250 L

في مثل هذه الأسئلة عندما تتغير ظروف الغازات فإننا نستخدم علاقة

$\frac{P_F V_F}{T_F} = \frac{P_i V_i}{T_i}$

اذا بدك تستخدمي المولات تحسبيها ع أساس المعلومات الابتدائية لأنه المولات ثابتة لنفس الحجم

$x_{CH_4} = \frac{n_{CH_4}}{n_{C_3H_8} + n_{CH_4}}$



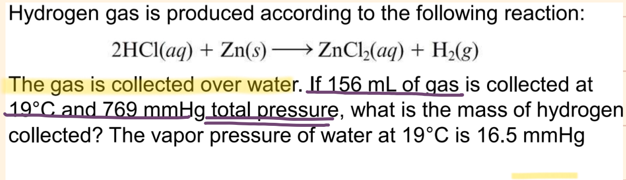
(Q) Each of the color spheres represents a different gas molecule. Calculate the partial pressures of the gases if the total pressure is 2.6 atm.

Mole fraction of $A = \frac{n_A}{n} = \frac{P_A}{P}$

$P_A = P *$ mole of fraction

Mole of fraction = moles of the gas that we want to find (Pa) for it / the Total number of molecules.

بنعدهم عد من الرسمة



Hydrogen gas is produced according to the following reaction:

$$2HCl(aq) + Zn(s) \longrightarrow ZnCl_2(aq) + H_2(g)$$

The gas is collected over water. If 156 mL of gas is collected at 19°C and 769 mmHg total pressure, what is the mass of hydrogen collected? The vapor pressure of water at 19°C is 16.5 mmHg

$P_T = P_{H_2} + P_{H_2O}$

$\downarrow$

$769 = P_{H_2} + 16.5$

$752.5 \text{ mmHg} = P_{H_2}$

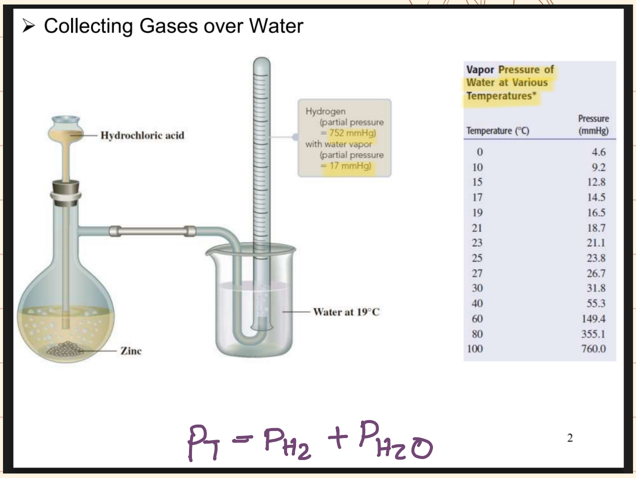
$\frac{752.5}{760} \text{ atm} = P_{H_2}$

$0.99 \text{ atm} = P_{H_2}$

$PV = nRT$

$n = \frac{PV}{RT} = \frac{0.99 \times 156\times10^{-3}}{0.082 \times (19+273)} = \frac{0.154}{23.9} = 6.46\times10^{-3}$

$m = n\,Mr = 6.46\times10^{-3} \times 2 = 0.0129\,g$

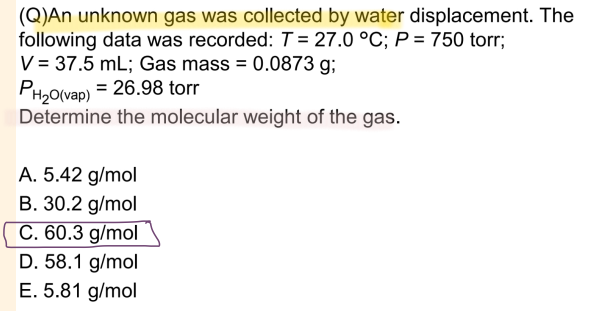


➢ Collecting Gases over Water

Vapor Pressure of Water at Various Temperatures*

Temperature (°C)	Pressure (mmHg)
0	4.6
10	9.2
15	12.8
17	14.5
19	16.5
21	18.7
23	21.1
25	23.8
27	26.7
30	31.8
40	55.3
60	149.4
80	355.1
100	760.0

$P_T = P_{H_2} + P_{H_2O}$



(Q)An unknown gas was collected by water displacement. The following data was recorded: $T = 27.0$ °C; $P = 750$ torr; $V = 37.5$ mL; Gas mass = 0.0873 g; $P_{H_2O(vap)} = 26.98$ torr

Determine the molecular weight of the gas.

A. 5.42 g/mol
B. 30.2 g/mol
[✓ C. 60.3 g/mol]
D. 58.1 g/mol
E. 5.81 g/mol

$P_T = P_g + P_{H_2O}$

$750 = P_g + 26.98$

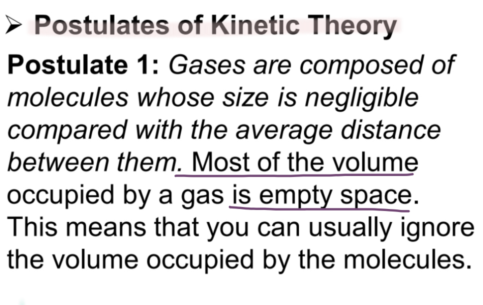
$\boxed{723 = P_g}$

$\frac{723}{760} = 0.95 = P_g \rightarrow PV = nRT$

$n = \frac{PV}{RT} = \frac{0.95 \times 37.5\times10^{-3}}{0.082\times(27+273)} = \frac{0.0356}{24.6} = 1.448\times10^{-3}$

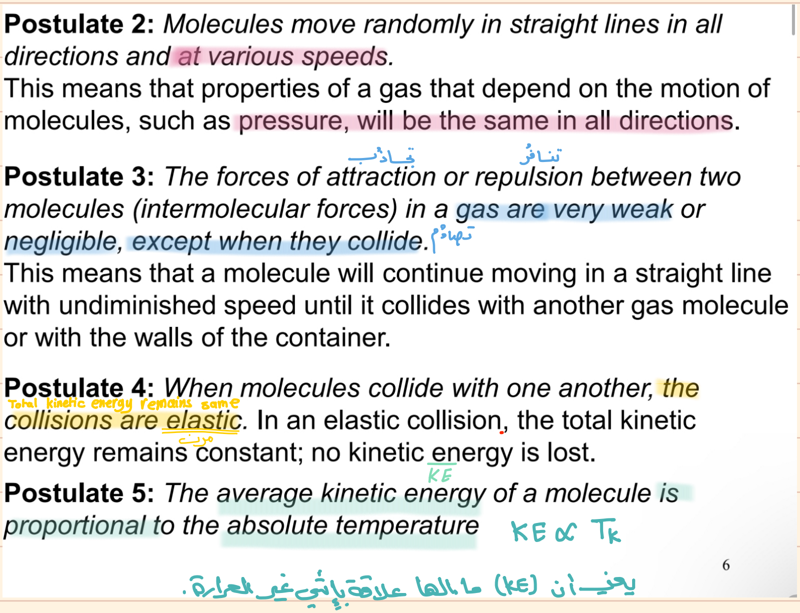
$Mr = \frac{m}{n} = \frac{0.0873}{1.448\times10^{-3}} = 60.3$

Kinetic Energy



➢ **Postulates of Kinetic Theory**

Postulate 1: *Gases are composed of molecules whose size is negligible compared with the average distance between them.* Most of the volume occupied by a gas is empty space. This means that you can usually ignore the volume occupied by the molecules.



Postulate 2: *Molecules move randomly in straight lines in all directions and at various speeds.* This means that properties of a gas that depend on the motion of molecules, such as pressure, will be the same in all directions.

تجاذب تنافر

Postulate 3: *The forces of attraction or repulsion between two molecules (intermolecular forces) in a gas are very weak or negligible, except when they collide.* تصادم This means that a molecule will continue moving in a straight line with undiminished speed until it collides with another gas molecule or with the walls of the container.

Postulate 4: *When molecules collide with one another, the collisions are elastic.* In an elastic collision, the total kinetic energy remains constant; no kinetic energy is lost.

Total kinetic energy remains same

مرن

KE

Postulate 5: *The average kinetic energy of a molecule is proportional to the absolute temperature* $KE \propto T_K$

6

يعني أن (KE) ما الها علاقة بإشي غير الحرارة.

*pressure is due to the collisions of the gas particales with the walles of the container

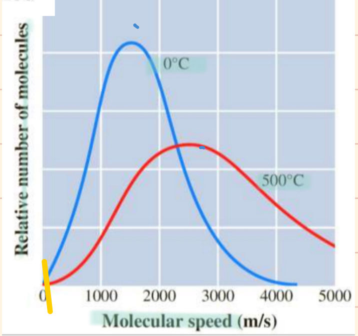
Molecular speeds: Diffusion anel Effusion.

→ root-meen-square (rms) molecular speed (u) $u = \sqrt{\frac{3RT \rightarrow K}{M_m}}$

8.314 $kg \cdot m^2 / s^2 \cdot K \cdot mol$

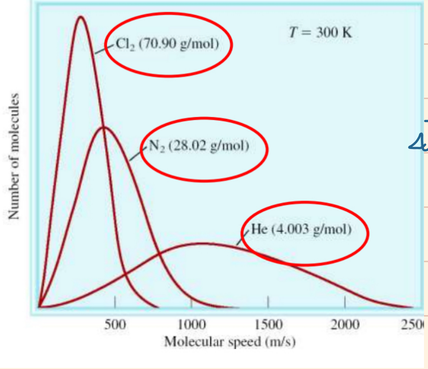
(kg /mol)

The same gas in different Tempretures



Maxwell's distribution of molecular speeds The distributions of speeds of H_2 molecules are shown for 0°C and 500°C. Note that the speed corresponding to the maximum in the curve (the most probable speed) increases with temperature.

different gases at the same Temprature



كلما قل ال molar mass للعنصر تزداد سرعته مع تثبيت درجة الحرارة.

Calculate the rms speed of O_2 molecules in a cylinder at 21°C & 15.7 atm.

$$u = \sqrt{\frac{3 \times 8.314 \times (21+273)}{32 \times 10^{-3}}} = \boxed{439 \ m/s}$$

عشانها kg/mol

At what temperature do H_2 molecules have the Same average kinetic energy?

Any two gases at the same temperature will have the same average kinetic Energy.

Because the Average kinetic Energy of A molecule is proportional to only T

---

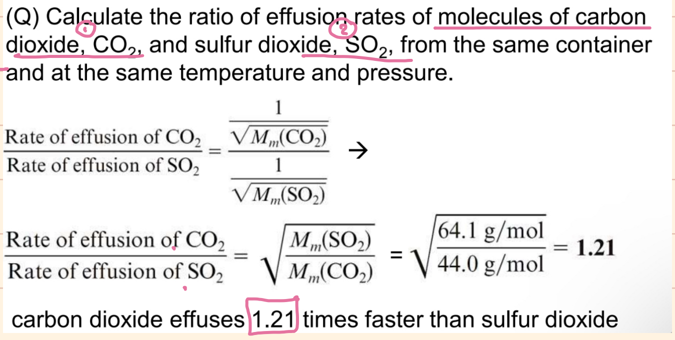
* Diffusion & Effusion

Diffusion: is the process whereby a gas spreads out through another gas.

Effusion: is the process in which a gas flows through a small hole in a container

Graham's law of Effusion

$$\text{Rate of effusion of molecules} \propto \frac{1}{\sqrt{M_m}} \rightarrow$$ For the same container at constant T and P



(Q) Calculate the ratio of effusion rates of molecules of carbon dioxide, ① CO_2, and sulfur dioxide, ② SO_2, from the same container and at the same temperature and pressure.

$\frac{CO_2}{SO_2}$ مطلوب ←

$$\frac{\text{Rate of effusion of } CO_2}{\text{Rate of effusion of } SO_2} = \frac{\frac{1}{\sqrt{M_m(CO_2)}}}{\frac{1}{\sqrt{M_m(SO_2)}}} \rightarrow$$

مقام المقام بطلع بسط بصير $\frac{SO_2}{CO_2}$

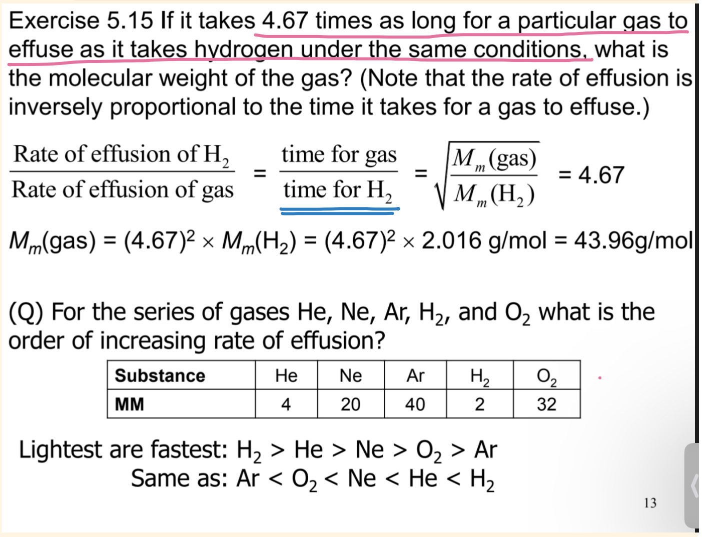
$$\frac{\text{Rate of effusion of } CO_2}{\text{Rate of effusion of } SO_2} = \sqrt{\frac{M_m(SO_2)}{M_m(CO_2)}} = \sqrt{\frac{64.1\text{ g/mol}}{44.0\text{ g/mol}}} = \mathbf{1.21}$$

carbon dioxide effuses $\boxed{1.21}$ times faster than sulfur dioxide

faster

$$\frac{\text{rate of effusion for gas 1}}{\text{rate of effusion for gas 2}} = \sqrt{\frac{M_2}{M_1}}$$

ابقي لصفحة السؤال



Exercise 5.15 If it takes 4.67 times as long for a particular gas to effuse as it takes hydrogen under the same conditions, what is the molecular weight of the gas? (Note that the rate of effusion is inversely proportional to the time it takes for a gas to effuse.)

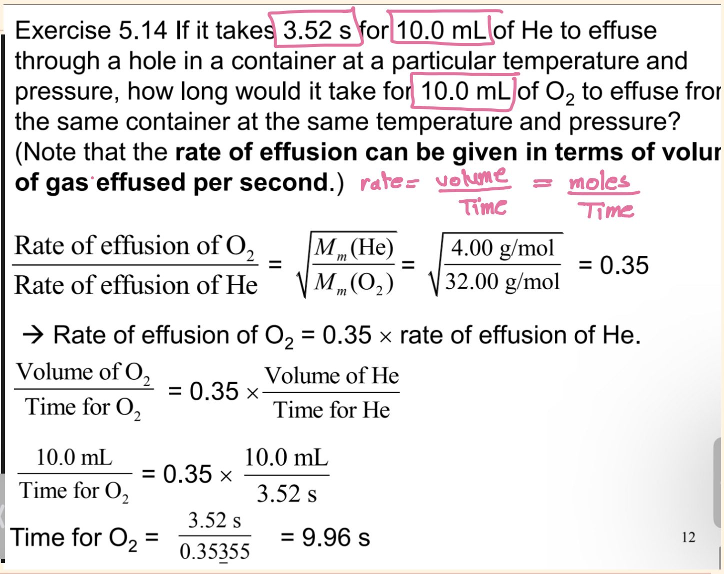
$$\frac{\text{Rate of effusion of H}_2}{\text{Rate of effusion of gas}} = \frac{\text{time for gas}}{\text{time for H}_2} = \sqrt{\frac{M_m(\text{gas})}{M_m(\text{H}_2)}} = 4.67$$

$M_m(\text{gas}) = (4.67)^2 \times M_m(\text{H}_2) = (4.67)^2 \times 2.016$ g/mol = 43.96g/mol

(Q) For the series of gases He, Ne, Ar, H_2, and O_2 what is the order of increasing rate of effusion?

Substance	He	Ne	Ar	H_2	O_2
MM	4	20	40	2	32

Lightest are fastest: H_2 > He > Ne > O_2 > Ar
Same as: Ar < O_2 < Ne < He < H_2



Exercise 5.14 If it takes 3.52 s for 10.0 mL of He to effuse through a hole in a container at a particular temperature and pressure, how long would it take for 10.0 mL of O_2 to effuse fror the same container at the same temperature and pressure? (Note that the **rate of effusion can be given in terms of volur of gas effused per second**.) rate= $\frac{\text{volume}}{\text{Time}} = \frac{\text{moles}}{\text{Time}}$

$$\frac{\text{Rate of effusion of O}_2}{\text{Rate of effusion of He}} = \sqrt{\frac{M_m(\text{He})}{M_m(\text{O}_2)}} = \sqrt{\frac{4.00 \text{ g/mol}}{32.00 \text{ g/mol}}} = 0.35$$

→ Rate of effusion of O_2 = 0.35 × rate of effusion of He.

$$\frac{\text{Volume of O}_2}{\text{Time for O}_2} = 0.35 \times \frac{\text{Volume of He}}{\text{Time for He}}$$

$$\frac{10.0 \text{ mL}}{\text{Time for O}_2} = 0.35 \times \frac{10.0 \text{ mL}}{3.52 \text{ s}}$$

$$\text{Time for O}_2 = \frac{3.52 \text{ s}}{0.35355} = 9.96 \text{ s}$$

The van der Waals equation

is an equation similar to the ideal gas law but includes two constants, a & b, to account for deviations from ideal behavior.

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

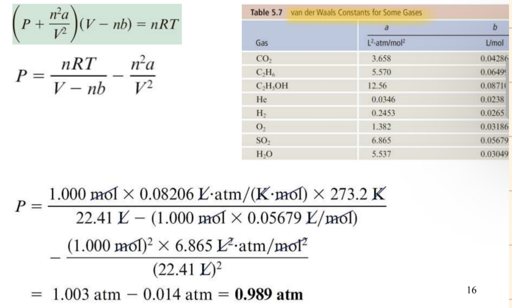
→ R= 0.082

↳ v (actual) = v (ideal) − nb

↓

$$p(\text{actual}) = p(\text{ideal}) - \frac{n^2 a}{v^2}$$

*imp



(Q)If sulfur dioxide were an ideal gas, the pressure at 0.0°C exerted by 1.000 mole occupying 22.41 L would be 1.000 atm (22.41 L is the molar volume of an ideal gas at STP). Use the van der Waals equation to estimate the pressure of this volume of 1.000 mol SO_2 at 0.0°C. See Table 5.7 for values of *a* and *b*.

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

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

Table 5.7 van der Waals Constants for Some Gases

Gas	a L²·atm/mol²	b L/mol
CO_2	3.658	0.04286
C_2H_6	5.570	0.0649
C_2H_5OH	12.56	0.0871
He	0.0346	0.0238
H_2	0.2453	0.0265
O_2	1.382	0.03186
SO_2	6.865	0.05679
H_2O	5.537	0.03049

$$P = \frac{1.000\ \cancel{\text{mol}} \times 0.08206\ \cancel{\text{L}}\cdot\text{atm}/(\cancel{\text{K}}\cdot\cancel{\text{mol}}) \times 273.2\ \cancel{\text{K}}}{22.41\ \cancel{\text{L}} - (1.000\ \cancel{\text{mol}} \times 0.05679\ \cancel{\text{L}}/\cancel{\text{mol}})} - \frac{(1.000\ \cancel{\text{mol}})^2 \times 6.865\ \cancel{\text{L}^2}\cdot\text{atm}/\cancel{\text{mol}^2}}{(22.41\ \cancel{\text{L}})^2}$$

$= 1.003 \text{ atm} - 0.014 \text{ atm} = \mathbf{0.989 \text{ atm}}$

What is the molar mass in(g/mol) of an unknown gas, which effuses with a rate equal to double the rate of Cl_2 gas (70.9)g/mol.

$$\frac{R_{Cl_2}}{R_A} = \sqrt{\frac{Mr_A}{Mr_{Cl_2}}} \longrightarrow \frac{\cancel{R_{Cl_2}}}{2\,\cancel{R_{A_2}}} = \sqrt{\frac{Mr_A}{70.9}}$$

$$\left(\frac{1}{2}\right)^2 * 70.9 = Mr_A = 17.7\,g/mol.$$

CH.6

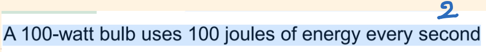
Thermodynamics : is the science of the relationships between heat & other forms of energy

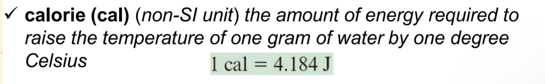
Thermochemistry : is one area of thermodynamics. It concerns the study of the quantity of heat absorbed or evolved (given out) by chemical reactions.

Energy : is the potential or capacity to move matter. can exist in different forms, including heat, light, electrical Energy and these different forms can be interconverted.

Kinetic Energy : The energy associated with an object by virtue of its motion.

$$E_K = \frac{1}{2}\overset{kg}{m}v^2 \rightarrow kg \cdot m^2/s^2 = joule \qquad watt = \frac{joule}{second}$$

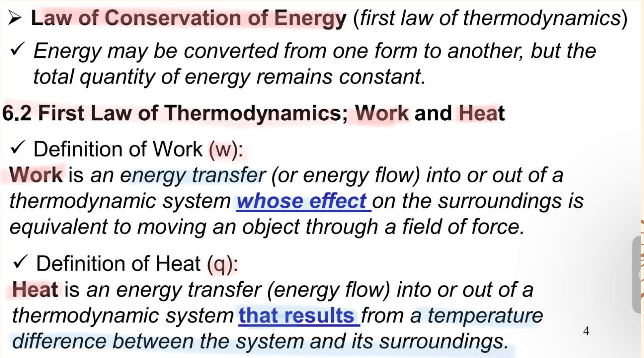

A 100-watt bulb uses 100 joules of energy every second


✓ **calorie (cal)** *(non-SI unit) the amount of energy required to raise the temperature of one gram of water by one degree Celsius*
1 cal = 4.184 J

potential Energy : The energy an object has by virtue of its position in a field of force

$$E_{Total} = E_k + E_p + U$$

U → internal Energy: The sum of the kinetic & potential Energies of the particles making up a substance.

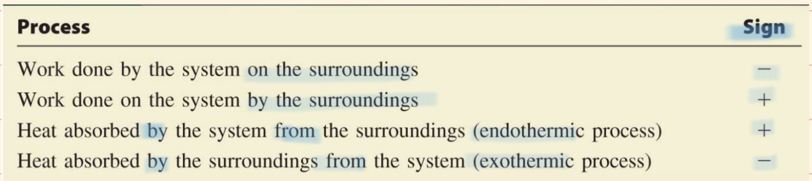

➢ **Law of Conservation of Energy** (*first law of thermodynamics*)

✓ *Energy may be converted from one form to another, but the total quantity of energy remains constant.*

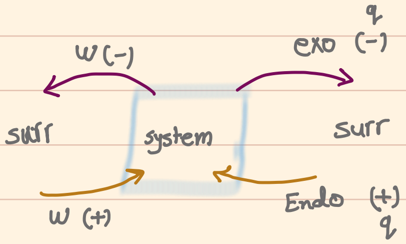
6.2 First Law of Thermodynamics; Work and Heat

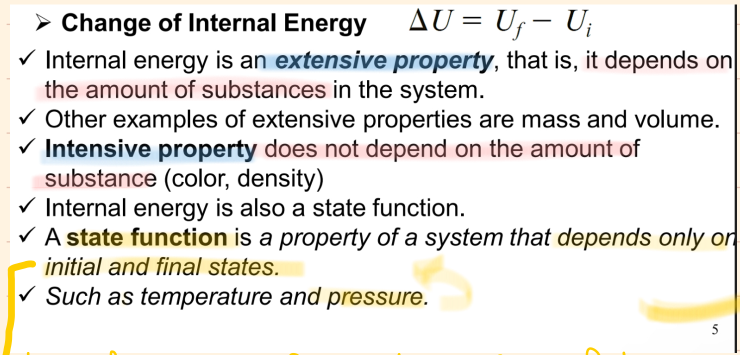
✓ Definition of Work (w):
Work *is an energy transfer (or energy flow) into or out of a thermodynamic system* ***whose effect*** *on the surroundings is equivalent to moving an object through a field of force.*

✓ Definition of Heat (q):
Heat *is an energy transfer (energy flow) into or out of a thermodynamic system* ***that results*** *from a temperature difference between the system and its surroundings.*



Process	Sign
Work done by the system on the surroundings	−
Work done on the system by the surroundings	+
Heat absorbed by the system from the surroundings (endothermic process)	+
Heat absorbed by the surroundings from the system (exothermic process)	−





- **Change of Internal Energy** $\Delta U = U_f - U_i$

✓ Internal energy is an ***extensive property***, that is, it depends on the amount of substances in the system.

✓ Other examples of extensive properties are mass and volume.

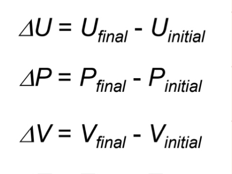
✓ **Intensive property** does not depend on the amount of substance (color, density)

✓ Internal energy is also a state function.

✓ A **state function** is *a property of a system that depends only on initial and final states.*

✓ *Such as temperature and pressure.*

5



$\Delta U = U_{final} - U_{initial}$

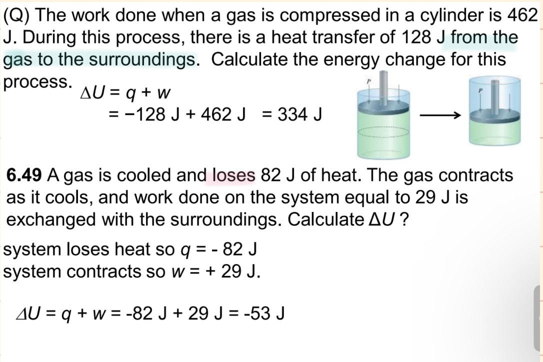
$\Delta P = P_{final} - P_{initial}$

$\Delta V = V_{final} - V_{initial}$

$\Delta T = T_{final} - T_{initial}$

is one of whose value for a system is determined by the composition of the system the volume
▷ the temperature and the pressure

$\Delta U = q + W$ → Be careful when u put the sign of each one (q, w)



(Q) The work done when a gas is compressed in a cylinder is 462 J. During this process, there is a heat transfer of 128 J from the gas to the surroundings. Calculate the energy change for this process.

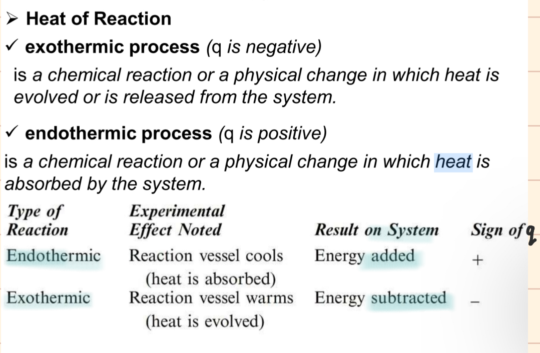
$\Delta U = q + w$

$= -128 \text{ J} + 462 \text{ J} = 334 \text{ J}$

6.49 A gas is cooled and loses 82 J of heat. The gas contracts as it cools, and work done on the system equal to 29 J is exchanged with the surroundings. Calculate ΔU ?

system loses heat so q = - 82 J
system contracts so w = + 29 J.

$\Delta U = q + w = -82 \text{ J} + 29 \text{ J} = -53 \text{ J}$



6.3 Heat of Reaction; Enthalpy of Reaction

- **Heat of Reaction**

✓ **exothermic process** (q *is negative)*

is a chemical reaction or a physical change in which heat is evolved or is released from the system.

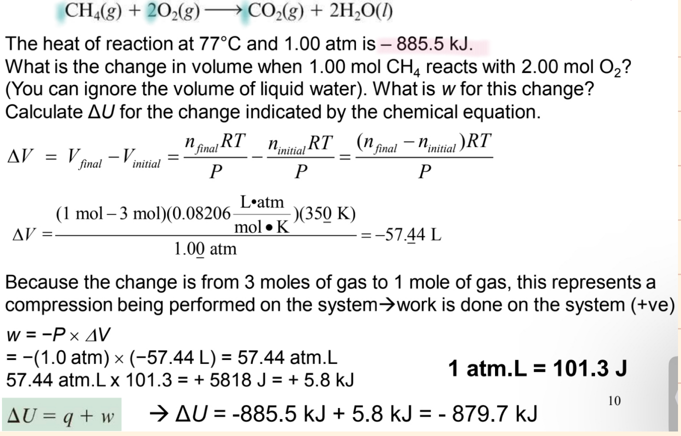
✓ **endothermic process** (q *is positive)*

is a chemical reaction or a physical change in which heat is absorbed by the system.

Type of Reaction	*Experimental Effect Noted*	*Result on System*	*Sign of q*
Endothermic	Reaction vessel cools (heat is absorbed)	Energy added	+
Exothermic	Reaction vessel warms (heat is evolved)	Energy subtracted	−

pressure – volume work → $w = -P\Delta V$

- Coffee cup Calorimeter $\Delta H = q$ → constant pressure
  (not for gases)
- bomb calorimeter $\Delta U = q$ → volume constant.
  (for gases)



Pressure-Volume Work $w = -P\Delta V$ = atm.L

1 atm.L = 101.3J

Exercise 6.4 Consider the combustion of CH_4.

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

The heat of reaction at 77°C and 1.00 atm is – 885.5 kJ.
What is the change in volume when 1.00 mol CH_4 reacts with 2.00 mol O_2? (You can ignore the volume of liquid water). What is *w* for this change? Calculate ΔU for the change indicated by the chemical equation.

$$\Delta V = V_{final} - V_{initial} = \frac{n_{final}RT}{P} - \frac{n_{initial}RT}{P} = \frac{(n_{final} - n_{initial})RT}{P}$$

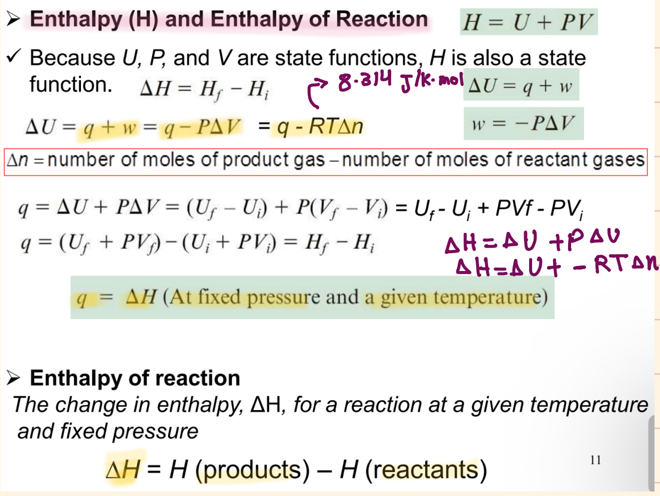
$$\Delta V = \frac{(1\text{ mol} - 3\text{ mol})(0.08206\frac{\text{L•atm}}{\text{mol}\bullet\text{K}})(35\underline{0}\text{ K})}{1.0\underline{0}\text{ atm}} = -57.\underline{4}4\text{ L}$$

Because the change is from 3 moles of gas to 1 mole of gas, this represents a compression being performed on the system→work is done on the system (+ve)

$w = -P \times \Delta V$
$= -(1.0\text{ atm}) \times (-57.44\text{ L}) = 57.44$ atm.L
57.44 atm.L x 101.3 = + 5818 J = + 5.8 kJ

1 atm.L = 101.3 J

$\Delta U = q + w$ → ΔU = -885.5 kJ + 5.8 kJ = - 879.7 kJ



Enthalpy (H) and Enthalpy of Reaction $H = U + PV$

✓ Because *U, P,* and *V* are state functions, *H* is also a state function. $\Delta H = H_f - H_i$

8.314 J/k.mol

$\Delta U = q + w$

$\Delta U = q + w = q - P\Delta V = q - RT\Delta n$

$w = -P\Delta V$

Δn = number of moles of product gas – number of moles of reactant gases

$q = \Delta U + P\Delta V = (U_f - U_i) + P(V_f - V_i) = U_f - U_i + PVf - PV_i$

$q = (U_f + PV_f) - (U_i + PV_i) = H_f - H_i$

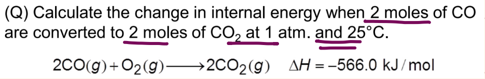
$\Delta H = \Delta U + P\Delta U$
$\Delta H = \Delta U + -RT\Delta n$

$q = \Delta H$ (At fixed pressure and a given temperature)

Enthalpy of reaction

The change in enthalpy, ΔH, *for a reaction at a given temperature and fixed pressure*

$\Delta H = H$ (products) – H (reactants)

ex. 

(Q) Calculate the change in internal energy when 2 moles of CO are converted to 2 moles of CO_2 at 1 atm. and 25°C.

$$2CO(g) + O_2(g) \longrightarrow 2CO_2(g) \quad \Delta H = -566.0\text{ kJ/mol}$$

الوِحَد مهمّة

$$\Delta H = \Delta U - \Delta n RT$$

$$-566\text{ kJ/mol} = \Delta U - (2-3)(8.314)\text{ J/k.mol }(25+273)\text{k}$$

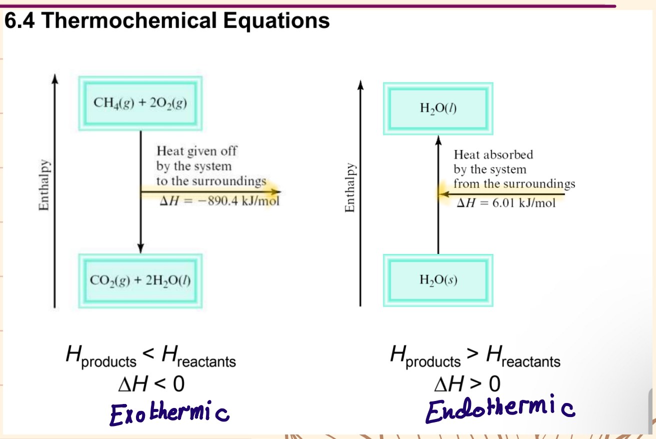
$$\frac{-566\text{ kJ}}{\text{mol}} = \Delta U + (8.314)\frac{\text{J}}{\cancel{\text{k}}\cdot\text{mol}}(298)\cancel{\text{k}}$$

$$\frac{-566\text{ kJ}}{\text{mol}} + (8.314)(298)\frac{\text{J}}{\text{mol}} = \Delta U$$

$$\frac{-566\text{ kJ}}{\text{mol}} + 2.477\frac{\text{kJ}}{\text{mol}} = \Delta U$$

$$-568.5\frac{\text{kJ}}{\text{mol}} = \Delta U$$

ΔH→ الطاقة يلي لازم أعطيها
لل reactants حتى يتم التفاعُل
أو هي الطاقة يلي تنتج من
التفاعُل لحا .



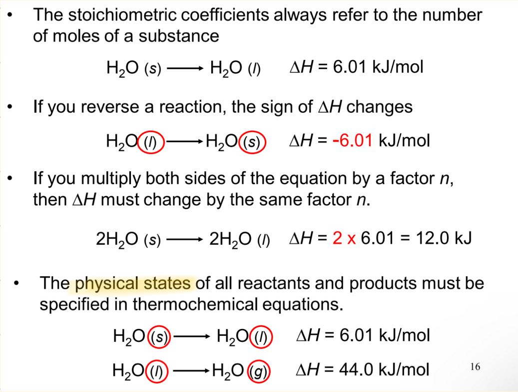
6.4 Thermochemical Equations

$H_{products} < H_{reactants}$
$\Delta H < 0$
Exothermic

$H_{products} > H_{reactants}$
$\Delta H > 0$
Endothermic

$CH_4\,(g) + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$ $\Delta H = -890.4\ kJ/mol$

1 mol from CH_4 will gives (890.4) ..
2 moles " O_2 " " (890.4) ..



- The stoichiometric coefficients always refer to the number of moles of a substance

$H_2O\,(s) \longrightarrow H_2O\,(l)$ $\Delta H = 6.01$ kJ/mol

- If you reverse a reaction, the sign of ΔH changes

$H_2O\,(l) \longrightarrow H_2O\,(s)$ $\Delta H = -6.01$ kJ/mol

- If you multiply both sides of the equation by a factor *n*, then ΔH must change by the same factor *n*.

$2H_2O\,(s) \longrightarrow 2H_2O\,(l)$ $\Delta H = 2 \times 6.01 = 12.0$ kJ

- The physical states of all reactants and products must be specified in thermochemical equations.

$H_2O\,(s) \longrightarrow H_2O\,(l)$ $\Delta H = 6.01$ kJ/mol
$H_2O\,(l) \longrightarrow H_2O\,(g)$ $\Delta H = 44.0$ kJ/mol

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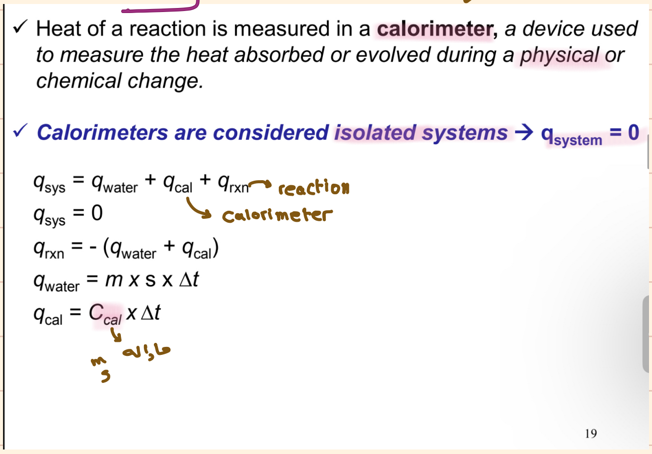
Measuring heat of The Reaction

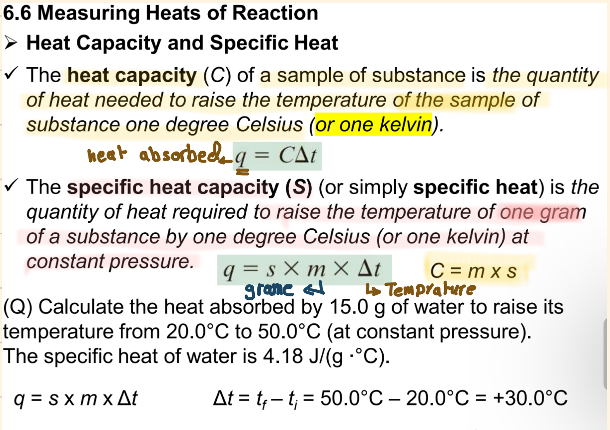


✓ Heat of a reaction is measured in a **calorimeter,** *a device used to measure the heat absorbed or evolved during a physical or chemical change.*

✓ ***Calorimeters are considered isolated systems → $q_{system} = 0$***

$q_{sys} = q_{water} + q_{cal} + q_{rxn}$ → reaction
$q_{sys} = 0$ → calorimeter
$q_{rxn} = -(q_{water} + q_{cal})$
$q_{water} = m \times s \times \Delta t$
$q_{cal} = C_{cal} \times \Delta t$
ab,l
m
s

19



6.6 Measuring Heats of Reaction

➢ **Heat Capacity and Specific Heat**

✓ The **heat capacity** (*C*) of a sample of substance is *the quantity of heat needed to raise the temperature of the sample of substance one degree Celsius* (*or one kelvin*).

heat absorbed ← $q = C\Delta t$

✓ The **specific heat capacity (*S*)** (or simply **specific heat**) is *the quantity of heat required to raise the temperature of one gram of a substance by one degree Celsius (or one kelvin) at constant pressure.*

$q = s \times m \times \Delta t$ $C = m \times s$
grame   Temprature

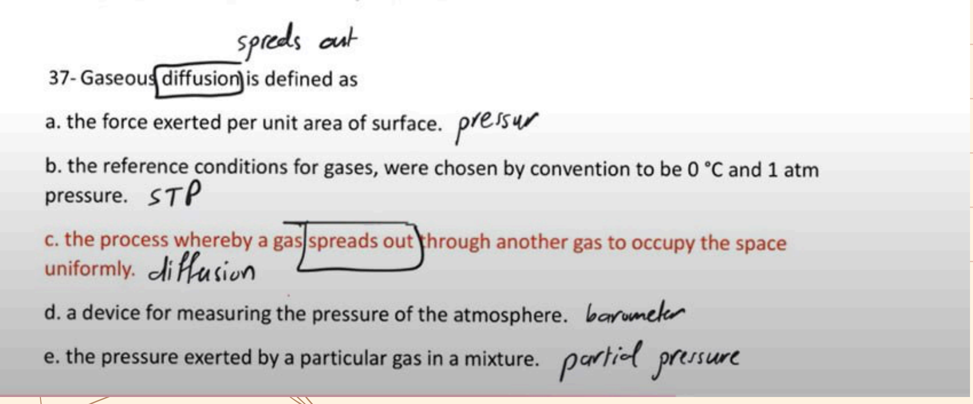
(Q) Calculate the heat absorbed by 15.0 g of water to raise its temperature from 20.0°C to 50.0°C (at constant pressure). The specific heat of water is 4.18 J/(g ·°C).

$q = s \times m \times \Delta t$ $\Delta t = t_f - t_i = 50.0°C - 20.0°C = +30.0°C$

$q = 4.18\ J/(g \cdot °C) \times 15.0\ g \times (+30.0°C) = \mathbf{1.88 \times 10^3\ J}$

$s = \frac{J}{g \cdot °C} = \frac{J}{g \cdot k}$ increased or decreased by $= \Delta T$

$q_{gained} = -q_{lost}$



37- Gaseous diffusion is defined as (spreds out)

a. the force exerted per unit area of surface. pressur

b. the reference conditions for gases, were chosen by convention to be 0 °C and 1 atm pressure. STP

c. the process whereby a gas spreads out through another gas to occupy the space uniformly. diffusion

d. a device for measuring the pressure of the atmosphere. barometer

e. the pressure exerted by a particular gas in a mixture. partial pressure

A bomb Calorimeter has heat capacity of 3.48 kJ/°C When 2g Sample of an oil is burned in this Calorimeter the temperature increased by 1.2°C Calculate the energy (kJ) of combustion for one grame of oil

$C = 3.48 \frac{kJ}{°C} \rightarrow m = 2g \rightarrow \Delta T = +1.2 \rightarrow q = ?!$ → for one grame

$q = C \Delta t = 3.48 \frac{kJ}{°\cancel{C}} \; 1.2 \cancel{°C} = 4.176 \; kJ$ هاي لل 2g

$\frac{4.176}{2} = 2.088 \rightarrow$ لل 1g

بس لأنه combustion

∴ أكيد هو exothermic فلازم الجواب يكون $\boxed{-2.088}$

molar heat $\rightarrow \frac{q}{mol} \rightarrow \frac{heat}{(n)} \rightarrow$ نفسها انه يطلب ال heat بوحدة kJ/mol

$$\frac{kJ}{g} \xrightarrow{*Mr} \frac{kJ}{mol}$$

A (2g) sample of a compound x Mr = 80 g/mol is decomposed in a bomb Calorimeter. The temperature of the Calorimeter was increase by 6.12°C. The heat capacity of the system is 1.23 $\frac{kJ}{g.C}$. What is the molar heat of decomposition for x?

$m = 2g$

$Mr = 80$

$\Delta T = 6.12°C$

$C = 1.23 \frac{kJ}{g.°C}$

molar heat = ?! $\rightarrow \frac{q}{mol}$

$q = C \Delta t$

$= 1.23 \times 6.12$

$= 7.5276 \; \frac{kJ}{g} \xrightarrow{*Mr} \frac{kJ}{mol}$

$\frac{q}{mol} = -602.2 \; \frac{kJ}{mol}$

$R \rightarrow q = 7.5276 \frac{kJ}{\cancel{g}} * 2\cancel{g}$

$q = 15 \; kJ$

$$\frac{q}{mol} = \frac{15}{\frac{2}{80}} = -600 \; \frac{kJ}{mol}$$

Heat of neutralization → ΔH_n → acid & base

ΔH_n = mass of solution * S(solution) * ΔTsolution

A quantity 100ml of 0.5M HCl was mixed with 100ml of 0.5M NaOH in a constant pressure Calorimeter of negligible heat capacity The initial temperature of the HCl & NaOH solution was the same = 22.5°C and the final temperature mixed solution was 25.86°C Calculate the heat change for the neutralization reaction on a molar basis.

assume the density of it = 1 g/ml

$$S = 4.184 \frac{J}{g.°C}$$

← اذا لم تعط في السؤال نعوضها، اذا لل H_2O

$$H_n = \text{mass solution} * S_{\underset{H_2O}{solution}} * \Delta T$$

=

$$= 200 * 4.184 * (3.36)°C$$

$$= {}^{-}2811.6 \text{ J}$$

$$\rightarrow \frac{KJ}{mol} \rightarrow \frac{-2.8116}{0.05} = {}^{-}56.2 \text{ KJ/mol}$$

$$m = d * v$$

$$= 1 \frac{g}{\cancel{ml}} * (100+100) \cancel{ml}$$

$$m = 200 g$$

HCl → M = 0.5

$v = 100 \times 10^{-3}$

$T_1 = 22.5°C$

NaOH → M = 0.5

$v = 10^{-1}$

$T_1 = 22.5°C$

$T_f = 25.86°C$

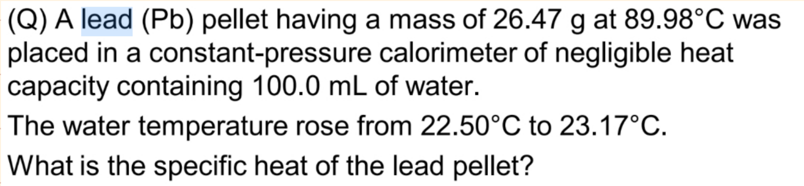
$NaOH + HCl \rightarrow H_2O + NaCl$

MV = 0.05   MV = 0.05

$$\boxed{n_{H_2O} = 0.05}$$

$pb \rightarrow m = 26.47$
$T = 89.98°C$

$H_2O \rightarrow v = 100\,ml$
$t_1 = 22.5$
$\rightarrow t_2 = 23.17 \rightarrow t \rightarrow$ المشتركة


(Q) A lead (Pb) pellet having a mass of 26.47 g at 89.98°C was placed in a constant-pressure calorimeter of negligible heat capacity containing 100.0 mL of water.

The water temperature rose from 22.50°C to 23.17°C.

What is the specific heat of the lead pellet?

$pb \rightarrow m = 26.47$
$T = 89.98°C$

$H_2O \rightarrow v = 100\,ml$
$t_1 = 22.5$
$t_2 = 23.17$
$\hookrightarrow t \rightarrow$ المشتركة

$S = ?!$

$$\Delta H_{H_2O} = -\Delta H_{Pb}$$

$$ms\Delta T = ms\Delta T$$

$$-100\,(4.184)\,(23.17 - 22.5) = 26.47 * S * (23.17 - 89.98)$$

$$\angle 280.3 = \angle 1768.55\,S$$

$$S = 0.1585$$

$$m = d \times v$$
$$= \frac{1\,g}{\cancel{ml}} * 100\,\cancel{ml} = 100$$

In a coffee-cup calorimeter, 2.6g of $CaCl_2$ was dissolved in 260g of water at a combined initial temperature of 23°C. The final temperature was 26.4°C. Calculate the enthalpy change of the reaction.

$CaCl_2 \rightarrow m = 2.6$ $\quad T_1 = 23°C$
$H_2O \rightarrow m = 260$ $\quad T_2 = 26.4°C$

$$\Delta H = \frac{q_{CaCl_2}}{n} = \frac{-q_{H_2O}}{n} = \frac{-ms\Delta T}{n} = \frac{-260 \times 4.184 \times (26.4 - 23)}{\frac{2.6}{2 \times 35.45 + 12}}$$

$$= \frac{-3698\,J}{0.0313\,mol}$$

$$118.16 = \frac{3.698\,kg}{0.0313\,mol}$$

3.36g of ethanol (C_2H_5OH) is burned in a bomb calorimeter with a heat capacity of 2.3 $\frac{kJ}{°C}$. The temperature of the Calorimeter increases from 12.1°C to 55.5C

Calculate the energy of combustion per mole.

$C = 2.3 \frac{kJ}{°C}$

$\Delta H = C \Delta T$

$= 99.82$

$\Delta T = 43.4 °C$

$\frac{\Delta H}{n} = \frac{99.82}{\quad}$

$n = \frac{m}{Mr} = \boxed{\frac{3.36}{Mr}}$

Calculate the mass of H_2O (g) would be obtained if the reaction released 369 kJ of heat. $Mr_{H_2O} = 18$ g/mol

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \quad \Delta H = -2043$

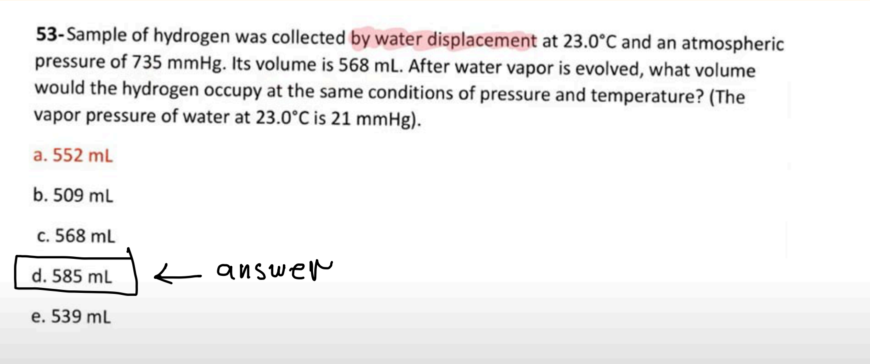
$\Delta H = \frac{q}{n} \rightarrow n = \frac{q}{\Delta H \text{ (per 4 moles of } H_2O)} * 4$

$= \frac{369}{2043} * 4 = 0.722$

$Mr\, n = m$

$18 * 0.722 = m$

13g =



53- Sample of hydrogen was collected by water displacement at 23.0°C and an atmospheric pressure of 735 mmHg. Its volume is 568 mL. After water vapor is evolved, what volume would the hydrogen occupy at the same conditions of pressure and temperature? (The vapor pressure of water at 23.0°C is 21 mmHg).

a. 552 mL

b. 509 mL

c. 568 mL

d. 585 mL ← answer

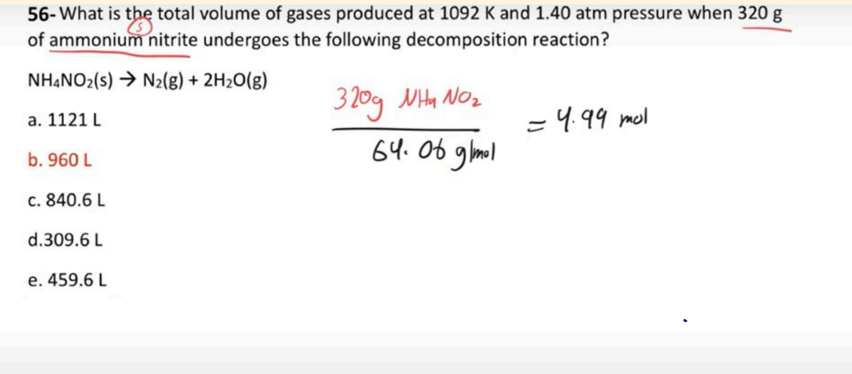
e. 539 mL

T remains constant → So we have to make a relationship btw P & V

$$P_1 V_1 = P_2 V_2$$

$$735(568) = (735-21)\ v_2$$

✓ $$\boxed{v_2 = 585\ ml}$$



56- What is the total volume of gases produced at 1092 K and 1.40 atm pressure when 320 g of ammonium nitrite undergoes the following decomposition reaction?

$NH_4NO_2(s) \rightarrow N_2(g) + 2H_2O(g)$

a. 1121 L

b. 960 L

c. 840.6 L

d.309.6 L

e. 459.6 L

$$\frac{320g\ NH_4NO_2}{64.06\ g/mol} = 4.99\ mol$$

ammonium nitrite → solid → we can't use $PV = nRT$ to find the moles

instead → $n = \frac{m}{Mr} = \frac{320}{64.06}$

$= 4.99$

Good Luck :)

دعوة حلوة منّك يا حلو ♥