# **Exam 3 –** Learning Objectives (by CR for 89-90)

**ACID-BASE Reactions** (explained in sections 6.1-6.4 of CiC)

**Step 1: write neutral ion-combos** (e.g. $Na_2CO_3$ not $NaCO_3$)

**Step 2: match reactors** with correct numbers (e.g. $H^+ + OH^-$ to form $H_2O$ ; or $H^+ + HCO_3^-$ to form $H_2CO_3$ , or $2\ H^+ + CO_3^{2-}$)

**Step 3: React-and-Balance** (reactors → $H_2O$ or $H_2CO_3$ [or $H_2O$ (l) + $CO_2$ (g)], and spectators → salt, which is a +/– combo that isn't an acid, isn't a base] Here are **neutralization** rxns:

examples: **H**Cl + Na**OH** → **HOH** + NaCl
**H**Cl + $NH_4$**OH** → $\mathbf{H_2O}$ + $NH_4OH$
**H**Cl + Na**$HCO_3$** → $\mathbf{H_2O}$ + $CO_2$ + NaCl
2 **H**Cl + $Na_2$**$CO_3$** → $\mathbf{H_2O}$ + $CO_2$ + 2 NaCl
[optional] $\mathbf{H_2}SO_4$ + **2** Na**OH** → 2 $\mathbf{H_2O}$ + $Na_2SO_4$
[optional] Mg**$(OH)_2$** + **2 H**Cl → 2 $\mathbf{H_2O}$ + $MgCl_2$
[later] Na**OH** + $CH_3COO$**H** → $\mathbf{H_2O}$ + $NaCH_3COO$

**Acid-Forming Reactions** (from Exam 2, Refrigerator Lab, ...)
On pages 255-256 of CiC, 2 sources of Acid Rain are $SO_3$ (from combustion of S to $SO_2$ -(air)→ oxidized to $SO_3$ ) and $NO_2$ (from NO (in high-temp engines/furnaces) -(air)→ oxidized to $NO_2$ ); normal (unpolluted) rain is slightly acidic (pH ≈ 5.3 on Nov 2, slide 25) due to dissolved $CO_2$ but this isn't defined as Acid Rain (pH range 3-5). 2nd proton: $H_2SO_4$ most, $H_2CO_3$ & $H_2SO_3$ a little.

$H_2O + CO_2 \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$ (normal acidic rain)
$H_2O + SO_2 \rightarrow H_2SO_3 \rightarrow H^+ + HSO_3^-$

A-Rain: $H_2O + SO_3 \rightarrow H_2SO_4 \rightarrow H^+ + HSO_4^-$ (and → $H^+ + SO_4^{2-}$)
A-Rain: $4\ NO_2 + 2\ H_2O + O_2 \rightarrow 4\ HNO_3 \rightarrow H^+ + NO_3^+$

NO

base: $NH_3$ (g) + $H_2O \rightarrow NH_4OH \rightarrow NH_4^+ + OH^-$

For the two lines below, you can look at a pH scale (e.g. as on my Quiz 6 handout) while you're thinking about pH relationships.
up/down relationships: for $SO_3 + H_2O$, [H+] increases (acidity ↑, pH ↓ ); $NH_3 + H_2O$, $[OH^-]$ increases (basicity ↑, pH ↑, acidity ↓ ).
dilutions: diluting acid makes it more neutral (pH = 7), less acidic, pH ↑ ; diluting base makes it more neutral, less basic, pH ↓ .

---

**"Main Concepts" on Study Guide** (all covered on ***handouts***),
***Above:*** Acid-Base (3f/3i), Acid Rain (4ab), demos ($NH_3$ , S).
***Quiz 6:*** CFCs [top], pH scale & calculations (3e/5a) [middle], [lower-middle] Solutions (3abcd) & conductivity/pH demo.
***Quiz 7a:*** mole calculations (5b) & lab calcltns, E balance (2bc).
***Quiz 7b:*** HC isomers (6), polarity (1), calculation-precision.
***Below:*** Polarity (1), Greenhouse balance/gases (2 = 7 8 9 10).

---

**1a-b-c-d: polarity of molecule** is determined by **electronegativity** (metals H≈C N/Cl O F) & **molecular geometry** ("canceling" due to symmetry?). **polarity of molecule** is observed in properties (like dissolves like, with polar water); if dissolves, it's polar [or it reacts and "disappears" into solution]; if (e.g., CFCs) doesn't dissolve, it's *nonpolar.* [also see bottom of #6, middle-right of #7b]

| | name of gas | molecular shape | polar? | reacts with $H_2O$? | name of rxn-product | |
|---|---|---|---|---|---|---|
| $NH_3$ | ammonia | trigonal pyramid | yes! | yes, → $NH_4OH$ | ammonium hydroxide * | |
| HCl | hydrogen chloride | (trivially linear) | yes! | yes, → HCl (aq) | hydrochloric acid | |
| $NO_2$ | nitrogen dioxide | bent (: , 3 dirns) • | yes | yes, → $HNO_3$ | nitric acid | |
| $SO_3$ | sulfur trioxide | trigonal planar | no | yes, → $H_2SO_4$ | sulfuric acid | |
| $SO_2$ | sulfur dioxide | bent (: , 3 dirns) | yes | yes, → $H_2SO_3$ | sulfurous acid | |
| *Does gas "wash out in rain"? above yes, below no* | | | *2 factors affect solubility* | | | |
| $CO_2$ | carbon dioxide | linear | no | yes, → $H_2CO_3$ | carbonic acid | |
| $CF_2Cl_2$ | dichlorodifluorom... | tetrahedral | small | no | n.a. | |
| $O_2$ | oxygen | (trivially linear) | no | no | n.a. | |
| $N_2$ | nitrogen | (trivially linear) | no | no | n.a. | |

* aka household ammonia (solution of ammonia in water); ammonia fountain demo (bottom-left of ho #6), more is above-and-right.

---

**Additional Study Questions** in the final part (6, 7 8 9 10) of the "Exam 3 Study Guide"; look at it while you read my comments.

**6a/e:** "drawing isomers" ***(#7b):*** W, $C_5H_{12}$ & $C_5H_{10}$ . F, $C_6H_{14}$ .
**6b:** creativity + ("only connectivity matters") same or different?

**7a:** "windows" has two ≠ meanings (here, Asmt 4) [p 108-110]
**7d/e, 10a-10g:** Nov 9 (slides 11-33, 65-86); bottom of my ***#7a***.
**10e:** fluorescence-ACE (Absorb UV, Convert, Emit visible) ≈ pavement-ACE (Abs visible, Convert [≠], Emit IR), sl 25-28.

**8a-e,h:** Nov 9/12, Slides 34-66. CiC, pages 119-123. Asmt 4.
**8d:** concentrations, $CO_2$ (.04%), $O_2$ (21%), $N_2$ (78%), Ar (.9%); most absorb IR (not atoms, diatomic symmetric molecules).
**8h:** Nov 9/12, sl 23-24. (over arrow: visible light, chlorophyll)

**9a-g:** Nov 9/12, sl 73-113/end. **9c** (CFCs by UV-C → Cl• , in stratosphere, $CH_4$ by •OH, $CO_2$ by ? (p 131 table, * comment); **9d/9e** (GWP is per molecule, concentration is 2nd factor; GWP depends on amount of IR-absorption, if absorbs in "windows", atmospheric lifetime. **9a** (sources of methane, p 132).

lead iodide demo {L 21, sl 30, → $PbI_2$ (**s**) }, heterogeneous soltn

**Old Exams: lab-calculations** for $HCO_3/CO_3$ (2011-I, 2012-II); graph-labels (e.g. transm vs abs); answer using **correct units**!
Comments about Coverage-Changes are in ***our sections-page.***