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
HCl + NH_4**OH** → $\mathbf{H_2O}$ + NH_4OH
HCl + Na**HCO₃** → $\mathbf{H_2O}$ + CO_2 + NaCl
2 **H**Cl + Na_2**CO₃** → $\mathbf{H_2O}$ + CO_2 + 2 NaCl
[optional] $\mathbf{H_2SO_4}$ + **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** → $\mathbf{H_2O}$ + $NaCH_3COO$

These ideas (left, below) are for demos (NH_3 , S) & 3f / 3i , 4a/4b.

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.

$H_2O + CO_2 \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$
$H_2O + SO_2 \rightarrow H_2SO_3 \rightarrow H^+ + HSO_3^-$
$\frac{1}{2}\ O_2$
A-Rain: $H_2O + SO_3 \rightarrow H_2SO_4 \rightarrow H^+ + HSO_4^-$ (and $\rightarrow H^+ + SO_4^{2-}$)
A-Rain: $4\ NO_2 + 2\ H_2O + O_2 \rightarrow 4\ HNO_3 \rightarrow H^+ + NO_3^+$
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" (objectives on Study Guide for Exam 3):
1a-b-c-d (below), 2a-b-c-d (at end), 3f / 3i & 4a-4b (above), 3e/5a (handout #6, middle "2a, 2a"), 3a-b-c-d (ho #6, "2b, 2b"), 5b (ho #7a). We can talk about these (+ old exams...) T-**W**-R-**F**.

LABS: check reactions above, calculations in both old exams.
demos: NH_3 (above, #6 bottom-left), cond/pH (#6 middle), lead iodide (L 21, sld 30, → PbI_2 (**s**)), S (rxns above).

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.	

* also 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), ≠ . [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 (not atoms, diatomic symmetric molecules) absorb IR.
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, I'm not sure about CO_2 (here or in 9e; see *, p 131 table); **9d/9e** (GWP is per molecule, concentration is 2nd factor; GWP depends on amount of IR-absorption, if it absorbs in "windows", atmospheric lifetime; **9a** (p 132).

I.O.U. – Tonight & tomorrow morning, I'll revise this semifinal version, and will add a few comments about the two Old Exams.