

C - S - N in Air Pollution - and the ozone chain ($N_2 \xrightarrow{hi T} NO \xrightarrow{O_3} NO_2 \xrightarrow{O_3} NO_3 \xrightarrow{O_3} O_3 \xrightarrow{O_3} O_2$) where each is formed [rxns often use O_3] & then reacts

	natural sources	human sources	reaction(s) to FORM it	reaction with H_2O	biological effects	properties: senses, lab
CO	CO if NOT enough O_2	C-fuel → GLOBAL WARMING due to CO_2	$C \xrightarrow{O_2} CO, more O_2 \rightarrow CO_2$	$CO + H_2O \rightarrow ?$	hemoglobin (blood) carries O_2 CO binds to hgm more strongly than O_2 cells don't get enough O_2 → suffocation	on Quiz / EXAM, cannot do BIO-experiment! CO is SENSELESS KILLER (2 meanings) colorless, odorless
	FOREST photosynthesis is ↓ of CO_2	CAR, PLANE, TRAIN engine exhausts outdoor grill/camp stove	$2C + 1 O_2 \rightarrow 2 CO$ INCOMPLETE combustion	$H_2O + CO_2 \rightarrow H_2CO_3$ below $H^+ + HCO_3^-$	HEALTH (at level of cells) CO ₂ can "smother" as in FIRE EXTINGUISHER, or Lake Nyos CO ₂ -disastr	CO ₂ also colorless, odorless in lab, $CO_2 - (H_2O) \rightarrow ACID$ LIME WATER TEST $Ca(OH)_2 + CO_2 \rightarrow CaCO_3(s) + H_2O$
CO ₂	FIRES (ANIMAL) RESPIRATION only CO_2	in LAB, $HCl + NaHCO_3 \rightarrow CO_2 + H_2O$	COMPLETE combustion $2C + 2 O_2 \rightarrow 2 CO_2$ SEQUENTIAL * $CO + \frac{1}{2} O_2 \rightarrow CO_2$	$H_2O + CO_2 \rightarrow H_2CO_3$ H ₂ O-solubility? med-Low		
SO ₂	volcanoes!	combustion of S-containing coal (1-3%)	$S + O_2 \rightarrow SO_2$ COMBUSTION	$H_2O + SO_2 \rightarrow H_2SO_3$ (makes solution acidic) → $H^+ + HSO_3^-$	Natural ACID RAIN (weak) with H_2CO_3	SO ₂ has ODOR (pungent, matches)
	(and some bacteria?)	more O_2	$S + O_2 \rightarrow SO_2$	H ₂ O-solubility? HIGH	pollutant ACID RAIN (strong) w/ H_2SO_3, H_2SO_4	in lab, $SO_2 - (H_2O) \rightarrow ACID$
SO ₃		SO ₃ indirect secondary RXN	$SO_2 + \frac{1}{2} O_2 \rightarrow SO_3$ simultaneous sequentially	$H_2O + SO_3 \rightarrow H_2SO_4$ $H^+ + HSO_4^-$	"ACID LUNGS" (similarly, "ACID LUNGS" w/ H_2SO_3, H_2SO_4 gen + H_2O) $HCl, HNO_3 \rightarrow H^+$	in lab, $SO_3 - (H_2O) \rightarrow ACID$ (as A-B indicator changes color) SO ₃ odor (sharp, → irritate)
N ₂	no, but Fig 6.28, C1-262, is nitrogen cycle (for Na and N-compounds)	not necessary or useful for IGB	N ₂ is start of O_3 chain; in rxns below, each uses chemical formed before it (a PRODUCT of O_3 is used in O_2 , etc)	also, $HCl(g) \xrightarrow{H_2O} HCl(aq)$ std. soln. # 63 & SOLUTION H ₂ O-solubility (Low) $Na(g) \xrightarrow{H_2O} Na(aq)$	or "BASE LUNGS" $NH_3 + H_2O \rightarrow NH_4OH(aq)$ excess OH- → $NH_4^+ + OH^-$ makes water basic	N ₂ is COLORLESS, ODORLESS ESSAY you DEMO: What did you DO? What did you OBSERVE? WHY did it happen? (explain)
NO	forest fire volcano lightning	ENGINE - car plane coal furnace bomb	$N_2 + O_2 \xrightarrow{HIGH TEMP} 2 NO$ (FREE RADICAL)	$NO + H_2O, O_2 \rightarrow HNO_2, HNO_3$ $4 NO_2 + 2 H_2O + O_2 \rightarrow 4 HNO_3$ is not simple "crunch together" as w/ $H_2O + CO_2$	NO is "poisonous" (w-28, rlds 59-60) NO _x → miscellaneous	odor ("slightly irritating") WAFT, don't snort
		when HOT high temp	to visualize EXCHANGE PARTNERS COMBINATION → 88			
NO ₂	(when is it NO, NO ₂ ?)	(when is it NO, NO ₂ ?)	at high & low concentration: ① $NO + O_3 \rightarrow NO_2 + O_2$ (each NO_2 & O_2) at low concn, in O_3 -chain: ② $NO + O_3 + VOC + OH \rightarrow NO_2 + OTHER STUFF$ (C1C, page 45)	caps, THIS → should be here, in NO ₂ -cell	NO ₂ → "poisonous" (w-28, rlds 59-60) at very low concentration (SO ₂ is more SENSITIVE) #4e (see ABI Stds, pg 24) IRRITATES, then → long-term damage $NO_2 \xrightarrow{H_2O} HNO_2 \rightarrow H^+ + NO_2^-$ in LUNGS	reddish-brown gas odor ("very nasty") $NO_2 - (H_2O) \rightarrow ACID$
O	same as for O_3 - why? ($O_2 \xrightarrow{2} O + O$ direct $O + O_2 \rightarrow O_3$ indirect)	also same as for O_3 (electr. as in direct or UV Air "Purifier")	STRATOSPHERE, $O_2 \xrightarrow{UV} 2 O$ (NOT IN CHAIN)	H_2O solid-solubility SO_2, HCl, CO_2, O_2, Na	produces O_3 (which is ⊖)	TESTS NO, NO ₂ , O ₂ , O ₃ , SO ₂ , HCl, CO ₂ , Na
O ₃	LIGHTNING (electricity) only in stratosphere, $O_2 \xrightarrow{2} 2 O \xrightarrow{O_2} O_3$ (not balanced)	from RXNS 3-4 in CHAIN $NO \xrightarrow{O_3} NO_2 \xrightarrow{O_3} O_3$	③ $NO_2 \xrightarrow{VISIBL LIGHT} NO + O$ ④ $O + O_2 \rightarrow O_3$ from split of NO_2 in ③		⊖ you LUNGS, ⊖ you EYES IRRITATION → DAMAGE short-term long-term (TIRES →) + damage to leaves, rubber	very pale blue odor ("sharp") (distinctive) know it
O ₂	PLANT photosynthesis $H_2O \xrightarrow{LIGHT} SUGARS + O_2$ causes CO_2 -decrease	lab: $2 H_2O \xrightarrow{K_2Cr_2O_7} 2 H_2 + O_2$ respn → only CO_2 (respn → CO_2) $CO_2 \uparrow$ from respiration	⑤ O_3 reacts w many things so O_3 gets away at night incl plant + animal tissue	$O_2(g) \xrightarrow{H_2O} O_2(aq)$ but enough for FISH H ₂ O-solubility? (Low)	LIFE! O_2 carried by hemoglobin (in blood) to cells	glowing splint in O_2 "catches on fire" COLOR less, ODOR less

OVER THE CONDITIONS, SOLVENT, CATALYST NOT THE MAIN REACTANTS

Where is "good O_3 " and why is it good? } UP HIGH in stratosphere (absorbs UV-B)

Where is bad ozone } DOWN LOW in troposphere (harmful for people)

CRITERIA POLLUTANTS
CO, SO₂, O₃, NO_x (NO + NO₂)
also PM_{2.5}, PM₁₀, Pb

some VOCs = C₅H₁₂, C₆H₁₄, ... (gasoline)
details of RXNS } hi T, UV-C, 600, + OH

⑤ $NaHCO_3 + HCl \rightarrow H_2O + CO_2 + NaCl$
 $H_2O + CO_2 \xrightarrow{LOW concentration} H_2CO_3$
 $\xrightarrow{HIGH concentration}$

when H_2CO_3 is at HIGH concentration as w- mine of "HCl + NaHCO₃" in lab:
 $H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow H_2O + CO_2(g)$
 $2H^+ + CO_3^{2-} \rightarrow H_2CO_3 \rightarrow H_2O + CO_2(g)$
AQUEOUS AQUEOUS AQUEOUS GAS

parenteses only if is necessary
 $Ca(OH)_2$
 (H_2CO_3)

make 2x2 grid for all ion-combinations: +1 +2 -1 -2 (bonus: also for +3 and -3)
polycyclic ions multi-atom ions
MEMORIZE

Ca ⁺	CaCl ₂	CaCO ₃
K ⁺	KCl	K ₂ CO ₃
Ca ²⁺	CaCl ₂	CaCO ₃