

1. Chemical Families and Cycles (81 pts: 3 each, except g is 15, h is 12, k is 9): Circle correct response(s).

- a. The chemical family of precursors that can be easily converted to NO_x is (circle one): NO_x SO_x HO_x O_x ?
- b. PAN and HONO are precursors that can be easily converted to NO_x . or ? **T**
- c. NO_x includes N_2O because it is reactive in the troposphere. or ? **F**
- d. NO_y is important because compounds in the NO_y family are stable enough to be transported to remote regions where they will thermally decompose into NO_x . or ? **T**
- e. SO_x is the chemical family that includes SO_2 , SO_4^{2-} (sulfate), and DMS. or ? **F**
- f. The most oxidized form of Carbon in the atmosphere is CO. or ? **F**
- g. Atmospheric reservoirs of Sulfur include (circle all that apply): SO_2 SO_4^{2-} DMS COS H_2S CO_2
- h. Atmospheric reservoirs of Nitrogen include (circle all that apply): N_2O N_2 NO_x NO_3^-
- i. The Nitrogen cycle is the pathways by which and reservoirs through which compounds of nitrogen are transferred among the atmosphere, the hydrosphere, the biosphere, the cryosphere, and the geosphere. **T**
- j. The geosphere has no emissions to the atmosphere. or ? **F**
- k. One interface across which sulfur is transferred is the ocean-atmosphere. or ? **T**
- l. The processes that control Sulfur transfers to the atmosphere include combustion emissions of SO_2 , volcanic emissions of SO_4^{2-} and SO_2 , soil emissions of H_2S and COS, and algae production of DMS and CS_2 , and wet/dry deposition of SO_4^{2-} and SO_2 to ocean and land surfaces, as well as in situ transformations. or ? **T**
- m. Fossil fuel burning is not an important manmade type of source of NO_x and SO_x . or ? **F**
- n. Most reactive Nitrogen in the atmosphere is removed by wet deposition or precipitation as HNO_3 . or ? **T**
- o. Most SO_2 in the atmosphere comes from (circle one): combustion algae soil
- p. DMS emitted by phytoplankton to the atmosphere produces (circle all that apply): MSA SO_4^{2-} SO_2 SF_6
- q. All combustion emissions are anthropogenic. or ? **F**
- r. Wildfires produce CO_2 from the combustion of trees. or ? **T**

2. Smog (51 pts: 3 each): Circle correct response.

- a. Air pollution is an atmospheric condition in which substances are present above normal levels. or ? **T**
- b. Air pollution produces a negligible effect on man, animals, vegetation, or materials. or ? **F**
- c. Smog is a severe pollution episode, usually characterized by severe detrimental effects on visibility, health, and/or crops. or ? **T**
- d. Oranges cause Los Angeles smog. or ? **F**
- e. The orange demonstration used high O_3 to cause VOC oxidation of terpenes emitted from oranges. or ? **T**
- f. The products of the VOC oxidation have very high volatility so they condense. or ? **F**
- g. Deposition grows particles large enough to visibly scatter light. or ? **F**
- h. The orange demonstration is similar to photochemical smog, in which high O_3 results in VOC oxidation, the products of which condense. or ? **T**
- i. Los Angeles photochemical smog involves gas phase reactions with NO_x and VOCs from fossil fuel burning and industrial sources to produce high O_3 , but no organics in particles. or ? **F**
- j. Terpenes from oranges are only a minor contributor (if at all) to the VOCs involved in LA smog. or ? **T**
- k. London smog resulted from SO_2 emitted by combustion of coal interacting with fog. or ? **T**
- l. The two reaction(s) that increase the production of ozone in the troposphere are (1) $\text{HO}_2 + \text{NO} \rightarrow \text{NO}_2 + \text{OH}$; (2) $\text{RO}_2 + \text{NO} \rightarrow \text{NO}_2 + \text{RO}$. or ? **F**
- m. The production of ozone is given by $P(\text{O}_3) = k_1[\text{HO}_2][\text{NO}] + k_2[\text{RO}_2][\text{NO}]$. or ? **T**
- n. Null cycles do not produce O_3 , but they produce precursors for most of the O_3 production. or ? **F**
- o. The hydroxyl radical OH is the "atmospheric dirt" because it produces pollutants. or ? **F**
- p. OH is formed from photolysis of ozone in the presence of water. or ? **T**
- q. The two reactions that form OH are: (1) $\text{O}_3 + h\nu \rightarrow \text{O}_2 + \text{O}(^1\text{D})$ and (2) $\text{O}(^1\text{D}) + \text{H}_2\text{O} \rightarrow 2\text{OH}$. or ? **T**

3. Tropospheric Ozone (51pts: 3 each, except h2 is 15): Circle correct response.

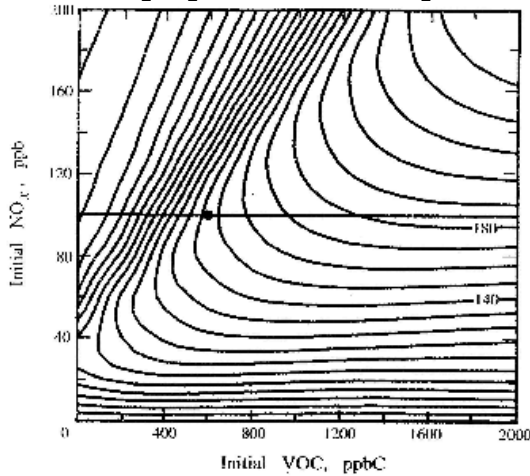


Figure: Ozone isopleth plot based on simulations of chemistry along air trajectories in Atlanta (Jeffries and Crouse, 1990). Each isopleth is 10 ppb higher in ozone as one moves upward and to the right.

- a) An ozone isopleth is a line showing constant ozone concentration: T or F? **T**
- b) The ozone mixing ratio that corresponds to initial VOC of 620 ppbC and NO_x of 100 ppb is: 140ppb or 500ppb or 100ppt?
- c) The ozone mixing ratio change if this initial VOC mixing ratio increases by 200 ppbC will increase by 100 ppb: T or F? **F**
- d) At the initial NO_x of 100 ppb, the VOC range for which ozone is insensitive to VOCs is from 1400 ppbC to 2000 ppbC: T or F? **T**
- e) VOC refers to volatile organic clouds: T or F? **F**
- f) VOCs will be found in the atmosphere in the liquid phase: T or F? **F**
- g) The important atmospheric oxidant in the troposphere that oxidizes CO is OH: T or F? **T**
- h) NO_x is needed for CO oxidation to produce more ozone than is lost: T or F? **T**
- g) CO oxidation in the atmosphere can produce ozone: T or F? **T**
- h) Reactions that summarize CO oxidation when NO_x is present include: CO+OH→CO₂+H H+O₂+M→HO₂
 HO₂+NO→NO₂+OH O₃+hv → O+O₂ NO₂+hv→NO+O O+O₂+M→O₃ HO₂→H+O₂+M CO₂+H→CO+OH
- i) The net reaction for CO oxidation when NO_x is present is CO+2O₂+hv → CO₂+O₃: T or F? **T**
- j) O₃ formation by CO oxidation when NO_x is present does not require sunlight: T or F? **F**
- k) At very high NO_x, HNO₃ is produced and removed by wet deposition, reducing net O₃ production: T or F? **T**

4. Particle Composition (67 pts: 3 each, except c is 18, k is 6, l is 4): Circle correct response(s).

- a) A suspension is a stable mixture of two phases: T or F? **T**
- b) An aerosol is a colloidal suspension of liquid or solid particles in a gas: T or F? **T**
- c) The size range of the main chemical components of atmospheric aerosol particles are
sulfates: submicron or supermicron? nitrates: submicron or supermicron?
ammonium: submicron or supermicron? organic carbon: submicron or supermicron?
sea salts: submicron or supermicron? minerals: submicron or supermicron?
- d) Particles in the accumulation mode have diameters between 0.1 to 1 μm: T or F? **T**
- e) Particles larger than 0.1 μm in the nucleation mode are lost rapidly to diffusion: T or F? **F**
- f) Particles larger than 1 μm have higher settling velocities because of their larger mass: T or F? **T**
- g) Particles cause improved atmospheric visibility and increased health problems: T or F? **F**
- h) Some particles also cause atmospheric warming: T or F? **T**
- i) Nucleation mode particles have shorter residence times than accumulation mode particles: T or F? **T**
- j) Coarse mode particles have longer residence times than accumulation mode particles: T or F? **F**
- k) Particle deposition velocity is determined by (circle all that apply): size density volatility?
- l) The long-lasting mode of particles that forms from the growth and coagulation of smaller particles is called the ____ mode (circle one): accumulation nucleation giant pollution coarse rain dust?
- m) Most atmospheric sulfate particles are from: fuel combustion volcanic eruptions tree scents desert dust?
- n) Black carbon particles in the atmosphere come from (circle one): combustion photochemical biogenic?
- o) Typical urban concentrations of particles exceed 10,000 particles cm⁻³: T or F? **T**
- p) The residence time of aerosol particles in the troposphere are typically (circle one): 1 sec 1 hr 1 wk 1 yr?