

Part I – Short Answer

Choose a letter to fill in the blanks. Use choices as many times as you wish.
Only one choice is needed per blank. All are 3 points each.

1. First set. How can you tell these apart? More than one choice may be possible, but all you need to give is ONE answer.

- | | |
|--|---------------------------------------|
| A. N ₂ and CO ₂ | E. O ₂ and He |
| B. Ar and Xe | F. CH ₄ and N ₂ |
| C. Ar and N ₂ | G. None of these |
| D. SO ₃ and NO ₂ | |

E **Glowing splint test.** In one flask it will go out; in the other it will ignite.

D **Color.** One gas is colorless, the other is not.

A **Acidity.** One gas dissolves in water to form an acidic solution, as shown by the presence of an indicator. The other does not.

G **Radioactivity.** One gas is radioactive, the other is not.

F **Flammability.** One gas can be lit with a match in the presence of O₂,
The other cannot.

2. Next set.

- | | | |
|------------|------------|------------------|
| A. methane | C. propane | E. NONE of these |
| B. butane | D. ethane | F. ALL of these |

F Which molecule is a hydrocarbon?

B Which molecule contains 4 carbon atoms (no more, no less)?

A Which molecule contains 4 hydrogen atoms (no more, no less)?

E Which molecule has 1 unshared pair of electrons (no more, no less)?

3. Last set, all in the context of visible light:

- | | | |
|-------------|------------|------------------|
| A. transmit | C. reflect | E. NONE of these |
| B. absorb | D. emit | |

B Chlorine molecules can _____ visible light and split to form chlorine atoms.

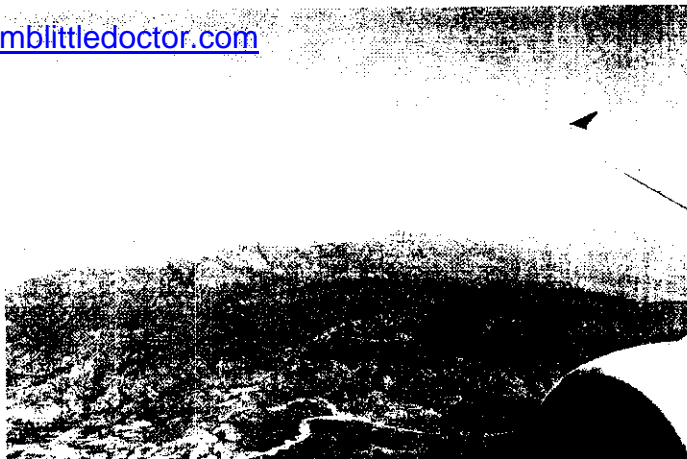
D Optical brighteners in fabrics absorb UV light and then _____ blue light.

A Sunglasses _____ visible light which is why we can see through them.

C White shirts _____ all wavelengths, which is why they appear white.

Part II – Carbon Monoxide

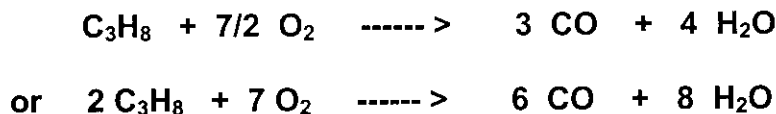
The photo to the right is from your textbook. It shows a forest fire burning to the north of Phoenix.



1. (4 points) Carbon monoxide is released by a forest fire. Which of these are released directly as well? Mark them with an X.

carbon monoxide carbon dioxide nitrogen monoxide
 ozone particulate matter (PM), soot

2. (5 points) Write the balanced chemical equation for the burning of **propane** with limited oxygen to form carbon monoxide. No partial credit.



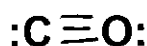
3. (4 points) Explain in 25 words or less why carbon monoxide is “the silent killer.”

It is a colorless, odorless gas, so you do not detect that you are breathing until it is too late.

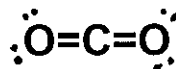
4. (4 points) Cigarette smoke may contain 2,000 ppm CO. Express this as a percent.

0.2%

5. (6 points) Both carbon monoxide and carbon dioxide are small molecules that are relatively unreactive. Draw Lewis structures for each. Be sure to label which is which. No partial credit.

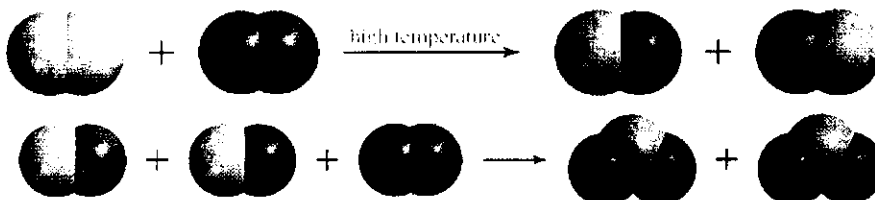


Carbon monoxide



carbon dioxide

(3 points each and -1 if structures are not labeled. Shapes do not need to be correct yet)



Part III – NO_x and SO_x

1. (4 points) Here are representations of two chemical reactions that we talked about, both from Chapter 1 of your textbook. Write the chemical equations that correspond to both of these.



2. (8 points) These questions refer to the chemistry of NO and NO₂.

Mark true statements with an X:

- NO is directly emitted from the exhaust pipes of cars.
- NO can be produced by lightning.
- Although burning coal can produce SO₂, it doesn't produce NO or NO₂.
- After exposure to NO, such as in silo gas, your lungs later may fill with fluid.

3. NO₂ is one of the players in the series of reactions that form ozone. In contrast, SO₂ is not involved.

a. (2 points) NO₂ splits in sunlight to produce oxygen atoms. Write the equation.



b. (5 points) SO₂ does not split in sunlight. To see why, first draw the Lewis structures (draw 2 resonance forms) for SO₂.



c. (3 points) Describe one way in which the Lewis structure of NO₂ is different from that of SO₂, hence NO₂ breaks down with visible light and SO₂ doesn't. No need to draw the Lewis structure for NO₂ (but you can if you want to).

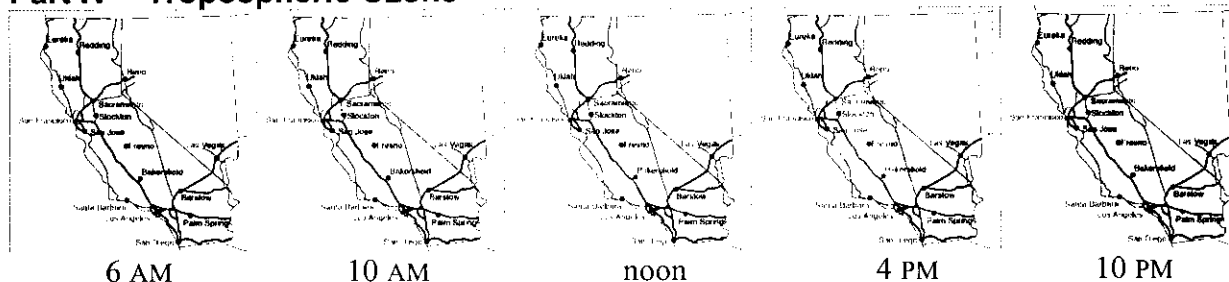
One way: NO₂ does not follow the octet rule

Another way: NO₂ has single bonds only.

4. (4 points) Both the nitrate ion and the sulfate ion, formed when NO₂ and SO₂ dissolve in rain. Write these chemical formulas.

 KNO₃ potassium nitrate CaSO₄ calcium sulfate

Part IV – Tropospheric Ozone



1. (8 points) For each set of conditions, circle the one that leads to higher ozone levels.

Cloudy

Windy

Low inversion layer

Cool day

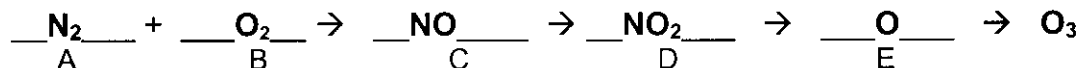
Sunny

No wind

High inversion layer

Warm day

2. (5 points) On a sunny day in urban area, how is ozone formed in the atmosphere? Fill in each blank with one chemical formula.



Elements A and B react in a car engine to form the compound C.

Slowly C forms D in the presence of VOCs, O₂ and OH radicals in the atmosphere.

D splits in sunlight to release E (a highly reactive species needed to produce ozone).

Then E immediately reacts with oxygen in the air to produce ozone, shown above.

3. (4 points) Filling your car with gas at night is one way to reduce ozone formation. During the day, pumping gasoline into your tank is connected to ozone formation. Explain the connection, step by step.

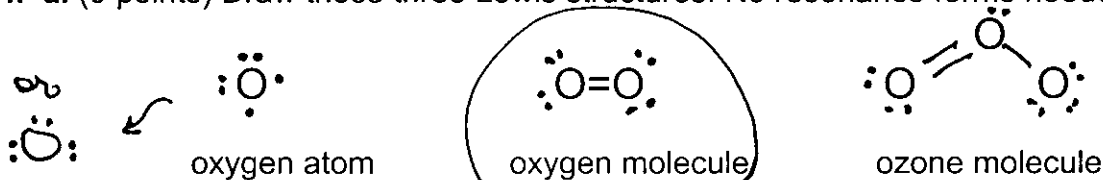
Key points: 1. Gasoline is volatile. Some evaporates when you pump it.

2. When the sun is out, VOCs in the atmosphere lead to the formation of NO₂

3. NO₂ in turn leads to ozone formation.

So pump gasoline at night!

4. a. (9 points) Draw these three Lewis structures. No resonance forms needed.



b. (2 points) Circle the one that is least reactive. (of the 3)

UV-A	400 nm – 320 nm
UV-B	320 nm – 280 nm
UV-C	280 nm – 200 nm

Part V – Ultraviolet Light

(Read the article attached to this exam, “Body tan caused by UV light from Sun”)

1. (8 points) Let’s start with the Sun. Mark the true statements.

- X The Sun emits UV-A, UV-B and UV-C.
- X The Sun emits more light in the visible region than in the UV region.
- UV emitted by the Sun has a longer wavelength than visible light emitted by the Sun.
- X Exposure to sunlight promotes formation of Vitamin D.

2. (2 points) The article points out that people with little melanin in their skin (light-skinned) tend to get sunburned. But sunlight is carcinogenic for everybody. What does **carcinogenic** mean?

Causes cancer!

3. The article points out that sunlight produces free radicals in the skin. These in turn can damage DNA.

a. (2 points) Free radicals are reactive. Why? (10 words or less)

They have an unpaired electron (don’t follow the octet rule)

b. (2 points) Free radicals are connected with tanning. How (10 words or less)?

“Free radicals oxidize and darken melanin”
(this is in the article)

4. The article urges people to wear sunscreen to prevent premature aging of skin and sunburn.

a. (3 points) Which types of light do today’s sunscreens protect against?
Circle all that apply (-1 each error).

UV-A **UV-B** UV-C visible

b. (2 points) **Zinc oxide** and **titanium dioxide** function as sun blocks.

Sunblocks reflect the radiation that causes sunburn.
absorb, reflect, transmit

UV-A	400 nm – 320 nm
UV-B	320 nm – 280 nm
UV-C	280 nm – 200 nm

Part VI – The Ozone Hole

1. (4 points) Ozone in the stratosphere protects life on our planet.

What does it primarily protect us from? UV-B
 (OK to put UV-C too. Must have UV-B. Just UV or UV-C is -1.)

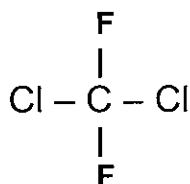
How does it protect us? It absorbs the UV-B light

2. (3 points) The ozone hole is not really a hole. Explain.

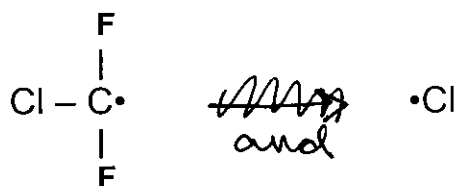
It is a thinning of the ozone layer. There is no "hole."

3. Chlorofluorocarbons, better known as CFCs, are responsible for the loss of ozone in the stratosphere.

a. (2 points) Draw the structural formula (shows all bonds) for any CFC.



b. (3 points) Draw structural formulas for the two products formed when this CFC absorbs UV light and splits to produce a species that reacts with ozone.



c. (3 points) Why don't CFCs split and react with ozone down here in the troposphere, where ozone is a pollutant? 10 words or less.

UV-C light is required. But UV-C does not reach the troposphere (because it is absorbed by O₂ at high altitudes).