Exam from 2004

Chemistry in Context

Exam 1

Short answer: answer the following questions with a word, sentence, equation or number.

$c = 3.0 \times 10^8$ m/sec

$h = 6.63 \times 10^{-34}$ J sec

$$E = \frac{h \cdot c}{\lambda} = h \cdot \nu$$

Also $N_A = 6.02 \times 10^{23}$ (atoms or molecules)/mole

1 nm = 10^{-9} m

$c = \lambda\nu$

1. Explain:
   a. The observation that clear winter nights tend to be colder than cloudy ones.

   The IR radiation given off by the earth at night will be absorbed by the water vapor in the clouds and heat will be eventually given off. Without clouds, the radiation is lost to space.

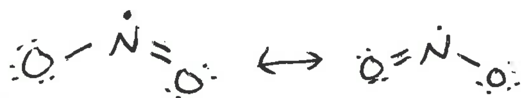
   b. How this relates to the greenhouse effect.

   Water is a greenhouse gas. Absorption of IR radiation + emission of heat is the greenhouse effect.

2.
   a. Draw the Lewis dot structure of NO_2

   This is a molecule that violates octet rule... there is an odd # of valence electrons!

   N: 5
   O: 6×2
   17 valence e⁻

   b. Would you expect NO_2 to be a greenhouse gas?

   yes. There is a dipole moment and it will change upon vibration. This is because it is bent.

3.
   a. Express the 0.9% of air which is argon in ppm.

   9000 ppm

   0.9000 or 0.9% × 10000 ppm/%

   b. In the cigarette lab, you found 0.30 mg of particles on the "smokers" filter and 0.05 mg on the "second-hand" smoke filter. What percentage of the smoke particles were on the "second-hand" filter?

   We didn't do this lab.

   14.3%

   $\frac{0.05}{0.30+0.05} \times 100\% = 14.3\%$

c. If you release 700 moles of CO_2 driving your Hummer 8 miles, how many grams of carbon did you release?

mass ratio of C in CO_2

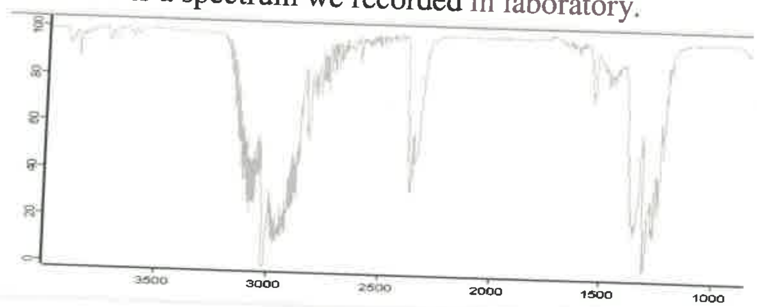
$\frac{12.01\ g\ C}{44.02\ g\ CO_2} = \frac{0.273\ g\ C}{1\ g\ CO_2}$

$700\ moles\ CO_2 \times \frac{44.02\ g\ CO_2}{1\ mol} = 30814\ g\ CO_2$

$30814\ g\ CO_2 \times \frac{0.273\ g\ C}{1\ g\ CO_2} = 8407\ g\ C$

8407 grams

4. Below is a spectrum we recorded in laboratory.



Wavenumber (cm^{-1})

a. What type of spectrum is this?

IR

b. Give the rough position of each position of maximum absorbance in the correct units.

~3000 cm^{-1}, ~2400 cm^{-1}, ~1400 cm^{-1}

c. What is the energy (J) associated with the greatest absorbance in this spectrum?

$3000\ cm^{-1} = 3.33\times10^{-4}\ cm$ or $3.33\times10^{-6}\ m$ (λ)

5.97×10^{-20} J

$E = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34}\ J\cdot s)(3\times10^{8}\ m/s)}{3.33\times10^{-6}\ m} = 5.97\times10^{-20}\ J$

5.

a. Calculate the energy of a 242 nm photon of light. Light of this wavelength has sufficient energy to break an O-O bond to produce oxygen radical.

(λ)

$242\ nm \times \frac{10^{-9}\ m}{1\ nm} = 2.42\times10^{-7}\ m$

$E = \frac{hc}{\lambda}$

$= \frac{(6.63\times10^{-34}\ J\cdot s)(3\times10^{8}\ m/s)}{2.42\times10^{-7}\ m} = 8.22\times10^{-19}\ J$

b. If it requires a photon of 320 nm to break one of the bonds in ozone, what can be said about the relative strength of these bonds?

Since 320 nm is longer than 242 nm (i.e. less energy in 320 nm) it must be easier to break a bond in O_3 than in O_2.

c. Draw the Lewis dot structure of ozone and oxygen and rationalize the relative bond strength.

ozone 

O_2 $\ddot{O}=\ddot{O}$

O_2 has a double bond and O_3 has ~1.5 bond. O_2 is a stronger bond + it takes more energy to break the bond.

6. ___ $C_8H_{18}O$ + O_2 --------------------> CO_2 + H_2O

a. Balance this equation for octanol being combusted in the presence of oxygen.

$$C_8H_{18}O + 12O_2 \longrightarrow 8CO_2 + 9H_2O$$

molecular weight: 130.224 g/mol 32 g/mol 44.01 g/mol 18.016 g/mol

b. If you burn 100g of $C_8H_{18}O$, how many g of CO2 are formed?

270.4 gram

c. How many moles is this?

6.144 moles

$$100g\ C_8H_{18}O \times \frac{1\ mol\ C_8H_{18}O}{130.224g} = 0.768\ mol\ C_8H_{18}O$$

$$0.768\ mol\ C_8H_{18}O \times \frac{8\ mol\ CO_2}{1\ mol\ C_8H_{18}O} = 6.144\ mol\ CO_2$$

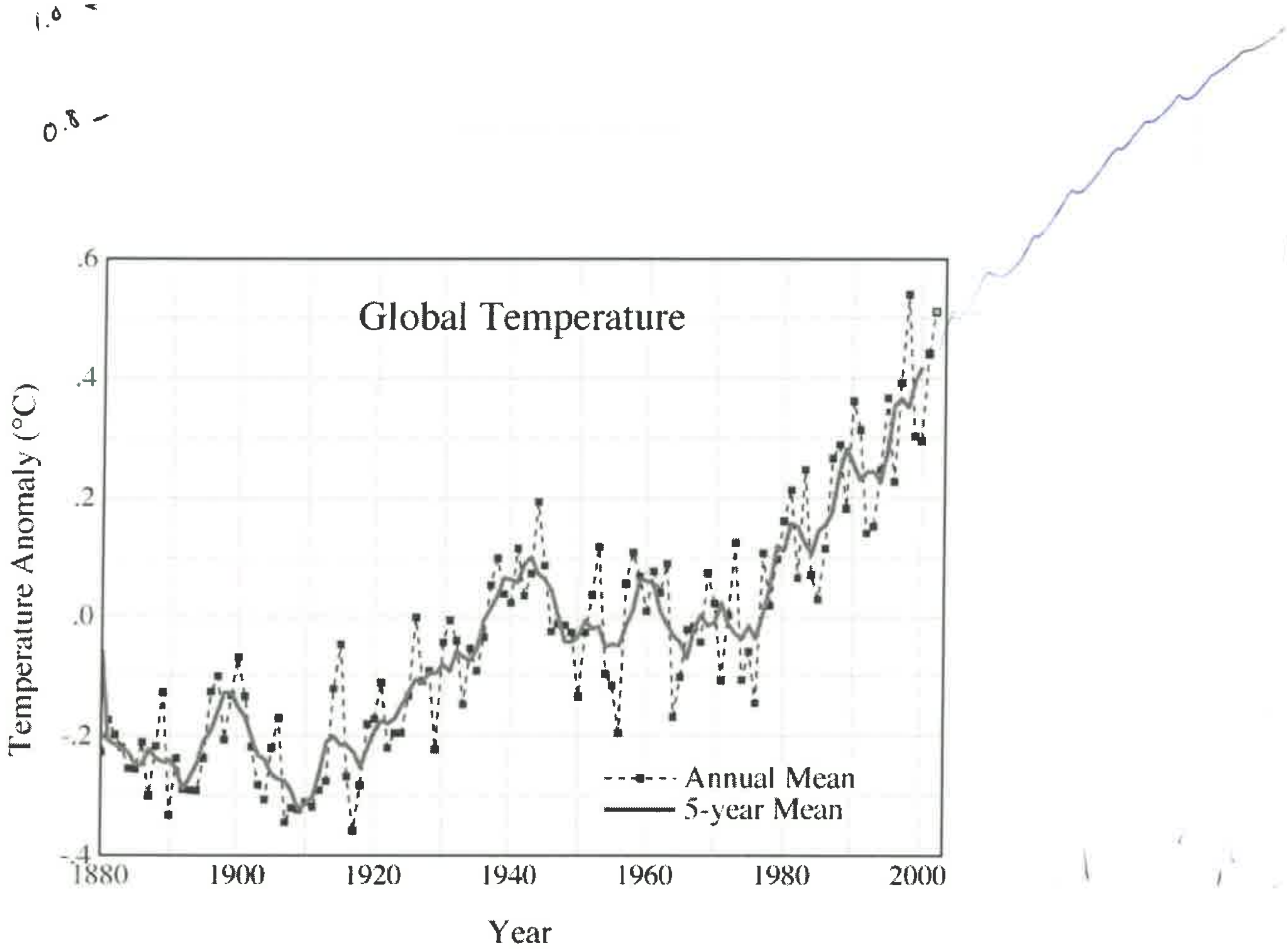
$$6.144\ mol\ CO_2 \times \frac{44.01\ g\ CO_2}{1\ mol\ CO_2} = 270.4\ g\ CO_2$$

7. What is climate forcing? Name two positive and negative climate forcings.

↑ a perturbation on the earth's energy balance

positive forcings: ① addition of greenhouse gases (CO_2, CH_4, N_2O etc) ② black carbon (soot)

negative forcings: ① land cover change ② volcano (stratospheric aerosols)



8.

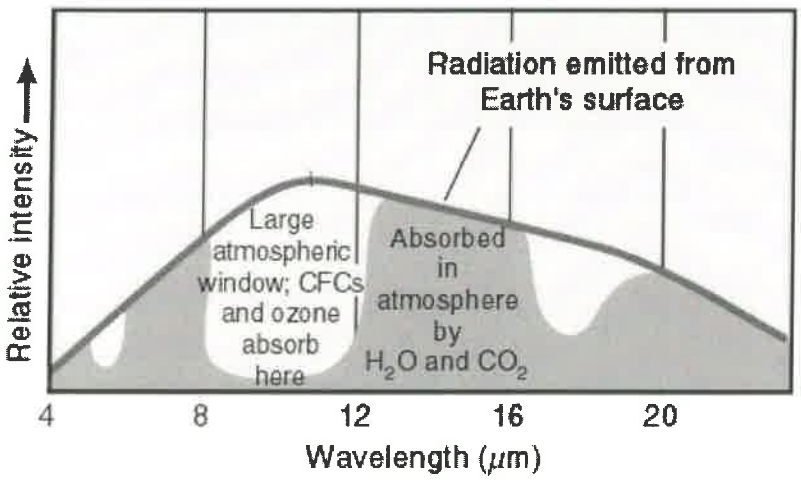
a. Given the above global temperature trends, how much might you expect temperature to increase by the year 2050? Explain your reasoning.

~1.0 degree C

If the trend observed from 1970 to 2000 continues for the next 50 years, we'd be ~1.0 °C above 1950-1980 average. (Also would accept other #s with valid reasons).

b. From 1940-1970, there was no increase in global temperature. Explain how this could have happened given that CO_2 levels were rising during this time period. It may be helpful to think about climate forcing.

The positive forcing of adding CO_2 to atmosphere must have been offset by negative forcings such as ~~reduced~~ change in land cover or emission of stratospheric aerosols.



9.

a. What region of the light spectrum is the above figure referring to?

IR

b. At what wavelength does most radiation exit the earth's atmosphere?

10 um

c. Would more of the sun's radiation be at longer or shorter wavelengths than 4 – 20 microns (10^{-6}m)?

shorter (most is UV and visible) which is shorter in wavelength than IR

10.

a. What is the difference between PM_{10} and $PM_{2.5}$?

Size (PM2.5 is smaller than PM10)

b. What are three major sources of these pollutants?

① coal combustion
② fuel combustion (gas + diesel)
③ biomass burning
④ livestock
⑤ fugitive dust

c. Which one has the most detrimental health effects? Why?

PM2.5. It can get deeper in the lungs than PM10.