AP® CHEMISTRY
2007 SCORING GUIDELINES (Form B)

Question 2

Answer the following problems about gases.

(a) The average atomic mass of naturally occurring neon is 20.18 amu. There are two common isotopes of naturally occurring neon as indicated in the table below.

Isotope	Mass (amu)
Ne-20	19.99
Ne-22	21.99

(i) Using the information above, calculate the percent abundance of each isotope.

Let x represent the natural abundance of Ne-20. $19.99x + 21.99(1-x) = 20.18$ $19.99x + 21.99 - 21.99x = 20.18$ $19.99x - 21.99x = 20.18 - 21.99$ $-2x = -1.81$ $x = 0.905$ $\Rightarrow$ percent abundances are: Ne-20 = 90.5% Ne-22 = 9.5%	One point is earned for the correct answer.

(ii) Calculate the number of Ne-22 atoms in a 12.55 g sample of naturally occurring neon.

$12.55 \text{ g Ne} \times \frac{1 \text{ mol Ne}}{20.18 \text{ g Ne}} \times \frac{0.095 \text{ mol Ne-22}}{1 \text{ mol Ne}} \times \frac{6.022 \times 10^{23} \text{ Ne-22 atoms}}{1 \text{ mol Ne-22}}$ $= 3.6 \times 10^{22}$ Ne-22 atoms	One point is earned for the correct molar mass. One point is earned for the correct fraction of Ne-22 in Ne. One point is earned for the number of atoms.

Question 2 (continued)

(b) A major line in the emission spectrum of neon corresponds to a frequency of $4.34 \times 10^{-14}\ s^{-1}$. Calculate the wavelength, in nanometers, of light that corresponds to this line.

$c = \lambda\nu \quad \Rightarrow \quad \lambda = \dfrac{c}{\nu}$ $\lambda = \dfrac{3.0\times10^{8}\ \mathrm{m\,s^{-1}}}{4.34\times10^{14}\ \mathrm{s^{-1}}} \times \dfrac{1\ \mathrm{nm}}{10^{-9}\ \mathrm{m}} = 690\ \mathrm{nm}$	One point is earned for the correct setup. One point is earned for the answer.

(c) In the upper atmosphere, ozone molecules decompose as they absorb ultraviolet (UV) radiation, as shown by the equation below. Ozone serves to block harmful ultraviolet radiation that comes from the Sun.

$$O_3(g) \xrightarrow{\text{UV}} O_2(g) + O(g)$$

A molecule of $O_3(g)$ absorbs a photon with a frequency of $1.00 \times 10^{15}\ s^{-1}$.

(i) How much energy, in joules, does the $O_3(g)$ molecule absorb per photon?

$E = h\nu$ $= 6.63 \times 10^{-34}\ \mathrm{J\ s} \times 1.00 \times 10^{15}\ \mathrm{s^{-1}}$ $= 6.63\times10^{-19}\ \mathrm{J}$ per photon	One point is earned for the correct answer.

(ii) The minimum energy needed to break an oxygen-oxygen bond in ozone is $387\ \mathrm{kJ\ mol^{-1}}$. Does a photon with a frequency of $1.00 \times 10^{15}\ s^{-1}$ have enough energy to break this bond? Support your answer with a calculation.

$\dfrac{6.63\times10^{-19}\ \mathrm{J}}{1\ \text{photon}} \times \dfrac{6.022\times10^{23}\ \text{photons}}{1\ \mathrm{mol}} \times \dfrac{1\ \mathrm{kJ}}{10^{3}\ \mathrm{J}} = 399\ \mathrm{kJ\ mol^{-1}}$ $399\ \mathrm{kJ\ mol^{-1}} > 387\ \mathrm{kJ\ mol^{-1}}$, therefore the bond can be broken.	One point is earned for calculating the energy. One point is earned for the comparison of bond energies.