

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.

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| <p>Let x represent the natural abundance of Ne-20.</p> $19.99x + 21.99(1-x) = 20.18$ $19.99x + 21.99 - 21.99x = 20.18$ $19.99x - 21.99x = 20.18 - 21.99$ $-2x = -1.81$ $x = 0.905$ <p>⇒ percent abundances are: Ne-20 = 90.5% Ne-22 = 9.5%</p> | <p>One point is earned for the correct answer.</p> |
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- (ii) Calculate the number of Ne-22 atoms in a 12.55 g sample of naturally occurring neon.

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| $12.55 \text{ g Ne} \times \frac{1 \text{ mol Ne}}{20.18 \text{ g Ne}} \times \frac{0.095 \text{ mol Ne-22}}{1 \text{ mol Ne}} \times \frac{6.022 \times 10^{23} \text{ Ne-22 atoms}}{1 \text{ mol Ne-22}}$ $= 3.6 \times 10^{22} \text{ Ne-22 atoms}$ | <p>One point is earned for the correct molar mass.</p> <p>One point is earned for the correct fraction of Ne-22 in Ne.</p> <p>One point is earned for the number of atoms.</p> |
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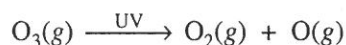
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Question 2 (continued)

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

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| $c = \lambda\nu \Rightarrow \lambda = \frac{c}{\nu}$ $\lambda = \frac{3.0 \times 10^8 \text{ m s}^{-1}}{4.34 \times 10^{14} \text{ s}^{-1}} \times \frac{1 \text{ nm}}{10^{-9} \text{ m}} = 690 \text{ nm}$ | <p style="text-align: center;">One point is earned for the correct setup.</p> <p style="text-align: center;">One point is earned for the answer.</p> |
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- (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.



A molecule of $\text{O}_3(\text{g})$ absorbs a photon with a frequency of $1.00 \times 10^{15} \text{ s}^{-1}$.

- (i) How much energy, in joules, does the $\text{O}_3(\text{g})$ molecule absorb per photon?

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| $E = h\nu$ $= 6.63 \times 10^{-34} \text{ J s} \times 1.00 \times 10^{15} \text{ s}^{-1}$ $= 6.63 \times 10^{-19} \text{ J per photon}$ | <p style="text-align: center;">One point is earned for the correct answer.</p> |
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- (ii) The minimum energy needed to break an oxygen-oxygen bond in ozone is 387 kJ mol^{-1} . Does a photon with a frequency of $1.00 \times 10^{15} \text{ s}^{-1}$ have enough energy to break this bond? Support your answer with a calculation.

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| $\frac{6.63 \times 10^{-19} \text{ J}}{1 \text{ photon}} \times \frac{6.022 \times 10^{23} \text{ photons}}{1 \text{ mol}} \times \frac{1 \text{ kJ}}{10^3 \text{ J}} = 399 \text{ kJ mol}^{-1}$ <p>$399 \text{ kJ mol}^{-1} > 387 \text{ kJ mol}^{-1}$, therefore the bond can be broken.</p> | <p style="text-align: center;">One point is earned for calculating the energy.</p> <p style="text-align: center;">One point is earned for the comparison of bond energies.</p> |
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Question 8

8. Suppose that a stable element with atomic number 119, symbol Q, has been discovered.

(a) Write the ground-state electron configuration for Q, showing only the valence-shell electrons.

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| $8s^1$ | One point is earned for the electron configuration. |
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(b) Would Q be a metal or a nonmetal? Explain in terms of electron configuration.

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| It would be a metal (OR an alkali metal). The valence electron would be held only loosely. | One point is earned for the correct answer and explanation, which must include reference to the valence electron. |
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(c) On the basis of periodic trends, would Q have the largest atomic radius in its group or would it have the smallest? Explain in terms of electronic structure.

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| It would have the largest atomic radius in its group because its valence electron is in a higher principal shell. | One point is earned for the correct answer and explanation; the size must refer to number of electron shells. |
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(d) What would be the most likely charge of the Q ion in stable ionic compounds?

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| +1 | One point is earned for the correct charge. (Must be consistent with configuration in part (a).) |
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(e) Write a balanced equation that would represent the reaction of Q with water.

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| $2 Q(s) + 2 H_2O(l) \rightarrow 2 Q^+(aq) + 2 OH^-(aq) + H_2(g)$ | One point is earned for H_2 as a product. One point is earned for balancing the equation. |
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(f) Assume that Q reacts to form a carbonate compound.

(i) Write the formula for the compound formed between Q and the carbonate ion, CO_3^{2-} .

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| Q_2CO_3 | One point is earned for the formula consistent with the charge given in part (d). |
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(ii) Predict whether or not the compound would be soluble in water. Explain your reasoning.

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| It would be soluble in water because all alkali metal carbonates are soluble. | One point is earned for the answer consistent with the identification of Q. |
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