# CHEMISTRY 121 MIDTERM 2

Oct. 28, 2005

Show all your reasoning/work for full marks

(4) 1) At a depth of 99 ft. and 4°C, a panicked diver fills his lungs with air (3.5 L total of both lungs), holds his breath and heads for the sunny surface at 25°C. Every 33 ft of water is the equivalent of 1.00 atm of pressure. Calculate the volume in the diver's lungs when he hits the surface. Did he make it? Explain.

$$\frac{P_1V_1}{nT_1} = \frac{P_2V_2}{nT_2}$$ ①

$$\frac{(4\text{ atm})(3.5\text{ L})}{277.15} = \frac{(1\text{ atm})(V_2)}{298.15}$$ ①

$V_2 = 15.06\text{ L}$

$= 1.5 \times 10^1\text{ L}$ ①

① clearly he blew up long before he hit the surface!

(4) 2) A standard car air bag (70.0 L) is inflated when sodium azide ($NaN_3$) is electronically decomposed to nitrogen gas and sodium metal. What mass of sodium azide is needed to inflate a standard air bag with $N_2$ gas at STP?

$$2\,NaN_3 \longrightarrow 3N_2(g) + 2Na(s)$$ ①

① $1.35 \times 10^2$ g $NaN_3$

135.42 g $NaN_3$

× 65 g/mol

2.08 mole $NaN_3$ needed ①

× 2/3

$x = 3.125$ moles of $N_2$ ①

as 70 L = x mole

22.4 L = 1 mole (at STP)

70.0 L STP

(3) 3) A room is filled with 50 L each of oxygen gas and carbon dioxide gas. These gases are escaping through <u>two</u> successive pinholes into another room. Calculate the relative volumes of gases pouring into the other room after passing through both pinholes.

$$\frac{v_{O_2}}{v_{CO_2}} = \left(\frac{m_{CO_2}}{m_{O_2}}\right)^{1/2} \quad (1)$$

$$= \left(\frac{44}{32}\right)^{1/2}$$

$$= \frac{1.173}{1} \quad (1)$$

= enrichment/pass

$\therefore$ 50 L × 1.173 = 58.63 L (first pass)

50 L × 1 = 50.00 L

↓

So 59 : 50 (v/v first pass)

↓

(1) 68.8 : 50 (v/v second pass)

$O_2 : CO_2$

(3) 4) A gas has the empirical formula of ClCO. A 124 mL flask at 25 °C and 22 torr contains 46.5 mg of the gas. Calculate the molecular formula of the gas. Explain your reasoning.

$$PV = nRT$$

$$\left(\frac{22\ \text{torr}}{760\ \text{torr/atm}}\right)(.124\text{L}) = \frac{.0465\text{g}}{MW}\left(\frac{0.08206\ \text{L atm}}{\text{mol K}}\right)(298.15\text{K}) \quad (1)$$

$$MW = 316.95\ \text{g/mol} \quad (1)$$

ClCO Empirical MW = 63.45 g/mol

$\therefore$ factor of 5

$\therefore$ $C_5Cl_5O_5$ (1)

(2) 5a) A new element has been found on the planet Magrathea and is given the symbol Ma. It is placed under radium on the periodic table. List two predictions for this new element.

(1) 1) Electron config ends in $8s^2$

(1) 2) It's a metal / Has a charge of 2+ / etc...

(2) b) Is Ma paramagnetic or diamagnetic? Explain.

No unpaired $e^{\ominus}$ ∴ diamagnetic

(1) (1)

6) Consider the sets of quantum numbers below.

| n | l | $m_l$ | $m_s$ | |
|---|---|---|---|---|
| 4 | 3 | -1 | -1/2 | (1) |
| 3 | 0 | 0 | +1/2 | |
| 2 | 1 | 0 | +1/2 | |
| 1 | 1 | 1 | +1/2 | (1) |

(2) a) In the above, identify each set of quantum numbers with the corresponding orbital (use n and l).

1st set = 4f (½)

2nd set = 3s (½)

3rd set = 2p (½)

4th set = 1p (½)

(3) b) Circle the sets of quantum numbers above which cannot apply to the selenium dianion. Explain.

$_{34}Se^{2-}$ = 36 $e^{\ominus}$

∴ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$ (1)

↑

Has no 4f ✗

Has 3s ✓

Has 2p ✓

Has no 1p ✗ (impossible anyway)

(2) 7) Discuss Hund's rule.

(1) In a set of degenerate orbitals (equal energy), electrons occupy separate orbitals before pairing up.
Remember sitting on a bus analogy?

Eg. $_7N = 1s^2\ 2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^1$ (1)

(3) 8) Calculate the wavelength of the electron in the helium cation (ground state).

$_2He^{\oplus}$ = 1 $e^{\ominus}$ system with $1s^1$ (1)

$E = -2.178\times10^{-18}\,J\,(Z^2/n^2)$ (1)

$= -2.178\times10^{-18}\,J\,(2^2/1^2)$

$= 8.71\times10^{-18}\,J$

$E = \frac{hc}{\lambda}$ $\therefore \lambda = \frac{(6.6262\times10^{-34}\,J\,s)(3\times10^{8}\,m/s)}{8.71\times10^{-18}\,J}$

note: abs. value taken

$= 2.28\times10^{-8}\,m$ (1)

(2) 9) Arrange the following atoms in order of increasing electropositivities. — opp. of electroneg.

Re Os Sn Cl F

(-1/2) error

$F < Cl < Sn < Os < Re$

(1) Bonus. Mendeleev predicted the properties of what element before it was even discovered. Ge (1)