CHEM 1000 Quiz #1 (Page 1 of 3)

1. An unknown gas is found to effuse 2.92 times more slowly than H_2 under identical conditions. What is the molar mass of the unknown gas?

$$R_A/R_B = \sqrt{M_B/M_A} \quad \text{so} \quad M_B = M_A \left(R_A/R_B\right)^2$$

$$M_{\text{unknown gas}} = 2.0158\ g/mol \times (2.92)^2 = 17.2\ g/mol$$

2. How many moles of gas are there in 1.0 L of ideal gas held at 30°C and a pressure of 1.05 bar?

$$P_{\text{in atmosphere}} = 1.05\ \text{bar} \times 100000\ \frac{Pa}{\text{bar}} \div 101325\ \frac{Pa}{atm} = 1.03627\ atm$$

$$n = \frac{PV}{RT} = \frac{1.03627\ atm \cdot 1.00\ L}{0.08206\ L\,atm\,K^{-1}\,mol^{-1} \cdot 303.15\ K} = 0.0417\ mol$$

3. A gas at 572 mmHg and 35°C occupies a volume of 6.15 L. Calculate its volume at STP.

$$STP = 1\ \text{bar} = \frac{100000\ Pa}{101.325\ Pa/atm} \times 760\ mmHg/atm = 750.06\ mmHg$$

$$V \propto T \text{ and } V \propto 1/P \text{ so}$$

$$V_{@STP} = 6.15\ L \times \frac{273.15\ K}{308.15\ K} \times \frac{572\ mmHg}{750.06\ mmHg} = 4.16\ L$$

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4. What is the mass of solid NH_4Cl formed when 73g of $NH_3(g)$ and 73.0g $HCl(g)$ react to completion?

↳ The molar masses are $\begin{cases} NH_3 & M = 17.03\ g/mol \\ HCl & M = 36.461\ g/mol \end{cases}$

$NH_3 + HCl \rightarrow NH_4Cl$ and $m(HCl) < m(NH_3)$
[So HCl is the limiting reagent.]

$m(HCl) = 73.0g \div 36.461\ g/mol = 2.0021\ mol$
2.0021 mol of NH_4Cl is produced or, in mass,
$m(NH_4Cl) = 2.0021\ mol \times 53.491\ bg/mol$
$= 107.1g\ NH_4Cl$
or $107g\ NH_4Cl$

5. Consider the following gases: CH_4, O_2, H_2O, CCl_4, Ne. Which has the largest value of the parameter 'b' in the van der Waals equation?

gas with largest 'b': CCl_4

6. In Thermodynamics, what is the difference between a closed system and an isolated system?

↳ A closed system can exchange energy with the surroundings, an isolated system can not.

7. A 40.0g sample of copper at 200°C is dropped into 100.0g of water initially at 25°C. Calculate the final temperature of the system. The specific heat capacity of water is $4.184\ J_g^{-1}{}^{\circ}C^{-1}$ and the specific heat capacity of copper is $0.385\ Jg^{-1}\,^{\circ}C^{-1}$.

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↳ $q_{Cu} = -q_{water}$

$m_{Cu} C_{sp,Cu} \Delta T_{Cu} = - m_{water} C_{sp,water} \Delta T_{water}$

$40.0 \cdot 0.385 \cdot (T_f - 200) = -100.0 \cdot 4.184 \cdot (T_f - 25)$

$15.4 T_f - 3080 = -418.4 T_f + 10460$

$(418.4 + 15.4) T_f = 10460 + 3080$

$T_f = \frac{10460 + 3080}{418.4 + 15.4} = 31.2°C$

$T_f = 31°C$

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CHEM 1000 → Quiz #2 (Page 1 of 2)

1. Dilution of Sulfuric acid is a highly exothermic process

$$H_2SO_4(l) + H_2O \rightarrow H_2SO_4(aq) \qquad \Delta H^\circ = -71.76\,kJ/mol$$

Suppose you dilute 1.00 mole of $H_2SO_4(l)$ to a 1.60M $H_2SO_4(aq)$ solution (density $d = 1.060\,g/mL$). If the initial temperature is 25°C, and the heat capacity of the $H_2SO_4(aq)$ solution is $3.50\,J\,g^{-1}\,K^{-1}$, what is the final temperature of the solution?

↳ The heat capacity of the solution is

$$C = 1000.0\,mL \times 1.060\,\frac{g}{mL} \times 3.5\,J\,g^{-1}K^{-1} = 3710\,JK^{-1}$$

$$q_{solution} = -q_{reaction} = 71760\,J$$

$$\Delta T = \frac{q_{solution}}{C} = \frac{71760\,J}{3710\,JK^{-1}} = 19.34\,K$$

$$T_{final} = 25^\circ C + 19.34^\circ C = 44.3^\circ C$$

2. The internal energy of an ideal gas is $\frac{3}{2}nRT$. 1 mole of ideal gas, confined within a cylinder by a piston, is heated from 25°C to 100°C while under a constant pressure of 1.01 bar.

a) Calculate the **work done** by the expanding gas, in joules.

↳ $w = -P_{ext}\Delta V = -nR\Delta T = -1.00 \cdot R \cdot 75.0K = -623.6J = -6.24 \times 10^2\,J$

b) How much heat did the gas absorb?

↳ $\Delta U = \frac{3}{2}nRT = \frac{3}{2} \cdot 1.00 \cdot R \cdot 75.0K = 935.4J$

$$q = \Delta U - w = 935.4J - -623.6J$$

$$q = 1559\,J \text{ or } 1.56 \times 10^3\,J$$

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3. What is the DeBroglie wavelength for an electron of mass $m_e = 9.109 \times 10^{-31}$ kg travelling at a speed of 3.000×10^7 m/s?

↳ $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{6.62607 \times 10^{-34}\ J \cdot s}{9.109 \times 10^{-31}\ kg \cdot 3.0 \times 10^7\ m/s}$

$\lambda = 2.425 \times 10^{-11}$ m

4. The standard enthalpy of combustion of cyclopropane (C_3H_6) is −2091 kJ/mol. The standard enthalpies of formation of $CO_2(g)$ and $H_2O(l)$ are −393.5 kJ/mol and −285.8 kJ/mol, respectively. Calculate the standard enthalpy of formation of cyclopropane.

↳ $C_3H_6 + \frac{9}{2} O_2(g) \rightarrow 3CO_2(g) + 3H_2O(l)$

$x \qquad 0 \qquad -393.5 \qquad -285.8 \qquad -2091$

$\Delta H_{combustion} = -2091 = 3 \times (-393.5) + 3 \times (-285.8) - x$

$x = 2091 - 3 \times 393.5 - 3 \times 285.8 = 53.1$

ΔH_f° (cyclopropane) = +53 kJ/mol

5. A hydrogen atom gets excited in its 4th energy level (4th Bohr's orbit). Then, as it relaxes back to ground state (n = 1, 1st energy level), it emits a photon. What is the wavelength associated with this photon?

↳ Energy diff. b/w 2 levels: $\Delta E = R_H/1^2 - R_H/4^2 = 2.179 \times 10^{-18}\ J \times (1 - 1/16)$

$\Delta E = 2.0428 \times 10^{-18}$ J

The emitted photon has that energy, so

$\Delta E = h\nu = hc/\lambda \Rightarrow \lambda = \frac{hc}{\Delta E} \Rightarrow \lambda = \frac{6.62607 \times 10^{-34}\ J \cdot s \cdot 2.9979 \times 10^8\ m/s}{2.0428 \times 10^{-18}\ J}$

$\lambda = 9.72399 \times 10^{-8}\ m = 9.724 \times 10^{-8}$ m

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1. Arrange these elements in increasing order of ionization energy:
F (Z=9), Ne (Z=10), Na (Z=11), Al (Z=13), P (Z=15)

↳ Na < Al < P < F < Ne

2. Write the chemical equation corresponding to the electron affinity of Cl.

↳ $Cl(g) + e^- \rightarrow Cl^-(g)$

3. Label each molecule below "covalent", "ionic", or "polar". Note the atomic numbers: O (Z=8), S (Z=16), Cl (Z=17).

↳ S_2: covalent SO: polar HCl: polar

4. T or F?

→ Metals generally have larger atomic radii than non-metals. True.

→ Metals generally have larger higher ionization energies than non-metals. False.

→ Metals generally have larger electronegativities than non-metals. False

5. Circle diamagnetic atomic species.

→ O^{2-} (Z=8) Mg (Z=12) Si (Z=14) Cl (Z=17)

6. Write the best Lewis structure you can for N_2O (N: Z=7, O: Z=8), and show the formal charge for each atom.

↳ There are 2×5+6 = 16 valence e^-

:N≡N—Ö:
0 +1 −1

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Formal charge.

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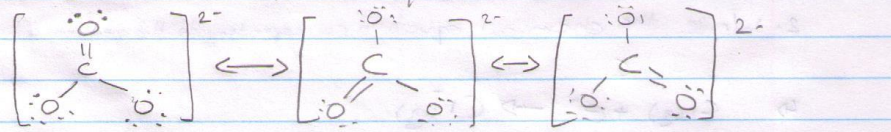
7. The three CO bond lengths in CO_3^{2-} are equal to 129 pm which is intermediate between those of a single bond (143 pm) and a double bond (120 pm). How do you explain that?

↳ There is resonance b/w 3 equivalent Lewis structures:

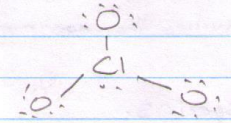


The bond angles for each C–O bond is $\frac{2}{3} \times 1 + \frac{1}{3} \times 2 = \frac{4}{3}$ which is intermediate b/w 1 & 2. So the bond lengths (which correlate w bond angles) are also intermediate b/w 143 pm and 120 pm.

8. Determine the electron group geometry, and the molecular shape, for each case. The relevant atomic numbers are O (Z=8), F (Z=9), Cl (Z=17), and Se (Z=34, Group 16).

a) ClO_3^-

→ $3 \times 6 + 7 + 1 = 26$ valence electrons, 13 pairs

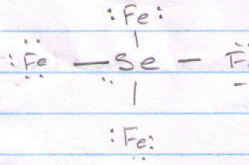


Electron group geometry: tetrahedral

Molecular shape: trigonal pyramidal

b) SeF_4

→ $6 + 4 \times 7 = 34$ valence electrons, 17 pairs



Electron group geometry: trigonal bipyramidal

Molecular shape: see-saw