1.) Metallic gold crystallizes in the face-centered cubic lattice with an edge length of 407 pm. From this information, estimate the density of gold in g/cm^3.

$$407\,pm \times \frac{1\,m}{10^{12}\,pm} \times \frac{10^{2}\,cm}{1\,m} = 407\times10^{-10}\,cm$$

$$4\ atoms\ Au \times \frac{196.97\ amu}{1\ atom\ Au} \times \frac{1.661\times10^{-24}\,g}{1\ amu} = 1.31\times10^{-21}\,g$$

$$\frac{1.31\times10^{-21}\,g}{(407\times10^{-10}\,cm)^3} \rightarrow 19.4\,g/cm^3$$

2.) Starting with a 70.8 g sample of benzene (C_6H_6, 78.11 g/mol) at 48.6°C and 1.00 atm of pressure, how much energy should be removed in order to lower its temperature to -68.5°C, at constant pressure?

$\Delta_{vap}H°$ = 33.9 kJ/mol $C_{P,liq}$ = 1.73 J/g°C $C_{P,s}$ = 1.51 J/g°C Normal $T_{melting}$ = 5.5°C $\Delta_{fus}H°$ = 9.8 kJ/mol $C_{P,gas}$ = 1.06 J/g°C ρ = 0.879 g/cm^3 Normal $T_{boiling}$ = 80.1°C

$$q_l = 70.8\,g \times \frac{1.73\,J}{g\,C} \times (5.5 - 48.6)°C$$

$$q_l = \frac{-5279\,J}{10^3} = -5.28\,kJ$$

48.6 → 5.5: $q_l = mc\Delta t$

$\Delta H = \Delta H_{fus} \times mol$

5.5 → -68.5: $q_s = mc\Delta t$

-68.5 → rxn

$$q_f = \frac{-9.8\,kJ}{mol}\left(\frac{20.6\,g}{78.11\,g/mol}\right) = -8.88\,kJ$$

$$q_s = 70.8\,g \times \frac{1.5\,J}{g\,C} \times (-68.5 - 5.5)°C = \frac{-7911\,J}{10^3} = -7.911\,kJ$$

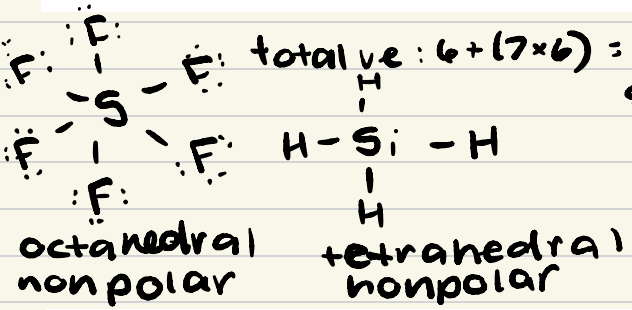
$$q_{tot} = -5.28\,kJ - 8.88\,kJ - 7.911\,kJ = -22.07\,kJ$$

3.) Place the following substances in order of *increasing* normal boiling point: SF_6, SiH_4, SF_4

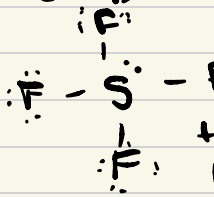
(1) $SF_6 < SF_4 < SiH_4$ (2) $SF_6 < SiH_4 < SF_4$ (3) $SiH_4 < SF_6 < SF_4$

(4) $SiH_4 < SF_4 < SF_6$ (5) $SF_4 < SF_6 < SiH_4$

$SiH_4 < SF_6 < SF_4$



SF_4: 6+(7×4) = 34 ve⁻ polar



4.) Identify the Period 2 element which has the following successive ionization energies, in kJ/mol

big ↙ core e⁻ ve⁻

$IE_1 = 520$; $IE_2 = 7298$; $IE_3 = 11{,}815$; $IE_4 = 16{,}000$;

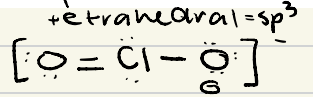
$IE_5 = 22{,}831$; $IE_6 = 27{,}277$; $IE_7 = 32{,}987$; $IE_8 = 38{,}235$

(1) Beryllium (2) Lithium (3) Nitrogen (4) Oxygen (5) Neon

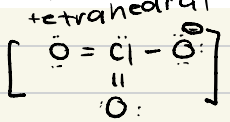
5.) When the chlorite ion is oxidized to form the chlorate ion, which of the following occurs?

(1) The Cl-O bond order changes from 1.50 to 1.33
(2) The formal charge on the chlorine atom changes from 0 to +1
(3) The oxidation state of the chlorine atom changes from +4 to +6
(4) The hybridization of the chlorine atom remains as sp^3
(5) The geometry of the anion changes from linear to trigonal planar

bent
tetrahedral = sp^3



trigonal pyramidal
tetrahedral



FC = ve⁻ − (dots + dashes)

ClO_2^-

7 + 12 + 1 = 20

ClO_3^- 7 + (6×3) + 1 = 26 ve⁻

BO: $\frac{3 \text{ bonds}}{2 \text{ atoms}} = 1.5$

BO: $\frac{5 \text{ bonds}}{3 \text{ atoms}} = 1.667$

FC: 7 − (4 + 3) = 0

FC: 7 − (5 + 2) = 0

ClO_2^-

(+3) −2×2

−4 O_2 Cl

−1 (total) = −4 + 3

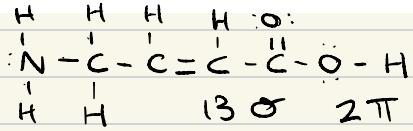
ClO_3^-

+5 −2×3

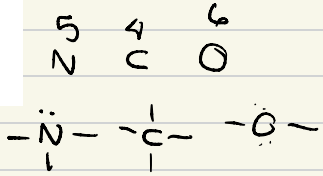
−6

6.) How many sigma and pi bonds, respectively, are in $NH_2CH_2CHCHCOOH$?

(1) 13, 2 (2) 12, 1 (3) 11, 4 (4) 10, 2 (5) 9, 1



13 σ 2π



7.) In an experiment, 25.0 ml of a gas with a pressure of 1.00 atm is contained in a balloon at 25.00°C. The balloon's temperature is adjusted until the pressure is 0.75 atm at a volume of 31.1 ml. What is the final temperature of the gas under the new conditions?

$P_1 = 1\,atm$ $\quad P_2 = 0.75\,atm$

$V_1 = 25\,mL$ $\quad V_2 = 31.1\,mL$

$T_1 = 25°C$ $\quad T_2 = ?$

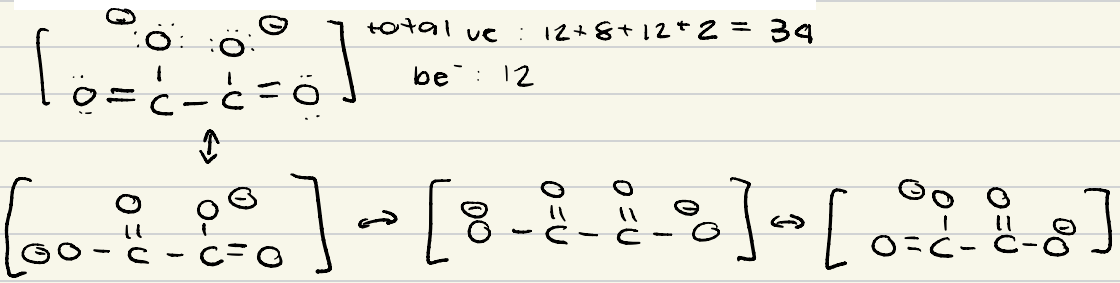
$298K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad T_2 = \frac{P_2V_2T_1}{P_1V_1}$$

$$T_2 = \frac{.75\,\cancel{atm} \times 31.1\,\cancel{mL} \times 298K}{1\,\cancel{atm} \times 25\,\cancel{mL}}$$

$T_2 = 278.03\,K = 5.03°C$

8.) How many resonance structures does the oxalate dianion $[O_2CCO2]^{2-}$ have? (4)



total ve : $12+8+12+2 = 34$

be⁻ : 12

9.) Compare the ionic sizes of Cl^- and K^+. (Z_{eff} = effective nuclear charge)

(1) K^+ will have a larger ionic size because its outer electrons experience a higher Z_{eff}

(2) K^+ will have a larger ionic size because its outer electrons experience a smaller Z_{eff}

(3) K^+ will have a smaller ionic size because its outer electrons experience a higher Z_{eff}

(4) K^+ will have a smaller ionic size because its outer electrons experience a smaller Z_{eff}

(5) K^+ will have the same ionic size because it and Cl^- experience the same Z_{eff}

$\uparrow Z_{eff}$ = smaller radius

10.) A mixture of Xe(g) and O_2(g), formed by the complete decomposition of XeO_4(g), is collected over water at 34°C at a total pressure of 760 mmHg. If the vapor pressure of water is 40 mmHg at 34°C, what is the partial pressure of O_2?

$XeO_4 \longrightarrow Xe + 2O_2$

$P_{tot} = P_{Xe} + P_{O_2} + P_{H_2O}$

$P_{tot} - P_{H_2O} = P_{Xe} + P_{O_2}$

$760\ mmHg - 40\ mmHg = 720\ mmHg = P_{Xe} + P_{O_2}$

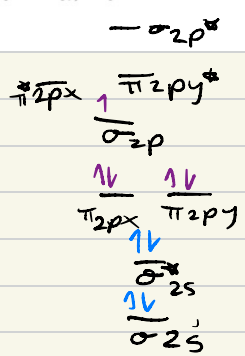
$X_{O_2} = \frac{2\ mol}{3\ mol} = \frac{2}{3}$ $\quad P_{O_2} = 720 \times \frac{2}{3} = 480\ mmHg$

11.) According to molecular orbital theory, what are the bond order and the number of unpaired electrons in CN, respectively? The valence molecular orbital sequence for CN is:

$\sigma_{2s}, \sigma^*_{2s}, \pi_{2px} = \pi_{2py}, \sigma_{2p}, \pi^*_{2px} = \pi^*_{2py}, \sigma^*_{2p}$

C
4 ve⁻

N
5 ve⁻



$BO = \frac{1}{2}(e^-_{in\ BO} - e^-_{A\ BO})$

$BO = \frac{1}{2}(7 - 2)$

$BO = 2.5$

12.) When 50.0 ml of 0.200 M $AgNO_3$ and 50.0 ml of 0.100 M $CaCl_2$, both at 25.0°C, are reacted in a coffee-cup calorimeter, the temperature of the reacting mixture increases to 26.0°C. Calculate ΔH in kJ/mol of AgCl produced. Assume the density of the solution is 1.05 g/~~ml~~ mL and the specific heat capacity of the solution is 4.20 J/g°C.

$2AgNO_3 + CaCl_2 \rightarrow 2AgCl + Ca(NO_3)_2$

50 mL 50 mL

0.2 M 0.1 M

$q = mc\Delta T$ $\quad m = 100\,mL \times \frac{1.05\,g}{1\,L} = 10.5\,g\,soln.$

$m = 10.5\,g$

$c = 4.2\,\frac{J}{g°C}$

$q = 10.5\,g \times 4.2\,\frac{J}{g°C} \times 1°C = 44.1\,J = \frac{0.0441\,kJ}{g\,soln.}$

$T = 26 - 25 = 1°C$

$.05L\,AgNO_3 \cdot \frac{2mol\,AgNO_3}{1L} \cdot \frac{2mol\,AgCl}{2mol\,AgNO_3} = .01mol\,AgCl$ $\quad \Delta H = \frac{.0441\,kJ}{.01mol}$

$.05L\,CaCl_2 \cdot \frac{1mol\,CaCl_2}{1L} \cdot \frac{2mol\,AgCl}{1mol\,CaCl_2} = .1\,mol\,AgCl$ $\quad = \frac{4.41\,kJ}{mol}$

13.) Rate data have been determined at a particular temperature for the reaction 2 NO(g) + Cl_2(g) → 2 NOCl(g). What is the numerical value for the rate constant?

Experiment	[NO] (M)	[Cl_2] (M)	Rate (M/s)
1	0.0300	0.0100	3.4×10^{-4}
2	0.0150	0.0100	8.5×10^{-5}
3	0.0150	0.0400	3.4×10^{-4}

$rate = k[NO]^x[Cl_2]^y$

$\left(\frac{[.03]}{[.015]}\right)^x = \frac{3.4 \times 10^{-4}}{8.5 \times 10^{-5}}$ $\quad \frac{[.04]}{[.01]} = \frac{[3.4 \times 10^{-4}]}{[8.5 \times 10^{-5}]}$

$2^x = 4$ $\quad 4^y = 4$

$x = 2$ $\quad y = 1$

$rate = k[NO]^2[Cl]$

$3.4 \times 10^{-4} = k[.03]^2[.01]$

$k = 37.8\,M^{-2}s^{-1}$

* 1g sample

$C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O$

$1.5g\ CO_2 \frac{1mol}{44.01gCO_2} \frac{1mol\ C}{1mol\ CO_2} \frac{12.01g}{1mol\ C} = 0.409g\ C$

$0.41g\ H_2O \frac{1mol\ H_2O}{18.02g\ H_2O} \frac{2mol\ H}{1mol\ H_2O} \frac{1.01g}{1mol\ H} = 0.046g\ H$

$1 - (.409 + .046) = 0.545g\ O$

$\frac{.545g\ O}{16g/mol} = \frac{.0341\ mol\ O}{.0341} \sim 1 \times 3 = 3$

$\frac{.409g\ C}{12.01g/mol} = \frac{0.03408\ mol\ C}{.0341} \sim 1 \times 3 = 3$

$\frac{.046g\ H}{1.01g/mol} = \frac{.046\ mol\ H}{.0341} \sim 1.3 \times 3 = 4$

empirical = $C_3H_4O_3 = 88.06g/mol$

$88.06 \times 2 \approx 170-180$ (multiply by 2)

$C_6H_8O_6$

15. $C_4H_8 \rightarrow 2\,C_2H_4$ $K = 87\,s^{-1}$ $t = 0.01s$

$$\ln \frac{[C_4H_8]_i}{[C_4H_8]_f} = kt \qquad e^{\ln\left(\frac{[2]}{[C_4H_8]}\right)} = e^{(87 \times .01)}$$

$$\frac{[2]}{[C_4H_8]_f} = 2.387 \qquad [C_4H_8] = 0.83\,M$$

$C_i = 2M$

$C_f = 2 \times .3 = .6$

$$\ln\left(\frac{2}{.6}\right) = 87\,s^{-1} \times t$$

$$1.2 = 87t$$

$$t = 0.0145$$