1.) Palladium crystallizes in the face-centered cubic lattice with a density of 12.0 g/cm^3. From this information, estimate the edge length of the cubic lattice in pm.

face-centered: 4 atoms/cell

MW_{Pd} = 106.42 g/mol

$d = 12.0\ g/cm^3$

$d = \frac{m}{V} \Rightarrow V = \frac{m}{d}$

edge length = $\sqrt[3]{V}$

$$\frac{4\text{ atoms}}{1\text{ cell}} \cdot \frac{1\text{ mol}}{6.022\times10^{23}\text{ atoms}} \cdot \frac{106.42\text{ g}}{1\text{ mol}} = 7.069\times10^{-22}\text{ g/cell}$$

$$V = \frac{7.069\times10^{-22}\text{ g}}{12.0\text{ g/cm}^3}$$

$$V = 5.89\times10^{-23}\text{ cm}^3$$

$$\text{edge length} = \sqrt[3]{5.89\times10^{-23}\text{ cm}^3}$$

$$= 3.89\times10^{-8}\text{ cm} \quad \times10^{-2}$$

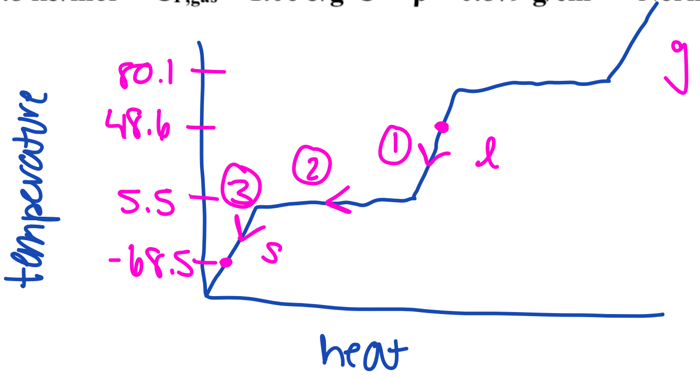
$$= 3.89\times10^{-10}\text{ m} \quad \times10^{12}$$

$$= \boxed{389\text{ pm}}$$

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?

$\Delta H_{vap}°$ = 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

$\Delta H_{fus}°$ = 9.8 kJ/mol $C_{P,gas}$ = 1.06 J/g°C ρ = 0.879 g/cm^3 Normal $T_{boiling}$ = 80.1°C



① cool the liquid
② freeze
③ cool the solid

$\frac{70.8g}{78g/mol} = 0.9077mol$

$q_1 = (70.8g)(1.73\ J/g°C)(5.5°C - 48.6°C)$

$q_1 = -5279\ J = \underline{-5.279kJ}$

$q_2 = -(0.9077mol)(9.8KJ/mol)$

$q_2 = -\underline{8.895\ KJ}$

$q_3 = (70.8g)(1.51\ J/g°C)(-68.5°C - 5.5°C)$

$q_3 = -7911J = -7.911KJ$

$q_{total} = -5.279KJ + (-8.895KJ) + (-7.911KJ)$

$q_{total} = -22.085KJ$

$\boxed{22.1KJ}$ of heat needs to be removed

3.) Which of the following will <u>decrease</u> the equilibrium concentration of an inert gas (such as N_2) in a beaker of water assuming that equilibrium is re-achieved?

I. Decreasing the temperature of the water → change vapor pressure of H_2O

II. Increasing the volume of the water → P_{N_2} doesn't change!

[✓ **III.**] **Decreasing the pressure of the gas above the liquid**

(1) I only (2) II only [✓ (III)] III only (IV) I and III (V) I, II, and III

Henry's Law: $S = k \cdot P$ $\quad [N_2] = K_{N_2} \cdot P_{N_2}$

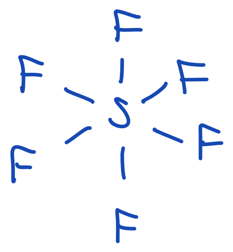
$S = [N_2]$

4.) 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) $SF_4 < SF_6 < SiH_4$

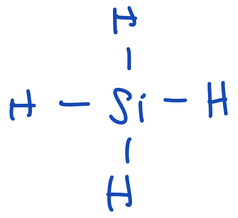
↑ IMFs → ↑ boiling point



AX_6 → octahedral

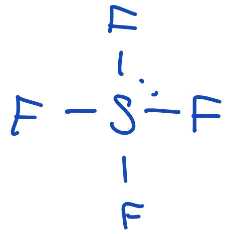
polar bonds, but molecule in nonpolar (octahedral)

IMFs: dispersion forces



nonpolar bonds

IMFs: dispersion



polar bonds

AX_4E → seesaw

molecule is polar

IMFs: dipole-dipole

SF_6 is larger than SiH_4

→ dispersion forces are stronger in SF_6

$SiH_4 < SF_6 < SF_4$

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

big jump ⟶ 1 valence e^- → Li

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

6.) 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

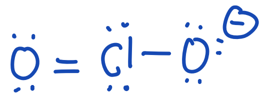
(2) The formal charge on the chlorine atom changes from 0 to +1

(3) The oxidation state of the chlorine atom changes from +4 to +6

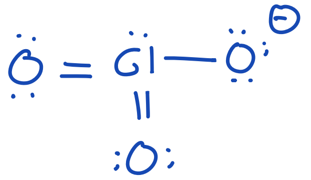
[✓ (4) The hybridization of the chlorine atom remains as sp3]

(5) The geometry of the anion changes from linear to trigonal planar

ClO_2^-



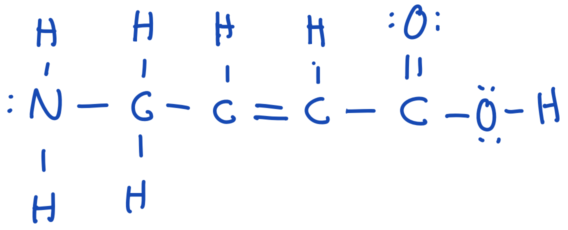
ClO_3^-



bond order	$\frac{3}{2} = 1.5$	$\frac{5}{3} = 1.67$
formal charge on Cl	$7-7=0$	$7-7=0$
ox. state of Cl	ClO_2^- $\downarrow \quad \downarrow$ $\boxed{+3} \quad -2 \times 2 = -4$	ClO_3^- $\downarrow \quad \downarrow$ $\boxed{+5} \quad -2 \times 3 = -6$
hybridization	AX_2E_2 $\downarrow$ sp^3	AX_3E $\downarrow$ sp^3
geometry	tetrahedral, bent	tetrahedral, trigonal pyramidal

7.) How many sigma and pi bonds, respectively, are in NH2CH2CHCHCOOH?

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



$\sigma : 13$

$\pi : 2$

8.) 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?

$V_1 = 25.0 mL$

$P_1 = 1.00 atm$

$T_1 = 25°C = 298K$

$V_2 = 31.1 mL$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$T_2 = \frac{P_2 V_2 T_1}{P_1 V_1}$$

$P_2 = 0.75\ \text{atm}$

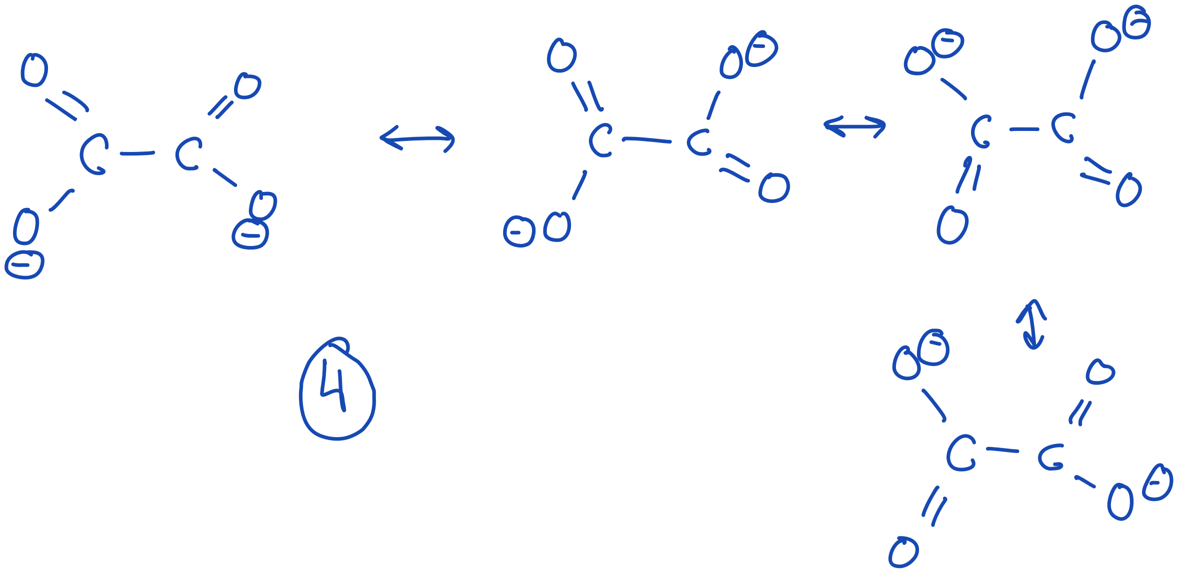
$T_2 = ?$

$$T_2 = \frac{(0.75\ \text{atm})(31.1\ \text{mL})(298\ \text{K})}{(1\ \text{atm})(25\ \text{mL})}$$

$$T_2 = 278.03\ \text{K}$$

$$= \boxed{5.03°\text{C}}$$

9.) How many resonance structures does the oxalate dianion $[O_2CCO_2]^{2-}$ have?



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10.) Compare the ionic sizes of Cl- and K+. (Zeff = effective nuclear charge)

(1) K+ will have a larger ionic size because its outer electrons experience a higher Zeff

(2) K+ will have a larger ionic size because its outer electrons experience a smaller Zeff

[✓ (3)] K+ will have a smaller ionic size because its outer electrons experience a higher Zeff

(4) K+ will have a smaller ionic size because its outer electrons experience a smaller Zeff

(5) K+ will have the same ionic size because it and Cl- experience the same Zeff

Cl^- & K^+ are isoelectronic (same # of e^-)

K^+ has 2 more protons than Cl^- → greater Z_{eff} → K^+ is smaller

11.) A sample of a hydrocarbon produced 3.14 grams of CO_2 and 1.28 grams of H_2O during combustion analysis. If the hydrocarbon has a molar mass between 50 and 60 g/mol, what is its molecular formula?

$$C_xH_y + O_2 \longrightarrow CO_2 + H_2O$$

$$3.14\,g\,CO_2 \cdot \frac{1\,mol\,CO_2}{44\,g\,CO_2} \cdot \frac{1\,mol\,C}{1\,mol\,CO_2} = \frac{0.07136\,mol\,C}{0.07136} = 1$$

$$1.28\,g\,H_2O \cdot \frac{1\,mol\,H_2O}{18\,g\,H_2O} \cdot \frac{2\,mol\,H}{1\,mol\,H_2O} = \frac{0.1422\,mol\,H}{0.07136} = 1.99 \sim 2$$

empirical formula: CH_2 $MW = 14\,g/mol$

$MW \times 2 = 28$

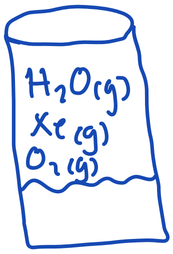
$MW \times 3 = 42$

$MW \times 4 = \underline{56}$

$$\boxed{C_4H_8}$$

12.) 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?

$$XeO_4(g) \longrightarrow Xe(g) + 2O_2(g)$$



$P = 760\,mmHg$ $P_{H_2O} = 40\,mmHg$

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

$P_{O_2} = 2 \cdot P_{Xe}$

$P = P_{H_2O} + P_{Xe} + 2P_{Xe}$

$P = P_{H_2O} + 3P_{Xe}$

$760 \text{ mmHg} = 40 \text{ mmHg} + 3 P_{xe}$

$720 \text{ mmHg} = 3 P_{xe}$

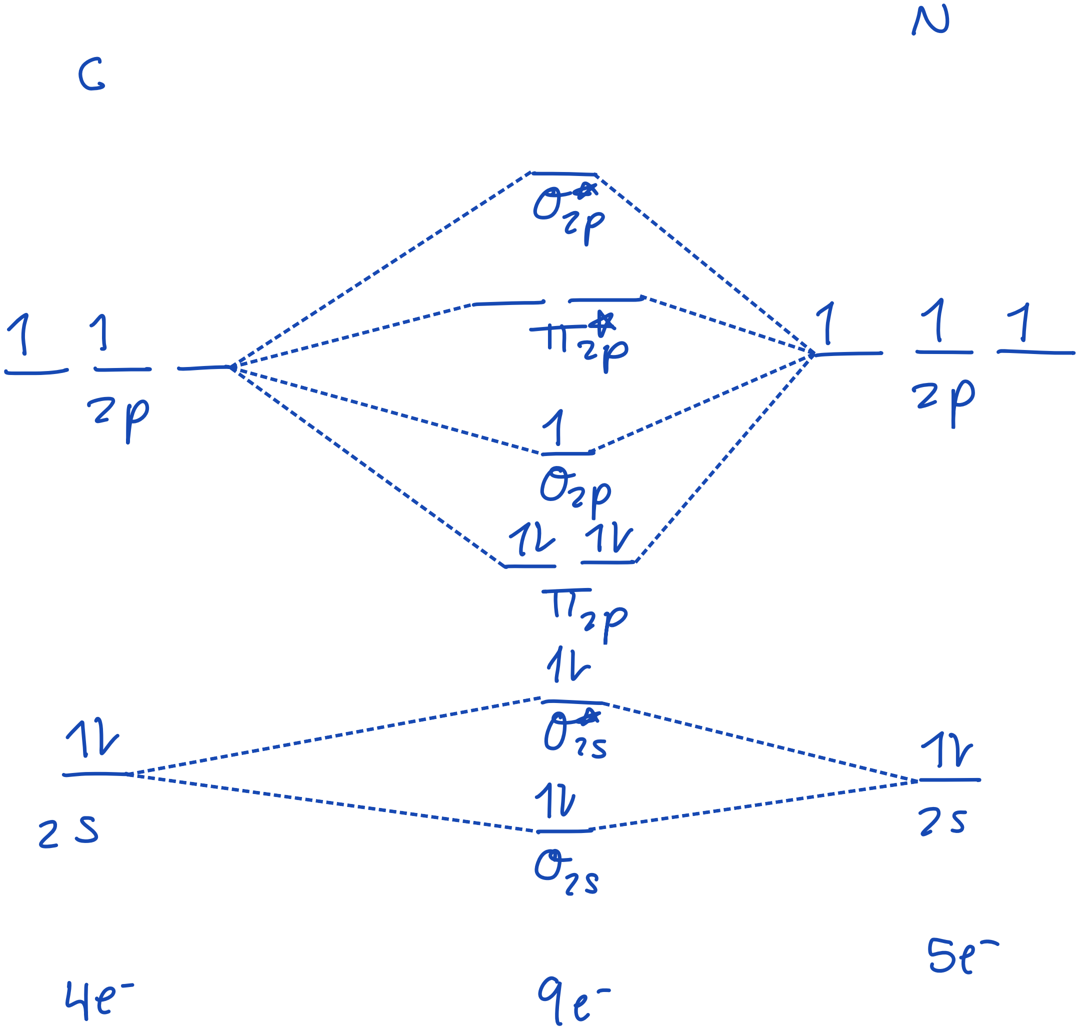
$240 \text{ mmHg} = P_{xe}$

$P_{O_2} = 2(240 \text{ mm Hg})$

$\boxed{P_{O_2} = 480 \text{ mmHg}}$

13.) 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:

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



$BO = \frac{1}{2}(7-2) = \frac{5}{2} = 2.5$

1 unpaired e⁻

14.) 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 and the specific heat capacity of the solution is 4.20 J/g°C.

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

50ml 50ml

0.2 M 0.1 M

$$\Delta H = \frac{q_{rxn}}{n_{AgCl}}$$

$$0 = q_{rxn} + q_{soln}$$

$$q_{rxn} = -q_{soln} \quad , \quad q_{soln} = m_{soln} \cdot C_{soln} \cdot \Delta T$$

$$d = \frac{m}{V} \Rightarrow m = d \cdot V$$

$$m_{soln} = (1.05 g/mL)(50mL + 50mL)$$

$$m_{soln} = 105g$$

$$q_{rxn} = -(105g)(4.70 J/g°C)(26°C - 25°C)$$

$$q_{rxn} = -441 J = -0.441 KJ$$

$$0.05L\ AgNO_3 \cdot \frac{0.2 mol\ AgNO_3}{1\ L} \cdot \frac{2\ mol\ AgCl}{2\ mol\ AgNO_3} = 0.01\ mol\ AgCl$$

$$0.05L\ CaCl_2 \cdot \frac{0.1 mol\ CaCl_2}{1\ L} \cdot \frac{2\ mol\ CaCl_2}{1\ mol\ CaCl_2} = 0.01\ mol\ AgCl$$

*no limiting reactant

$$\Delta H = \frac{-0.441\ KJ}{0.01\ mol\ AgCl} = \boxed{-44.1\ KJ/mol\ AgCl}$$

15.) A 150.0 ml sample of an aqueous solution at 25.0°C contains 15.2 mg of an unknown nonelectrolyte compound. The solution has an osmotic pressure of 8.44 torr, what is the molar mass of the unknown compound?

$\Pi = iMRT$

nonelectrolyte → $i = 1$

$\Pi = 8.44\ \text{torr} \cdot \frac{1\ \text{atm}}{760\ \text{torr}} = 0.0111\ \text{atm}$

$T = 25°C = 298K$

$M = \frac{\Pi}{iRT}$

$M = \frac{0.0111\ \text{atm}}{(1)(0.0821 \frac{L \cdot atm}{mol \cdot K})(298K)} = 4.54 \times 10^{-4}\ M$

$(4.54 \times 10^{-4} M)(0.150L) = 6.81 \times 10^{-5}\ mol$

$15.2\ mg = 0.0152g$

$MW = \frac{0.0152g}{6.81 \times 10^{-5}\ mol} = \boxed{223.2 g/mol}$

16.) Benzene (C_6H_6, 78.11 g/mol) is a liquid at room temperature with a normal boiling point of 80°C, and its molal boiling point elevation constant K_b is 2.65 °C kg/mol. Anthracene ($C_{14}H_{10}$, 178.23 g/mol) is a solid at room temperature but is quite soluble in liquid benzene. Predict the boiling point of a solution that is 25%-by-mass anthracene dissolved in benzene.

$\Delta T_b = i m K_b$

$m = \frac{mol\ C_{14}H_{10}}{Kg\ C_6H_6}$

Assume 100g of solution:

$\frac{25g\ C_{14}H_{10}}{178\ g/mol} = 0.1404\ mol\ C_{14}H_{10}$

$m = \frac{0.1404 mol}{0.075 Kg}$

$75g\ C_6H_6 = 0.075\ Kg$

$m = 1.87m$

nonelectrolyte → $i = 1$

$$\Delta T_b = (1)(1.87m)(2.65°C \cdot kg/mol)$$

$$\Delta T_b = 4.96°C$$

$$T_b = 80°C + 4.96°C = \boxed{84.96°C}$$