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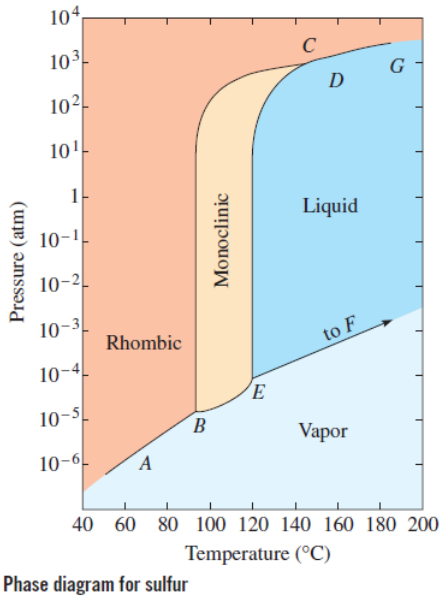
Chemistry 123 : Final Exam B

The 68 pts exam consists of 7 questions and students have the whole class period to complete the exam. Answers must be written in the box provided or else no credit is provided. Use the empty space provided to do your work. A periodic table is provided at the end. Fill in your name along with your student ID number.

Problem 1 : Sulfur Phase Diagram Answer the following questions for the phase diagram of sulfur. (4 pts)



Phase diagram for sulfur

(a) Determine all triple points.

(b) Suppose a sulfur sample is at 1 atm and 140°C. The sample is cooled to 80°C at constant pressure then subsequently, the pressure is decreased to 10^{-3} atm at constant temperature. What state of matter is sulfur ?

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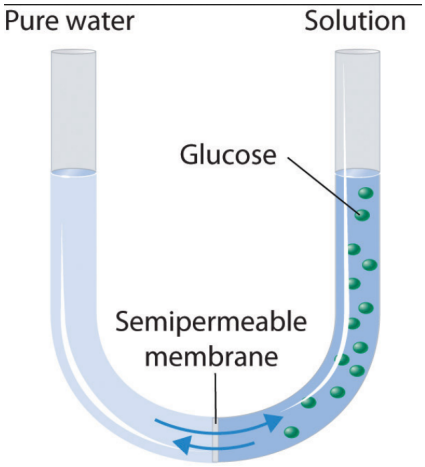
Problem 2 : Osmotic Pressure Osmotic pressure is the minimum pressure which needs to be applied to a solution to prevent the inward flow of its pure solvent across a semipermeable membrane. (8 pts)



(a) For the image above, there is pure water and glucose solutions separated by a semipermeable membrane. Describe what will happen to the water level of each solution once equilibrium is achieved.

(b) What is the osmotic pressure of a solution prepared by adding 10.35 g of sucrose ($C_{12}H_{22}O_{11}$) to water to make 175.0 mL of solution at 25.00°C.

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Problem 3 : Heating Curve Iodine (I_2) is a unique element in that the non-metallic and dark-grey material is solid at room temperature. Suppose you have 115.0g of I_2 at room temperature 25.0°C and heat the material to 175.5°C. The melting and boiling points of I_2 are 114°C and 184°C, respectively. Enthalpy of fusion and enthalpy of vaporization are 7.824 kJ/mol and 20.752 kJ/mol, respectively. Solid I_2 has specific heat of 0.427 J/(g °C) and liquid I_2 has specific heat of 2.150 J/(g °C). (10 pts)

(a) Give a brief answer why I_2 is a solid at room temperature while Bromine (Br_2) is a gas.

(b) Draw a graph of the heating curve for I_2 described in the problem above. Label the y-axis as temperature (°C) and the x-axis as heat added.

(c) Using the graph in (b), calculate the total heat in kJ required to heat 115.0g I_2 from 25.0°C to 175.5°C.

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Problem 4 : Intermolecular Forces For the following compounds : H_2SO_3, $C_{10}H_{22}$ (decane), H_2O, NH_3, CH_3CF_3. Answer the following questions. (10 pts)

(a) List out all types of intermolecular forces for the compounds listed above.

(b) Rank from highest to lowest boiling point.

(c) Rank from highest to lowest vapor pressure.

(d) Rank from strongest to weakest intermolecular interactions.

(e) **Extra Credit (5 pts) :** Dispersion is present in all materials. Provide both the textbook definition and Prof. Nguyen's landmark publication definition of dispersion. Include illustration if needed. No partical credit is given for this question.

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Problem 5 : Photoelectric Effect When light shines on a metal, electrons can be ejected from the surface of the metal in a phenomenon known as the photoelectric effect. You perform an experiment to eject electrons from nickel (Ni) metal. It is known that a wavelength of 400 nm is the minimum energy to eject an electron from Ni. (12 pts)

(a) Determine the work function (Φ), or the minimum energy in J to eject an electron, of the Ni metal.

(b) How much energy in kJ is required to eject a mole of electrons from Ni metal ? (Hint : One photon with enough energy ejects 1 electron.)

(c) What is the velocity of the electron if a photon with a frequency 1.5×10^{15} Hz hits the surface of Ni metal and ejects an electron ? The mass of an electron is 9.109×10^{-31} kg.

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Problem 6 : Valence Bond Theory and Molecular Orbital Theory (10 pts)

(a) Draw the Lewis structure of $\underline{\mathrm{P}}\mathrm{O}_4^{3-}$. Indicate all resonance structures, resonance hybrid structure, structural geometry and electronic arrangement. For the underlined atom, indicate what hybridized orbital.

(b) Provide the definitions of valence bond theory and molecular orbital theory. What is the nuance difference between the two theories ?

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Problem 7 : Limiting Reagent Magnesium silicide (Mg_2Si) is a type of semiconductor. However, it is highly reactive reactive with water (H_2O) according to the unbalanced chemical equation (14 pts)

$$Mg_2Si(s) + H_2O(l) \rightarrow Mg(OH)_2(aq) + SiH_4(g)$$

(a) Write the balanced chemical equation of the reaction above.

(b) Which reactant is the limiting if there are 50.0g $H_2O(l)$ and 70.0g $Mg_2Si(s)$?

(c) How much $Mg(OH)_2$ in g is produced based on the amount of reactant in part (b) ?

(d) What is the percent yield if a scientist collected 78.9g of $Mg(OH)_2$?

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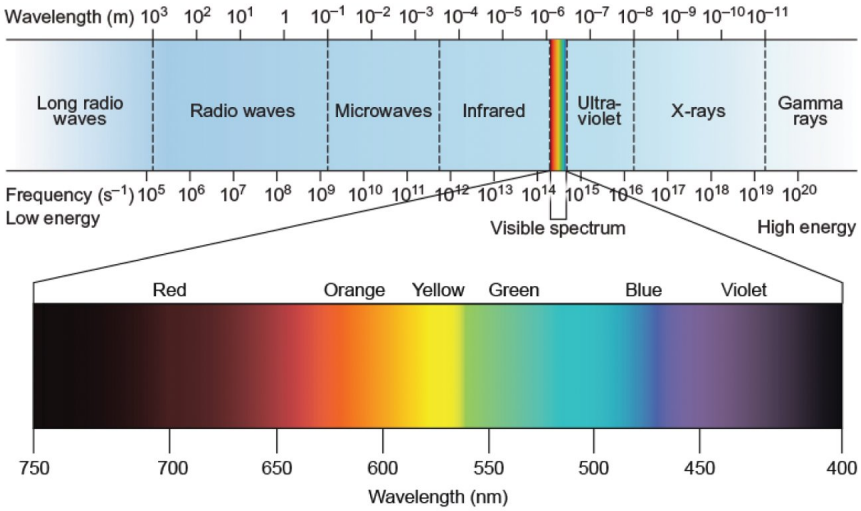
Chemistry 123 : Apppendix 2 - Formulas and Constants



$$c = \lambda\nu$$

$$E = h\nu = \frac{hc}{\lambda}$$

$$h = 6.626 \times 10^{-34}\ \text{J s}$$

$$c = 3.00 \times 10^{8}\ \text{m/s}$$

$$\text{KE} = h\nu - \Phi$$

$$\text{KE} = \frac{1}{2}mv^2$$

$$m_{\text{electron}} = 9.109 \times 10^{-31}\ \text{kg}$$

$$N_A = 6.022 \times 10^{23}\text{particles/mol}$$

$$q = mc\Delta T$$

$$q = n\Delta H_{\text{fus/vap}} = m\Delta H_{\text{fus/vap}}$$

$$\Pi = iMRT$$

$$R = 8.3145\text{J/(mol K)} = 0.08205\text{L atm/(mol K)}$$

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1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.94	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078		21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.922	34 Se Selenium 78.97	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62		39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium [97]	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	53 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.293
55 Cs Cesium 132.905	56 Ba Barium 137.327	* 57 - 70	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	78 Ir Iridium 192.217	79 Pt Platinum 195.084	80 Au Gold 196.997	81 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon [222]
87 Fr Francium [223]	88 Ra Radium [226]	** 89 - 102	103 Lr Lawrencium [262]	104 Rf Rutherfordium [267]	105 Db Dubnium [270]	106 Sg Seaborgium [269]	107 Bh Bohrium [270]	108 Hs Hassium [270]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [281]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [293]	118 Og Oganesson [294]

*Lanthanide series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.242	61 Pm Promethium [145]	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.045
**Actinide series	89 Ac Actinium [227]	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium [237]	94 Pu Plutonium [244]	95 Am Americium [243]	96 Cm Curium [247]	97 Bk Berkelium [247]	98 Cf Californium [251]	99 Es Einsteinium [252]	100 Fm Fermium [257]	101 Md Mendelevium [258]	102 No Nobelium [259]