SF CHM 1025
SECOND PROBLEM SET

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QUESTIONS ON STOICHIOMETRY AND WRITING SIMPLE EQUATIONS

(Read handout on Balancing Chemical Equations before doing problems below)

1. Produce the balanced chemical equation for each.
   a. Sodium metal and chlorine gas react to form solid sodium chloride.
   b. Carbon and oxygen gas react to yield carbon monoxide gas.
   c. Carbon and oxygen gas react to yield carbon dioxide gas.
   d. Potassium metal and liquid water react to form H_2 gas and aqueous potassium and hydroxide ions.
   e. Hydrogen and nitrogen gas react to form ammonia.
   f. The liquids, dichlorine heptoxide, Cl_2O_7, and H_2O combine to give aqueous H_3O^+ and ClO_4^- ions.
   g. Hydrogen gas reacts with Fe_3O_4 yielding iron metal and liquid water.
   h. Iron (II) persulfide (FeS_2) and oxygen gas yield iron (III) oxide and sulfur dioxide gas.

2. Write equations for the following transformations:
   a. Iron reacts with air to form Fe_2O_3 (a form of rust).
   b. Sulfur is burned in air to form gaseous sulfur dioxide.
   c. A water solution of sodium chloride is evaporated to dryness.
   d. Liquid ethyl alcohol (C_2H_5OH) reacts with O_2 gas to produce carbon dioxide gas and liquid water.
   e. Water is electrolyzed to form its constituent elements.
   f. A lit match is placed in a mixture of elemental hydrogen and oxygen (to form what?).

3. Balance the following chemical reactions by inspection.
   a. $Mg\ (s) + N_2\ (g) \longrightarrow Mg_3N_2\ (s)$
   b. $Bi^{+3}\ (aq) + H_2S\ (g) + H_2O\ (\ell) \longrightarrow Bi_2S_3\ (s) + H_3O^+\ (aq)$
   c. $Al\ (s) + H_3O^+\ (aq) \longrightarrow Al^{+3}\ (aq) + H_2\ (g) + H_2O\ (\ell)$
   d. $C_8H_{18}\ (\ell) + O_2\ (g) \longrightarrow CO_2\ (g) + H_2O\ (\ell)$
   e. $CO_3^{-2}\ (aq) + NO\ (g) + O_2\ (g) \longrightarrow NO_2^-\ (aq) + CO_2\ (g)$
   f. $HCO_3^-\ (aq) + Cu^{+2}\ (aq) \longrightarrow CuCO_3\ (s) + CO_2\ (g) + H_2O\ (\ell)$
   g. $P_4O_{10} + H_2O \longrightarrow H_3PO_4$

4. A) Write statements using the terms, atoms, ions, molecules, and/or formula units, as appropriate, to describe the information given to a chemist by equations (a), (b), and (c) above.
   B) Write statements using moles to describe the information given to a chemist by equations (a), (b), and (c) above.

5. Consider the following balanced equation: $4\ P_4 + 5\ S_8 \longrightarrow 4\ P_4S_{10}$
   a. How many moles of P_4S_{10} are produced when 0.50 mole of S_8 reacts according to the above equation?
   b. How many moles of P_4 are required to react with 16.0 g sulfur?

6. Consider the following balanced equation: $3\ NaN_3 \longrightarrow Na_3N + 4\ N_2$
   a. How many moles of N_2 are produced by the decomposition of 0.219 mol of NaN_3 according to the above equation?
   b. How many moles of NaN_3 are required to produce 25.0 g N_2?

7. Consider this reaction: $2\ Al\ (s) + 6\ HCl\ (g) \longrightarrow Al_2Cl_6\ (s) + 3\ H_2\ (g)$
   a. Calculate the mass of hydrogen formed when 25.0 g of the active metal aluminum reacts with excess HCl.
   b. What mass of Al must be allowed to react with excess HCl to produce 1.00×10^{24} molecules of H_2 gas?

8. Given that iron metal reacts with bromine to produce iron (III) bromide,
   a. Write the balanced equation.
   b. What mass of Br_2 would be required to react completely with 210 g Fe?
   c. What mass of $FeBr_3$ could be recovered from the reaction of 210 g Fe and excess Br_2?
   d. Calculate the percent yield of $FeBr_3$ if 974 g of $FeBr_3$ are produced in part c.

9. Into a sealed reaction flask were placed 1.00 g magnesium metal with 1.00 g of nitrogen gas. Heating drove the reaction to completion to yield only one product, magnesium nitride, Mg_3N_2.

   $3\ Mg + N_2 \longrightarrow Mg_3N_2$

   a. Identify the reactant present in excess.
   b. What is the theoretical yield of magnesium nitride?
   c. How many grams of the excess reagent remained after the reaction is completed?

10. Consider the following balanced equation:

    $6\ ClO_2 + 3\ H_2O \longrightarrow 5\ HClO_3 + HCl$

    a. How many moles of $HClO_3$ are produced from 14.3 g of ClO_2?
    b. How many grams of H_2O are needed to produce 5.74 g of HCl?
    c. How many grams of $HClO_3$ are produced when 4.25 g of ClO_2 are added to 0.853 g H_2O?

11. Hydrazine, N_2H_4, and hydrogen peroxide, H_2O_2, have been used as rocket propellents. They react according to the equation: $7\ H_2O_2 + N_2H_4 \longrightarrow 2\ HNO_3 + 8\ H_2O$

    a. How many moles of HNO_3 are formed from 0.0250 mol N_2H_4?

    b. How many moles of H_2O_2 react with 22.0 g N_2H_4?

    c. How many grams of H_2O are formed if 1.87 mol HNO_3 are produced?

    d. How many grams of H_2O_2 are needed to produce 45.8 g HNO_3?

12. Compare the quantities of heat liberated per mole of iron formed when the oxides Fe_3O_4 and Fe_2O_3 are reduced by aluminum.

    $3\ Fe_3O_4\ (s) + 8\ Al\ (s) \longrightarrow 4\ Al_2O_3\ (s) + 9\ Fe\ (s)$ $\Delta H° = -3.34009 \times 10^3$ kJ

    $Fe_2O_3\ (s) + 2\ Al\ (s) \longrightarrow Al_2O_3\ (s) + 2\ Fe$ (s $\Delta H° = -8.5019 \times 10^2$ kJ

13. Calculate the amount of heat released when 10.0 g ethyl alcohol, C_2H_5OH burns in oxygen to CO_2 and H_2O and the products are cooled to 25.0°C.

    $C_2H_5OH + 3\ O_2 \longrightarrow 2\ CO_2 + 3\ H_2O$ $\Delta H° = -1.368 \times 10^3$ kJ

14. How much heat energy is released when 6.00 lb (about one gallon) of gasoline with a combustion that corresponds to octane is completely burned and the products are cooled to 25.0°C? Use the following equation and note that: 1 lb = 453.6 g.

    $2\ C_8H_{18} + 25\ O_2 \longrightarrow 16\ CO_2 + 18\ H_2O$ $\Delta H° = -1.09413 \times 10^4$ kJ

15. How much heat would be required in order to produce 562.0 g of mercury metal, Hg, from solid mercury(II) oxide, HgO.

    $2\ HgO \longrightarrow 2\ Hg + O_2$ $\Delta H° = +1.8158 \times 10^2$ kJ

QUESTIONS INVOLVING SOLUTIONS

16. In which physical state (solid, liquid, or gas) is it easiest to carry out chemical reactions? Explain.
17. What is the definition of the word "solution?"
18. What are the components of a solution? How are they distinguished?
19. Why are most chemical reactions carried out in liquid solution?
20. Generally, what is the most "convenient" concentration unit for chemists to use? Why?
21. What is the definition of "Molarity?"
22. What is the molarity of sugar, $C_{12}H_{22}O_{11}$, if 53.5 g of sugar are dissolved to give 746 mL of solution?
23. What is the molarity of KCl if 1.45 g of KCl are dissolved to give 50.0 mL of solution?
24. How many grams of $NaNO_3$ are there in 75.0 mL of 1.00 M $NaNO_3$ solution?

QUESTIONS INVOLVING ATOMIC MODELS

25. Indicate whether energy is emitted or absorbed when the following electron transitions occur in hydrogen according to the Bohr model:

a. n = 2 to n = 1   b. n = 2 to n = 4   c. ionization of an e^- in the n = 2 state.

26. a) using the Bohr equation, calculate the energy of the photon emitted for each of the following electronic transitions;

i) n = 4 to n = 3   ii) n = 3 to n = 2   iii) n = 2 to n = 1

Take note of the magnitude of the energy differences between adjacent levels as n increases.

b) Calculate the wavelength of each of the photons above and classify each with respect to the region of the spectrum.

QUESTIONS ON ELECTRON CONFIGURATIONS

27. Each electron in an atom may be characterized by a set of four quantum numbers. For each of the following parts, tell how many different sets of quantum numbers are possible such that each set contains all of the values listed:

a) $n = 4, \ell = 0$ b) $n = 4, \ell = 1$ c) $n = 4, \ell = 2$

d) $n = 4, \ell = 3$ e) $n = 4, \ell = 3, m_\ell = 0$

28. Which of the following sets of quantum numbers is not allowable? Why not?

a) $n = 2, \ell = 1, m_\ell = 0$ b) $n = 2, \ell = -1$ c) $n = 3, \ell = 0, m_\ell = 0$

d) $n = 3, \ell = 1, m_\ell = -1$ e) $n = 2, \ell = 0, m_\ell = -1$ f) $n = 3, \ell = 3, m_\ell = 2$

29. What type of electron orbital (i.e., s, p, d, or f) is designated by:

a) $n = 2, \ell = 1, m_\ell = -1$ b) $n = 4, \ell = 0, m_\ell = 0$ c) $n = 5, \ell = 2, m_\ell = 0$

30. What are the n and ℓ quantum number designations for the subshells 3s, 4p, and 5d?

31. What is the Pauli Exclusion Principle?

32. Write down the aufbau order as developed in class for the first seven levels.

33. What is Hund's Rule of maximum multiplicity?

34. How many orbitals constitute each of the sublevels, s, p, d, and f, respectively? Use ↑ or ↓ designations to distinguish between +½ and -½ spins on electrons, respectively, and write the correct box diagram electron configurations for:

a) 2, 4 and 5 electrons in a p sublevel;   b) 2, 5 and 7 electrons in a d sublevel;

c) 6, 7, and 8 electrons in an f sublevel.

Comment on the relative degree of magnetic character of each of the configurations.

35. Write the notations for the ground state electronic configuration of the following atoms, and state whether each atom is paramagnetic or diamagnetic. Diagram the valence electron configurations.

a) C b) Cl c) K d) Al

e) Sr f) Sn g) V h) Zn

QUESTIONS ABOUT IONIC SUBSTANCES

36. a) Why is the radius of a positive ion smaller than the radius of its parent atom?

b) Why do negative ions have larger radii than their parent atoms?

37. How would you expect the sizes of the hydrogen ion (H^+) and the hydride ion (H^-) to compare with that of the He atom? Explain.

38. Certain elements react to form salts by forming their characteristic ions. Based on their positions in the periodic table, predict the charges for the ions expected for the following elements.

a) Mg b) K c) Al

d) P e) I f) Te

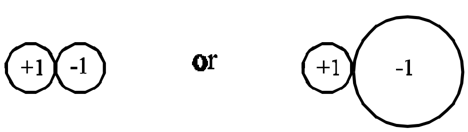
39. Based on their positions in the periodic table and the expected charges for their respective characteristic ions predict the formulas for the salts formed by the following pairs of elements.

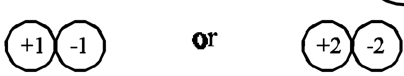
a) Ca and S_8 b) Li and P_4 c) Ga and F_2

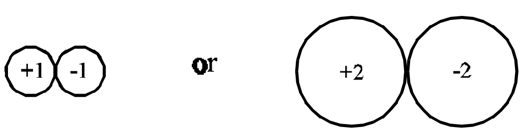
d) Mg and N_2 e) Al and O_2 f) Na and H_2

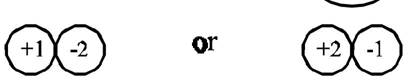
QUESTIONS ABOUT COULOMB'S LAW

40. For each of the following set of ion pairs, decide which pair of ions has the higher or larger force of attraction and why?

a) 

b) 

c) 

d) 

41. How would you expect the force of attraction between positive ion A and negative ion B to be affected by the following changes?

    a) the charge on A is doubled
    b) the charge on B is doubled
    c) the charges on both A and B are doubled
    d) the radii of both A and B are simultaneously doubled

42. For each of the following pairs of salts, decide which salt contains the greater cation-anion force of attraction. Explain your reasoning.

    a) NaF or NaCl   b) NaF or MgO   c) KCl or RbBr

QUESTIONS ABOUT BONDING

43. Arrange the following individual bonds in order of increasing polarity based on their positions in the periodic table :

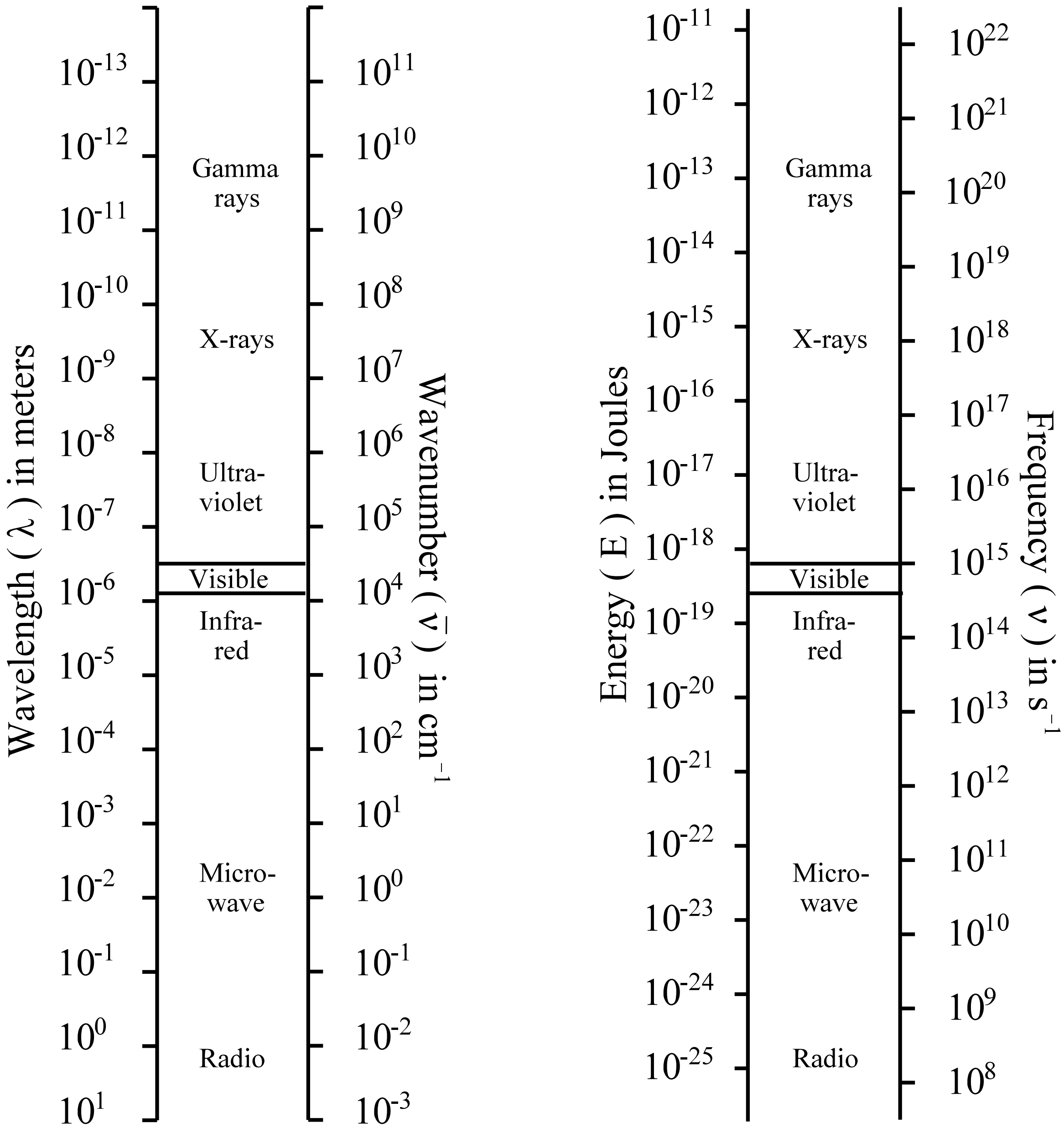
    a) H-F, H-C, H-H   b) P-S, Si-Cl, Al-Cl   c) Cl-I, P-P, C-N, O-H

44. Based on actual electronegativity differences, classify the bonds in the following as ionic, polar covalent, or nonpolar covalent. Are there any surprises based on "general trends"?

    a) I_2 b) LiCl   c) MgTe   d) Cl_2O e) H_2S

    f) Cs_2O g) BCl_3 h) SO_2 i) Al_2O_3

THE ELECTROMAGNETIC SPECTRUM



Basic Laws of Radiation

$E = h \bullet \nu$

$c = \lambda \bullet \nu$

$\bar{\nu} = 1/\lambda$

Periodic Table of the Elements

IA																	VIIIA
1 **H** 1.0079	IIA											IIIA	IVA	VA	VIA	VIIA	2 **He** 4.002602
3 **Li** 6.941	4 **Be** 9.012182											5 **B** 10.81	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.998403	10 **Ne** 20.180
11 **Na** 22.9897693	12 **Mg** 24.305	IIIB	IVB	VB	VIB	VIIB		VIIIB		IB	IIB	13 **Al** 26.981539	14 **Si** 28.0855	15 **P** 30.973762	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.08	21 **Sc** 44.95591	22 **Ti** 47.867	23 **V** 50.9415	24 **Cr** 51.996	25 **Mn** 54.93804	26 **Fe** 55.845	27 **Co** 58.93320	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.92160	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.90585	40 **Zr** 91.224	41 **Nb** 92.90638	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.90550	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.41	49 **In** 114.818	50 **Sn** 118.71	51 **Sb** 121.760	52 **Te** 127.60	53 **I** 126.90447	54 **Xe** 131.29
55 **Cs** 132.905452	56 **Ba** 137.33	57 **La*** 138.9055	72 **Hf** 178.49	73 **Ta** 180.94788	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.08	79 **Au** 196.966567	80 **Hg** 200.59	81 **Tl** 204.3833	82 **Pb** 207.2	83 **Bi** 208.98040	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac**† (227)	104 **Rf** (265)	105 **Db** (268)	106 **Sg** (272)	107 **Bh** (273)	108 **Hs** (276)	109 **Mt** (279)	110 **Ds** (281)	111 **Rg** (273)	112 **Cn** (285)	113 (287)	114 (289)	115 (291)	116 (292)		118 (294)
			*	58 **Ce** 140.116	59 **Pr** 140.90765	60 **Nd** 144.242	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.964	64 **Gd** 157.25	65 **Tb** 158.92535	66 **Dy** 162.500	67 **Ho** 164.93032	68 **Er** 167.259	69 **Tm** 168.93421	70 **Yb** 173.05	71 **Lu** 174.9668
			†	90 **Th** 232.03806	91 **Pa** 231.03588	92 **U** 238.02891	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (261)	103 **Lr** (264

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