REVIEW WORKSHEET

(Note: Gas constant R=62.36 L*Torr*mol^{-1} K^{-1} when using Torr instead of atm)

1. Write the full and net ionic equation for each of the processes below.

a. Silver nitrate + sodium oxalate

a) $2AgNO_{3(aq)} + Na_2C_2O_{4(aq)} \rightarrow Ag_2C_2O_{4(s)} + 2NaNO_{3(aq)}$ (full)

$2Ag^+_{(aq)} + C_2O_4{}^{2-}_{(aq)} \rightarrow Ag_2C_2O_{4(s)}$ (NI)

b. Hydrobromic acid + ammonia

$HBr_{(aq)} + NH_{3(aq)} \rightarrow NH_4Br_{(aq)}$

$H_3O^+_{(aq)} + NH_{3(aq)} \rightarrow NH_4^+{}_{(aq)} + H_2O(l)$

c. Iron (II) nitrate + sodium hydroxide

$Fe(NO_3)_{2(aq)} + 2NaOH_{(aq)} \rightarrow 2NaNO_{3(aq)} + Fe(OH)_{2(s)}$

$Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Fe(OH)_{2(s)}$ (NI)

d. Acetic acid + barium hydroxide

$2CH_3COOH_{(aq)} + Ba(OH)_{2(aq)} \rightarrow Ba(CH_3COO)_{2(aq)} + 2H_2O_{(l)}$

$CH_3COOH_{(aq)} + OH^-_{(aq)} \rightarrow CH_3COO^-_{(aq)} + H_2O_{(l)}$

2a. Predict the electron configurations of S, K ,Ti, Sn.
S: 1s2 2s2 2p6 3s2 3p4
K: 1s2 2s2 2p6 3s2 3p6 4s1
Ti: 1s2 2s2 2p6 3s2 3p6 3d2 4s2
Sn: 1s2 2s2 2p6 3s2 3p6 3d10 4s2 4p6 4d10 5s2 5p2

2b. Write the shorthand electron configuration for:
Ni [Ar] 3d8 4s2
Ge [Ar] 3d10 4s2 4p2
Cs [Xe] 6s1
Br [Ar] 3d10 4s2 4p5

3. An electron in a hydrogen atom is excited from the ground state to the n = 4 state. Comment on the correctness of the following statements (True or False).
a. n = 4 is the first excited state.
b. It takes more energy to ionize (remove) the electron from n = 4 than from the ground state.
c. The wavelength of light emitted when the electron drops from n = 4 to n = 1 is longer than that from n = 4 to n = 2.
d. The wavelength the atom absorbs in going from n = 1 to n = 4 is the same as that emitted as it goes from n = 4 to n = 1.

a) False (n=1 ground state, so n=2 1st excited state)
b) False (as n goes up, the absolute value of E decreases)
c) False ($E_{4\to1} > E_{4\to2}$, so $\lambda_{4-1} < \lambda_{4-2}$, since $E \propto \lambda^{-1}$)
d) True

4. Below is a list of successive ionization energies in kJ/mol for a period 3 element. Identify the element and explain how you came to that conclusion.

IE1 = 1012; IE2 = 1900; IE3 = 2910; IE4 = 4960; IE5 = 6270; IE6 = 22,200

Phosphorus - The jump between IE5 and IE6 indicates that the removal of the 6th electron is that of a core electron.

5. Which type of intermolecular force accounts for each of these differences?
a. CH_3OH boils at 65 ˚C; CH_3SH boils at 6 ˚C.
b. Xe is a liquid at atmospheric pressure and 120 K, whereas Ar is a gas under the same conditions.
c. Kr, atomic weight 84 g/mol, boils at 120.9 K, whereas Cl_2, molecular weight 71 g/mol, boils at 238 K.
d. Acetone boils at 56 ˚C, whereas 2-methylpropane boils at -12 ˚C.

Acetone 2-Methylpropane

a) CH_3OH can H-bond
CH_3SH cannot (dipole-dipole only)
b) Xe (~131 $g\,mol^{-1}$) is more polarizable than Ar (~40 $g\,mol^{-1}$) ⇒ stronger LDFs
c) Both Cl_2 and Kr are nonpolar (have LDFs only). Cl_2 must be more polarizable (more polarized $\bar{e}$ cloud).
d) Acetone is a polar molecule (dipole-dipole) while 2-methylpropane isn't. (LDFs only)

6. Arrange these compounds in order of increasing boiling point. Explain your reasoning
a. CH_4 b. CH_3CH_3 c. CH_3CH_2Cl d. CH_3CH_2OH

$CH_4 < CH_3CH_3 < CH_3CH_2Cl < CH_3CH_2OH$

CH_4 and CH_3CH_3 are small and nonpolar (only have LDFs) so should have the lowest BP. CH_3CH_3 is larger than CH_4 (30 g/mol vs. 16 g/mol) - more polarizable, stronger LDFs.
CH_3CH_2OH can H-bond - will have the highest BP.
CH_3CH_2Cl second highest BP (dipole-dipole).

7. Determine if the following reactions is a redox reaction. If it is a redox reaction, identify which element is oxidized and which is reduced; provide before and after oxidation state numbers.

a. $Sn\ (s) + 4HNO_3\ (aq) \rightarrow SnO_2\ (s) + 4NO_2\ (g) + 2H_2O$

REDOX! Sn = oxidized (0 to +4), N = reduced (+5 to +4)

b. $Hg_2(NO_3)_2\ (aq) + 2\ KBr\ (aq) \rightarrow Hg_2Br_2\ (s) + KNO_3\ (aq)$

Not redox

c. $4\ Al\ (s) + 3O_2\ (g) \rightarrow 2\ Al_2O_3\ (s)$

REDOX! Al = oxidized (0 to +3), O = reduced (0 to -2)

8. Compute the ΔH for the following reactions using both bond enthalpies:

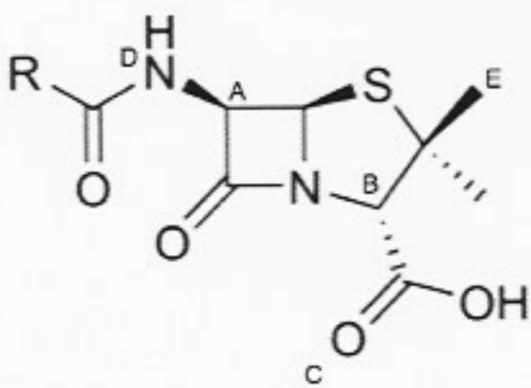
a. ___H_2 (g) + ___Br_2 (g) → _2_HBr (g)

[1(H-H) + 1(Br-Br)] - [2(H-Br)] = [-436 + 193] - [2(366)] = -103kJ/mol

b. _2_H_2O_2 (g) → _2_H_2O(g) + ___O_2 (g)

[4(O-H) + 2(O-O)] - [4(O-H) + 1(O=O)] = 2(146) - 490 = -206kJ/mol

9. Below is the structure of penicillin:



a. Fill in all lone pairs in the above molecule. Each Oxygen and the Sulfur should have two lone pairs, each Nitrogen should have one lone pair

b. What is the hybridization of atoms labeled A-E?

A: sp^3 B: sp^3 C: sp^2 D: sp^3 E: sp^3

c. What is the electron geometry at the atoms labeled B-E?

B: tetrahedral C: trigonal planar D: tetrahedral E: tetrahedral

d. Discuss one way penicillin can interact with the aqueous environment of the body using IMFs

The lone pairs on O, N could accept a hydrogen bond from water. The hydrogen bonded to N and O (NH and OH) could donate a hydrogen bond to water. Aqueous environment = water.

10. What mass of sodium acetate can be obtained from mixing 15.0 g of $NaHCO_3$ with 150. mL of 0.100 M acetic acid?

$$NaHCO_3 + HC_2O_2H_3 \rightarrow NaC_2O_2H_3 + H_2O + CO_2$$

15.0g $NaHCO_3$ * (1 mol $NaHCO_3$ / 84.01g) * (1 mol $NaC_2O_2H_3$ / 1 mol $NaHCO_3$) * (82.03g / 1mol $NaC_2O_2H_3$) = 14.6g

0.150L $HC_2O_2H_3$ * (0.100 mol $HC_2O_2H_3$ / 1 L) * (1 mol $NaC_2O_2H_3$ / 1 mol $HC_2O_2H_3$) * (82.03g / 1mol $NaC_2O_2H_3$) = 1.23g

Acetic acid is limiting. You can only get 1.23 g of sodium acetate.

11. Formic acid, HCO_2H, is a monoprotic weak acid.

a. Write a full and net ionic equations for the reaction of aqueous formic acid and aqueous potassium hydroxide:

$$HCO_2H(aq) + KOH(aq) \rightarrow H_2O(l) + KCO_2H(aq)$$

FULL: $HCO_2H(aq) + K^+(aq) + OH^-(aq) \rightarrow H_2O(l) + K^+(aq) + CO_2H^-(aq)$

NET: $HCO_2H(aq) + OH^-(aq) \rightarrow H_2O(l) + CO_2H^-(aq)$

b. If you combine 60 g formic acid and 60 g potassium hydroxide how much water (in grams) will you produce? Which is the limiting reactant?

HCO_2H: $60g\,HCO_2H \times \frac{1mol\,HCO_2H}{46g\,HCO_2H} \times \frac{1mol\,H_2O}{1mol\,HCO_2H} \times \frac{18g\,H_2O}{1mol\,H_2O}$ = 24 g H_2O formed

KOH: $60g\,KOH \times \frac{1mol\,KOH}{56g\,KOH} \times \frac{1mol\,H_2O}{1mol\,KOH} \times \frac{18g\,H_2O}{1mol\,H_2O}$ = **19g H_2O formed**

and **KOH** is the limiting reacta

12. Sweat cools the body because evaporation is an endothermic process:

$$H_2O_{(l)} \rightarrow H_2O_{(g)} \quad \Delta H^o_{rxn} = +44.01 \text{ kJ}$$

Estimate the mass of water that must evaporate from the skin to cool the body by 0.50ºC. Assume a body mass of 95 kg and that the specific heat capacity of the body is 4.0 J/g*K.

$q_{body} = mc\Delta T$ (c = 4.0 J/g°C, m = 95000 g, ΔT = 0.5°C)

$= (4.0 \frac{J}{g°C})(95000\ g)(0.50°C)$

$= 1.9 \cdot 10^5\ J = 190\ kJ$ Needed

$$190\ kJ \times \frac{1\ mol\ rxn}{44.01\ kJ} \times \frac{1\ mol\ H_2O}{1\ mol\ rxn} \times \frac{18\ g\ H_2O}{1\ mol\ H_2O} = \boxed{78\ g}$$

13. Lakes that have been acidified by acid rain (HNO_3 and H_2SO_4) can be neutralized by a process called liming, in which limestone ($CaCo_3$) is added to the acidified water. What mass of limestone (in kg) would be required to completely neutralize a 15.2 billion-liter lake that is 1.8 x 10^{-5} M in H_2SO_4 and 8.7 x 10^{-6} M in HNO_3?

① kg to neutralize the H_2SO_4: $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$

$$\frac{1.8 \cdot 10^{-5}\ mol\ H_2SO_4}{1\ L} \times 15.2 \cdot 10^9\ L = 2.74 \cdot 10^5\ mol\ H_2SO_4 \times \frac{1\ mol\ CaCO_3}{1\ mol\ H_2SO_4} \times \frac{100\ g\ CaCO_3}{1\ mol\ CaCO_3} \times \frac{1\ kg}{1000\ g}$$

$= 2.7 \cdot 10^4\ kg\ CaCO_3$

② kg to neutralize the HNO_3: $CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

$$\frac{8.7 \cdot 10^{-6}\ mol\ HNO_3}{1\ L} \times 15.2 \cdot 10^9\ L = 1.32 \cdot 10^5\ mol\ HNO_3 \times \frac{1\ mol\ CaCO_3}{2\ mol\ HNO_3} \times \frac{100\ g\ CaCO_3}{1\ mol\ CaCO_3} \times \frac{1\ kg}{1000\ g}$$

$= 6.6 \cdot 10^3\ kg\ CaCO_3$

③ Add them up!: $2.7 \cdot 10^4\ kg + 6.6 \cdot 10^3\ kg = \boxed{3.4 \cdot 10^4\ kg}$

14. Find the mass of barium metal (in grams) that must react with oxygen gas to produce enough barium oxide to prepare 1.0 L of a 0.10 M solution of OH^-

Equations: $2Ba + O_2 \rightarrow 2BaO$

$BaO + H_2O \rightarrow Ba(OH)_2$

$\frac{0.1 \text{ mol } OH^-}{L} \times 1.0 L = 0.1 \text{ mol } OH^-$ needed!

so $0.1 \text{ mol } OH^- \times \frac{1 \text{ mol } Ba(OH)_2}{2 \text{ mol } OH^-} \times \frac{1 \text{ mol } BaO}{1 \text{ mol } Ba(OH)_2} \times \frac{2 \text{ mol } Ba}{2 \text{ mol } BaO} \times \frac{137 \text{ g } Ba}{1 \text{ mol } Ba}$

$= \boxed{6.9 \text{ g } Ba}$

Acetone (CH_3COCH_3) and chlorobenzene (C_6H_5Cl) are two common organic solvents

15. CaO (s) reacts with water to form $Ca(OH)_2$ (aq). If 6.50 g CaO is combined with 99.70g H_2O in a coffee cup calorimeter, the temperature of the resulting solution increases from 21.7 ºC to 43.1 ºC. Calculate the enthalpy change for the reaction per mole of CaO. Assume that the specific heat capacity of the solution is 4.18 J/g•K.

$q_{soln} + q_{rxn} = 0 \qquad q_{soln} = -q_{rxn}$

Sol'n: $m = 99.70g + 6.50g = 106.20g$

$c = 4.18 \frac{J}{g \cdot °C}$

$\Delta T = 43.1 - 21.7 = 21.4°C$

rxn

$mc\Delta T = -q_{rxn}$

$= (106.20g)(4.18 \frac{J}{g°C})(21.4°C)$

$-q_{rxn} = 9.50 \cdot 10^3 J$

so $q_{rxn} = \frac{-9.50 \cdot 10^3 J}{6.50 g CaO} \times \frac{56 g CaO}{1 mol CaO}$

$= \boxed{-8.20 \cdot 10^4 J/mol}$

16. If you put 120 volts of electricity through a pickle, the pickle will smoke and start glowing orange-yellow. The light is emitted because sodium ions in the pickle become excited; their return to the ground state results in light emission.

a. The wavelength that is emitted is 589 nm. Calculate its frequency.

b. What is the energy of 0.10 mol of these photons?

c. Calculate the energy gap between the excited and ground states for the sodium ion.

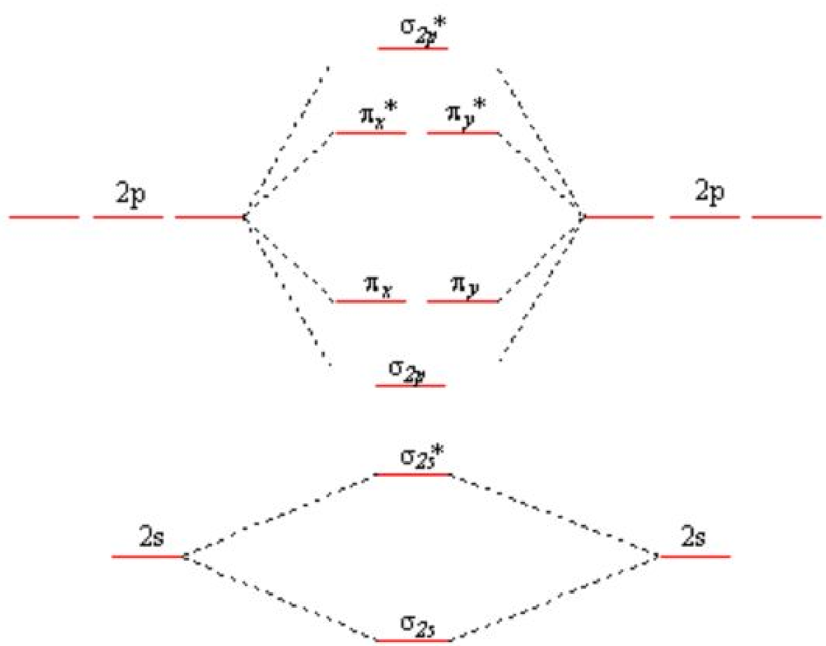
a) $\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}\ m\,s^{-1}}{589 \times 10^{-9}\ m} = \boxed{5.09 \times 10^{14}\ s^{-1}}$

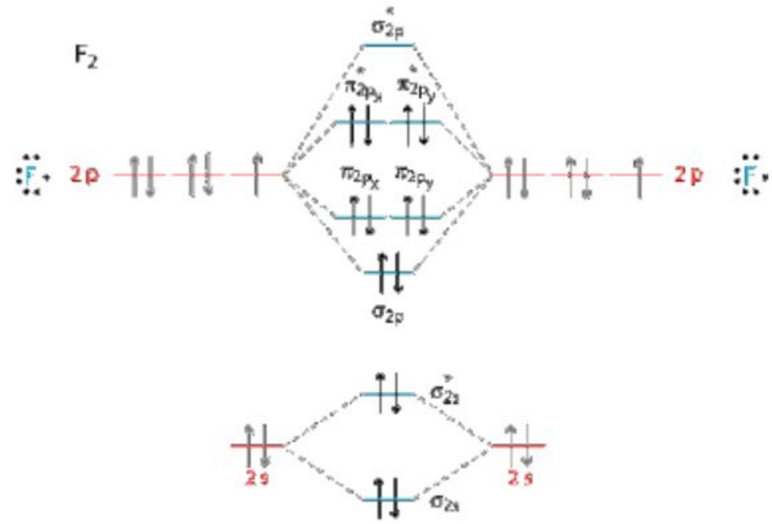
b) $E = h\nu = (6.626 \times 10^{-34}\ J\,s)(5.09 \times 10^{14}\ s^{-1}) = 3.37 \times 10^{-19}\ J/photon$

$0.10\ mol \times \frac{6.022 \times 10^{23}\ photons}{1\ mol} \times \frac{3.37 \times 10^{-19}\ J}{1\ photon} = \boxed{20.\ kJ}$

c) energy gap: $E = h\nu = \boxed{3.37 \times 10^{-19}\ J}$

17. Fill in the molecular orbital diagram for F_2, give the bond order, and identify whether it is diamagnetic or paramagnetic.





Bond order: ½ (8-6) = 1; Diamagnetic

18. A gaseous hydrogen and carbon containing compound is decomposed and found to contain 82.66% carbon and 17.34% hydrogen by mass. The mass of 158 mL of the gas, measured at 556 torr and 25 ˚C, was 0.275 g. What is the molecular formula of the compound?

1) $82.66\text{ g C} \times \frac{1\text{ mol}}{12.011\text{ g}} = 6.88\text{ mol C}$

$17.34\text{ g H} \times \frac{1\text{ mol}}{1.008\text{ g}} = 17.2\text{ mol H}$

$CH_{2.5} = C_2H_5$ EF

$PV = nRT \Rightarrow (556\text{ torr})(0.158\text{ L}) = n(62.36\text{ L torr mol}^{-1}\text{K}^{-1})(298.15\text{ K})$

$\Rightarrow n = 4.72\times10^{-3}\text{ mol}$

$\frac{0.275\text{ g}}{4.72\times10^{-3}\text{ mol}} = 58\text{ g/mol}$ C_2H_5: $M = 2\times12+5 \sim 29\text{ g/mol}$

$58/29 = 2 \Rightarrow \boxed{C_4H_{10}}$

GOOD LUCK!