Spring 2023 CHM2045 Exam 1 Review Solutions

The material covered is from chapters 1-4

1. The two most abundant isotopes of chlorine are ^{35}Cl (34.99 amu) and ^{37}Cl (36.99 amu). What are their percent abundances? (Hint: Use value from periodic table) → Cl = 35.45 amu

a) ^{35}Cl is 37%; ^{37}Cl is 63%
b) ^{35}Cl is 23%; ^{37}Cl is 77%
c) ^{35}Cl is 77%; ^{37}Cl is 23%
d) ^{35}Cl is 63%; ^{37}Cl is 37%
e) ^{35}Cl is 50%; ^{37}Cl is 50%

$35.45 = 34.99(1-x) + 36.99x$
$35.45 = 34.99 - 34.99x + 36.99x$
$0.46 = 2x$
$x = 0.23$ → $^{37}Cl = 23\%$
$1-x = 1-0.23 = 0.77$ → $^{35}Cl = 77\%$

2. Given the name of the compound, write its molecular formula.

a) Vanadium (v) nitride: V_2N_5 → V_3N_5
b) Iron (i) nitrate: $Fe^{+}NO_3^{-}$ → $FeNO_3$
c) Tin (iv) fluoride: $Sn^{4+}(F^{-})_4$ → SnF_4
d) Copper (ii) phosphate: $(Cu^{2+})_3(PO_4^{3-})_2$ → $Cu_3(PO_4)_2$
e) Ammonium dichromate: $(NH_4^{+})_2Cr_2O_7^{2-}$ → $(NH_4)_2Cr_2O_7$

3. What are the moles of each ion and the number of each atom in 78.5 g of aluminum sulfate?

I.	0.241 mol Al^{3+}	V.	$2.76*10^{23}$ atoms Al	IX.	$1.66*10^{24}$ atoms O
II.	0.459 mol Al^{3+}	VI.	$5.47*10^{24}$ atoms Al	X.	$9.32*10^{23}$ atoms O
III.	0.987 mol SO_4^{2-}	VII.	$4.14*10^{23}$ atoms S		
IV.	0.688 mol SO_4^{2-}	VIII.	6.3510^{25} atoms S		

a) II, IV, V, VII, IX
b) I, III, VI, VIII, X
c) I, II, IV, VI, VIII, X
d) II, III, V, VII, IX
e) None of the above

$(78.5\,g\,Al_2(SO_4)_3)\left(\frac{1\,mol\,Al_2(SO_4)_3}{342.15\,g\,Al_2(SO_4)_3}\right)\left(\frac{2\,mol\,Al^{3+}}{1\,mol\,Al_2(SO_4)_3}\right) = 0.459\,mol\,Al^{3+}$

$(78.5\,g\,Al_2(SO_4)_3)\left(\frac{1\,mol\,Al_2(SO_4)_3}{342.15\,g\,Al_2(SO_4)_3}\right)\left(\frac{3\,mol\,SO_4^{2-}}{1\,mol\,Al_2(SO_4)_3}\right) = 0.688\,mol\,SO_4^{2-}$

$(78.5\,g\,Al_2(SO_4)_3)\left(\frac{1\,mol\,Al_2(SO_4)_3}{342.15\,g}\right)\left(\frac{2\,mol\,Al}{1\,mol\,Al_2(SO_4)_3}\right)\left(\frac{6.022\times10^{23}\,atoms}{1\,mol}\right) = 2.76\times10^{23}\,atoms\,Al$

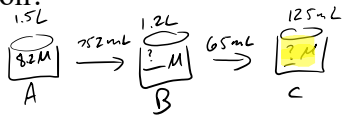
$(78.5\,g\,Al_2(SO_4)_3)\left(\frac{1\,mol\,Al_2(SO_4)_3}{342.15\,g}\right)\left(\frac{3\,mol\,S}{1\,mol\,Al_2(SO_4)_3}\right)\left(\frac{6.022\times10^{23}\,atoms}{1\,mol}\right) = 4.14\times10^{23}\,atoms\,S$

$(78.5\,g\,Al_2(SO_4)_3)\left(\frac{1\,mol\,Al_2(SO_4)_3}{342.15\,g}\right)\left(\frac{12\,mol\,O}{1\,mol\,Al_2(SO_4)_3}\right)\left(\frac{6.022\times10^{23}\,atoms}{1\,mol}\right) = 1.66\times10^{24}\,atoms\,O$

$Al_2(SO_4)_3 = 342.15\,g/mol$
$(Al = 26.98\,g/mol)\times 2$
$+ (S = 32.06\,g/mol)\times 3$
$+ (O = 16\,g/mol)\times 12$

4. You have a concentrated stock solution of HCl. The concentration is 8.2 M and there is 1.5 L of stock solution. 752 mL of stock solution are taken and diluted to 1.2 L in a volumetric flask. 65 mL of this new solution are taken and diluted to 125 mL in another volumetric flask. What is the final concentration?

a) 2.7 M
b) 6.2 M
c) 8.2 M
d) 3.4 M
e) 4.5 M



$(752\,mL)\left(\frac{1\,L}{1000\,mL}\right)\left(\frac{8.2\,mol}{1\,L}\right) = 6.1664\,mol\,HCl$

$\frac{(6.1664\,mol\,HCl)}{1.2\,L} = 5.13866\,M\,HCl\,B$

$(65\,mL)\left(\frac{1\,L}{1000\,mL}\right)\left(\frac{5.13866\,mol\,HCl\,B}{1\,L}\right) = 0.334\,0125\,mol\,HCl$

$\frac{0.334\,0129\,mol\,HCl}{(125\,mL)\left(\frac{1\,L}{1000\,mL}\right)} = 2.7\,M\,HCl\,C$

5. Given a volume of 60 mL and a concentration of 0.925 M of hydrobromic acid, how many mols of HBr are there and what is the mass of HBr?

a) 0.91 mol, 7.1 g
b) 0.056 mol, 4.5 g
c) 0.014 mol, 9.1 g
d) 6.2 mol, 32.1 g
e) 8.4 mol, 65.4 g

$(60\,mL)\left(\frac{1\,L}{1000\,mL}\right)\left(\frac{0.925\,mol\,HBr}{1\,L}\right) = 0.056\,mol\,HBr$

$(60\,mL)\left(\frac{1\,L}{1000\,mL}\right)\left(\frac{0.925\,mol\,HBr}{1\,L}\right)\left(\frac{80.9119\,g\,HBr}{1\,mol\,HBr}\right) = 4.5\,g\,HBr$

6. Write the balanced molecular and net ionic equations for the combination of silver nitrate and sodium chromate.

$AgNO_3 + Na_2CrO_4 \rightarrow Ag^+ CrO_4^{2-} + Na^+ NO_3^-$

$2AgNO_3 + Na_2CrO_4 \rightarrow Ag_2CrO_4 + 2NaNO_3$

$Ag^+ \quad NO_3^- \rightarrow AgNO_3$

$Na^+ \quad CrO_4^{2-} \rightarrow Na_2CrO_4$

Molecular Equation:

$2AgNO_3\,(aq) + Na_2CrO_4\,(aq) \rightarrow Ag_2CrO_4\,(s) + 2\,NaNO_3\,(aq)$

Net Ionic Equation: no spectator ions

$2Ag^+ + 2NO_3^- + 2Na^+ + CrO_4^{2-} \rightarrow Ag_2CrO_4(s) + 2Na^+ + 2NO_3^-$

$2\,Ag^+(aq) + CrO_4^-(aq) \rightarrow Ag_2CrO_4\,(s)$

7. Given 2.68 mol of strontium phosphate, what are the mols of phosphate ion in 689 mL?

a) 9.81 mol
b) 4.38 mol
c) 7.78 mol
d) 2.43 mol
e) 6.75 mol

$Sr^{2+} \quad PO_4^{3-} \rightarrow Sr_3(PO_4)_2$

$\frac{2.68\,mol\,Sr_3(PO_4)_2}{(689\,mL)\left(\frac{1\,L}{1000\,mL}\right)} = 3.89\,M\,Sr_3(PO_4)_2$

$\left(\frac{3.89\,mol\,Sr_3(PO_4)_2}{1\,L}\right)\left(\frac{2\,mol\,PO_4^{3-}}{1\,mol\,Sr_3(PO_4)_2}\right)\left(\frac{1\,L}{1000\,mL}\right)(689\,mL) = 7.78\,mol\,PO_4^{3-}$

8. Gypsum is a common hydrate salt. It has the general formula $CaSO_4 \cdot xH_2O$. If the molar mass of gypsum is 172.17 g/mol, what is x?

a) 1
b) 2
c) 3
d) 4
e) 5

$Ca = 40.078\,g/mol \times 1$

$S = 32.06\,g/mol \times 1$

$+ \; O = 16\,g/mol \times 4$

$CaSO_4 = 136.14\,g/mol$

$H_2O \Rightarrow H = 1.008\,g/mol \times 2$, $O = 16\,g/mol$

$18.0165\,g/mol$

$172.17\,g/mol - 136.14\,g/mol = 36.03\,g/mol$

$CaSO_4 \cdot xH_2O \quad CaSO_4$

$\frac{36.03\,g/mol}{18.016\,g/mol}\left(\frac{x\,mol\,H_2O}{1\,mol\,H_2O}\right) = 2$

$x = 2$

9. What is the mass of CO_2 if 8.2g of nonene (C_9H_{18}) and 20g of O_2 are combusted? And which is the limiting reactant?

a) Nonene, 23g
b) O_2, 16g
c) Nonene, 25g
d) O_2, 18g
e) O_2, 27g

$2\left(C_9H_{18} + \frac{27}{2}O_2 \rightarrow 9CO_2 + 9H_2O\right) \rightarrow 2C_9H_{18} + 27O_2 \rightarrow 18CO_2 + 18H_2O$

$C_9H_{18} \quad \frac{27}{2}O_2 \quad 9(C+9) \quad 9(H\times18) \quad 9(O\times9)$

$C = 12.011\,g/mol$

$H = 1.008\,g/mol$

$O = 16\,g/mol$

$C_9H_{18} = 9(12.011) + 18(1.008) = 128.25\,g/mol$

$O_2 = 16 \times 2 = 32\,g/mol$

$CO_2 = (12.011) + 2(16) = 44.011\,g/mol$

$(8.2\,g\,C_9H_{18})\left(\frac{1\,mol\,C_9H_{18}}{128.2\,g\,C_9H_{18}}\right)\left(\frac{18\,mol\,CO_2}{2\,mol\,C_9H_{18}}\right)\left(\frac{44.011\,g\,CO_2}{1\,mol\,CO_2}\right) = 25\,g\,CO_2$

$(20\,g\,O_2)\left(\frac{1\,mol\,O_2}{32\,g\,O_2}\right)\left(\frac{18\,mol\,CO_2}{27\,mol\,O_2}\right)\left(\frac{44.011\,g\,CO_2}{1\,mol\,CO_2}\right) = 18\,g\,CO_2$

10. Write the balanced molecular and net ionic equations of NaI and Pb(NO3)2.

Molecular Equation:

$2NaI\ (aq) + Pb(NO_3)_2\ (aq) \rightarrow 2NaNO_3\ (aq) + PbI_2\ (s)$

Net Ionic Equation:

$Pb^{2+}\ (aq) + 2I^-\ (aq) \rightarrow PbI_2\ (s)$

11. What is the mass of $V(OH)_5$ formed 624 mL of 0.389 M VCl_5 reacts with 893 mL of 0.651 M of $Ca(OH)_2$?

a. 30.6g
b. 98.2g
c. 33.0g
d. 74.6g
e. 31.6g

$2\,VCl_5 + 5\,Ca(OH)_2 \rightarrow 2\,V(OH)_5 + 5\,CaCl_2$

$(624\,mL)\left(\frac{1\,L}{1000\,mL}\right)\left(\frac{0.389\,mol\,VCl_5}{1\,L}\right)\left(\frac{2\,mol\,V(OH)_5}{2\,mol\,VCl_5}\right)\left(\frac{135.978\,g\,V(OH)_5}{1\,mol\,V(OH)_5}\right) = 33.01\,g\ V(OH)_5$

$(893\,mL)\left(\frac{1\,L}{1000\,mL}\right)\left(\frac{0.651\,mol\,Ca(OH)_2}{1\,L}\right)\left(\frac{2\,mol\,V(OH)_5}{5\,mol\,Ca(OH)_2}\right)\left(\frac{135.978\,g\,V(OH)_5}{1\,mol\,V(OH)_5}\right) = 31.62\,g\ V(OH)_5$

12. Using the question 11's chemical reaction, how many mL are left over of the excess reactant?

a. 30mL
b. 90mL
c. 512mL
d. 26mL
e. 410mL

$(893\,mL)\left(\frac{1\,L}{1000\,mL}\right)\left(\frac{0.651\,mol\,Ca(OH)_2}{1\,L}\right)\left(\frac{2\,mol\,VCl_5}{5\,mol\,Ca(OH)_2}\right)\left(\frac{1\,L}{0.389\,mol}\right)\left(\frac{1000\,mL}{1\,L}\right) = 597.78\,mL$

624 mL (initial) − 597.78 mL (used) = 26.22 mL → 26 mL leftover

13. Balance and identify the type of reaction, oxidizing agent, and reducing agent of each equation:

$N_2O_5 \rightarrow NO_2 + O_2$

$2N_2O_5 \rightarrow 4NO_2 + O_2$

Decomposition reaction; Oxidizing Agent is N_2O_5, Reducing Agent is N_2O_5

$S_8 + F_2 \rightarrow SF_4$

$S_8 + 16F_2 \rightarrow 8SF_4$

Combination reaction; Oxidizing Agent is F_2, Reducing Agent is S_8

$CsI + Cl_2 \rightarrow CsCl + I_2$

$2CsI + Cl_2 \rightarrow 2CsCl + I_2$

Displacement reaction; Oxidizing Agent is Cl_2, Reducing Agent is CsI

14. Given the reaction $Fe_3O_4 + H_2 \rightarrow Fe + H_2O$, if 0.250g H_2 makes 1.49 g of H_2O, what is the percent yield?

a. 52.3%
b. 66.7%
c. 95.2%
d. 12.4%
e. 75.3%

$\%\text{yield} = \frac{\text{actual}}{\text{theoretical}} \times 100\%$ $Fe_3O_4 + H_2 \rightarrow Fe + H_2O$ $Fe_3O_4 + 4H_2 \rightarrow 3Fe + 4H_2O$

$\frac{1.49}{2.23} \times 100\% = 66.7\%$ Fe 3, O 4 | H_2 4 | 3 Fe+3 | H_2O 1, 1

$(0.250\ g\ H_2)\left(\frac{1\ mol\ H_2}{2.016\ g\ H_2}\right)\left(\frac{4\ mol\ H_2O}{4\ mol\ H_2}\right)\left(\frac{18.016\ g\ H_2O}{1\ mol\ H_2O}\right) = 2.23\ g\ H_2O$

15. Given $7.13*10^{19}$ Ca atoms, what is the mass of calcium in grams? Ca = 40.078 g/mol

a. $5.23*10^{-3}$
b. $6.35*10^{-3}$
c. $4.74*10^{-3}$
d. $9.24*10^{-3}$
e. $4.93*10^{-3}$

$(7.13\times10^{19}\ Ca\ \text{atoms})\left(\frac{1\ mol}{6.022\times10^{23}\ \text{atoms}}\right)\left(\frac{40.078\ g\ Ca}{1\ mol\ Ca}\right) = 0.00474\ g\ Ca$

$4.74\times10^{-3}\ g\ Ca$

16. Given 1 mol, what is the mass percent of each element in $C_6H_{12}O_6$? → MM = 180.16 g/mol

mass % = $\frac{g\ \text{element}}{g\ \text{molecule}}$

I.	60% C	III.	6.7% H	V.	31.6 % O
II.	40% C	IV.	8.4% H	VI.	53.3% O

a. I, IV, VI
b. II, IV, VI
c. I, IV, V
d. II, III, VI
e. II, IV, V

$\frac{(1\ mol\ C_6H_{12}O_6)\left(\frac{6\ mol\ C}{1\ mol\ C_6H_{12}O_6}\right)\left(\frac{12.01\ g\ C}{1\ mol\ C}\right)}{180.16\ g\ C_6H_{12}O_6} \times 100\% = 40\%\ \text{mass C}$

$\frac{(1\ mol\ C_6H_{12}O_6)\left(\frac{12\ mol\ H}{1\ mol\ C_6H_{12}O_6}\right)\left(\frac{1.008\ g\ H}{1\ mol\ H}\right)}{180.16\ g\ C_6H_{12}O_6} \times 100\% = 6.7\%\ \text{mass H}$

$\frac{(1\ mol\ C_6H_{12}O_6)\left(\frac{6\ mol\ O}{1\ mol\ C_6H_{12}O_6}\right)\left(\frac{16.0\ g\ O}{1\ mol\ O}\right)}{180.16\ g\ C_6H_{12}O_6} \times 100\% = 53.3\%\ \text{mass O}$

17. What volume of 0.6143 M of strontium hydroxide would neutralize 72.59 mL of a 0.8291 M solution of hydrochloric acid? Sr^{2+} OH^- H^+Cl^- → $[H^+] = [OH^-]$

a. 62.43mL
b. 48.99mL
c. 75.12mL
d. 36.25mL
e. 95.13mL

$Sr(OH)_2 + 2HCl \rightarrow SrCl_2 + 2H_2O$ (Sr 1, OH 2 | 2 | H+2, Cl×2 | Sr 1, Cl 2 | 2 | H+2, OH×2)

$(72.59\ mL)\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.8291\ mol\ HCl}{1\ L}\right)\left(\frac{1\ mol\ H^+}{1\ mol\ HCl}\right)\left(\frac{1\ mol\ OH^-}{1\ mol\ H^+}\right)\left(\frac{1\ mol\ Sr(OH)_2}{2\ mol\ OH^-}\right)\left(\frac{1\ L}{0.6143\ mol\ Sr(OH)_2}\right)\left(\frac{1000\ mL}{1\ L}\right) = 48.99\ mL$

neutralization step

18. An unknown metal M reacts with sulfur to make M_2S_3. If 1.62g of M reacts with 2.88g of sulfur, what is M and the name of M_2S_3?

a. V; vanadium (iii) sulfide
b. Fe; iron (iii) sulfide
c. Au; gold (iii) sulfide
d. Al; aluminum sulfide
e. Cr; chromium (iii) sulfide

S^{2-} ∴ M_2S_3 M = +3

3 | 2 (2 → 3) | +6 | −6

$(2.88\ g\ S)\left(\frac{1\ mol\ S}{32.06\ g\ S}\right) = 0.0898\ mol\ S$

$(0.0898\ mol\ S)\left(\frac{2\ mol\ M}{3\ mol\ S}\right) = 0.0599\ mol\ M$

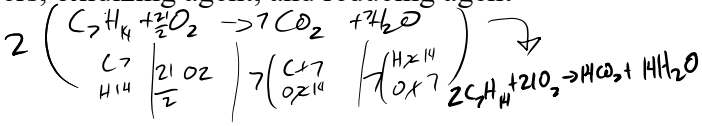
$\frac{1.62\ g\ M}{0.0599\ mol\ M} = 26.98\ g/mol$ → Al

∴ M = Al

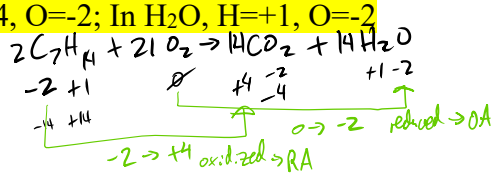
Al_2S_3 is Aluminum sulfide

19. Balance the equation and identify the oxidation numbers, oxidizing agent, and reducing agent for the combustion of C_7H_{14}.

$2\ C_7H_{14} + 21\ O_2 \rightarrow 14\ CO_2 + 14\ H_2O$



In C_7H_{14}, C=-2 H=+1; In O_2, O=0; In CO_2, C=+4, O=-2; In H_2O, H=+1, O=-2



Oxidizing Agent: O_2

Reducing Agent: C_7H_{14}

20. What is the empirical formula of a compound that is 40% C, 6.71% H, and 53.3% O? What is the molecular formula given that the molar mass is 240.24 g/mol?

a. CH_2O; $C_9H_{18}O_9$
b. C_2HO; $C_{16}H_8O_8$
c. CH_2O; $C_8H_{16}O_8$
d. CHO_2; $C_9H_9O_{18}$
e. CH_2O; $C_6H_{12}O_6$