AP Chemistry Summer Review Key

1. Scientific Notation

(1) 350,000,000 cal ⇒ 3.5×10^{8} cal
(2) 0.0000721 mol ⇒ 7.21×10^{-5} mol
(3) 0.0000000809 Å ⇒ 8.09×10^{-8} Å
(4) 765,400,000,000 atoms ⇒ 7.654×10^{11} atoms

2. Significant Figures

(1) Multiplying / Dividing: the result has the same number of <u>significant figures</u> as the least precise measurement.
Adding / Subtracting: the result has the same number of <u>decimal places</u> as the least precise measurement.

(2) # Significant Figures

(a) 1.92 mm ⇒ 3
(b) 0.030200 kJ ⇒ 5
(c) 6.022×10^{23} atoms ⇒ 4
(d) 460.00 L ⇒ 5
(e) 0.00036 cm^3 ⇒ 2
(f) 100 ⇒ 1
(g) 1001 ⇒ 4
(h) 0.001 ⇒ 1
(i) 0.0101 ⇒ 3

(3) Calculations & Significant Figures

(a) 1.27 g / 5.296 cm^3 = 0.239803625 g/cm^3 ⇒ <u>0.240 g/cm^3</u>

(b) 12.235 g / 1.01 L = 12.11386139 g/L ⇒ <u>12.1 g/L</u>

(c) 12.2 g + 0.38 g = 12.58 g ⇒ <u>12.6 g</u>

(d) 17.3 g + 2.785 g = 20.085 g ⇒ <u>20.1 g</u>

(e) 2.1 × 3.21 = 6.741 ⇒ <u>6.7</u>

(f) 200.1 × 120 = 2412 ⇒ <u>2400</u>

(g) 17.6 ÷ 2.838 + 2.3 + 110.77 = 119.2715504 ⇒ <u>119.3</u>

3. Metric System & Dimensional Analysis

(1) Classify

1. mg ⇒ mass
2. mL ⇒ volume
3. cm^3 ⇒ volume
4. mm ⇒ length
5. μL ⇒ volume
6. g/mL ⇒ density
7. kJ ⇒ energy

(2) Dimensional Analysis

1. $\frac{515\,mm}{} \cdot \frac{1\,km}{1000\,mm} = .515\,km$

2. $\frac{200\,mm}{} \cdot \frac{1\,m}{1000\,mm} = .2\,m$

3. $\frac{325\,days}{} \cdot \frac{24\,hr}{1\,day} \cdot \frac{60\,min}{1\,hr} \cdot \frac{60\,s}{1\,min} = 28100000\,s$ or $2.81 \times 10^7\,s$

4. $\frac{20\,L}{} \cdot \frac{1000\,mL}{1\,L} = 20000\,mL$ or $2 \times 10^4\,mL$

4. Element Symbols, Names, Atomic Structure, Isotopes, & Mass

(1) Element symbols

(a) carbon ⇒ C
(b) sulfur ⇒ S
(c) titanium ⇒ Ti
(d) nitrogen ⇒ N
(e) helium ⇒ He
(f) krypton ⇒ Kr
(g) fluorine ⇒ F
(h) scandium ⇒ Sc
(i) arsenic ⇒ As

(2) Element Names

(a) Na ⇒ sodium
(b) Au ⇒ gold
(c) Ag ⇒ silver
(d) Sn ⇒ tin
(e) Fe ⇒ iron
(f) Hg ⇒ mercury
(g) K ⇒ potassium

(3) Definitions

(a) atomic number ⇒ # protons in an atom's nucleus (also # e^-)

(b) atomic mass ⇒ weighted average mass of all the isotopes of an element

(c) mass number ⇒ total # protons and # neutrons in the nucleus of an element.

(d) isotopes ⇒ atoms of an element that have differing # of neutrons

(e) metalloid ⇒ one of 7 elements that have properties of both metals and nonmetals

(4) Isotopes

(a) $^{39}_{19}K$ ⇒ $19p^+$ and $20n^0$

(b) $^{23}_{11}Na$ ⇒ $11p^+$ and $12n^0$

(c) $^{208}_{82}Pb$ ⇒ $82p^+$ and $126n^0$

(d) $^{33}_{15}P$ ⇒ $15p^+$ and $18n^0$

(5) Atomic mass.

$$AM = (83.9134\,amu \cdot .005) + (83.9094\,amu \cdot .099) + (86.9089\,amu \cdot .07) + (87.9056\,amu \cdot .826) \Rightarrow 87.420\,amu$$

5. Matter and Physical/Chemical Changes

(1) Physical or Chemical?

(a) corrosion of aluminum ⇒ CP
(b) melting ice ⇒ PP
(c) pulverizing an aspirin ⇒ PP
(d) digesting a candy bar ⇒ CP
(e) explosion of nitroglycerin ⇒ CP
(f) milk turning sour ⇒ CP
(g) burning paper ⇒ CP
(h) forming frost ⇒ PP
(i) bleaching hair ⇒ CP
(j) copper hammered flat ⇒ PP

(2) Particles and charge

(a)

Cl atom	Cl ion
$17p^+$	$17p^+$
$17e^-$	$18e^-$
$18n^0$	$18n^0$
0 charge	-1 charge

(b)

Na atom	Na ion
$11p^+$	$11p^+$
$11e^-$	$10e^-$
$12n^0$	$12n^0$
0 charge	+1 charge

(3) Distinguish

(a) element ⇒ contains only 1 type of atom
compound ⇒ contains 2 or more elements, chemically breaks down into elements

(b) element ⇒ contains only 1 type of atom
mixture ⇒ physical blend of 2 or more elements/compounds, can be separated by physical processes

(c) homogeneous mixture - looks uniform
heterogeneous mixture - can see individual components

6. Electron Configurations & Periodic Trends

(1) Orbital Diagrams

(a) Li ⇒ $3e^-$ $1s^2 2s^1$ ↿⇂ (1s) ↿ (2s)

(b) Ga ⇒ $31e^-$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$

↿⇂ (1s) ↿⇂ (2s) ↿⇂ ↿ (2p) ↿⇂ (3s) ↿⇂ ↿ (3p) ↿⇂ (4s) ↿⇂ ↿ ↿ ↿ ↿ ↿ (3d) ↿ (4p)

(c) Fe ⇒ $26e^-$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

↿⇂ (1s) ↿⇂ (2s) ↿⇂ ↿ ↿ (2p) ↿⇂ (3s) ↿⇂ ↿ (3p) ↿⇂ (4s) ↿ ↿ ↿ ↿ ↿ (3d)

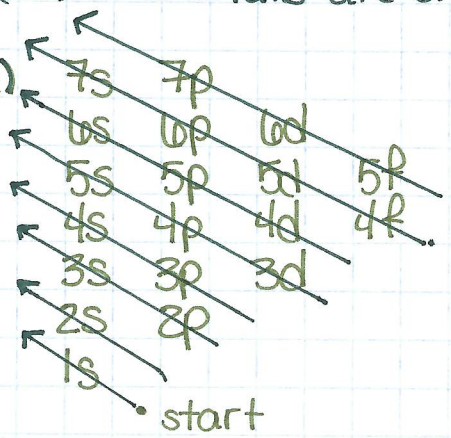
(d) N ⇒ $7e^-$ $1s^2 2s^2 2p^3$ ↿⇂ (1s) ↿⇂ (2s) ↿ ↿ ↿ (2p)

(2) Orbital Shapes

(a)(i) s = 1 orbital/energy level
(ii) p = 3 orbitals/energy level
(iii) d = 5 orbitals/energy level
(iv) f = 10 orbitals/energy level

(b)(i) s orbitals are on levels 1 → 7
(ii) p orbitals are on levels 2 → 7
(iii) d orbitals are on levels 3 → 6
(iv) f orbitals are on levels 4 → 5

(c)



(3)(a) Aufbau principle ⇒ electrons are added one at a time to each orbital
(b) Pauli Exclusion principle ⇒ no 2 electrons can have the same set of quantum numbers
(c) Hund's Rule ⇒ the lowest energy configuration for an atom is one having the maximum number of unpaired electrons, with unpaired electrons having parallel spins

(4) Arrow diagrams show you the electrons and their spins each each orbital

(5) See # 4

7. Nomenclature

(1) Classify

(a) F_2 diatomic molecule
(b) Cl_2 diatomic molecule
(c) C element
(d) NaCl ionic compound
(e) KF ionic compound
(f) CO_2 molecular compound
(g) H_2 diatomic molecule
no (h)!
(i) Fe_2O_3 ionic compound
(j) MgO ionic compound
(k) O_2 diatomic molecule
(l) I_2 diatomic molecule
(m) CO molecular compound
(n) K_2CO_3 ionic compound
(o) Ag element

(2) Write formulas

(a) calcium sulfate $CaSO_4$
(b) ammonium phosphate $(NH_4)_3PO_4$
(c) lithium nitrite $LiNO_2$
(d) iron (II) perchlorate $Fe(ClO_4)_2$
(e) barium oxide BaO
(f) cobalt (III) sulfide Co_2S_3
(g) sodium bromate $NaBrO_3$
(h) calcium iodide CaI_2
(i) manganese (II) carbonate $MgCO_3$

(3) Write formulas

(a) calcium carbonate $CaCO_3$
(b) copper (II) phosphite $Cu_3(PO_3)_2$
(c) sodium chloride $NaCl$
(d) rubidium oxide Rb_2O
(e) calcium sulfate $CaSO_4$
(f) sodium nitrate $NaNO_3$
(g) magnesium acetate $Mg(C_2H_3O_2)_2$
(h) potassium cyanide KCN
(i) zinc (II) nitrate $Zn(NO_3)_2$
(j) iron (III) oxalate $Fe_2(C_2O_4)_3$
(k) nickel (II) fluoride NiF_2

(4) Name

(a) SF_6 sulfur hexafluoride
(b) P_4S_{10} tetraphosphorous decasulfide
(c) NI_3 nitrogen triiodide
(d) PCl_5 phosphorous pentachloride
(e) CCl_4 carbon tetrachloride

(5) Write formulas

(a) hydrochloric acid HCl
(b) perchloric acid $HClO_4$
(c) carbonic acid H_2CO_3
(d) nitrous acid HNO_2
(e) nitric acid HNO_3
(f) chlorous acid $HClO_2$
(g) perchloric acid $HClO_4$
(g) phosphoric acid H_3PO_4
(h) acetic acid $HC_2H_3O_2$
(i) sulfurous acid H_2SO_3
(j) sulfuric acid H_2SO_4
(k) hypochlorous acid $HClO$
(l) chloric acid $HClO_3$

8. Moles, mass, Particle Calculations

(1) molar mass

(a) NH_3

N 1×14.01 g/mol = 14.01 g/mol
H 3×1.01 g/mol = + 3.03 g/mol
17.04 g/mol

(b) $NaHCO_3$

Na 1×22.99 g/mol = 22.99 g/mol
H 1×1.01 g/mol = 1.01 g/mol
C 1×12.01 g/mol = 12.01 g/mol
O 3×16.00 g/mol = + 48.00 g/mol
84.01 g/mol

(c) Os Os = 190.23 g/mol

(2) $\frac{4.56 \text{ mol } N_2 \mid 6.02 \times 10^{23} \text{ molecules}}{\mid 1 \text{ mol}} = 2.75 \times 10^{24}$ molecules N_2

(3) $\frac{5.6 \text{ mol } CH_4 \mid 16.05 \text{ g}}{\mid 1 \text{ mol}} = 90. \text{ g } CH_4$

mm

C 1×12.01 g/mol = 12.01 g/mol
H 4×1.01 g/mol = + 4.04 g/mol
16.05 g/mol

(4) mass of hydrated copper compound = 23.4 g
− 18.82 g
4.6 g

mass of dehydrated copper compound = 20.94 g
− 18.82 g
2.12 g

mass of water = mass of hydrated copper compound − mass of dehydrated copper compound
= 4.6 g − 2.12 g = 2.5 g

% water = $\frac{\text{mass of water}}{\text{mass of hydrated copper compound}} \times 100 = \frac{2.5 \text{ g}}{4.6 \text{ g}} \times 100$
= 54%

(5)(a) $\frac{3.86\,g\ CO_2 \mid 1\ mol}{\mid 44.01\,g} = .0877\ mol\ CO_2$

mm

C $1 \times 12.01\ g/mol = 12.01\ g/mol$
O $2 \times 16.00\ g/mol = +\ 32.00\ g/mol$
$44.01\ g/mol$

(b) $\frac{6.0 \times 10^5\,g\ N_2H_2 \mid 1\ mol}{\mid 30.04\,g} = 2.0 \times 10^4\ mol\ N_2H_2$

mm

N $2 \times 14.01\ g/mol = 28.02\ g/mol$
H $2 \times 1.01\ g/mol = +\ 2.02\ g/mol$
$30.04\ g/mol$

(6) % composition

$$\%\,element = \frac{mass\ element}{molar\ mass} \times 100$$

(a) SO_3

mm

S $1 \times 32.07\ g/mol = 32.07\ g/mol$
O $3 \times 16.00\ g/mol = +\ 48.00\ g/mol$
$80.07\ g/mol$

$\%\,S = \frac{32.07\ g/mol}{80.07\ g/mol} \times 100 = 40.05\%\,S$

$\%\,O = 100\% - 40.05\%\,S = 59.95\%\,O$

(b) CH_3COOCH_3

mm

C $2 \times 12.01\ g/mol = 24.02\ g/mol$
H $6 \times 1.01\ g/mol = 6.06\ g/mol$
O $2 \times 16.00\ g/mol = +\ 32.00\ g/mol$
$62.08\ g/mol$

$\%\,C = \frac{24.02\ g/mol}{62.08\ g/mol} \times 100 = 38.69\%\,C$

$\%\,H = \frac{6.06\ g/mol}{62.08\ g/mol} \times 100 = 9.76\%\,H$

$\%\,O = \frac{32.00\ g/mol}{62.08\ g/mol} \times 100 = 51.55\%\,O$

(c) $Al(NO_3)_3$

mm

Al $1 \times 26.98\ g/mol = 26.98\ g/mol$
N $3 \times 14.01\ g/mol = 42.03\ g/mol$
O $9 \times 16.00\ g/mol = +\ 144.00\ g/mol$
$213.01\ g/mol$

$\%\,Al = \frac{26.98\ g/mol}{213.01\ g/mol} \times 100 = 12.67\%\,Al$

$\%\,N = \frac{42.03\ g/mol}{213.01\ g/mol} \times 100 = 19.73\%\,N$

$\%\,O = 100\% - 12.67\%\,Al - 19.73\%\,N$
$= 67.60\%\,O$

(7) Empirical Formula

(a) 10.4% C — 27.8% S — 61.7% Cl

$\frac{10.4\text{ g C}}{12.01\text{ g/mol}}$ — $\frac{27.8\text{ g S}}{32.07\text{ g/mol}}$ — $\frac{61.7\text{ g Cl}}{35.45\text{ g/mol}}$

$= \frac{.8659\text{ mol C}}{.8659\text{ mol}}$ — $= \frac{.8669\text{ mol S}}{.8659\text{ mol}}$ — $= \frac{1.7405\text{ mol Cl}}{.8659\text{ mol}}$

= 1 C — = 1 S — = 2 Cl

EF = $CSCl_2$

(b) 21.7% C — 9.6% O — 68.7% F

$\frac{21.7\text{ g C}}{12.01\text{ g/mol}}$ — $\frac{9.6\text{ g O}}{16.00\text{ g/mol}}$ — $\frac{68.7\text{ g F}}{19.00\text{ g/mol}}$

$= \frac{1.8068\text{ mol C}}{.6000\text{ mol}}$ — $= \frac{.6000\text{ mol O}}{.6000\text{ mol}}$ — $= \frac{3.6158\text{ mol F}}{.6000\text{ mol}}$

= 3 C — = 1 O — = 6 F

EF = C_3OF_6

(8) $\frac{1.587\text{ g As}}{74.92\text{ g/mol}}$ — $\frac{3.755\text{ g Cl}}{35.45\text{ g/mol}}$

$= \frac{.02118\text{ mol As}}{.02118\text{ mol}}$ — $= \frac{.1059\text{ mol Cl}}{.02118\text{ mol}}$

= 1 As — = 5 Cl

EF = $AsCl_5$

(9)(a) H_2O_2 ⇒ HO

(b) C_6H_{12} ⇒ CH_2

(c) CH_4 ⇒ CH_4

(d) H_2SO_4 ⇒ H_2SO_4

(e) $C_4H_6O_2$ ⇒ C_2H_3O

(10)(a) EF = CH_2

mm

C ≃ 12 g/mol
H ≃ + 2 g/mol
~14 g/mol

$\frac{84\ g/mol}{\sim 14\ g/mol} = 6$

MF = C_6H_{12}

(b) EF = NH_2Cl

mm

N ≃ 14 g/mol
H ≃ 1 g/mol
Cl ≃ + 35 g/mol
~50 g/mol

$\frac{51.5\ g/mol}{\sim 50\ g/mol} \simeq 1$

MF = NH_2Cl

(11) 75.6% C | 8.80% H | 15.5% O

$\frac{75.6\ g\ C}{12.01\ g/mol}$ | $\frac{8.80\ g\ H}{1.01\ g/mol}$ | $\frac{15.5\ g\ O}{16.00\ g/mol}$

$= \frac{6.2948\ mol\ C}{.9688\ mol}$ | $= \frac{8.7129\ mol\ H}{.9688\ mol}$ | $= \frac{.9688\ mol\ O}{.9688\ mol}$

$= (6.5\ C)2$ | $= (9\ H)2$ | $= (1\ O)2$

EF = $C_{13}H_{18}O_2$

mm

C ≃ 156 g/mol
H ≃ 18 g/mol
O ≃ + 32 g/mol
~176 g/mol

$\frac{206\ g/mol}{\sim 176\ g/mol} \simeq 1$

MF = $C_{13}H_{18}O_2$

(12)(a) Never true, C_6H_6 has an empirical formula of CH
(b) Always true, there is more Cu is Cu_2O than in CuO
(c) sometimes true,
(d) Never true, moucular formulas are true formulas, empirical formulas are simplified.

9. Chemical Reactions

(1) Balance & Type of Reaction

(a) $BF_3(g) + 3H_2O(l) \rightarrow 3HF(l) + H_3BO_3(s)$ precipitation

(b) $6MgO(s) + Fe(s) \rightarrow 2Fe_2O_3(s) + 6Mg(s)$ single-replacement

(c) $2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$ decomposition

(d) $CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + C_2H_2(g)$ double-replacement

(e) $CaCN_2(s) + 3H_2O(l) \rightarrow CaCO_3(aq) + 2NH_3(g)$ double-replacement

(f) $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$ combustion

(g) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ synthesis

(h) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ synthesis

(i) $H_2(g) + I_2(g) \rightarrow 2HI(g)$ synthesis

(j) $2Na(s) + I_2(g) \rightarrow 2NaI(s)$ synthesis

(k) $2Na_2O(s) + 2H_2O(l) \rightarrow 4NaOH(aq) + 2H_2(g)$ double-replacement

(l) $CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$ synthesis

(m) $3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$ synthesis

(n) $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$ double-replacement
acid-base

(2)

<u>limiting reactant</u> - reactant that is used up 1st in a reaction, controls how much product can be made

<u>theoretical yield</u> - amount of product that may be made based on the limiting reactant (mathematical)

<u>actual yield</u> - amount of product actually is made in real-life, never as much as the theoretical yield.

(3) $4NH_3(g) + 6NO(g) \rightarrow 5N_2(g) + 6H_2O(l)$

(a) $\frac{12.3\ mol\ NO}{} \left| \frac{4\ mol\ NH_3}{6\ mol\ NO} \right. = 8.20\ mol\ NH_3$

(b) $\frac{5.87\ mol\ NO}{} \left| \frac{5\ mol\ N_2}{6\ mol\ NO} \right. = 4.89\ mol\ N_2$

(4) $Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$

$\frac{4.00\ g\ AgNO_3}{} \left| \frac{1\ mol\ AgNO_3}{169.88\ g\ AgNO_3} \right| \frac{1\ mol\ Cu}{2\ mol\ AgNO_3} \left| \frac{63.55\ g\ Cu}{1\ mol\ Cu} \right. = .748\ g\ Cu$

MM

Ag $1 \times 107.87\ g/mol = 107.87\ g/mol$
N $1 \times 14.01\ g/mol = 14.01\ g/mol$
O $3 \times 16.00\ g/mol = +\ 48.00\ g/mol$
$169.88\ g/mol$

(5) $2NaOH(s) + CO_2(g) \rightarrow Na_2CO_3(s) + H_2O(l)$

NaOH is the limiting reactant

$\frac{1.85\ mol\ NaOH}{} \left| \frac{1\ mol\ Na_2CO_3}{2\ mol\ NaOH} \right. = .925\ mol\ Na_2CO_3$

moles of sodium carbonate produced (theoretical yield)

$\frac{1.00\ mol\ CO_2}{} \left| \frac{1\ mol\ Na_2CO_3}{1\ mol\ CO_2} \right. = 1.00\ mol\ Na_2CO_3$

moles of CO_2 excess reactant used:

$\frac{1.85\ mol\ NaOH}{} \left| \frac{1\ mol\ CO_2}{2\ mol\ NaOH} \right. = .925\ mol\ CO_2$ used

amount of excess reactant left over
= original amount of CO_2 − amount of CO_2 used
= 1.00 mol − .925 mol = .075 mol CO_2

(6) $C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr$

Theoretical Yield

(a) $\frac{30.0\,g\,C_6H_6}{} \left| \frac{1\,mol\,C_6H_6}{78.12\,g\,C_6H_6} \right| \frac{1\,mol\,C_6H_5Br}{1\,mol\,C_6H_6} \left| \frac{157.01\,g\,C_6H_5Br}{1\,mol\,C_6H_5Br} \right. = 60.3\,g\,C_6H_5Br$

$\frac{65.0\,g\,Br_2}{} \left| \frac{1\,mol\,Br_2}{159.80\,g\,Br_2} \right| \frac{1\,mol\,C_6H_5Br}{1\,mol\,Br_2} \left| \frac{157.01\,g\,C_6H_5Br}{1\,mol\,C_6H_5Br} \right. = 63.9\,g\,C_6H_5Br$

MM

C $6 \times 12.01\,g/mol = 72.06\,g/mol$
H $6 \times 1.01\,g/mol = +\ 6.06\,g/mol$
$78.12\,g/mol$

mm

C $6 \times 12.01\,g/mol = 72.06\,g/mol$
H $5 \times 1.01\,g/mol = 5.05\,g/mol$
Br $1 \times 79.90\,g/mol = +\ 79.90\,g/mol$
$157.01\,g/mol$

mm

Br $2 \times 79.90\,g/mol = 159.80\,g/mol$

(b) $\%\,yield = \frac{actual\,yield}{theoretical\,yield} \times 100 = \frac{56.7\,g}{60.3\,g} \times 100 = 94.0\%$

(7)(a) $Cl_2(g) + 3\,F_2(g) \rightarrow 2\,ClF_3$

(b) $\frac{1.75\,mol\,Cl_2}{} \left| \frac{2\,mol\,ClF_3}{1\,mol\,Cl_2} \right. = 3.50\,mol\,ClF_3$

$\frac{3.68\,mol\,F_2}{} \left| \frac{2\,mol\,ClF_3}{3\,mol\,F_2} \right. = 2.45\,mol\,ClF_3$

F_2 is the limiting reactant

10. Molarity

(1) solute = substance that gets dissolved in a solution, present in lesser amounts
solvent = substance that does the dissolving, present in larger amounts
molarity = moles of solute / volume of solution in Liters, a measure of concentration

(2) $M = n/V = .0345\,mol / .400\,L = .0863\,mol/L$

(3) $n = \frac{20.0\,g\,NaOH}{} \left| \frac{1\,mol}{40.00\,g} \right. = .500\,mol$

mm

Na $= 22.99\,g/mol$
O $= 16.00\,g/mol$
H $= +\ 1.01\,g/mol$
$40.00\,g/mol$

$M = .500\,mol / .200\,L = 2.50\,mol/L$

(4) $n = m \cdot V = .360\ mol/L \cdot .0400\ L = .0144\ mol\ NaCl$

$$mass = \frac{.0144\ mol}{} \left| \frac{58.44\ g}{1\ mol} \right. = .842\ g\ NaCl$$

mm

Na 22.99 g/mol
Cl + 35.45 g/mol
58.44 g/mol