General Chemistry 1 *(CHEM 1141)*

Shawnee State University – Fall 2019

October 24, 2019

Exam # 2 A

Name KEY

Please write your full name, and the exam version (2 A) that you have on the scantron sheet !
(Bubble in the best answer choice for each question on the green & white scantron sheet in pencil !)

Please ☑ check the box next to your correct section number.

Section Number

- ☐ 1. (Monday Lab, 11:10 AM – 1:55 PM)
- ☐ 2. (Wednesday Lab, 11:10 AM – 1:55 PM)
- ☐ 3. (Monday Lab, 2:30 PM – 5:20 PM)
- ☐ 4. (Wednesday Lab, 2:30 PM – 5:20 PM)
- ☐ 5. (Thursday Lab, 12:30 PM – 3:20 PM)
- ☐ 6. (Tuesday Lab, 12:30 PM – 3:20 PM)

Multiple Choice: _____ **/ 50**

Q21: _____ **/ 10**

Q22: _____ **/ 10**

Q23: _____ **/ 10**

Q24: _____ **/ 10**

Q25: _____ **/ 10**

BONUS: _____ **/ 3**

TOTAL: _____ **/ 100**

You are only allowed to use a TI30–XIIS or equivalent non–programmable calculator on this exam !
(This means no cell phones, no smart phones, no smart watches, no ipads, or any other such devices will be allowed !)

Each problem in this section (multiple choice) is worth 2.5 points !

Q1. What is the coefficient for O_2 when the following combustion reaction of the alcohol is correctly balanced using the lowest set of whole number coefficients?

$$\underline{2}\ CH_4O(l) + \underline{3}\ O_2(g) \rightarrow \underline{2}\ CO_2(g) + \underline{4}\ H_2O(l)$$

A) 3

B) 5

C) 7

D) 9

Q2. What is the molarity of a solution formed by dissolving 97.7 g of LiBr in enough water to yield 750.0 mL of solution ?

A) 0.130 M

B) 0.768 M

C) 1.12 M

D) 1.50 M

$$[LiBr] = \frac{\#\text{mol LiBr}}{\#\text{L}} = \frac{1.125\text{mol}}{0.7500\text{L}} = 1.50\ \frac{\text{mol}}{\text{L}}\ \text{OR}\ \text{M}$$

$$750.0\text{mL} \times \frac{1\text{L}}{1000\text{mL}} = 0.7500\text{L}$$

$$97.7\text{g LiBr} \times \frac{1\text{mol LiBr}}{86.84\text{g LiBr}} = 1.125\text{mol LiBr}$$

Q3. When dissolved in water, NaOH behaves as:

A) an acid that forms Na^+ and OH^- ions

B) an acid that forms NaO^- and H^+ ions

C) a base that forms Na^+ and OH^- ions

D) a base that forms NaO^- and H^+ ions

Q4. Identify the diprotic acid.

A) H_2SO_4 $2H^+$/molecule $H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$

B) HCl

C) NaCl

D) $Mg(OH)_2$

Q5. Which of the following is an acid–base reaction?

A) $C(s) + O_2(g) \longrightarrow CO_2(g)$

B) $MgSO_4(aq) + Pb(NO_3)_2(aq) \rightarrow Mg(NO_3)_2(aq) + PbSO_4(s)$

C) $Fe(s) + 2\,AgNO_3(aq) \rightarrow 2\,Ag(s) + Fe(NO_3)_2(aq)$

D) $2\,HClO_4(aq) + Ca(OH)_2(aq) \rightarrow 2\,H_2O(l) + Ca(ClO_4)_2(aq)$

"H^+" + "OH^-" $\rightarrow$ H_2O

Q6. Aluminum reacts with hydrochloric acid as shown below in the balanced reaction equation.

$$\mathbf{2\,Al(s) + 6\,HCl(aq) \rightarrow 2\,AlCl_3(aq) + 3\,H_2(g)}$$

The correct number of moles of HCl(aq) that would be required to react completely with 2.1moles of Al(s) would be _____ of HCl(aq).

A) 1.6 moles

B) 4.8 moles

$2.1\,\text{mol Al} \times \frac{6\,\text{mol HCl}}{2\,\text{mol Al}} = 6.3\,\text{mol HCl}$

C) 6.3 moles

D) 7.2 moles

Q7. What is the limiting reactant when 0.543 moles of N_2O_4 reacts with 1.05 moles of N_2H_4?

$$N_2O_4(l) + 2\,N_2H_4(l) \rightarrow 3\,N_2(g) + 4\,H_2O(g)$$

A) $N_2O_4(l)$

B) $N_2H_4(l)$

C) $N_2(g)$

D) $H_2O(g)$

if 0.543 mol N_2O_4 reacts, it needs:

$$0.543\,\text{mol}\,N_2O_4 \times \frac{2\,\text{mol}\,N_2H_4}{1\,\text{mol}\,N_2O_4} = 1.086\,\text{mol}\,N_2H_4$$

- since we have fewer mol N_2H_4 than needed, than (1.05)

N_2H_4 must be limiting reactant and N_2O_4 is in excess.

Q8. What is the concentration of a solution that is prepared by adding 15.0 mL of water to 5.0 mL of 12.0 M HCl?

$M_1V_1 = M_2V_2$

A) 3.00 M

B) 4.00 M

C) 12.0 M

D) 15.0 M

$$\rightarrow M_2 = \frac{M_1V_1}{V_2} = \frac{12.0\,M \times 5.0\,mL}{(5.0\,mL + 15.0\,mL)} = 3.00\,M$$

(final vol = 5.0 mL acid + 15.0 mL water = 20.0 mL)

Q9. Which pair of solutions listed below would form a precipitate when mixed at 25 °C?

A) $LiCl(aq) + Mg(NO_3)_2(aq) \longrightarrow MgCl_2(aq) + 2\,LiNO_3(aq)$

B) $NaC_2H_3O_2(aq) + NaOH(aq) \longrightarrow NaOH(aq) + NaC_2H_3O_2(aq)$ [no rxn!]

C) $H_2SO_4(aq) + K_2CO_3(aq) \longrightarrow K_2SO_4(aq) + H_2O(l) + CO_2(g)\uparrow$

D) $Ba(NO_3)_2(aq) + Na_2SO_4(aq) \longrightarrow BaSO_4(s) + 2NaNO_3(aq)$

Q10. What piece of glassware should be used to prepare a solution of precise concentration in the lab?

A) buret

B) graduated cylinder

C) volumetric flask — holds a precise volume of the solution!

D) Erlenmeyer flask

Q11. Which substance contains a sulfur atom with an oxidation state of +2?

must be: +2

(?) (?) (-2) (-2) (-2) 2-

S S O O O

-2 (same as charge)

A) SO_4^{2-}

B) $S_2O_3^{2-}$

C) H_2SO_4

D) Na_2SO_3

Q12. Which of the following ionic compounds will be ***SOLUBLE*** in water?

A) NH_4NO_3

B) AgBr

C) $Fe(OH)_3$

D) $CaCO_3$

Q13. What is the percentage *(by mass)* of ***nitrogen*** in $Ca(NO_3)_2$?

$$\%\,N = \frac{2 \times N}{1 \times Ca + 2 \times N + 6 \times O} \times 100$$

$$= \frac{2 \times 14.01}{1 \times 40.08 + 2 \times 14.01 + 6 \times 16.00} \times 100 = 17.07\%$$

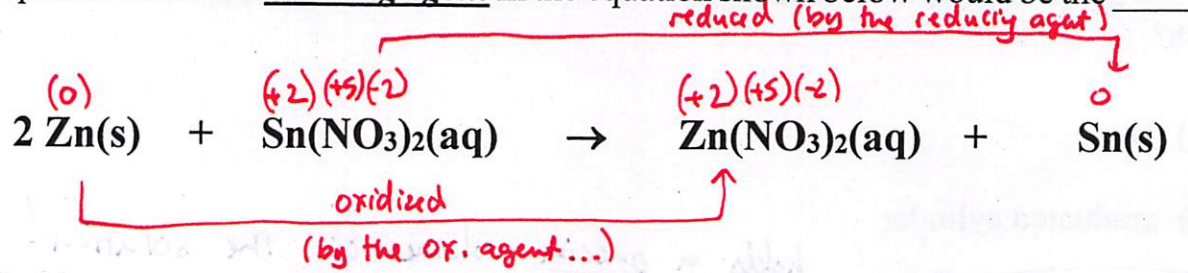
A) 13.72 % N

B) 17.07 % N

C) 24.42 % N

D) 58.50 % N

Q14. The species that is the ***reducing agent*** in the equation shown below would be the _____.



A) Sn(s)

B) $Sn(NO_3)_2(aq)$

C) Zn(s)

D) $Zn(NO_3)_2(aq)$

Q15. What is the conversion factor for a 4.10 M solution of KCl?

A) 4.10 M / 1 L

B) 4.10 moles / 1 L

4.10 mol KCl = 1 L

→ $\frac{4.10\ mol\ KCl}{1\ L}$ or $\frac{1\ L}{4.10\ mol\ KCl}$

C) 4.10 g / mL

D) 1 mole / 4.10 L

Q16. Which of the following contains the ***largest*** number of atoms?

A) 12 g of potassium

B) 12 g of magnesium — smallest molar/atomic mass → more atoms!

C) 12 g of calcium

D) 12 g of iron

Q17. What is the correct formula for copper(I) carbonate dihydrate?

$Cu^{+}\ CO_3^{2-}\ \underset{2}{1}\ \underset{H_2O}{1}$

A) $CoCO_3 \cdot \frac{1}{2} H_2O$

B) $Cu(CO_3)_2 \cdot H_2O$

C) $Co_2CO_3 \cdot 2\ H_2O$

D) $Cu_2CO_3 \cdot 2\ H_2O$

Q18. Which of the following is an example of an extensive property?

(depends on amount/extent)

A) density

B) temperature

C) mass

D) color

Q19. The correct number of protons (p^+), neutrons (n^0), and electrons (e^-) in sodium–24 would be:

mass # → 24 → $24(p^+ + n^0)$

atomic # → 11 → Na → $24 - 11 = \#n^0 = 13n^0$

$11p^+$ → same # e's → $11e^-$ for atom

A) $11\,p^+, 24\,n^0, 11\,e^-$

B) $11\,p^+, 13\,n^0, 11\,e^-$

C) $16\,p^+, 32\,n^0, 16\,e^-$

D) $19\,p^+, 20\,n^0, 39\,e^-$

Q20. Mercury is the only metal that is a liquid at room temperature and the density of mercury is 13.6 g / cm^3. What is the volume of mercury in a flask that contains 848 g of mercury?

$d = m/V \rightarrow V = \frac{m}{d} = \frac{848\,g}{13.6\,g/cm^3} = 62.4\,cm^3$ or mL

A) 16.0 mL

B) 0.624 mL

C) 6.24 mL

D) 62.4 mL

Each problem in this section (short answer) is worth 10 points !

All work must be shown in order to receive full credit !

You must use the factor–label (conversion–factor) method for all conversions !

Be sure to include units where applicable !

All numeric answers must be rounded to the correct number of significant figures !

Q21. The antacid Milk of Magnesia contains magnesium hydroxide. If 25.0 mL of stomach acid *(HCl)* reacts completely with 10.1 mL of 0.139 M $Mg(OH)_2$, then what is the concentration *(molarity)* of the stomach acid ?

$2HCl(aq) + Mg(OH)_2(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$

$[HCl] = \frac{\#mol\ HCl}{\#L\ HCl}$ ← $10.1mL \times \frac{1L}{1000mL} \times \frac{0.139mol\ Mg(OH)_2}{1L} \times \frac{2mol\ HCl}{1mol\ Mg(OH)_2} = 0.002808mol\ HCl$

$25.0mL = 0.0250L$

$\rightarrow [HCl] = \frac{0.002808mol}{0.0250L} = 0.112M$

Q22. Provide a correctly balanced reaction equation that shows the chemical reaction that takes place when an aqueous solution of silver nitrate is mixed with an aqueous solution of sodium sulfate. In addition, provide the correct full ionic as well as the net ionic equation for this reaction. Be sure to show all state symbols and charges where appropriate.

Complete Balanced Reaction Equation *(Molecular Equation)*

$2\ AgNO_3(aq) + Na_2SO_4(aq) \rightarrow Ag_2SO_4(s) + 2NaNO_3(aq)$

Complete Ionic Equation

$2Ag^+(aq) + 2NO_3^-(aq) + 2Na^+(aq) + SO_4^{2-}(aq) \rightarrow Ag_2SO_4(s) + 2Na^+(aq) + 2NO_3^-(aq)$

Net Ionic Equation

$2Ag^+(aq) + SO_4^{2-}(aq) \rightarrow Ag_2SO_4(s)\downarrow$

Q23. The molecular equation for the reaction between solid iron metal and oxygen gas is shown below. Answer each of the questions listed below the reaction equation.

$$4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$$

Provide a correctly balanced equation for this reaction by writing the correct coefficients in front of each reactant and product.

The correct IUPAC *(systematic)* name for the product $Fe_2O_3(s)$ would be iron(III) oxide.

Show how to determine *(by calculation)* the theoretical yield of $Fe_2O_3(s)$ that could be produced if 8.05 g of Fe(s) is reacted with 3.52 g of $O_2(g)$.

$$8.05\,g\,Fe \times \frac{1\,mol\,Fe}{55.85\,g\,Fe} \times \frac{2\,mol\,Fe_2O_3}{4\,mol\,Fe} \times \frac{159.70\,g\,Fe_2O_3}{1\,mol\,Fe_2O_3} = 11.5\,g\,Fe_2O_3$$ (*) smaller → theoretical yield → Fe: LR

$$3.52\,g\,O_2 \times \frac{1\,mol\,O_2}{32.00\,g\,O_2} \times \frac{2\,mol\,Fe_2O_3}{3\,mol\,O_2} \times \frac{159.70\,g\,Fe_2O_3}{1\,mol\,Fe_2O_3} = 11.7\,g\,Fe_2O_3$$ → O_2: XS

The limiting reactant is Fe.

Given the above conditions, a CHEM 1141 student carries out this reaction and obtains 9.76 g of $Fe_2O_3(s)$. Show how to determine *(and then calculate)* the percent yield for this reaction.

$$\%\ yield = \frac{actual\ yield}{theoretical\ yield} \times 100 = \frac{9.76\,g}{11.5\,g} \times 100 = 84.9\%$$

Q24. Answer each of the questions listed involving sodium carbonate.

A) What is the molar concentration of a solution that is prepared by dissolving 15.9 g of Na_2CO_3 in enough water to give a total volume of 589 mL?

$[Na_2CO_3] = \frac{\#\text{mol } Na_2CO_3}{\#\text{ L}} = \frac{0.150\text{ mol}}{0.589\text{ L}} = 0.255\text{ M}$

$15.9\text{ g } Na_2CO_3 \times \frac{1\text{ mol } Na_2CO_3}{105.99\text{ g } Na_2CO_3} = 0.150\text{ mol } Na_2CO_3$

$589\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} = 0.589\text{ L}$

B) If you had a 1.50 M solution of Na_2CO_3, what volume would contain 0.30 moles of solute in both L and mL?

$0.30\text{ mol } Na_2CO_3 \times \frac{1\text{ L}}{1.50\text{ mol } Na_2CO_3} = 0.20\text{ L}$ (2 s.f.)

$= 200\text{ mL}$ or $2.0 \times 10^2\text{ mL}$ (2 s.f.)

C) How would you prepare 100. mL of a 0.350 M solution of Na_2CO_3 from a stock solution that is 13.0 M.

(M_1) (V_2) (M_2)

$M_1V_1 = M_2V_2$

$\rightarrow V_1 = \frac{M_2V_2}{M_1} = \frac{0.350\text{ M} \times 100.\text{ mL}}{13.0\text{ M}} = 2.69\text{ mL}$

→ add 2.69 mL of 13.0 M Na_2CO_3 to a 100.00 mL volumetric flask + add water until total volume is 100.00 mL. Shake.

D) Write a balanced molecular equation for the reaction between aqueous solutions of Na_2CO_3 and H_2SO_4.

(Be sure to include the state symbols (s, l, g, or aq) for all reactants & products !)

$Na_2CO_3(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)\uparrow$

Q25. From the given list of possible answers, choose the correct answer for each of the questions below.

Possible Answers

HF **HCl** **solute** **solvent** **dilute** **$NaNO_3$** **AgCl** **CH_4** **$KMnO_4$** **$MnCl_2$**

Which is a strong acid? HCl

Which is an ionic compound that is insoluble in water? AgCl

Which compound contains an atom with an oxidation state of +7? $KMnO_4$ (+7)

Which compound contains an atom with an oxidation state of –4? CH_4 (-4)

Which is the greater component in a solution? solvent

3 Point Bonus Question

What is the Arrhenius definition of an acid and base?

An Arrhenius acid is defined as: forms H_3O^+ when dissolved in water

An Arrhenius base is defined as: forms OH^- when dissolved in water

Exam checklist

(Check the boxes to certify the following:)

- ❒ My full name is written legibly on the front page
- ❒ My correct lab section has been indicated on the front page
- ❒ My full name is written legibly on the scantron sheet
- ❒ My exam version *(2A, 2B, 2C, or 2D)* is written on the scantron sheet
- ❒ I have shown work for all problems *(where appropriate)*, paying attention to
    - o Significant figures / decimal places
    - o Units
- ❒ I have used the conversion–factor method for all conversions
- ❒ If I have torn off the back page *(periodic table)*, I will not turn it in with my exam!

Thank–you from the Chemistry Professors and Good Luck!

Useful Information

$$N_A \textit{ (Avogadro's number)} = 6.022 \times 10^{23}$$

TABLE 5.1 Solubility Rules for Ionic Compounds in Water

Compounds Containing the Following Ions Are Generally Soluble	Exceptions
Cl^-, Br^-, and I^-	When these ions pair with Ag^+, Hg_2^{2+}, or Pb^{2+}, the resulting compounds are insoluble.
SO_4^{2-}	When SO_4^{2-} pairs with Sr^{2+}, Ba^{2+}, Pb^{2+}, Ag^+, or Ca^{2+}, the resulting compound is insoluble.
Compounds Containing the Following Ions Are Generally Insoluble	**Exceptions**
OH^- and S^{2-}	When these ions pair with Li^+, Na^+, K^+, or NH_4^+, the resulting compounds are soluble. When S^{2-} pairs with Ca^{2+}, Sr^{2+}, or Ba^{2+}, the resulting compound is soluble. When OH^- pairs with Ca^{2+}, Sr^{2+}, or Ba^{2+}, the resulting compound is slightly soluble.
CO_3^{2-} and PO_4^{3-}	When these ions pair with Li^+, Na^+, K^+, or NH_4^+, the resulting compounds are soluble.

Periodic Table of the Elements

IA	IIA											IIIA	IVA	VA	VIA	VIIA	VIIIA
1																	*18*
1 H 1.008	*2*											*13*	*14*	*15*	*16*	*17*	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [98]	44 Ru 101.1	45 Rh 102.9	46 Pd 108.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.60	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba* 137.3	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po [210]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra** [226]	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [265]	109 Mt [268]	110 [269]	111 [272]	112 [277]	113	114 [285]	115	116 [289]	117	118 [293]

*	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm [145]	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.50	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
**	89 Ac [227]	90 Th 232.0	91 Pa 231.0	92 U 238.0	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 [259]