General Chemistry 2 *(CHEM 1141)*

Shawnee State University – Autumn 2022

October 20, 2022

Exam # 2A

Name KEY

Please print your full name, and the exam version (2A) that you have on the scantron sheet!

(Bubble in the best answer choice for each question on the scantron sheet in pencil!)

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

Section #:

- ❒ 1. (Mon Lab, 10:10 AM – 1:00 PM)
- ❒ 2. (Wed Lab, 10:10 AM – 1:00 PM)

} **Fleeman**

- ❒ 3. (Tue Lab, 11:00 AM – 1:50 PM)
- ❒ 4. (Thu Lab, 11:00 AM – 1:50 PM)

} **Napper**

Multiple Choice:	_____	**/ 50**
Q21:	_____	**/ 10**
Q22:	_____	**/ 10**
Q23:	_____	**/ 10**
Q24:	_____	**/ 10**
Q25:	_____	**/ 10**
BONUS:	_____	**/ 3**
TOTAL:	_____	**/ 100**

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

Q1. The volume of a gas is proportional to the temperature of a gas is known as

A) Avogadro's Law

B) Charles's Law

C) Boyle's Law

D) Ideal Gas Law

$V \propto T$, $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Q2. Identify the major ionic species present in an aqueous solution of $FeCl_3$:

A) Fe^{+}, 3 Cl^{-}

B) Fe^{2+}, 3 Cl^{-}

C) Fe^{3+}, 3 Cl^{-}

D) Fe^{3+}, 3 Cl^{3-}

$FeCl_3(s) \xrightarrow{H_2O} Fe^{3+}(aq) + 3Cl^{-}(aq)$

Q3. For which of the following acids is chlorine in the +5 oxidation state?

A) $HClO_2$

B) $HClO_3$

C) $HClO_4$

D) HCl

(+1) ? (-2)

$HClO_3$

overall charge $= 0 = (+1) + (?) + 3(-2) = -5 + (?)$, so $Cl = (+5)$

Q4. How many moles of water are produced when 1.0 mole of NH_3 reacts according to the following chemical equation?

$$\mathbf{4\ NH_3 + 5\ O_2 \longrightarrow\ 4\ NO + 6\ H_2O}$$

A) 0.67 moles

B) 1.0 moles

C) 1.3 moles

D) 1.5 moles

$1.0 mol\ NH_3 \times \frac{6\ mol\ H_2O}{4\ mol\ NH_3} = 1.5 mol\ H_2O$

Q5. A 20.00 mL sample of 0.101 5 M nitric acid is introduced into a flask, and water is added until the volume of the solution reaches 250. mL. What is the concentration of nitric acid in the final solution?

A) 3.25×10^{-2} M

B) 8.12×10^{-3} M

C) 0.406 M

D) 5.08×10^{-4}

$M_1V_1 = M_2V_2$

$\rightarrow M_2 = \frac{M_1V_1}{V_2} = \frac{0.1015\,M \times 20.00\,mL}{250.\,mL}$

$= 8.12 \times 10^{-3}\,M$

Q6. A mixture of three gases has a total pressure of 1.82 atm at 298 K. The mixture is found to contain 1.27 mol CO_2, 3.04 mol CO, and 1.50 mol Ar.

What is the partial pressure of Ar?

A) 0.258 atm

B) 1.50 atm

C) 0.470 atm

D) 0.824 atm

$P_{Ar} = \chi_{Ar} \times P_{TOTAL}$

$= \left(\frac{1.50\,mol}{1.27\,mol + 3.04\,mol + 1.50\,mol}\right) \times 1.82\,atm$

$= 0.470\,atm$

Q7. A volume of gas occupies 1.40×10^3 mL at 25 °C and 760 mmHg. What volume will it occupy at the same temperature and 380 mmHg?

A) 700 mL

B) 1,050 mL

C) 1,140 mL

D) 2,800 mL

$P_1V_1 = P_2V_2 \rightarrow V_2 = \frac{P_1V_1}{P_2} = \frac{760\,mmHg \times 1.40 \times 10^3\,mL}{380\,mmHg}$

$= 2.80 \times 10^3\,mL$

Q8. Choose the statement below that is **false**:

A) a weak acid solution consists mostly of non-ionized acid molecules

B) non-electrolyte solutions do not conduct electricity

C) a strong acid solution consists of only partially ionized acid molecules

D) a strong electrolyte completely dissociates into ions in water

strong acids undergo ~100% ionization/dissociation

Q9. The following equation represents the formation of nitrogen dioxide, a major component of smog:

$$2\ NO + O_2 \longrightarrow 2\ NO_2$$

If 0.88 mol of NO is reacted with 0.79 mol of O_2 to produce NO_2, the limiting reactant is

A) NO

B) O_2

C) NO_2

D) both NO and O_2

(LR) $0.88\,mol\ NO \times \frac{2\,mol\,NO_2}{2\,mol\,NO} = 0.88\,mol\ NO_2$ (*) smaller, so this is actual yield.

(XS) $0.79\,mol\ O_2 \times \frac{2\,mol\,NO_2}{1\,mol\,O_2} = 1.6\,mol\ NO_2$

Q10. You have two HCl solutions, labeled solution A and solution B. Solution A has a greater concentration than solution B. Which of the following statements is true?

A) If you have equal volumes of both solutions, solution B must contain more moles of HCl

B is more dilute ... $[\,] = \#\,mol / vol\,(L)$

B) If you have equal moles of HCl in both solutions, solution B must have a greater volume.

C) To obtain equal concentrations of both solutions, you must add a certain amount of water to solution B.

D) Adding more moles of HCl to both solutions will make them less concentrated.

Q11. Which combination of solutions will result in a solid being formed?

A) $AgNO_3(aq) + HCl(aq)$ → $AgCl(s) + HNO_3(aq)$

B) $HBr(aq) + LiHCO_3(aq)$

C) $NaCl(aq) + Na_2CO_3$

D) $NH_4NO_3(aq) + KI(aq)$

looking for a base ←

Q12. Which substance would cause litmus to turn blue?

A) NaCl(aq)

B) $NH_4NO_3(aq)$

C) $HC_2H_3O_2(aq)$

D) LiOH(aq) - strong base

Q13. 13.8 g of LiBr(s) is dissolved in water, so that the total volume is 250. mL. What is the molar concentration of the solute?

A) 0.159 M

B) 0.636 M

C) 0.0006 M

D) 0.0552 M

$[LiBr] = \frac{\#mol}{\#L} = \frac{0.1589\ mol}{0.250\ L} = 0.636\ M$ (① / ②)

Li: 6.941
Br: 79.90
$86.841\ g/mol$

① $13.8\ g\ LiBr \times \frac{1\ mol\ LiBr}{86.84\ g\ LiBr} = 0.1589\ mol\ LiBr$

② $250.\ mL \times \frac{1\ L}{1000\ mL} = 0.250\ L$

Q14. For the following redox reaction:

$$2Fe^{2+}(aq) + 2H^{+}(aq) + H_2O_2(aq) \rightarrow 2Fe^{3+}(aq) + 2H_2O(l)$$

(+2) (+3)

The reducing agent is — gets oxidized ... causes reduction

A) Fe^{2+}

B) H_2O_2

C) H^+

D) Fe^{3+}

(+2) (+3)
$Fe^{2+} \rightarrow Fe^{3+}$ OX (inc. in ox#)

Q15. Calculate the density of $CO_2(g)$ in the atmosphere of Venus, where the temperature is 467 °C at a pressure of 93 atm.

A) 67.4 g/L

B) 3.69×10^7 g/L

C) 107 g/L

D) 2.33×10^7 g/L

$pM_0 = dRT$

$d = pM_0/RT = \frac{93\ atm \times 44.019\ g/mol}{0.08206\ \frac{atm \cdot L}{mol \cdot K} \times 740.\ K} = 67.49\ g/L$

$C = 12.01$
$2 \times O = 2 \times 16.00$
$44.019\ g/mol$

Q16. How many moles of LiBr are contained in 20.00 mL of 0.500 M LiBr(aq)?

A) 10.0 mol

B) 0.010 0 mol

C) 40.0 mol

D) 0.025 0 mol

$\frac{20.00\ mL \mid 1\ L \mid 0.500\ mol}{1000\ mL \mid 1\ L} = 0.0100\ mol$

Q17. When dealing with gases, standard temperature and pressure corresponds to:

A) 1 atm, 0 °C

B) 1 atm, 100 °C

C) 760 mmHg, 0 K

D) 760 mm Hg, 100 K

Q18. Which of the following elements is a diatomic gas at room temperature and pressure?

A) argon

B) boron

C) carbon

D) chlorine

$H_2(g)$, $N_2(g)$, $O_2(g)$, $F_2(g)$, $Cl_2(g)$

Q19. Which net ionic equation cannot be correct?

A) $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$ ✓

B) $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$ ✓

C) $Na_2^+(aq) + Cl_2^-(aq) \longrightarrow Na_2Cl_2(s)$

D) $3Ca^{2+}(aq) + 2PO_4^{3-}(aq) \longrightarrow Ca_3(PO_4)_2(s)$ ✓

Na_2^+ : not a polyatomic ion

Cl_2^- :

$Na^+ Cl^- = NaCl$ (1:1)

soluble, so (aq)

Q20. What is the best piece of glassware to use when preparing a solution of known concentration in the lab?

A) Erlenmeyer flask

B) graduated cylinder

C) beaker

D) volumetric flask ✓ accurate when preparing known volume.

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

All work must be shown to receive 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. Provide a correctly balanced reaction equation that shows the chemical reaction that takes place when an aqueous solution of iron(II) bromide is mixed with an aqueous solution of potassium carbonate. 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)*

$\_\_ FeBr_2(aq) + \_\_ K_2CO_3(aq) \rightarrow$ $2KBr(aq)$ + $FeCO_3(s)$

Fe^{2+} Br^- K^+ CO_3^{2-}

Complete Ionic Equation

$Fe^{2+}(aq) + 2Br^-(aq) + 2K^+(aq) + CO_3^{2-}(aq) \rightarrow 2K^+(aq) + 2Br^-(aq) + FeCO_3(s)$

Net Ionic Equation

$Fe^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow FeCO_3(s)$

Q22. A gaseous compound is 30.4% nitrogen and 69.6% oxygen by mass. A 5.25-gram sample of the gas occupies a volume of 1.00 L and exerts a pressure of 980. mmHg at −4 °C.

Determine the:

(a) molar mass of the gas

$P = 980.\ mmHg \times \frac{1\ atm}{760\ mmHg}$

$= 1.2895\ atm$

$pM_0 = dRT \rightarrow M_0 = \frac{dRT}{P}$

$T = -4 + 273$

$= 269\ K$

$d = m/V = \frac{5.25\ g}{1.00\ L} = 5.25\ g/L$

$\rightarrow M_0 = \frac{5.25\ g/L \times 0.08206 \frac{atm \cdot K}{mol \cdot K} \times 269\ K}{1.2895\ atm}$

$= \boxed{89.2\ g/mol}$

(b) molecular formula of the gas

Assume 100 g

$30.4\ g\ N \times \frac{1\ mol\ N}{14.01\ g\ N} = 2.170\ mol\ N$

$69.6\ g\ O \times \frac{1\ mol\ O}{16.00\ g\ O} = 4.35\ mol\ O$

$\div 2.17$ mol

1.00 N

2.00 O

$\rightarrow \boxed{NO_2}$ empirical formula

$N = 14.01$

$2 \times O = 2 \times 16.00$

$46.01\ g/mol$

$\rightarrow \frac{89.2}{46.01} = 1.94 \approx 2$

$\rightarrow (NO_2)_2 = \boxed{N_2O_4}$

Q23. A 25.00 mL sample of battery acid (H_2SO_4) is obtained and placed in a flask, along with two drops of phenolphthalein indicator. A buret is filled with 0.100 0 M NaOH(aq) and placed above the acid. If the initial reading of the buret is 0.03 mL, and the final reading (when a pale pink color persists) is 32.13 mL—calculate the molar concentration (molarity) of the acid.

Show all work, being sure to include units and the correct number of digits at every step in your calculation.

$H_2SO_4(aq) + 2\ NaOH(aq) \rightarrow 2\ H_2O(l) + Na_2SO_4(aq)$

$$[H_2SO_4] = \frac{\#\text{mol } H_2SO_4}{\#\text{L } H_2SO_4}$$ ① ②

① $V_{NaOH} = 32.13\text{mL} - 0.03\text{mL} = 32.10\text{mL}$

$$32.10\text{mL} \left|\frac{1\text{L}}{1000\text{mL}}\right| \frac{0.1000\text{ mol NaOH}}{1\text{L}} \left|\frac{1\text{ mol } H_2SO_4}{2\text{ mol NaOH}}\right| = 1.605\times10^{-3}\text{ mol } H_2SO_4 \quad (4\text{sf})$$

② $$25.00\text{mL} \left|\frac{1\text{L}}{1000\text{mL}}\right| = 0.02500\text{L} \quad (4\text{sf.})$$

→ $$[H_2SO_4] = \frac{1.605\times10^{-3}\text{ mol}}{0.02500\text{ L}} = \boxed{0.06420\text{ M}}$$

Q24. (a) 100.0 mL of 3.00 M HCl(aq) was added to an excess of $Na_2CO_3(aq)$. What volume of gas should be formed at a temperature of 23 °C and a pressure of 753 mmHg?

$$\mathbf{2\ HCl(aq) + Na_2CO_3(aq) \rightarrow 2\ NaCl(aq) + H_2O(l) + CO_2(g)}$$

a gas!

$P = 753\ mmHg \times \frac{1\ atm}{760\ mmHg} = 0.9908\ atm$

$T = 23 + 273 = 296\ K$

$\#mol\ CO_2\ (g): \quad \frac{100.0\ mL}{1000\ mL} \times \frac{1\ L}{1\ L} \times \frac{3.00\ mol\ HCl}{1\ L} \times \frac{1\ mol\ (O_2(g))}{2\ mol\ HCl} = 0.150\ mol\ CO_2(g)$

$pV = nRT \rightarrow V = \frac{nRT}{P} = \frac{0.150\ mol \times 0.08206\ \frac{atm \cdot L}{mol \cdot K} \times 296\ K}{0.9908\ atm}$

$= \boxed{3.68\ L}$ 3 s.f.

(b) If the actual volume of gas formed was 3.37 L—calculate the percent yield of the reaction.

$\%\ yield = \frac{actual}{theoretical} \times 100 = \frac{3.37\ L}{3.68\ L} \times 100 = \boxed{91.6\%}$ 3 s.f.

(recall Avogadro's law: $V \propto n$)

Q25. The production of aluminum from bauxite is an incredibly energy intensive process. Approximately 5% of electricity generated in the United States is used to produce it.

The simplified chemical equation for this process is:

$$\mathbf{2\ Al_2O_3(l) \rightarrow 4\ Al(l) + 3\ O_2(g)}$$

Being sure to use the conversion-factor method, showing all work, and using the correct number of digits, please answer the following questions:

(a) If 0.100 mol of oxygen is formed, how many moles of aluminum oxide must have been used up?

$$0.100\ \text{mol}\ O_2 \times \frac{2\ \text{mol}\ Al_2O_3}{3\ \text{mol}\ O_2} = 0.0667\ \text{mol}\ Al_2O_3$$

(b) If 2,240 g of Al_2O_3 are used up, how many moles of aluminum can be made?

$$2{,}240\ \text{g}\ Al_2O_3 \times \frac{1\ \text{mol}\ Al_2O_3}{101.96\ \text{g}\ Al_2O_3} \times \frac{4\ \text{mol}\ Al}{2\ \text{mol}\ Al_2O_3} = 43.9\ \text{mol}\ Al$$

(c) If 2,240 g of Al_2O_3 are used up, and 1090 g of aluminum are formed, calculate the percent yield of this reaction.

$$43.9\ \text{mol}\ Al \times \frac{26.98\ \text{g}\ Al}{1\ \text{mol}\ Al} = 1184\ \text{g}\ Al$$

$$\%\ \text{yield} = \frac{\text{actual}}{\text{theor.}} \times 100 = \frac{1090\ \text{g}}{1184\ \text{g}} \times 100 = \boxed{92.1\%}$$ 3 s.f.

3 Point Bonus Question

Name three strong inorganic acids.

1. Nitric acid ($HNO_{3(aq)}$) Hydrochloric acid ($HCl_{(aq)}$)
2. Sulfuric acid ($H_2SO_{4(aq)}$) Hydrobromic acid ($HBr_{(aq)}$)
3. Perchloric acid ($HClO_{4(aq)}$) Hydroiodic acid ($HI_{(aq)}$)

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 (A, B, C, or D) is written on the scantron sheet
- ☑ I have shown work for all problems (where appropriate), paying attention to
    - Significant figures / decimal places
    - 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!

Partial List of Solubility Rules

TABLE 4.2 Solubility Rules for Common Ionic Compounds in Water at 25°C

Soluble Compounds	Exceptions
Halides (Cl^-, Br^-, I^-)	Halides of Ag^+, Hg_2^{2+}, and Pb^{2+}
Sulfates (SO_4^{2-})	Sulfates of Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Compounds	**Exceptions**
Carbonates (CO_3^{2-}), phosphates (PO_4^{3-}), chromates (CrO_4^{2-}), and sulfides (S^{2-})	Compounds containing alkali metal ions and the ammonium ion
Hydroxides (OH^-)	Compounds containing alkali metal ions and the Ba^{2+} ion

Useful information:

$M_1V_1 = M_2V_2$ $N_A = 6.022 \times 10^{23}\ mol^{-1}$

1 atm = 101,325 Pa = 760 mmHg = 760 torr

$R = 0.08206\ L \cdot atm/mol \cdot K$

$$p_1V_1 = p_2V_2 \qquad \frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$$pV = nRT \qquad p\mathcal{M} = dRT$$

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** 106.4	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]