General Chemistry 1 *(CHEM 1141)*

Shawnee State University – Autumn 2024

November 14, 2024

Exam # 2 A

Name KEY

Please print 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 scantron sheet in pencil!)

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

Section #:

- ❒ 1. (Mon Lab, 11:10 AM – 1:55 PM) } **Fleeman**
- ❒ 2. (Wed Lab, 11:10 AM – 1:55 PM) } **Fleeman**
- ❒ 3. (Tue Lab, 11:00 AM – 1:50 PM) } **Napper**
- ❒ 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. What is the molarity of a $NaNO_3$ solution made by diluting 250.0 mL of a 1.60 M solution to a final volume of 400.0 mL?

A) 0.160M

B) 0.200M

C) 1.00 M

D) 1.20 M

$M_1V_1 = M_2V_2$

$\rightarrow M_2 = \frac{M_1V_1}{V_2} = \frac{1.60M \times 250.0mL}{400.0mL}$

$= 1.00M$

Q2. What is the molarity of a solution that contains 1.50 mol HCl in 2.50 L of solution?

A) 0.600 M

B) 1.20 M

C) 1.40 M

D) 1.67 M

$[HCl] = \frac{\#mol}{\#L} = \frac{1.50mol}{2.50L} = 0.600\frac{mol}{L}$ OR M

Q3. What does NOT change when a solution is diluted by the addition of solvent?

A) volume of solvent

B) mass of solvent

C) number of moles of solute

D) molarity of the solution

dil. eq: $M_1V_1 = M_2V_2$

$\frac{mol}{L} \times L$ $\quad$ $\frac{mol}{L} \times L$

$= mol\ solute$

Q4. Which of the following compounds is insoluble in water?

A) KI

B) PbI_2

C) Na_2CO_3

D) NH_4OH

Iodides are generally soluble, but Pb^{2+} compound is an exception!

Q5. The volume of a gas is doubled while the temperature is held constant. The pressure of the gas

$P_1V_1 = P_2V_2$ (Boyle)

A) remains unchanged

B) is reduced by one-half

$P_2 = P_1 \frac{V_1}{V_2} = P_1 \times \left(\frac{1}{2}\right)$ ↳ $V_2 = 2V_1$

C) is doubled

D) depends on the type of gas in the container

Q6. A mixture of gases contains 1.5 moles of oxygen, 3.0 moles of nitrogen, and 0.5 mole of argon. If the total pressure is 700 mmHg, what is the partial pressure of the nitrogen gas?

$P_{N_2} = X_{N_2} \cdot P_{TOT}$

$= \frac{3.0\,mol}{5.0\,mol} \times 700.\,mmHg = 420.\,mmHg$

$X_{N_2} = \frac{n_{N_2}}{n_{TOT}}$

A) 70 mmHg

B) 210 mmHg

C) 350 mmHg

D) 420 mmHg

Q7. Give the equation for the standard enthalpy of formation (ΔH_f^o) for $CaCO_3$.

↳ form 1 mol of substance from its elements in most stable form.

A) $Ca(s) + C(s, graphite) + 3/2\ O_2(g) \longrightarrow CaCO_3(s)$

B) $2\ Ca(s) + 2\ C(s, graphite) + 3\ O_2(g) \longrightarrow 2\ CaCO_3(s)$

C) $Ca(s) + C(s, graphite) + 3\ O(g) \longrightarrow CaCO_3(s)$

D) $CaCO_3(s) \longrightarrow Ca(s) + C(s, graphite) + 3\ O(g)$

Q8. Determine the oxidation number of **sulfur** in $S_2O_3^{2-}$.

$\sum$ Ox.# = charge (per atom)

A) +2

B) -2

C) +3

D) +4

→ $2 \times \underbrace{Ox\#(S)} + 3 \times \underbrace{Ox.\#(O)} = -2$

→ $2 \times (x) + 3 \times (-2) = -2$

O = -2 in most compounds (rule)

→ $2x = -2 + 6 = +4$

→ $x = +\frac{4}{2} = (+2)$

Q9. A student observed that when ammonium nitrate is dissolved in water, the temperature of the water decreases. Which statement describes this process?

A) The process is exothermic and heat is absorbed.

B) The process is exothermic and heat is released.

C) The process is endothermic and heat is absorbed.

D) The process is endothermic and heat is released.

$\Delta H > 0$ (endothermic)
feels cold (H_2O loses q + gets colder)

Q10. What is the chemical formula of the salt produced in the neutralization reaction of potassium hydroxide (KOH) with sulfuric acid (H_2SO_4)?

A) H_2O

B) KSO_4

C) K_2SO_4

D) KCl

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

$K^+ OH^- + H^+ SO_4^{2-}$ → $K^+ SO_4^{2-} + H^+ OH^-$

double-rep.

2 1 1:1

Q11. When going from a molecular to a full-ionic equation, "$MgCl_2(aq)$" would be written as:

A) $Mg(s) + Cl_2(g)$

B) $Mg^{2+}(aq) + Cl_2(g)$

C) $Mg(s) + Cl_2^-(aq)$

D) $Mg^{2+}(aq) + 2\ Cl^-(aq)$

Q12. Which combination of reactants will form a gas?

A) $NaOH(aq) + H_2SO_4(aq)$

B) $HNO_3(aq) + Na_2CO_3(aq)$

C) $Mg(OH)_2(aq) + LiHCO_3(aq)$

D) $HCl(aq) + Ca(NO_3)_2(aq)$

$2H^+ + CO_3^{2-} \rightarrow$ "H_2CO_3" $\rightarrow H_2O(l) + CO_2(g)\uparrow$

from HNO_3 from Na_2CO_3

carbonic acid (v. unstable)

Q13. In a chemical reaction, the **oxidizing agent** is the species that:

A) increases in oxidation number

B) is reduced by another reactant

C) causes another species to decrease in oxidation number

D) loses electrons to another substance

↳ causes oxidation
- is itself reduced (gains e^-s)
(ox # ↓)

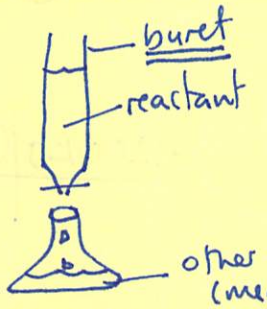
Q14. In a titration, the device used to deliver a variable volume of reactant is called a(n):

A) volumetric pipet

B) indicator

C) buret

D) volumetric flask



Q15. Which of the following elements is not a gas at room temperature and pressure?

A) bromine $Br_2(\ell)$ ... one of two elements that are liquids @ room temp

B) hydrogen $H_2(g)$

C) krypton $Kr(g)$

D) fluorine $F_2(g)$

→ one (two!) of five diatomic gases!

Q16. Which gas law states that volume is proportion to number of moles?

A) Avogadro's

B) Boyle's

C) Charles's

D) Gay Lussac's

Q17. The temperature of 2.00 mol of an ideal gas which has a pressure of 1.50 atm and a volume of 18.4 L is:

A) 2.01 K

B) 168 K

C) 192 K

D) 1.13 K

$pV = nRT$

$$\rightarrow T = \frac{pV}{nR} = \frac{1.50\,\text{atm} \times 18.4\,\text{L}}{2.00\,\text{mol} \times 0.08206\,\frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}}}$$

$$= 168\,\text{K}$$

Q18. A 15.0 g sample of an unknown metal with a temperature of 34.9 °C loses 129 J of heat and ends up at 21.1 °C. What is the specific heat capacity of the metal?

A) 3200 J/g·°C

B) 0.124 J/g·°C

C) 119 J/g·°C

D) 0.623 J/g·°C

$q = m \cdot c \cdot \Delta t$

$$\rightarrow c = \frac{q}{m \cdot \Delta t} = \frac{-129\,\text{J}}{15.0\,\text{g} \times (21.1^\circ\text{C} - 34.9^\circ\text{C})}$$

$$= 0.623\,\text{J/g}\cdot^\circ\text{C}$$

Q19. Given $C_2H_6(g) + 7/2\ O_2(g) \longrightarrow 2\ CO_2(g) + 3\ H_2O(g)$; $\Delta H = -1560$ kJ/mol

how many moles of $H_2O(g)$ will be produced when 1200 kJ of heat is given off?

A) 2.3

B) 1.6

C) 0.77

D) 0.43

$$\frac{-1200\text{kJ} \left| \frac{3\text{ mol } H_2O}{} \right.}{\left. -1560\text{kJ} \right|} = 2.3\text{ mol } H_2O$$

Q20. Which has a ΔH_f^o value of 0?

A) Ar(s)

B) Na(l)

C) C(s,diamond)

D) He(g)

└ most stable form of the (noble gas)

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 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. During photosynthesis, plants use light energy to convert carbon dioxide and water to sugar and oxygen gas as shown in the equation below:

$$6\,CO2(g) + 6H_2O(l) \longrightarrow C_6H_{12}O_6(s) + 6O_2(g)$$

A. Determine the enthalpy of reaction (ΔH_{rxn}°) for the photosynthesis reaction given the following:

$\Delta H_f^{\circ} CO_2(g) = -393.5$ kJ/mol

$\Delta H_f^{\circ} H_2O(l) = -285.8$ kJ/mol

$\Delta H_f^{\circ} C_6H_{12}O_6(s) = -1273.3$ kJ/mol

$\Delta H^{\circ}_{rxn} = \sum n \cdot \Delta H_f^{\circ}(\text{products}) \ominus \sum n \cdot \Delta H_f^{\circ}(\text{reactants})$

$= [1 \times \Delta H_f^{\circ}(C_6H_{12}O_6) + 6 \times \Delta H_f^{\circ}(O_2)] \ominus [6 \times \Delta H_f^{\circ}(CO_2) + 6 \times \Delta H_f^{\circ}(H_2O)]$

$= \left[1 \times -1273.3 \frac{kJ}{mol}\right] \ominus \left[6 \times -393.5 \frac{kJ}{mol} + 6 \times -285.8 \frac{kJ}{mol}\right] = +2{,}802.5 \frac{kJ}{mol}$

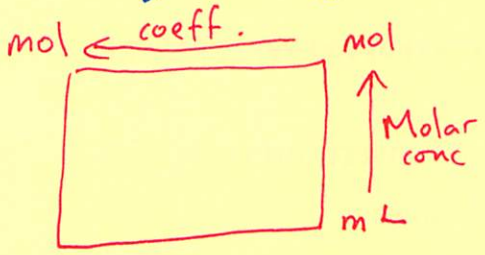
B. How much heat in kJ is (released or absorbed, **circle one**) if 2.004 g of CO_2 is reacted?

endothermic, $\Delta H > 0$

$$2.004\,g\,CO_2 \times \frac{1\,mol\,CO_2}{44.01\,g\,CO_2} \times \frac{2{,}802.5\,kJ}{6\,mol\,CO_2} = +21.27\,kJ$$ absorbed

Q22. If 16.3 mL of a 0.185 M $Mg(OH)_2$ solution is used to titrate 0.0250 L of gastric juice (HCl), what is the molarity of the HCl solution? Be sure to write a balanced chemical equation.

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



$$16.3\,mL \left|\frac{1\,L}{1000\,mL}\right| \frac{0.185\,mol\ Mg(OH)_2}{1\,L} \left|\frac{2\,mol\ HCl}{1\,mol\ Mg(OH)_2}\right. = 6.03\times10^{-3}\,mol\ HCl$$

$$[HCl] = \frac{\#mol}{\#L} = \frac{6.03\times10^{-3}\,mol}{0.0250\,L} = \boxed{0.241\,M}$$

Q23. Given the balanced chemical equation:

$$\overset{(0)}{3\,Mg(s)} + \overset{(+1)}{2\,H_3PO_4(aq)} \longrightarrow \overset{(+2)}{Mg_3(PO_4)_2(s)} + \overset{(0)}{3\,H_2(g)}$$

(i) Calculate the oxidation numbers for the atoms Mg and H on each side of the equation.

elements: (0) → $\overset{(0)}{H_2}$, $\overset{(0)}{Mg}$

monatomic ions: (charge) $\overset{(+2)}{Mg^{2+}}$

hydrogen: (+1) in most compounds $\overset{(+1)}{H_3PO_4}$

Remember: ox # is for each atom!

(ii) If 150.0 mL of 3.000 M H_3PO_4 reacts with an excess of Mg, how many moles of hydrogen gas is formed?

$$\frac{150.0\,mL}{1000\,mL} \times \frac{1\,L}{1\,L} \times \frac{3.000\,mol\,H_3PO_4}{1\,L} \times \frac{3\,mol\,H_2}{2\,mol\,H_3PO_4} = \boxed{0.6750\,mol\,H_2}$$

(iii) If 10.0 g of Mg and 250.0 mL of 3.000 M H_3PO_4 react, what volume of gas is formed at a pressure of 1.10 atm and a temperature of 35 °C? Be sure to clearly identify the limiting reactant as part of your answer!

(LR)

$$\frac{10.0\,g\,Mg}{24.31\,g\,Mg} \times \frac{1\,mol\,Mg}{3\,mol\,Mg} \times \frac{3\,mol\,H_2}{} = 0.411\,mol\,H_2$$

(*) theoretical yield (smallest value)

$$\frac{250.0\,mL}{1000\,mL} \times \frac{1\,L}{1\,L} \times \frac{3.000\,mol\,H_3PO_4}{1\,L} \times \frac{3\,mol\,H_2}{2\,mol\,H_3PO_4} = 1.125\,mol\,H_2$$

(XS)

$$pV = nRT \rightarrow V = \frac{nRT}{P} = \frac{0.411\,mol \times 0.08206\,\frac{atm \cdot L}{mol \cdot K} \times 308\,K}{1.10\,atm}$$

35+273

$$= \boxed{9.44\,L}$$

Q24. *Clearly show all work for this problem, being sure to explain which equation(s) is(are) being used!*

(i) A 150 mL sample of gas is compressed from an initial pressure of 250 Pa to a final pressure of 1200 Pa. What will its new volume be?

$P_1V_1 = P_2V_2$ (Boyle)

$$V_2 = \frac{P_1V_1}{P_2} = \frac{250\,Pa \times 150\,mL}{1200\,Pa} = 31\,mL \quad (2\,s.f.)$$

(ii) What volume would 54.0 g of $CH_4(g)$ occupy at a temperature of −58 °C and a pressure of 455 mmHg?

$pV = nRT$

$\rightarrow V = \frac{nRT}{P}$

$$\rightarrow V = \frac{3.366\,mol \times 0.08206\,\frac{atm \cdot L}{mol \cdot K} \times 215\,K}{0.5987\,atm}$$

$$= \boxed{99.2\,L} \quad (3\,s.f.)$$

$$n = 54.0\,g\,CH_4 \times \frac{1\,mol\,CH_4}{16.04\,g\,CH_4} = 3.366\,mol$$

$T = -58 + 273 = 215\,K$

$$p = 455\,mmHg \times \frac{1\,atm}{760\,mmHg} = 0.5987\,atm$$

(iii) A gas bubble has a pressure of 125 mmHg at a temperature of 245 K and a volume of 35.0 mL. If the bubble is cooled down to 212 K while simultaneously compressed to 25.0 mL, what will its final pressure be?

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ (combined gas law)

$$P_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{V_2} = \frac{125\,mmHg \times 35.0\,mL}{245\,K} \times \frac{212\,K}{25.0\,mL}$$

$$= \boxed{151\,mmHg} \quad 3\,s.f.$$

Q25. Write out the **balanced** molecular, full-ionic, and net-ionic equation for the reaction below:

Molecular: ___ $Pb(NO_3)_2(aq)$ + 2 $NH_4I(aq)$ → $PbI_2(s)$ + $2NH_4NO_3(aq)$

Full-ionic: $Pb^{2+}(aq) + 2NO_3^-(aq) + 2NH_4^+(aq) + 2I^-(aq) \rightarrow PbI_2(s) + 2NH_4^+(aq) + 2NO_3^-(aq)$

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

3 Point Bonus Question

Write the chemical formula for three strong inorganic acids.

$HCl(aq)$ $HNO_3(aq)$
$HBr(aq)$ $H_2SO_4(aq)$
$HI(aq)$ $HClO_4(aq)$

(any 3!)

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 or B) 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:

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

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

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

$R = 0.08206$ L·atm/mol·K

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

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

$q = m \cdot c . \Delta T$

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]