Name: Student #: SOLUTIONS

VERSION A

CH110/120 – Fundamentals of Chemistry/Introductory Chemistry

Midterm #1

Friday, October 2^{nd}, 2015
5:35-6:50 pm
Instructor: Dr. Louise Dawe

Instructions:

Multiple choice:

1. On this paper test, mark your first (and second, and third) answers. Your IFAT card will not be returned, but this paper test will, and you might want a record of your answers for later study.

2. On your IFAT card, scratch your selection. A star will identify the correct answer
   - Star can be anywhere in the box, not just the middle!
   - Little scratches count as an attempt
   - Be careful to keep your place if you skip questions!
   - Scratch with care to avoid tearing the form
   - Plastic (ID cards) seems to be gentler than metal (coins)

3. Each multiple choice is worth 2 points. If you get a question wrong (no star where you scratch), go back and re-read the questions and try again
   - If it is right on the second try it is worth 1 point.
   - If it is right on the third try it is still worth 1/2 a point.

4. After you are finished, go back and make note of any questions that you would like discussed.

5. Only your IFAT card will count for marks, so it is your responsibility to ensure that you return it to the exam room proctors. Missing IFAT cards will get zero marks.

6. You only get one IFAT card. If you "mess it up", there will be no replacement provided.

7. Keep your IFAT card turned face-down when you are not using it.

Long Answer Problems: Answer in the space provided.

Allowed aids: Non-programmable calculator. No additional aids permitted.

Good luck!

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MC 1		LA 1a	/1
MC 2		LA 1b	/1
MC 3			/1.5
MC 4			/1.5
MC 5		LA 1c	/1
MC 6			/1
MC 7		LA 2a	/1
MC 8			/1
MC 9		LA 2b	/1
MC 10			/1
Total	/20	Total	/11
Overall Total	/31		

I. Multiple Choice Questions (10 questions, 2 marks each)

1. What are the stoichiometric coefficients needed in order to balance the equation?

$$\underline{3}\ MgO(s) + \underline{2}\ Fe(s) \rightarrow \underline{1}\ Fe_2O_3(s) + \underline{3}\ Mg(s)$$

A) 1, 1, 2, 3

B) 2, 3, 1, 1

C) 2, 3, 1, 3

D) 3, 6, 2, 3

E) 3, 2, 1, 3

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2. How many moles of ethanol are present in 1.50 g of ethanol (CH_3CH_2OH)? 46.0682g·mol⁻¹

A) 0.0145 mol
B) 30.7 mol
C) 0.0326 mol
D) 69.0 mol
E) 9.03×10^{23} mol

$$\frac{1.50\,g}{46.0682\,g \cdot mol^{-1}} = 0.0326\,mol$$

3. What is the molar mass of butane if 5.19×10^{16} molecules of butane weigh 5.00 μg?

A) 0.0172 g/mol
B) 5.80×10^{13} g/mol
C) 431 g/mol
D) 172 g/mol
E) 58.0 g/mol

$$\frac{5.00\times10^{-6}\,g}{5.19\times10^{16}\,molecules\left(\frac{1\,mol}{6.022\times10^{23}\,molecules}\right)} = 58.0\,g\cdot mol^{-1}$$

4. Sodium sulfide is combined with iron(III) nitrate in aqueous solution. What will be the solid product of this reaction?

A) Fe_2S_3
B) $NaNO_3$
C) Na_2S
D) $Fe(NO_3)_3$
E) No reaction takes place

5. A $Cu(ClO_4)_2$ solution is 0.205 mol L^{-1}. How many mL of this solution are needed to make 4.50×10^2 mL of a solution that is 0.374 mol L^{-1} in ClO_4^- ion?

A) 8.51×10^{-5} mL
B) 1.70×10^{-4} mL
C) 1.64×10^{3} mL
D) 4.10×10^{2} mL
E) 8.21×10^{2} mL

$C_1 = 0.205\,mol\cdot L^{-1}\,Cu(ClO_4)_2$; $C_f = 0.374\,mol\cdot L^{-1}\,ClO_4^-\left(\frac{1\,mol\,Cu(ClO_4)_2}{2\,mol\,ClO_4^-}\right) = 0.187\,mol\cdot L^{-1}\,Cu(ClO_4)_2$

$$V_1 = \frac{C_f V_f}{C_1} = \frac{(0.187\,mol\cdot L^{-1})(450\,mL)}{(0.205\,mol\cdot L^{-1})} = 4.10\times10^{2}\,mL$$

6. A student dissolved 0.0200 mol of $FeCl_3$ in enough water to make 2.50×10^2 mL of stock solution. She took 6.25 mL of the stock solution and then diluted it with water to give 1.00 L of a final solution. How many grams of Cl^- ion are in the final solution? (Molar masses: $FeCl_3$ = 162.207 g/mol; molar mass of Cl^- = 35.453 g/mol)

A) 1.33×10^{-2} g
B) 1.77×10^{-2} g
C) 5.32×10^{-2} g
D) 2.43×10^{-1} g
E) 2.13 g

$$\left(\frac{0.0200\,mol\,FeCl_3}{0.250\,L}\right)(0.00625\,L)\left(\frac{3\,mol\,Cl^-}{1\,mol\,FeCl_3}\right)\left(\frac{35.453\,g}{1\,mol\,Cl^-}\right)$$

$$= 0.0532\,g$$
$$= 5.32\times10^{-2}\,g$$

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7. Which one of the following is **not** a property used to determine the physical behaviour of an **ideal** gas?

A) Amount of gas
B) Molar mass of the gas
C) Volume
D) Temperature
E) Pressure

8. What is the total pressure in a 10.0 L flask which contains 0.127 mol of H_2 (g) and 0.288 mol of N_2 (g) at 293.15 K?

$$P_{Total} = \frac{n_{Total} R T}{V} = \frac{(0.415\ mol)(0.08206\ L \cdot atm \cdot mol^{-1} \cdot K^{-1})(293.15K)}{10.0L}$$

$$= 0.998\ atm$$

A) 0.0681 atm
B) 0.306 atm
C) 0.998 atm
D) 0.387 atm
E) 0.693 atm

9. A gas with an initial volume of 4.0 L at 300 K is compressed to a volume of 2.0 L while simultaneously being heated to 600 K. What happens to the gas pressure? (Note: The amount of gas does not change)

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$P_2 = \frac{P_1 V_1 T_2}{T_1 V_2} = \frac{P_1 (4.0L)(600K)}{(300K)(2.0L)} = 4P_1$$

A) Quadruples
B) Doubles
C) Halves
D) Quarters
E) Remains unchanged

10. Four identical flasks each contain the same amount of gas at 25.0 °C. Flask A contains CH_4, flask B contains N_2, flask C contains Ar and flask D contains CO_2. Which flask exhibits the greatest pressure?

A) Flask A
B) All four flasks exhibit the same pressure
C) Flask C
D) Flask D
E) Flask B

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II. Problems **(Show your work and give your answer in the space provided. Use the back of the page if you require extra space.)**

1. Iron(III) oxide reacts with carbon monoxide according to the following *unbalanced* equation:

$$Fe_2O_3\,(s) + CO\,(g) \rightarrow Fe\,(s) + CO_2\,(g)$$

(1 point) (a) Write out the full balanced equation below. Include phases.

$$Fe_2O_3\,(s) + 3CO\,(g) \rightarrow 2Fe\,(s) + 3CO_2\,(g)$$

(4 points) (b) What volume of carbon dioxide will be produced when 22.55 g of Fe_2O_3 are combined with 14.78 g of CO under standard temperature and pressure (STP; that is, temperature is 273.15 K and pressure is 1.00 bar.) Molar masses: CO = 28.0101 g/mol; CO_2= 44.0095 g/mol; Fe_2O_3= 159.6932 g/mol; Fe = 55.8475 g/mol

$$n_{CO_2} \text{ produced if } Fe_2O_3 \text{ limits} = 22.55\,g\,Fe_2O_3 \left(\frac{1\,mol\,Fe_2O_3}{159.6932\,g\,Fe_2O_3}\right)\left(\frac{3\,mol\,CO_2}{1\,mol\,Fe_2O_3}\right) = 0.4236_2\,mol\,CO_2$$

$$n_{CO_2} \text{ produced if } CO \text{ limits} = 14.78\,g\,CO \left(\frac{1\,mol\,CO}{28.0101\,g}\right)\left(\frac{3\,mol\,CO_2}{3\,mol\,CO}\right) = 0.5276_6\,mol\,CO_2$$

{ Fe_2O_3 limits the yield of CO_2 & is therefore the limiting reactant. }

$$V_{CO_2} \text{ produced @ STP} = 0.4236_2\,mol \left(\frac{22.7\,L}{1\,mol}\right) = 9.62\,L$$

or $$V = \frac{nRT}{P} = \frac{0.4236_2\,mol\,(0.08314\,L\cdot bar\cdot mol^{-1}\cdot K^{-1})(273.15\,K)}{1.00\,bar} = 9.62\,L$$

(2 points) (c) How many grams of the excess reagent will be left over after the reaction is complete? Assume 100% yield.

$m_{available} - m_{required}$

$$= 14.78\,g - 0.4236_2\,mol\,CO_2 \left(\frac{3\,mol\,CO}{3\,mol\,CO_2}\right)\left(\frac{28.0101\,g\,CO}{1\,mol\,CO}\right)$$

$$= 14.78\,g - 11.86_5\,g \quad \boxed{= 2.92\,g \text{ of CO in XS}}$$

Name: Student #: $\rightarrow 18°C + 273.15 = 291.15 K$

2. A gas mixture contains 1.25 g N_2 and 0.85 g O_2 in 1.5 L container at 18 °C. Calculate:

$28.0134 g \cdot mol^{-1}$ $31.9988 g \cdot mol^{-1}$

(2 marks) (a) the mole fraction of N_2 and the mole fraction of O_2.

$$n_{N_2} = 1.25 g \left(\frac{1 mol\ N_2}{28.0134 g}\right) = 0.0446_2\ mol\ N_2$$

$$n_{O_2} = 0.85 g \left(\frac{1 mol\ O_2}{31.9988 g}\right) = 0.0265\ mol\ O_2$$

$$n_{Total} = n_{N_2} + n_{O_2} = 0.071_1\ mol$$

$$\chi_{N_2} = \frac{n_{N_2}}{n_{Total}} = \frac{0.0446_2\ mol}{0.071_1\ mol} = 0.62_7 = 0.63$$

$$\chi_{O_2} = 1 - \chi_{N_2} = 1 - 0.62_7 = 0.37_3 = 0.37$$

(2 marks) (b) the partial pressure of N_2 and the partial pressure of O_2, expressed in bar.

$$P_{Total} = \frac{n_{Total} RT}{V} = \frac{(0.071_1\ mol)(0.08314\ L \cdot bar \cdot mol^{-1} \cdot K^{-1})(291\ K)}{1.5 L}$$

$$= 1.1_4\ bar$$

$$P_{N_2} = (P_{Total})(\chi_{N_2}) = (1.1_4\ bar)(0.62_7) = 0.71\ bar$$

$$P_{O_2} = (P_{Total})(\chi_{O_2}) = (1.1_4\ bar)(0.37_3) = 0.43\ bar$$

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PERIODIC TABLE OF THE ELEMENTS

KEY: 6 C 12 011 (atomic number; atomic mass)

s-block — d-block — p-block

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
													1 H 1 0079				2 He 4 0026
3 Li 6 941	4 Be 9 0122											5 B 10 811	6 C 12 0107	7 N 14 0067	8 O 15 9994	9 F 18 9984	10 Ne 20 1797
11 Na 22 9898	12 Mg 24 3050											13 Al 26 9815	14 Si 28 0855	15 P 30 9738	16 S 32 065	17 Cl 35 453	18 Ar 39 948
19 K 39 0983	20 Ca 40 078	21 Sc 44 9559	22 Ti 47 867	23 V 50 9415	24 Cr 51 9961	25 Mn 54 9380	26 Fe 55 8475	27 Co 58 9332	28 Ni 58 0934	29 Cu 63 546	30 Zn 65 409	31 Ga 69 723	32 Ge 72 61	33 As 74 9216	34 Se 78 96	35 Br 79 904	36 Kr 83 798
37 Rb 85 4678	38 Sr 87 62	39 Y 88 9059	40 Zr 91 224	41 Nb 92 9064	42 Mo 95 94	43 Tc (99)	44 Ru 101 07	45 Rh 102 9055	46 Pd 106 42	47 Ag 107 8682	48 Cd 112 411	49 In 114 818	50 Sn 118 710	51 Sb 121 75	52 Te 127 60	53 I 126 9045	54 Xe 131 29
55 Cs 132 9054	56 Ba 137 327	57 La 139 9055	72 Hf 178 49	73 Ta 180 9479	74 W 183 84	75 Re 186 207	76 Os 190 23	77 Ir 192 217	78 Pt 195 078	79 Au 196 9665	80 Hg 200 59	81 Tl 204 3833	82 Pb 207 2	83 Bi 208 9804	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (260)	109 Mt (268)									

f block

Lanthanides	58 Ce 140 116	59 Pr 140 9077	60 Nd 144 24	61 Pm (147)	62 Sm 150 36	63 Eu 151 964	64 Gd 157 25	65 Tb 158 925	66 Dy 162 50	67 Ho 164 9303	68 Er 167 259	69 Tm 168 9342	70 Yb 173 04	71 Lu 174 967
Actinides	90 Th 232 0381	91 Pa 231 0359	92 U 238 0289	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)	103 Lr (262)

Parenthesis indicates the most stable isotope

SOME USEFUL CONSTANTS

Quantity and Symbol	Value	Quantity and Symbol	Value
ΔH_{fusion}, H_2O(s) at 273 K	6 01 kJ mol^{-1}	Rydberg constant, R_H	1.097 x 10^7 m^{-1}
$\Delta H_{vaporization}$, H_2O(*l*) at 373 K	40 7 kJ mol^{-1}	Velocity of light in a vacuum, c	2 998 x 10^8 m s^{-1}
Specific Heat Capacity of H_2O(*l*)	4.184 J g^{-1} K^{-1}	Planck's Constant, h	6 626 x 10^{-34} J s
Specific Heat Capacity of H_2O(s) at 0°C	1 960 J g^{-1} K^{-1}	Density of H_2O(*l*) (near 0°C)	1.000 g mL^{-1}

Avogadro Constant, N_A 6 022 x 10^{23} mol^{-1}

Ideal Gas Constant, R 8 314 L kPa mol^{-1} K^{-1} = 8 314 J mol^{-1} K^{-1} = 0 08314 L bar mol^{-1} K^{-1} = 0 08206 L atm mol^{-1} K^{-1}

CONVERSION FACTORS

1 bar = 10^5 Pa = 100 kPa = 750.1 mmHg = 750 1 torr = 0 9860 atm

1 cal = 4 184 J (exactly)

1 L = 1 dm^3 (exactly) 1 L bar = 100 J

1 L atm = 101.3 J

SOME USEFUL FORMULAS

$$\left(P + \frac{n^2a}{V^2}\right)(V - nb) = nRT \qquad u_{rms} = \sqrt{\frac{3RT}{M}} \qquad \ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$E_n(J) = -2.179 \times 10^{-18}\frac{Z^2}{n^2} \qquad r_n = \frac{n^2 a_o}{Z^2}$$

$$PV = nRT \qquad e_k = \frac{1}{2}mu^2 \qquad \lambda\nu = c \qquad C = k_H P_{gas} \text{ or } kP_{gas}$$

$$\lambda = \frac{h}{mu} \qquad \Delta E(J) = Z^2 \times 2.179 \times 10^{-18}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) \qquad \Delta U = q + w \qquad \pi = iCRT \text{ or } iMRT$$

$$\Delta H = \Delta U + RT\Delta n_{gases}$$

$$\Delta T_f = -iK_f m \qquad \Delta T_b = iK_b m \qquad P_A = x_A P^\circ_A \qquad P_T = x$$

$$\Delta H^\circ = \sum \nu_p \Delta_f H^\circ \text{ (products)} - \sum \nu_r \Delta_f H^\circ \text{ (reactants)} \qquad {}_A P^\circ_A + x_b P^\circ_b \text{ (mixture of volatile liquids)}$$