CHEMISTRY LAB

INVITATIONAL EXAM

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SCHOOL NAME:

ANSWER KEY

TEAM NO.:

STUDENT NAMES:

Patrick O'Neill

pg 1 = 25 pts
pg 2 = 20 pts
pg 3 = 15 pts
pg 4 = 20 pts
pg 5 = 20 pts
+ up to 5 BONUS for sig figs

= 105/100

I. BALANCING REATIONS = 10

2pts each; NO partial credit

Balance the following reactions:

1) 2 $H_{2(g)}$ + ___ $O_{2(g)}$ → 2 $H_2O_{(l)}$

2) 2 $HCl_{(aq)}$ + ___ $Ba(OH)_{2(aq)}$ → 2 $H_2O_{(l)}$ + ___ $BaCl_{2(aq)}$

3) 3 $Pb(NO_3)_{2(aq)}$ + 2 $FeCl_{3(aq)}$ → 3 $PbCl_{2(s)}$ + 2 $Fe(NO_3)_{3(aq)}$

4) ___ $C_3H_{8(g)}$ + 5 $O_{2(g)}$ → 3 $CO_{2(g)}$ + 4 $H_2O_{(l)}$

5) 2 $HC_2H_3O_{2(aq)}$ + ___ $Na_2CO_{3(aq)}$ → ___ $H_2O_{(l)}$ + ___ $CO_{2(g)}$ + 2 $NaC_2H_3O_{2\,(aq)}$

II. NOMENCLATURE = 10

1pt each; NO partial credit

Complete the following table:

Chemical Name	Chemical Formula
Sodium Chloride	NaCl
Lithium Hydride	LiH
Calcium Peroxide	CaO_2
Ammonium Nitrate	NH_4NO_3
Hypochlorous Acid	HClO
Magnesium Fluoride	MgF_2
Carbon Dioxide	CO_2
Copper (I) Oxide	Cu_2O
Tetraphosphorous Decoxide	P_4O_{10}
Sulfurous Acid	H_2SO_3

III. STOICHIOMETRY = 5 on THIS PAGE

if math is wrong but work is neat & organized, look for these steps worth half a point partial credit each

5) Copper (II) Oxide will decompose when it is heated strongly.

$4\ CuO_{(s)} \rightarrow 2\ Cu_2O_{(s)} + O_{2(g)}$

How many grams of oxygen can be obtained from 2.64 g $CuO_{(s)}$?

63.5 + 16.0 = 79.5 g/mol 0.5pt

16.0 × 2 = 32 g/mol 0.5pt

$$2.64\text{ g } CuO_{(s)} \times \frac{\text{mol } CuO_{(s)}}{79.5\text{ g } CuO_{(s)}} \times \frac{\text{mol } O_{2(g)}}{4\text{ mol } CuO_{(s)}} \times \frac{32.0\text{ g } O_{2(g)}}{\text{mol } O_{2(g)}} = 0.266\text{ g } O_{2(g)}$$

0.5pt 0.5pt 0.5pt

+4pts ✓

+ 1pt – label w/ "g O_2"

(5 total for problem)

pg subtotal 25

10 possible

if all 3 stoichiometry answers are present (even if wrong) and are all presented with exactly 3 sig figs, award +2 extra credit

6) Barium Hydroxide will react with phosphoric acid in an acid-base reaction. Predict the products, then identify how many grams of each product is produced if 1 mol of $Ba(OH)_{2(s)}$ is reacted in an excess of $H_3PO_{4(aq)}$.

$Ba(OH)_{2(s)} + H_3PO_{4(aq)} \longrightarrow H_2O_{(l)} + Ba_3(PO_4)_2$ correct reaction = 2

$3\,Ba(OH)_{2(s)} + 2\,H_3PO_{4(aq)} \longrightarrow 6\,H_2O_{(l)} + Ba_3(PO_4)_2$ balanced = 2

$2\times1.0 + 16.0 = 18.0$ g/mol

$$1\text{ mol } Ba(OH)_{2(s)} \times \frac{6\text{ mol } H_2O_{(l)}}{3\text{ mol } Ba(OH)_2} \times \frac{18.0\text{ g } H_2O_{(l)}}{1\text{ mol } H_2O_{(l)}} = 36.0\text{ g } H_2O$$

answer = 2, label = 1

$3\times137.3 + 2\times31.0 + 8\times16.0 = 601.9$ g/mol

$$1\text{ mol } Ba(OH)_{2(s)} \times \frac{1\text{ mol } Ba_3(PO_4)_2}{3\text{ mol } Ba(OH)_2} \times \frac{601.9\text{ g } Ba_3(PO_4)_2}{\text{mol } Ba_3(PO_4)_2} = 201.\text{ g } Ba_3(PO_4)_2$$

answer = 2 label = 1

IV. CONCENTRATION AND DILUTION

2 → = 10 possible

1) What is the molarity of 1.0 mol NaCl dissolved in 1.0L of H_2O?

$$\text{Molarity} = \frac{\text{mol}}{\text{L}} = \frac{1.0\text{ mol NaCl}_{(aq)}}{1.0\text{ L } H_2O_{(l)}} = 1.0\text{M}$$ +2

2) What is the molarity of 100.g NaCl dissolved in 800mL H_2O?

$23.0 + 35.5 = 58.5$ g/mol

$$100.\text{ g NaCl} \times \frac{\text{mol NaCl}}{58.5\text{ g NaCl}} = 1.71\text{ mol NaCl}$$

H_2O: 800mL → .800L

$$M = \frac{\text{mol}}{\text{L}} = \frac{1.71\text{ mol NaCl}_{(aq)}}{.800\text{L } H_2O_{(l)}} = 2.14\text{M}$$ +2

3) What is the molality of 100.g $HC_2H_3O_2$ added to 500. mL of water?

$1.0 + 2\times12.0 + 3\times1.0 + 2\times16.0 = 60.0$ g/mol

$$100\text{g } HC_2H_3O_2 \times \frac{\text{mol } HC_2H_3O_2}{60.0\text{g } HC_2H_3O_2} = 1.67\text{ mol } HC_2H_3O_2$$

H_2O: 500mL = 500.g = .500kg

$$m = \frac{\text{mol solute}}{\text{kg solvent}} = \frac{1.67\text{M } HC_2H_3O_{2(aq)}}{.500\text{ kg } H_2O_{(l)}} = 3.34\text{m}$$ +3

4) If I begin with 3.0L of 5.0M NaCl, how much water must I add to obtain 2.0M NaCl?

$C_1V_1 = C_2V_2$ (also written $M_1V_1 = M_2V_2$ or $M_iV_i = M_fV_f$)

$(5.0\text{M})(3.0\text{L}) = (2.0\text{M})(V_2)$

$V_2 = 7.5$L +2 OR that 4.5L must be ADDED to properly dilute. +1 (3pts total)

IF SIG FIGS ARE PROPERLY USED ON ALL FOUR ANSWERS (2,3,3,2) AWARD 1 bonus point

pg subtotal /20

IV. SOLUTIONS AND COLLIGATIVE PROPERTIES

CIRCLE THE CORRECT ANSWER

multiple choice = 2pts each = 10 TOTAL

1) Describes the equilibrium point at which rate of dissolution is equal to rate of precipitation (usually in mol/kg)

A. Molality
B. Normality
C. Miscibility
D. Solubility

2) The scattering of light particles caused by colloids that tends to reflect blue better than other colors

A. Tyndall Effect
B. Cairn Principle
C. Crawford Phenomenon
D. Holdert's Diffraction

3) Used to measure the light absorbance of solutions

A. Spectrophotometer
B. Scanning Electron Microscope
C. Kinetoscope
D. Chromatographer

4) A solution with a much LOWER concentration than that of solution within a semi-permeable membrane (such as a cell)

A. Hypotonic
B. Supertonic
C. Hypertonic
D. Isotonic

5) The amount of light absorbed by a substance at a given wavelength is directly proportional to its concentration in a solution.

A. Crawford Phenomenon
B. Beer's Law
C. Raoult's Law
D. Henry's Law

worth 5pts

6) How many grams of $(NH_4)_3PO_4$ need to be added to 500. mL of H_2O so that the freezing point of the solution is lowered to –8.3° C? Assume that the ammonium phosphate completely dissociates. (K_f = 1.86° C/*m*)

$\Delta T = K_f m i$ (+1 partial... +0.5 if w/o i)

$8.3^\circ C = (1.86^\circ C/m) \times m \times 4$

$(NH_4)_3PO_4$

$14\times3+4\times3+31+4\times16 = 149.0\ g/mol$

$m = 1.12$ (+1 partial) $\rightarrow$ $\frac{1.12\ mol\ (NH_4)_3PO_4}{kg\ H_2O} \times 0.500 kg\ H_2O \times \frac{149\ g\ (NH_4)_3PO_4}{mol\ (NH_4)_3PO_4} = 83 g\ (NH_4)_3PO_4$

+5 if correct

(+1 bonus) if correct w/ 2 sig figs

☆ The answer of 370 g may be common as students forget the Vant Hoff Factor (i). This answer is worth 2.5/5 and IS eligible for the sigfig bonus pt.

pg subtotal /15

worth 5 pts

7) What is the osmotic pressure of a .50M solution of $Ca(NO_3)_2$ at 25 ºC in water? Assume i=3.0.
HINT: R= .08206 L atm/mol K

$\Pi = MRT\,i$ → +2 partial; +0.5 if no i

$\Pi = (.50\ \frac{mol}{L})(.08206\ \frac{L \cdot ATM}{MOL \cdot K})(298k)(3.0)$

$\Pi = 3.7\ ATM$ +5 if correct, (+1 bonus) if 2 sig figs

worth 5 pts

8) Given that you assumed i = 3.0, would you expect the actual osmotic pressure to be higher or lower than your calculation? Why?

$\Pi = MRT(i)$ ← increases in i increase Π

The actual osmotic pressure will be lower +2 because while the ideal Vant Hoff Factor for $Ca(NO_3)_{2(aq)} = 3.0$ it doesn't actually act as three totally independent ions in solution. Rather, the Ca^{2+} ions do weakly associate with the NO_3^- ions. +3 The actual Vant Hoff Factor is probably 2.1 - 2.7 ish.

V. CHEMICAL KINETICS

CIRCLE THE CORRECT ANSWER

MULTIPLE CHOICE = 2 pts each = 10 pts total

1) When a catalyst is added to a system at equilibrium, a decrease occurs in the

(A) activation energy
B) heat of reaction
C) potential energy of the reactants
D) rate constant
E) potential energy of the products

2) For the following reaction the rate of reaction can be properly stated as:
$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3\,(g)}$

A) $d[N_2]/dt$
B) $d[H_2]/dt$
C) $d[NH_3]/dt$
D) $3\ d[H_2]/dt$
(E) $2d[NH_3]/dt$

3) Using the reaction from problem #2, which is true?

A) $d[N_2]/dt = 3\ d[H_2]/dt$
B) $-d[N_2]/dt = +\ 1/3\ d[H_2]/dt$
C) $-2/3\ d[H_2]/dt = +\ d[NH_3]/dt$
(D) $-3\ d[H_2]/dt = +2\ d[NH_3]/dt$
E) $2/3\ d[H_2]/dt = +\ d[NH_3]/dt$

4) What is a heterogeneous catalyst?

A) a heat sensitive catalyst
(B) a catalyst in a different phase than the reactants
C) a pH dependent catalyst
D) a catalyst in the same phase as the reactants

5) Reaction speed increases when the surface area of a _____ reactant increases.

(A) solid
B) liquid
C) gas
D) solid or liquid
E) solid or gas
F) gas or liquid

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6) Given the following experimental data, find the rate law and the rate constant for the reaction:

out of 8

$$NO\,(g) + NO_2\,(g) + O_2\,(g) \rightarrow N_2O_5\,(g)$$

Run	$[NO]_o$, M	$[NO_2]_o$, M	$[O_2]_o$, M	Initial Rate, Ms^{-1}
1	0.10 M	0.10 M	0.10 M	2.1×10^{-2}
2	0.20 M	0.10 M	0.10 M	4.2×10^{-2}
3	0.20 M	0.30 M	0.20 M	1.26×10^{-1}
4	0.10 M	0.10 M	0.20 M	2.1×10^{-2}

$r = K[NO^-][NO_2]$ +3 $\rightarrow K = \dfrac{r}{[NO^-][NO_2]}$

value for K ...

$K = \dfrac{2.1 \times 10^{-2}}{[.1][.1]} = 2.1$ +2 partial

units for k ...

$K = \dfrac{mol/s \cdot \cancel{L}}{\cancel{mol/L} \cdot mol/L} = \dfrac{L}{mol \cdot s}$ +2 partial

$K = 2.1\ \dfrac{L}{mol \cdot s}$ +5

out of ~~7~~ 2

7) The half-life of a radioisotope is found to be 30 minutes. If the decay follows first order kinetics, what percentage of isotope will remain after 2.00 hours?

2 hrs = 4 half lives $\quad \dfrac{1}{2^4} = \dfrac{1}{16} = 6.25\%$ +2

out of 10

8) The mechanism of a reaction is shown below.

a) What is the overall reaction?
b) Which compounds are intermediates?
c) Predict the rate law based on this mechanism.
d) What is the overall order of the reaction?

$HOOH + I^- \rightarrow HOI + OH^-$	(slow)
$HOI + I^- \rightarrow I_2 + OH^-$	(fast)
$2OH^- + 2H_3O^+ \rightarrow 4\,H_2O$	(fast)

(A) $H_2O_2 + 2\,I^- + 2\,H_3O^+ \longrightarrow I_2 + 4\,H_2O$ +3

(or just $2\,H^+$) and $2\,H_2O$

(B) HOI, OH (x2) +1pt +1pt −1pt for extra answer ... not to score less than zero for part B though!

(C) $r = k[HOOH][I^-]$ +3

(D) 2ND ORDER +2

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