CHEM 1032
PRACTICE
UNIT ASSESSMENT 4

SECTION: _____

NAME: Key

TUID: | | | | | | | | | |

Before the Unit Assessment begins, read the rest of this page, and follow the instructions.

!!! Do not turn this page until given the signal to begin !!!

Put away everything besides pencil(s) and a scientific calculator.

- Non-programmable (scientific) calculators are permitted. Graphing calculators **are not permitted** (such as these models: TI-83, TI-84, TI-89, Casio FX-9750).
- Any other electronic devices - including cell phones, smart phones, and smart watches - **are not permitted**. If you are not sure what is permitted, ask *before* the exam begins.

When you are told to begin work, open the booklet and read the directions.

A periodic table and other useful information can be found on the next page.

Grading. Each question is graded by your instructor using the scale below.

1 - Excellent
- The student demonstrates a deep understanding of concepts and problem-solving techniques.
- Calculations are clear and legibly written.
- Any mistakes are minor or careless errors that do not indicate a major conceptual misunderstanding.

0.5 - Fair
- The student demonstrates a partial understanding of concepts and techniques.
- Calculations are clear and legibly written but contain errors.
  - The student may have started out correctly but gone on a tangent or not finished the problem.
  - The student may have used pattern matching to answer a different, more familiar question instead.

0 - Unsatisfactory/Incomplete
- The student did not demonstrate an understanding of the problem or has minimal understanding.
- Calculations are unclear, missing, or incomplete.
  - The student may have written some appropriate formulas or diagrams, but nothing further.
  - The student may have done something entirely wrong.
  - The student may have written almost nothing or nothing at all.

Unit Assessment Time: 50 minutes.
It is to your advantage to answer every question.

!!! Do not turn this page until given the signal to begin !!!

Units:

amu	*atomic mass unit*
atm	*atmosphere*
g	*gram*
h	*hour*
J	*joule*
K	*kelvin*
mmHg	*unit of pressure*
M	*molarity*
K	*kelvin*
L	*liter*
mol	*mole*
s	*second*

Symbols:

H	*enthalpy*
ν	*frequency*
M	*molar mass*
mol	*mole*
P	*pressure*
t	*time*
T	*temperature*
V	*volume*

Constants:

N_A	*Avogadro's number*
R	*ideal gas constant*

SI (Metric) Prefixes:

c	*centi-*
d	*deci-*
k	*kilo-*
m	*milli-*

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.008																		2 **He** 4.0026
3 **Li** 6.94	4 **Be** 9.0122												5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305												13 **Al** 26.982	14 **Si** 28.085	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078(4)		21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845(2)	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546(3)	30 **Zn** 65.38(2)	31 **Ga** 69.723	32 **Ge** 72.630(8)	33 **As** 74.922	34 **Se** 78.971(8)	35 **Br** 79.904	36 **Kr** 83.798(2)
37 **Rb** 85.468	38 **Sr** 87.62		39 **Y** 88.906	40 **Zr** 91.224(2)	41 **Nb** 92.906(2)	42 **Mo** 95.95	43 **Tc**	44 **Ru** 101.07(2)	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60(3)	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-70 *	71 **Lu** 174.97	72 **Hf** 178.49(2)	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23(2)	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po**	85 **At**	86 **Rn**
87 **Fr**	88 **Ra**	89-102 **	103 **Lr**	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**	110 **Ds**	111 **Rg**	112 **Cn**	113 **Nh**	114 **Fl**	115 **Mc**	116 **Lv**	117 **Ts**	118 **Og**

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [144.91]	62 **Sm** 150.36(2)	63 **Eu** 151.96	64 **Gd** 157.25(3)	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05
89 **Ac** [227.03]	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**

!!!! FOR CREDIT, BE CLEAR AND WRITE LEGIBLY !!!!

Cerium is a useful element because it can easily switch between Ce^{4+} and Ce^{3+}. However, cerium oxide (CeO_2) nanoparticles are incredibly dangerous if inhaled, causing oxidative stress in bronchial cells and causing damage to DNA in fibroblasts. Despite this, CeO_2 nanoparticles are commonly used in industrial applications and found in catalytic converters to decrease emission of NO_x gases.

A reaction of interest is of Ce^{3+} with Ag^+ to plate Ag, where the initial concentration of Ce^{3+} is 0.100 M.

$$Ce^{3+}_{(aq)} + Ag^{+}_{(aq)} \rightarrow Ce^{4+}_{(aq)} + Ag_{(s)}$$

$Ce^{3+} \rightarrow Ce^{4+}$ OX anode
1.70 V

Part I – Multiple Choice Questions (1 pt each)

Excellent Answer = 1 pt *Fair Answer = 0.5 pts* *Unsatisfactory Answer = 0 pts*

$Ag^+ \rightarrow Ag$ red cathode
0.80

$E^\circ_{cell} = E_{cath} - E_{anode}$
$= 0.80 - 1.70$
$= -0.90$ V
electrolytic because nonspontaneous

C 1. How would you best describe the cell?

A. Represents a galvanic cell, with an E°_{cell} of -0.90 V.
B. Represents a galvanic cell, with an E°_{cell} of +0.90 V.
C. Represents an electrolytic cell, with an E°_{cell} of -0.90 V.
D. Represents an electrolytic cell, with an E°_{cell} of +0.90 V.

C 2. What amperage (A) is required to plate 3.75 g of $Ag_{(s)}$ in 45 min?

A. 3.35 A
B. 2.70 A
C. 1.24 A
D. 74.5 A

$A = \frac{C}{s}$ $3.75\,g \left| \frac{1\ mole\ Ag}{107.87\ g\ Ag} \right| \frac{1\ mole\ e^-}{1\ mole\ Ag} \left| \frac{96485\ C}{1\ mole\ e^-} \right. = \frac{3354\ C}{2700\ s} = 1.24\ A$

$45\ min \left| \frac{60\ s}{1\ min} \right. = 2700\ s$

C 3. Which condition would require the least amount of external voltage to plate $Ag_{(s)}$?

A. 0.100 M Ce^{4+} and 0.001 M Ag^+
B. 0.100 M Ce^{4+} and 0.100 M Ag^+
C. 0.001 M Ce^{4+} and 0.100 M Ag^+
D. 1.000 M Ce^{4+} and 1.000 M Ag^+

Ce^{4+} product ↓ conc
Ag^+ reactant ↑ conc
→ will yield smallest Q

A 4. If the external voltage is set to exactly that required to plate Ag, will oxidation or reduction of water occur?

A. Yes, reduction of water will occur.
B. Yes, oxidation of water will occur.
C. Yes, oxidation and reduction of water will occur.
D. No, neither oxidation nor reduction of water will occur.

only reduction will occur

2 H2O (l) + 2 e- —> H2 (g) + 2 OH- (aq)

-0.80 V

D 5. After 652 s the $[Ce^{3+}]$ is measured to be 0.345 M. What is the average rate over this time?

A. The average rate is 3.76×10^{-4} M/s.
B. The average rate is 5.29×10^{-4} M/s
C. An error has occurred, no Ce^{3+} is present at the start of the reaction.
D. An error has occurred, the concentration at 652 s is not possible.

0.100 M
initial Ce^{3+} = ~~1.000 M~~
0.345 M is not possible

Part II – Open Answer Questions – *See Page 1 for full grading details*

Excellent Answer = 1 pt *Fair Answer = 0.5 pts* *Unsatisfactory Answer = 0 pts*

A second reaction of interest is of CeO_2 with divalent iron (Fe^{2+}) which was studied to understand the kinetics of the reaction. At 25 °C, the value of *k* for the reaction is 0.0507 s^{-1}.

$$CeO_{2\,(s)} + Fe^{2+}_{(aq)} \rightarrow Ce^{3+}_{(aq)} + Fe^{3+}_{(aq)}$$

Experiment	Initial [Fe^{2+}] (M)	Initial CeO_2 (g)	Initial Rate of Reaction (M/s)
1	1.5×10^{-5}	2.5	7.58×10^{-7}
2	1.5×10^{-5}	5.0	7.58×10^{-7}
3	3.0×10^{-5}	5.0	1.52×10^{-6}

6. Balance the redox reaction in acidic conditions.

Show your work in this box.

$1e^- + 4H^+ + CeO_2 \rightarrow Ce^{3+} + 2H_2O$

$Fe^{2+} \rightarrow Fe^{3+} + 1e^-$

$4H^+ + CeO_2 + Fe^{2+} \rightarrow Ce^{3+} + Fe^{3+} + 2H_2O$

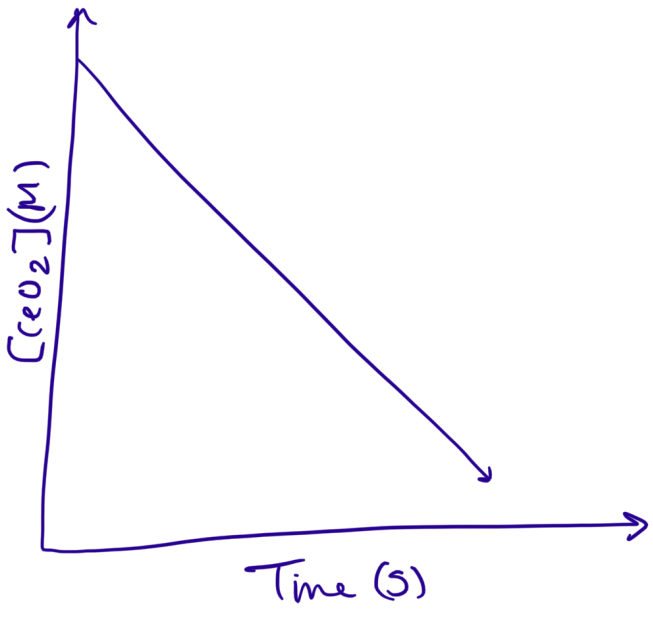
7. The reaction is 1st order with respect to Fe^{2+}. What is the order of CeO_2? Explain and sketch a graph of CeO_2 concentration vs time. *Be sure to label your axes.*

Determine order here…..

CeO_2 is 0th order. When doubling the conc of CeO_2 while keeping Fe^{2+} constant there is no change in rate.

Also, the value of k has units of first order, therefore only Fe^{2+} can affect rate

Sketch graph here….



8. Using Experiment 3, determine how long it would take for the concentration of Fe^{2+} to reach 1.5×10^{-5} M ?

Show your work in this box.

1st order

$\ln[A]_t = -kt + \ln[A]_0$

$\ln(1.5 \times 10^{-5}\ M) = -0.0507\ s^{-1}(t) + \ln(3.0 \times 10^{-5}\ M)$

$t = 13.7\ s$

or 1/2 life because

$\frac{1.5 \times 10^{-5}}{3.0 \times 10^{-5}} = 0.5$

$t_{1/2} = \frac{0.693}{0.0507\ s^{-1}} = 13.7\ s$

WRITE TIME HERE → 13.7 s

9. If the temperature of the reaction were doubled, how would you expect the **rate, rate constant,** and **reaction order** to change? Explain below.

Circle one: ***Rate Increases***	***Rate Stays the Same***	***Rate Decreases***
Circle one: ***Rate Constant Increases***	***Rate Constant Stays the Same***	***Rate Constant Decreases***
Circle one: ***Reaction Order Increases***	***Reaction Order Stays the Same***	***Reaction Order Decreases***

Explain here….

Both rate and rate constant are T dependent. As T increases the speed of the molecules increase and there is more Energy to get over activation energy barrier.

Reaction order does not change w/ T.

10. Compare Reaction 1 (Ce with Ag) and Reaction 2 (Ce with Fe), what is the relationship between the ΔG^o values?

Explain your answer….

R2 is spontaneous ($E^\circ_{cell} = 1.170\,V - 0.771\,V = 0.929\,V$) while R1 is nonspontaneous ($E = -0.96\,V$). So R2 ΔG° ⊖ and R1 ΔG° ⊕ thus...

CIRCLE THE CORRECT RELATIONSHIP→ $\Delta G^o_{R1} > \Delta G^o_{R2}$ *or* $\Delta G^o_{R1} = \Delta G^o_{R2}$ *or* $\Delta G^o_{R1} < \Delta G^o_{R2}$

END OF EXAM
!!! DON'T FORGET TO CHECK YOUR WORK !!!!

Useful information:

1 atm = 760 mmHg 1 mmHg = 1 torr 0 °C = 273 K

R = 8.314 J/(mol K) = 0.08206 (L atm)/(mol K)

$E_{cell} = E_{cathode} - E_{anode}$ $\Delta G° = -nFE^o_{cell}$ F = 96,485 C/mol e^-

$E^o_{cell} = \frac{0.0592\ V}{n} \log K$ (at T = 25 °C) $E_{cell} = E^o_{cell} - \frac{0.0592\ V}{n} \log Q$ (at T = 25 °C)

$[A] = -kt + [A]_o$ $t_{½} = \frac{[A]_o}{2k}$

$\ln[A]_t = -kt + \ln[A]_o$ $t_{½} = \frac{0.693}{k}$

$\frac{1}{[A]_t} = kt + \frac{1}{[A]_o}$ $t_{½} = \frac{1}{k[A]_o}$

$k = Ae^{-Ea/RT}$ $\ln k = -\frac{E_a}{R}\left(\frac{1}{T}\right) + \ln A$ $\ln\left(\frac{k_2}{k_1}\right) = -\frac{E_a}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$

Half-Reaction	***E*° (V)**
$F_2\,(g) + 2\ e^- \longrightarrow 2\ F^-\,(aq)$	+2.866
~~$Au^{3+}\,(aq) + 3e^- \longrightarrow Au\,(s)$~~ $Ce^{4+} + 1e^- \rightarrow Ce^{3+}$	~~+1.498~~ +1.70
$Cl_2\,(g) + 2\ e^- \longrightarrow 2\ Cl^-\,(aq)$	+1.35827
$O_2\,(g) + 4\ H^+\,(aq) + 4e^- \longrightarrow 2\ H_2O\,(l)$	+1.229
$Pt^{2+}\,(aq) + 2\ e^- \longrightarrow Pt\,(s)$	+1.20
$Br_2\,(aq) + 2e^- \longrightarrow 2\ Br^-\,(aq)$	+1.0873
$Ag^+\,(aq) + e^- \longrightarrow Ag\,(s)$	+0.7996
$Hg_2^{2+}\,(aq) + 2\ e^- \longrightarrow 2\ Hg\,(l)$	+0.7973
$Fe^{3+}\,(aq) + e^- \longrightarrow Fe^{2+}\,(aq)$	+0.771
$I_2\,(s) + 2\ e^- \longrightarrow 2\ I^-\,(aq)$	+0.5355
$Cu^{2+}\,(aq) + 2\ e^- \longrightarrow Cu\,(s)$	+0.34
$Sn^{4+}\,(aq) + 2\ e^- \longrightarrow Sn^{2+}\,(aq)$	+0.151
$2\ H^+\,(aq) + 2\ e^- \longrightarrow H_2\,(g)$	0.00
$Pb^{2+}\,(aq) + 2\ e^- \longrightarrow Pb\,(s)$	−0.1262
$Sn^{2+}\,(aq) + 2\ e^- \longrightarrow Sn\,(s)$	−0.1375
$Ni^{2+}\,(aq) + 2\ e^- \longrightarrow Ni\,(s)$	−0.257
$Co^{2+}\,(aq) + 2\ e^- \longrightarrow Co\,(s)$	−0.28
$Cd^{2+}\,(aq) + 2\ e^- \longrightarrow Cd\,(s)$	−0.4030
$Fe^{2+}\,(aq) + 2\ e^- \longrightarrow Fe\,(s)$	−0.447
$Cr^{3+}\,(aq) + 3\ e^- \longrightarrow Cr\,(s)$	−0.744
$Mn^{2+}\,(aq) + 2\ e^- \longrightarrow Mn\,(s)$	−1.185
$Zn^{2+}\,(aq) + 2\ e^- \longrightarrow Zn\,(s)$	−0.7618
$Al^{3+}\,(aq) + 3\ e^- \longrightarrow Al\,(s)$	−1.662
$Mg^{2+}\,(aq) + 2\ e^- \longrightarrow Mg\,(s)$	−2.372
$Na^+\,(aq) + e^- \longrightarrow Na\,(s)$	−2.71
$Ca^{2+}\,(aq) + 2\ e^- \longrightarrow Ca\,(s)$	−2.868
$Ba^{2+}\,(aq) + 2\ e^- \longrightarrow Ba\,(s)$	−2.912
$K^+\,(aq) + e^- \longrightarrow K\,(s)$	−2.931
$Li^+\,(aq) + e^- \longrightarrow Li\,(s)$	−3.04

2 H2O (l) + 2 e- —> H2 (g) + 2 OH- (aq) -0.80

USE THIS PAGE FOR SCRAP. IT WILL NOT BE GRADED.