Chem 150
Second Midterm exam
November 13, 2009
M. S. de Vries

____________________(1 point)
Name (Please Print)

____________________(1 point)
Perm #

c = 3 x 10^8 m/s
h = 6.626 x 10^{-34} J.s
N = 6.022 x 10^{23} mol^{-1}
F = 96,500 C/mol

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[1] Mark one answer (3 points each):

(a)  [] Random error decreases accuracy  
     [] Systematic error decreases precision  
     [X] Random error decreases precision  
     [] Systematic error increases accuracy

(b)  In an electrochemical cell **at equilibrium**  
     [] $E^o = 0$  
     [X] $E = 0$  
     [] $E = (0.05916/n) \log K$

(c)  In an atomic flame, which requires a more constant temperature?  
     [X] Emission spectroscopy  
     [] Absorption spectroscopy  
     [] It does not matter

(d)  A buffer functions optimally when:  
     [] pH = 7  
     [X] pH = pK$_a$  
     [] pH > pK$_a$  
     [] pH < pK$_a$

(e)  The equilibrium constant of a reaction depends on:  
     [] The concentrations of the reagents  
     [X] The temperature  
     [] The concentrations of the products  
     [] None of the above

(f)  When titrating a *strong acid* with a *strong base* the pH at the equivalence point will be:  
     
     pH = ____ 7 ____

(g)  Ag(s) | AgCl(s) | Cl$^{-}(aq)$ || can serve as a reference electrode:  
     {TRUE} {FALSE}

(h)  The redox potential of the standard hydrogen electrode is 0 Volt:  
     {TRUE} {FALSE}
[2] (5 points)

A buffer was prepared by dissolving 0.36 mol of the weak acid HA ($K_a = 1.0 \times 10^{-5}$) plus 0.036 mol of its conjugate base Na$^+$A$^{-}$ in 1.00 L. Find the pH.

\[ \text{pK}_a = -\log(1.0 \times 10^{-5}) = 5 \]

\[ \text{pH} = \text{pK}_a + \log \left( \frac{0.036}{0.36} \right) \]
\[ = 5 + (-1) = 4 \]

[3] (4 points each)

Consider the titration of the weak acid HA with NaOH.

(a) At what fraction of $V_e$ does pH equal $pK_a$?

[] 0.1
[X] 0.5
[] 1
[] 2

(b) At the equivalence point the pH is:

[] less than 7
[] equal 7
[X] more than 7
[] unpredictable
The sensitivity of a coulometer is governed by the delivery of its minimum current for its minimum time. Suppose that 9.65 mA can be delivered for 0.2 s.

(a) (5 points)
How many moles of electrons are delivered by 9.65 mA for 0.2 s?

\[ (9.65 \times 10^{-3} \text{ A})(0.2 \text{ sec})/(96500 \text{ C/mol}) = 2.00 \times 10^{-8} \text{ moles} \]

(b) (3 points)
How many moles of a two-electron reducing agent are required to deliver the same number of electrons?

1 mole of reducing agent for every 2 moles of electrons:

1.00 \times 10^{-8} \text{ moles}
A compound is dissolved in water. The absorbance at 340 nm is 0.0300 in a 2.00 cm cuvet. The molar absorptivity for this compound is $\varepsilon_{340} = 1.50 \times 10^4 \text{ M}^{-1}\text{cm}^{-1}$.

(a) (5 points)
What is the concentration, expressed as molarity?

Beer’s law
$A = \varepsilon bc$ or $c = A/\varepsilon b$

$c = 0.0300 / (1.50 \times 10^4)(2.00)$

$= 1.00 \times 10^{-6} \text{ mol/L}$

(b) (3 points)
The molar mass is 87.3 g/mol. What is the concentration in ppm?

$(87.3 \text{ g/mol}) (10^{-6} \text{ mol/L}) = 87.3 \times 10^{-6} \text{ g/L}$

$= 87.3 \mu\text{g/L}$

$= 8.73 \times 10^{-2} \text{ mg/L}$

$= 8.73 \times 10^{-2} \text{ ppm}$
[6] (3 points each)

A solution of the ion Fe(ferrozine)$_3^{4+}$ has a visible absorption maximum at 600 nm.

For light at the absorption maximum calculate:

(a) The frequency

\[ \nu = \frac{c}{\lambda} = \frac{3 \times 10^8 \text{ m/s}}{600 \times 10^{-9} \text{ m}} = 5 \times 10^{14} \text{ s}^{-1} \]

(b) The energy per photon in Joules

\[ E = h\nu = (6.626 \times 10^{-34} \text{ Js}) (5 \times 10^{14} \text{ s}^{-1}) = 3.3 \times 10^{-19} \text{ J} \]

(c) 600 nm light is red. What color do you expect the solution to have:

[X] blue-green

[ ] red

(d) The visible absorption is caused by:

[ ] Molecular vibrations

[X] Electronic excitations

[ ] Molecular rotations
[7] (3 points)

By how many volts will the potential of a Mg$^{2+}$ ion-selective electrode change if the electrode is removed from $1.00 \times 10^{-4} \text{ M MgCl}_2$ and placed in $1.00 \times 10^{-3} \text{ M MgCl}_2$?

- 0.0296
- 0.1
- 0.35
- 1
- 10
- 35

\[
E = k + \frac{0.05916}{n} \log [X]
\]

\[
E_2 - E_1 = \frac{0.05916}{2} \log \frac{[X_2]}{[X_1]}
\]

\[= (0.0296) (1)\]

[Bonus] (3 points)

CO$_2$ is a greenhouse gas because it absorbs heat radiation from the earth. Which is a true statement:

- CO$_2$ absorbs visible light but not IR radiation
- [X] CO$_2$ absorbs IR radiation but not visible light
- CO$_2$ never absorbs any radiation.
- CO$_2$ absorbs both visible light and IR radiation
- none of the above