Summer 2006 Chemistry Practice103 final

Carbonic acid, H_2CO_3 (aq), is diprotic.

H_2CO_3 (aq) $=$ H^+(aq) $+ HCO_3^-$ (aq) $Ka_1 = 4.2$ x 10^{-7}

HCO_3^-(aq) $=$ H^+(aq) $+ CO_3^{2-}$(aq) $Ka_2 = 4.8$ x 10^{-11}
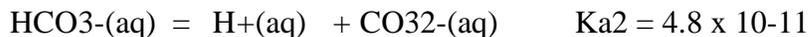
Aqueous solutions saturated with CO_2 contain $[H_2CO_3] = 0.05M$.

Ksp value: $FeCO_3$ 3.5 x 10^{-11}

1.1†
1 What is the $[HCO_3^-]$ at a pH of 6.5 in a solution saturated with CO_2 ?

1.2 What is the $[CO_3^{2-}]$ in the solution in 1.1 ?

1.3 What is the solubility of $FeCO_3$ in a solution of pH=6.5 that is saturated with CO_2 ?

2. Calculate the pH of the following solutions.

2.1 A mixture of 30.0 mL of 0.250M sulfuric acid, H_2SO_4, a strong diprotic acid, with 76.0 mL of 0.350M KOH, a strong base.

2.2 A 0.010M solution of pyridine (call it py) a weak base with $Kb = 1.5$ x 10^{-9} .

3.1 Use the data given below to estimate the equilibrium constant for the oxidation of sulfur dioxide to sulfur trioxide under standard conditions (1 atm, 298K): $2 SO_2(g) +$ $O_2(g)$ $=$ $2SO_3(g)$

Substance	$SO_2(g)$	$O_2(g)$	$SO_3(g)$
of/kJ/mol	-296.8	0	-395
So/J/molK	248.2	110.9	256.8

3.2 Use the same data to estimate the equilibrium constant for the process at 555K.

3.3 Explain how you would use your results in 3.1 and 3.2 to design a commercial process for producing sulfur trioxide from sulfur dioxide and oxygen. Why might this process be of commercial importance?

4. Phosphorous acid, H_3PO_3 is diprotic. $Ka_1 = 5.0$ x 10^{-2}; $Ka_2 = 2.0$ x 10^{-7}. The bottles on your laboratory shelf contain pure phosphorous acid (molar mass 82.0 g/mol); solid potassium phosphite, $K H_2PO_3$ (molar mass 120.0 g/mol); and solid dipotassium phosphite, K_2HPO_3 (molar mass 158g/mol). You also have available 2 liters of a 0.250M KOH solution, a balance, and plenty of laboratory glassware but, alas, no pH meter.

4.1 Explain, and use precise quantities, how you would prepare 0.500 L of a pH = 6.90 buffer that is 0.35M in phosphorus compounds from these materials.

4.2 To 0.200 L of the buffer you prepared in 4.1 you add 10.0 mL of the 0.250M KOH solution. Calculate the new pH of this mixture.

5.1 A standard hydrogen electrode (SHE) and a silver wire are dipped into a saturated aqueous solution of silver sulfate, Ag_2SO_4 at 298K. Ksp for silver sulfate = 1.2 x 10-5

$Ag^+(aq) + e^- = Ag(s)$ $E_o = 0.800V$; $2H^+(aq) + 2e^- = H_2(g)$ $E_o = 0.000V$
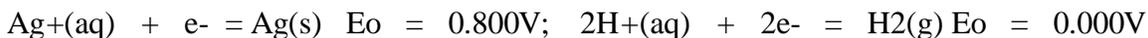
Calculate the potential for this cell.

5.2 Sketch the cell indicating the anode, the cathode , and the direction of electron flow in it.

5.3 Calculate the current in amperes needed to plate 3.5g of silver per hour on to your heirloom candlesticks from a silver nitrate, $AgNO_3$, solution. The atomic mass of silver is 108g/mol.

6.1 Calculate the binding energy in J/nucleon of U-238, of nuclear mass 238.0508 amu.

6.2 The half-life of sodium-24, an isotope used in research medicine, is 15.0 h. A saline solution containing 25 micrograms of Na-24 is injected into a research subject. If the lowest detection level for Na-24 is 1.0 micrograms, how long can the radioactivity due to this isotope be studied in this research subject?

6.3 Explain why both fission processes of heavy nuclei and fusion processes of light nuclei can be used in principle to generate energy.

FOR EACH PART CIRCLE THE LETTER OF THE BEST ANSWER

7.1 The rating of the ability of a gasoline to burn smoothly in an internal combustion is its
a. boiling point.
b. energy value.
c. fuel density.
d. molar mass.
e. octane rating.

7.2 The process of fractional distillation is used to
a. break large molecules in a mixture into smaller ones, and completely separate them.
b. break large molecules in a mixture into smaller ones, and partially separate them.
c. completely separate the many components of a complex mixture.
d. partially separate the many components of a complex mixture.
e. separate the two components of a simple mixture.

7.3 Which of these pollutants are associated with gasoline and its combustion?
    a. carbon monoxide
    b. nitrogen oxides
    c. ozone
    d. hydrocarbons
    e. all of the above

7.4 One fuel (A) has a higher fuel value than another (B). If samples of A and B yield the same amount of energy on combustion, then the sample of A must _____ than the sample of B.
a. weigh less
b. have a smaller volume
c. cost less
d. cost more
e. weigh more

7.5 Greenhouse gases in the atmosphere contribute to global warming mainly by
a. absorbing ultraviolet light energy from the sun and emitting it as infrared radiation.
b. absorbing ultraviolet light energy from the sun and storing it as molecular vibrations.
c. absorbing infrared light energy from the sun and storing it as molecular vibrations.
d. absorbing ultraviolet light energy from the earth and storing it as molecular vibrations.
e. absorbing infrared light energy from the earth and storing it as molecular vibrations.

7.6 In high density polyethylene, the polymer chains are _____ ; in low density polyethylene, the polymer chains are _____ .
   a. unbranched; cross-linked
    b. branched; cross-linked
    c. unbranched; branched
    d. branched; unbranched
    e. cross-linked; branched

7.7 The monomers used to produce addition polymers must contain _____ in their molecular structure.
a. sulfur atoms
b. double bonds
c. benzene rings
d. branched carbon chains
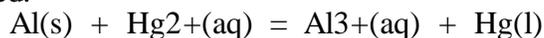e. two or more different functional groups

8. Short answers for 8.1 ñ 8.5; circle correct answer(s); no explanation required

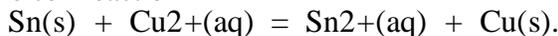8.1 In the following (unbalanced) redox reaction which atom(s) undergo reduction?

K_2CrO_4 + KI + HCl = $CrCl_3$ + KIO_2 + H_2O
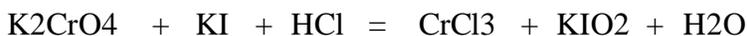
K   Cr   O   I   H   Cl

8.2 When the reaction shown below is balanced, the coefficients are _____, and _____ electrons are transferred.

$$Al(s) + Hg2+(aq) = Al3+(aq) + Hg(l)$$

a. 1, 3, 1, and 3; 6
b. 2, 3, 2, and 3; 6
c. 3, 2, 3, and 2; 6
d. 2, 3, 2, and 3; 12
e. 3, 2, 3, and 2; 12

8.3 Consider the cell reaction

$$Sn(s) + Cu2+(aq) = Sn2+(aq) + Cu(s).$$

The value of Eocell is 0.447 V at 25(C. Calculate the value of (G(and K for this cell.
a. -86.3 kJ; 1.34 (1015
b. -43.1 kJ; 1.37 (1043
c. 43.1 kJ; 3.55 (107
d. 86.3 kJ; 7.92 (10-16
e. 86.3 kJ; 2.00 (1086

8.4 The value of Ecell at 25oC for the cell shown below is +1.27 V. What is the value of Eocell?

$$Cd(s) | Cd2+(aq), 2.0 M || Ag+(aq), 2.0 M | Ag(s)$$

a. 1.57 V
b. 1.28 V
c. 1.26 V
d. 1.23 V
e. 0.97 V

. 8.5 An electrolytic reaction is a system in which
a. the reaction conditions are manipulated to change the value of Eocell to a favorable one.
b. a reactant-favored reaction is forced to produce electricity by the input of heat or light.
c. the same element is both oxidized and reduced.
d. electricity is used to produce a chemical reaction.
e. a chemical reaction is used to produce electricity.