Chemistry 4B, Exam II Name _____

March 5, 2018 SID _____

Professor R.J. Saykally TA _____

1. (20) _____
2. (10) _____
3. (15) _____
4. (20) _____
5. (10) _____
6. (10) _____
7. (15) _____

TOTAL EXAM SCORE (100) _____

Rules:

1. Work all problems to ***3 significant figures***
2. No lecture notes or books permitted
3. No word processing calculators (including graphing calculators) or cell phones
4. Time: 50 minutes
5. Physical Constants and Conversion Factors, Masses of Select Elementary Particles, and Standard Reduction Potentials included
6. **Show all work for full credit and partial credit**

1. (20 points) A galvanic cell is constructed that carries out the reaction

$$Pb^{2+}(aq) + 2\ Cr^{2+}(aq) \rightarrow Pb(s) + 2\ Cr^{3+}(aq)$$

The initial concentration of $Pb^{2+}(aq)$ is 0.25 M, that of $Cr^{2+}(aq)$ is 0.30 M, and that of $Cr^{3+}(aq)$ is 0.0030 M and T = 25°C.

(a) Calculate the standard cell potential.

(b) Calculate the initial cell voltage, in units of mV.

(c) What is the maximum electrical work this cell can do, in units of kJ?

(d) Calculate the equilibrium constant for the overall cell reaction.

2. (10 points) Consider the fuel cell that accomplishes the overall reaction

$$CO\,(g) + \tfrac{1}{2}\,O_2\,(g) \rightarrow CO_2\,(g)$$

$$\Delta G^\circ = -257.21 \text{ kJ/mol}$$

If the fuel cell operates with 64% efficiency, calculate the amount of electrical work generated *per gram* of CO_2 produced. The gas pressures are constant at 1 atm, and the temperature is 25°C.

3. (15 points) A 0.100 M neutral aqueous $CaCl_2$ solution is electrolyzed using platinum electrodes at 298 K. A current of 1.50 A passes through the solution for 50.0 hours.

(a) Write the half-reactions occurring at the anode and at the cathode.

(b) What is the decomposition potential?

(c) Calculate the mass, in grams, of the product formed at the cathode.

4. (20 points) Strontium-90 is one of the most hazardous products of nuclear weapons testing because of its long half-life ($t_{1/2}$ = 28.1 years) and its tendency to accumulate in bone.

(a) Write nuclear equations for the decay of ^{90}Sr via the successive emission of two β^- particles.

(b) The atomic mass of ^{90}Sr is 89.9073 u and that of ^{90}Zr is 89.9043 u. Calculate the energy released per ^{90}Sr atom in decaying to ^{90}Zr in MeV.

(c) What will be the initial activity of 1.0 g of ^{90}Sr released into the environment, in Bq?

(d) What activity, in Bq, will the material from part (c) show after 100 years?

5. (10 points) The specific activity of ^{14}C in the biosphere is 0.255 Bq g^{-1}. What is the age, in years, of a piece of papyrus from an Egyptian tomb if its beta counting rate is 0.153 Bq g^{-1}? The half-life of ^{14}C is 5730 years.

6. (10 points) Complete and balance the following equations for nuclear reactions that are thought to take place in stars:

(a)

$$2\ {}^{12}_{6}\mathrm{C} \rightarrow ?\ + {}^{1}_{0}\mathrm{n}$$

(b)

$$? + {}^{1}_{1}\mathrm{H} \rightarrow {}^{12}_{6}\mathrm{C} + {}^{4}_{2}\mathrm{He}$$

7. (15 points)

(a) Explain why elements heavier than ^{56}Fe are not synthesized in normal stars.

(b) Write the net equation for the fusion reaction that powers our sun.

(c) Write out the p-p chain mechanism for this net fusion process.