1 \( \mathcal{F} = 96,500 \text{ C/mol} = 96,500 \text{ J/V} \cdot \text{mol} \)

Multiple Choice (5 points each. Put answers in CAPS in the left margin.)

1. Iron objects such as storage tanks and underground pipelines can be protected from corrosion by connecting them through a wire to a piece of: (Use table on back page. See discussion problem 3.)
   a) Ag   b) Al   c) Cu   d) Ni

2. The oxidation number of chromium in \( \text{H}_2\text{Cr}_2\text{O}_7 \) is:
   a) +6   b) +4   c) +2   d) -2   e) -4

3. In the following reaction which is the reducing agent?
   \( \text{AgNO}_3\text{(aq)} + \text{NaCl}(aq) \longrightarrow \text{AgCl(s)} + \text{NaNO}_3\text{(aq)} \)
   a) \( \text{AgNO}_3 \)   b) \( \text{NaCl} \)   c) \( \text{NO}_3^- \)   d) \( \text{Cl}^- \)   e) None of the above

4. Carbon-11 is a radioactive isotope of carbon with a half-life of 20 min. What fraction of the initial number of \( ^{11}\text{C} \) atoms will remain after 80 min?
   a) \( \frac{1}{2} \)   b) \( \frac{1}{4} \)   c) \( \frac{1}{8} \)   d) \( \frac{1}{16} \)   e) \( \frac{1}{32} \)

5. Which of the following nuclei will probably be least stable?
   a) \( ^{12}\text{C} \)   b) \( ^{11}\text{B} \)   c) \( ^{23}\text{Na} \)   d) \( ^{40}\text{Ca} \)   e) \( ^{30}\text{P} \)

6. Which of the following is false?
   a) Protons are a type of nucleon.
   b) Alpha particle emission tends to be a high energy process.
   c) The externally induced conversion of one nucleus into another is called nuclear transmutation.
   d) For light nuclei \((Z \leq 20)\), the optimum neutron-to-proton ratio is about 1:1.
   e) All isotopes of technicium and promethium are radioactive.

7. A saturated solution of lanthanum fluoride, \( \text{LaF}_3 \), \( 9.3 \times 10^{-6} \text{ M} \). What is its solubility product constant?
   a) \( 9 \times 10^{-11} \)   b) \( 3 \times 10^{-15} \)   c) \( 2 \times 10^{-19} \)   d) \( 7 \times 10^{-21} \)   e) \( 4 \times 10^{-24} \)
8. A certain chemical reaction has $\Delta H = 89 \text{ kJ/mol}$ and $\Delta S = -55 \text{ J/mol}\cdot\text{K}$. When does this reaction proceed spontaneously?

a) The reaction is always spontaneous.
b) The reaction is spontaneous only at high temperatures.
c) The reaction is spontaneous only at low temperatures.
d) The reaction is never spontaneous.

Discussion Questions (You must show your work to receive credit.):

1. Define: (16 points)
   
anode –
   
voltaic cell –
   
radioactive –
   
nuclear transmutation –

2. Balance the following equation in basic solution by any method you choose. Show and label the balanced half-reactions in either acid or basic solution. (12 points, partial credit for balancing in acidic solution)

   \[ \text{CrO}_2^{2-}(aq) + \text{ClO}^-(aq) \rightarrow \text{Cl}^- (aq) + \text{CrO}_4^{2-}(aq) \]

3. For the elements in Multiple Choice question 1: (i) write out the electrochemical cell that would yield the greatest favorable cell potential, (ii) calculate $E^\circ_{\text{cell}}$ for it, and (iii) calculate $\Delta G^\circ$ for this potential. (10 points)
4. Calculate the binding energy for $^{37}$Cl. (nuclear mass = 36.956576 amu, $^1p =$ 1.00728 amu, $^1n =$ 1.00867 amu) (5 points)

5. A sample of curium-243 was prepared. After 1.00 yr the activity of the sample had declined from 3012 disintegrations per second to 2921 disintegrations per second. What is the half-life of the process? (5 points)

6. Complete the following (8 points)
   i) Write out a balanced equation for polonium-207 undergoes positron emission.

   ii) Complete the following equation: $^{246}$Cm + $^{12}$C → $^4$1n +

7. Explain how the entropy increase in a compound on going from a solid at 0 K to a gas on slow heating is manifested. (5 points)

8. Provide the physical reason why one can ignore the ionization of a weak acid when calculating the pH of a buffer solution. That is, in a typical calculation you will have “[HA] + x” as one of the terms in the calculation for a weak acid problem and then neglect the x under normal circumstances. Why do you not worry about x in a buffer problem? (5 points)