SIC 102
Exam III

1. Hydrogen peroxide reacts with iodine to form water and iodate in the following unbalanced reaction:

$$H_2O_2(aq) + I_2(aq) \rightarrow H_2O(l) + IO_3^-(aq)$$

a) Assign oxidation states to all atoms.

b) Identify which atom is getting oxidized and which atom is getting reduced.

c) Using the method of half-reactions, balance this chemical equation.

d) What volume of 0.050 <u>M</u> $H_2O_2(aq)$ is required to produce 0.75 mol of $IO_3^-(aq)$?

2. Darmstadtium was first synthesized at the Heavy Ion Research Center at Darmstadt in southern Germany in 1994. Darmstadtium-269 was synthesized by the nuclear fusion of lead-208 and nickel-62. The half-life of ^{269}Ds is 270 ms.

a) Write a balanced equation for the nuclear reaction that produces $^{269}_{110}\mathrm{Ds}$. What additional particle is produced?

b) The unstable ^{269}Ds undergoes a series of three alpha decays and then a beta decay. Write balanced nuclear reactions for this decay series.

c) Suppose that 1.21 μg of ^{269}Ds are synthesized. How much darmstadtium-269 is left after one second (1000 ms)?

3. The following table is the activity series from the textbook:

a) Are the following reactions spontaneous?

i) $Al^{3+} + Cr \rightarrow Al + Cr^{3+}$

ii) $2Li + Cu^{2+} \rightarrow 2Li^{+} + Cu$

iii) $Zn^{2+} + Mn \rightarrow Zn + Mn^{2+}$

b) Does magnesium dissolve in acid? Explain.

TABLE 16.1

Activity Series of Metals

$Li(s) \rightarrow Li^{+}(aq) + e^{-}$
$K(s) \rightarrow K^{+}(aq) + e^{-}$
$Ca(s) \rightarrow Ca^{2+}(aq) + 2\,e^{-}$
$Na(s) \rightarrow Na^{+}(aq) + e^{-}$
$Mg(s) \rightarrow Mg^{2+}(aq) + 2\,e^{-}$
$Al(s) \rightarrow Al^{3+}(aq) + 3\,e^{-}$
$Mn(s) \rightarrow Mn^{2+}(aq) + 2\,e^{-}$
$Zn(s) \rightarrow Zn^{2+}(aq) + 2\,e^{-}$
$Cr(s) \rightarrow Cr^{3+}(aq) + 3\,e^{-}$
$Fe(s) \rightarrow Fe^{2+}(aq) + 2\,e^{-}$
$Ni(s) \rightarrow Ni^{2+}(aq) + 2\,e^{-}$
$Sn(s) \rightarrow Sn^{2+}(aq) + 2\,e^{-}$
$Pb(s) \rightarrow Pb^{2+}(aq) + 2\,e^{-}$
$\mathbf{H_2}(g) \rightarrow \mathbf{2H^{+}}(aq) + \mathbf{2e^{-}}$
$Cu(s) \rightarrow Cu^{2+}(aq) + 2\,e^{-}$
$Ag(s) \rightarrow Ag^{+}(aq) + e^{-}$
$Au(s) \rightarrow Au^{3+}(aq) + 3\,e^{-}$

c) Write a balanced chemical equation for the dissolution of magnesium in acid.

d) What mass of magnesium can dissolve in 250.0 mL of 12.1 M HCl?

4. Bromate reacts with hydrazine to produce bromide and nitrogen:

$$BrO_3^-(aq) + N_2H_4(aq) \rightarrow Br^-(aq) + N_2(g)$$

a) Assign oxidation states to all atoms in this reaction.

b) Which reagent is the oxidizing agent? Which reagent is the reducing agent?

c) Using the method of half-reactions, balance this chemical equation.

d) What volume of 0.10 <u>M</u> bromate solution is necessary to react completely with 20.1 g of $N_2H_4(aq)$?

5. Chrome plating is an electrochemical process that deposits solid chromium on metallic objects to improve their appearance and increase their resistance to corrosion. The source of chromium is typically a chromium (VI) compound.

a) Suppose chromate (CrO_4^{2-}) is reduced completely to chromium metal. Write a balanced half-reaction for this process.

b) When an automobile fender is chrome plated, 270 g of chromium are deposited on the fender. How many moles of electrons are required in this process?

c) Suppose the electrochemical cell for this process can supply 100 amps (100 coulombs / second) of current. There are 96,485 coulombs / mol e^-. How long does it take to chrome plate the fender?

6. Marie Curie received the Nobel Prize in chemistry in 1911 for her discovery of the elements radium and polonium. Radium-226 is naturally occurring, albeit very active. Purified radium samples are literally so radioactive that they glow. The half-life of radium-226 is 1,622 years.

a) Radium-226 decays to radon-222. Write a balanced nuclear equation for this process. What additional particle is produced?

b) How long does it take for 99% of a sample of radium-226 to decay? This illustrates the problem of waste generated by nuclear processes; even a fairly active nuclide persists for a long time.

For the following questions, circle the letter that corresponds to the best answer.

7. How many neutrons, protons, and electrons are in tungsten-184?

A) 110 neutrons, 74 protons, 110 electrons
B) 74 neutrons, 184 protons, 184 electrons
C) 184 neutrons, 74 protons, 74 electrons
D) 110 neutrons, 74 protons, 74 electrons
E) 110 neutrons, 74 protons, 184 electrons

8. The following observations are made in the laboratory:

$Cd(s) + Ni^{2+}(aq) \rightarrow Cd^{2+}(aq) + Ni(s)$ spontaneous
$Cd(s) + Fe^{2+}(aq) \rightarrow Cd^{2+}(aq) + Fe(s)$ not spontaneous
$Fe(s) + Ni^{2+}(aq) \rightarrow Fe^{2+}(aq) + Ni(s)$ spontaneous

Which of the following is true about the relative reactivities of cadmium, nickel, and iron metal?

A) $Ni(s) > Cd(s) > Fe(s)$
B) $Fe(s) > Cd(s) > Ni(s)$
C) $Cd(s) > Ni(s) > Fe(s)$
D) $Ni(s) > Fe(s) > Cd(s)$
E) $Fe(s) > Ni(s) > Cd(s)$

9. Addition of a neutron to thorium-233 can induce fission to strontium-89, tellurium-141, and another particle(s):

$$ {}^{1}_{0}n + {}^{233}_{90}Th \rightarrow {}^{89}_{38}Sr + {}^{141}_{52}Te + ? $$

What is the other particle(s)?

A) ${}^{4}_{2}He$
B) $3\ {}^{1}_{0}n$
C) $4\ {}^{1}_{0}n$
D) $4\ {}^{1}_{1}p$
E) ${}^{3}_{2}He$

10. Which of the following statements are *true* about oxidation-reduction reactions?

I. Oxidation is a loss of electrons
II. An oxidizing agent loses electrons
III. The oxidation state of a reducing agent will decrease
IV. A reducing agent gets reduced
V. Reduction is a loss of electrons

A) **I** and **III**
B) **II** and **IV**
C) **II**, **IV**, and **V**
D) **I**, **III**, and **IV**
E) **I** only

11. An artifact contains 25.0% of the amount of ^{14}C present in living things. The half-life of ^{14}C is 5,730 years. How old is the artifact?

A) 1,432 years
B) 2,865 years
C) 11,460 years
D) 17,190 years
E) 22,920 years

Equations for radioactive decay

$$N = N_0 \, e^{-(\ln 2)\frac{t}{t_{1/2}}}$$

$$\ln\left(\frac{N}{N_0}\right) = -(\ln 2)\frac{t}{t_{1/2}}$$