CHM 102
Exam III

1. In aqueous solution, dithionite reacts with bismuth (III) to produce sulfite and bismuth metal:

$$S_2O_4^{2-}\,(aq) + Bi^{3+}(aq) \;\rightarrow\; SO_3^{2-}\,(aq) + Bi(s)$$

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

b) Which reagent reacts as an oxidizing agent? Which reagent reacts as a reducing agent?

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

d) What volume of 0.10 $\underline{M}$ $S_2O_4^{2-}\,(aq)$ is required to make 50.0 g of Bi(s)?

2. Nobelium-259 was first discovered in 1965, and is most conveniently synthesized by the nuclear fusion of neon-22 nuclei with uranium-238.

a) Write a balanced nuclear equation for the formation of ^{259}No. What other particle is produced?

b) Nobelium-259 decays to fermium-255 with a half-life of 58 minutes. Write a balanced nuclear equation for this process. What form of radioactive decay is this?

c) How long does it take for a 99% of a sample of 1.0×10^{-6} g of ^{259}No to decay?

3. One of the steps in the industrial synthesis of nitric acid is the reaction of ammonia with oxygen to form nitric oxide and water:

$$NH_3(g) + O_2(g) \rightarrow NO(g) + H_2O(g)$$
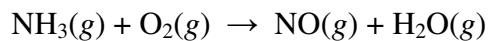
a) Assign oxidation states to all atoms in this reaction.

b) Which atom is getting oxidized? Which atom is getting reduced?

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

d) A standard DOT 105J series rail car full of ammonia contains 33,500 gallons (1.27×10^5 L). How many moles of oxygen are required to completely react with this quantity of ammonia? The density of liquid ammonia is 0.6818 g / mL.

4. Explain the following phenomena:

a) Permanganate (MnO_4^-) is a common strong oxidizing agent, but manganese in permanganate is never oxidized.

b) A source of gamma radiation is more dangerous than a source of alpha radiation, despite the fact that an alpha particle can cause more molecular damage than a gamma ray.

c) The molar mass of a natural sample of bromine is about 80 g / mol, but bromine has no naturally occurring isotope of mass number 80.
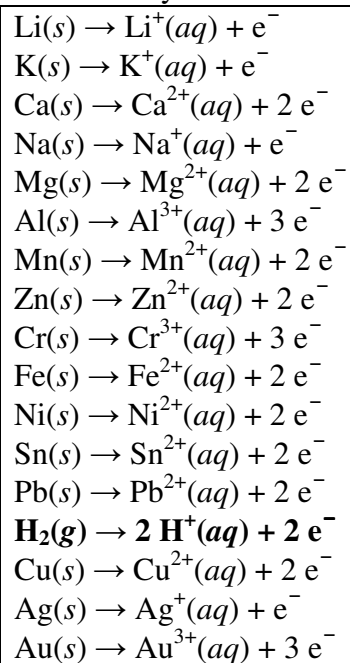
5. For this problem, refer to the activity series at the right:

a) Are the following reactions spontaneous?

i) $Sn + Cu^{2+} \rightarrow Sn^{2+} + Cu$

ii) $Li^+ + Ag \rightarrow Li + Ag^+$

iii) $Ni^{2+} + Fe \rightarrow Ni + Fe^{2+}$
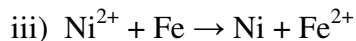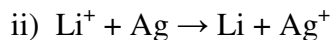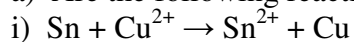
b) Suppose you were choosing materials for a chemical plant. Would you pick copper or steel pipe for a process that runs under acidic conditions? Explain.

The Activity Series

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

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

d) How many moles of HCl are required to dissolve 100.0 g of Zn?

For the remaining questions, choose the letter that corresponds to the best answer.

6. Which of the following are oxidation-reduction reactions?

I. $PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$
II. $Cu(s) + 2\ AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2\ Ag(s)$
III. $CO_2(g) + 2\ LiOH(s) \rightarrow Li_2CO_3(s) + H_2O(l)$
IV. $2\ HCl(aq) + 2\ Na_2CrO_4(aq) \rightarrow Na_2Cr_2O_7(aq) + 2\ NaCl(aq) + H_2O(l)$
V. $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$

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

7. How many neutrons, protons, and electrons are in an atom of platinum-195?

      (A)   78 neutrons, 78 protons, 195 electrons
      (B)   78 neutrons, 78 protons, 117 electrons
      (C)   117 neutrons, 78 protons, 195 electrons
      (D)   117 neutrons, 78 protons, 78 electrons
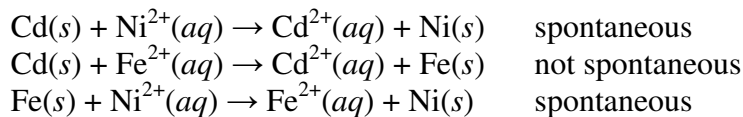   (E)   195 neutrons, 78 protons, 78 electrons

8. Astatine-217 is unstable and undergoes the following series of decays: α, β, α, β. What nucleus is formed at the end of this decay series?

      (A) $^{209}_{79}Au$

      (B) $^{207}_{81}Tl$

      (C) $^{209}_{81}Tl$

      (D) $^{207}_{82}Pb$

      (E) $^{209}_{83}Bi$

9. Tritium has a half-life of 12.3 years. How long does it take for a 48 g sample of tritium to decay to 6.0 g?

      (A)   12 years
      (B)   21 years
   (C)   25 years
      (D)   37 years
      (E)   49 years

10. The following observations are made in the laboratory:

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

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

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

11. Strontium-90 is an unstable nuclide produced in nuclear fallout that is dangerous because it can replace calcium in the bones. It is consumed by the following process:

$$^{90}_{38}Sr \rightarrow ^{0}_{-1}e + ^{90}_{39}Y$$
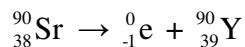
What is this process an example of?

(A) fission
(B) positron emission
(C) α decay
(D) β decay
(E) γ decay

12. Which of the following statements are *false* about oxidation-reduction reactions?

I.   Oxidation is a loss of electrons.
II.   An oxidizing agent loses electrons.
III.   The oxidation state of an oxidizing agent will increase.
IV.   A reducing agent gets reduced.
V.   An atom undergoing reduction will have a decrease in oxidation state.

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

13. The nuclide $^{232}_{90}$Th is radioactive. When one of these atoms decays, a series of α and β emissions occur, taking the atom through many transformation to end up as an atom of $^{208}_{82}$Pb. How many α particles are emitted in converting $^{232}_{90}$Th to $^{208}_{82}$Pb ?

      (A)   6
      (B)   8
      (C)   2
      (D)   214
      (E)   4

14. In the following reaction, what is oxidized and what is reduced?

   3 CoSO$_4$(aq) + 5 KI(aq) + KIO$_3$(aq) + 3 H$_2$O(l) → 3 Co(OH)$_2$(s) + 3 K$_2$SO$_4$(aq) + 3 I$_2$(aq)
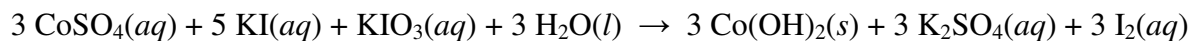
      (A)   Co^{2+} is oxidized and the I in IO$_3^-$ is reduced.

      (B)   I$^-$ is oxidized and the I in IO$_3^-$ is reduced.

      (C)   I in IO$_3^-$ is oxidized and H$_2$O is reduced.

      (D)   I$^-$ is oxidized and Co^{2+} is reduced.

      (E)   None of these are correct.

15. An artifact contains 12.5% 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)   1,910 years
      (B)   2,865 years
      (C)   11,460 years
      (D)   17,190 years
      (E)   22,920 years

Equations for radioactive decay

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

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