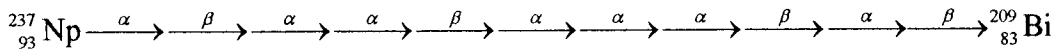
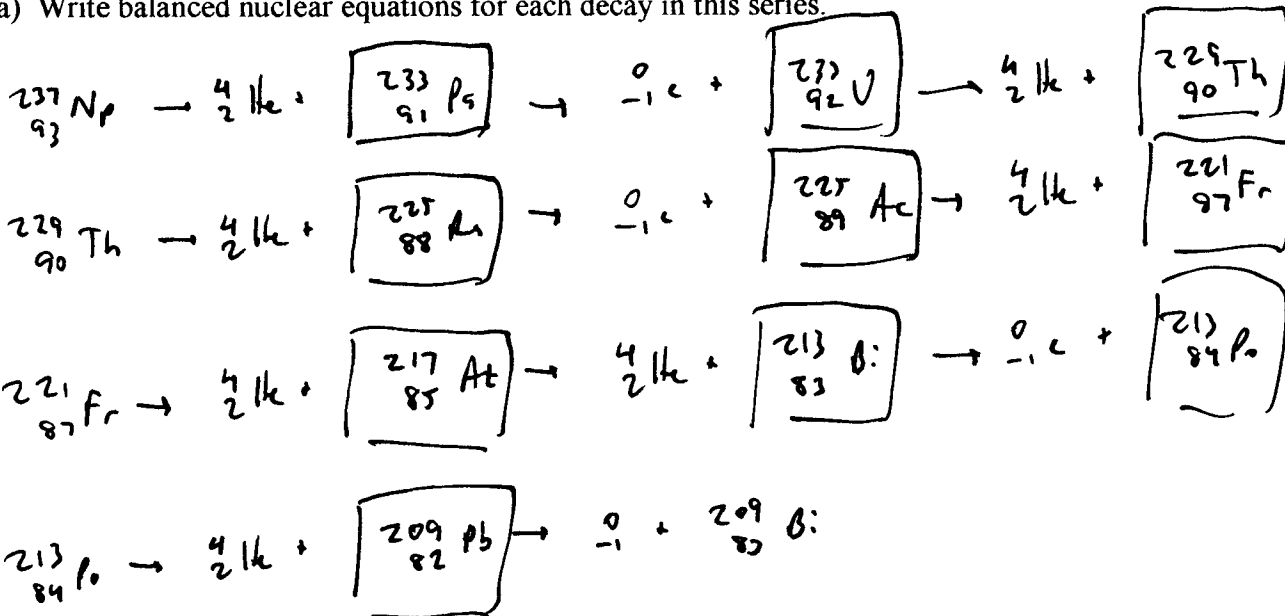


CHM 102
Exam III

1. The neptunium-237 decay series is one of the four natural radioactive series through which unstable isotopes decay to eventual stability. The members of this series are no longer found in nature because the half-life of the slowest decay is small compared to the age of the earth.



a) Write balanced nuclear equations for each decay in this series.



b) The half-life of ${}^{221}\text{Fr}$, one of the isotopes within this series, is 4.8 minutes. How long does it take for 99% of a 1.0 mg sample of francium-221 to decay?

IF 99% DECAYS, 1% IS LEFT, SO $N/N_0 = 1/100$.

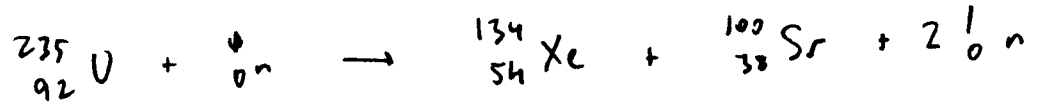
$$\ln\left(\frac{N}{N_0}\right) = -(\ln 2) \frac{t}{t_{1/2}}$$

$$\ln\left(\frac{1}{100}\right) = -(\ln 2) \frac{t}{4.8}$$

$$\boxed{t = 32 \text{ minutes}}$$

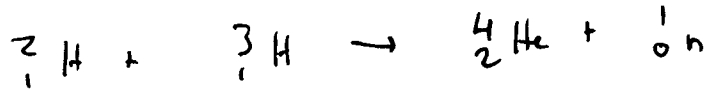
3. Balance the following nuclear equations, each of which produce neutrons.

a) Uranium-235 reacts with a neutron to produce xenon-134 and strontium-100.



5

b) Hydrogen-2 reacts with hydrogen-3 to form helium-4.



5

c) What kind of nuclear process does the reaction in part (a) illustrate? What kind of nuclear process does the reaction in part (b) illustrate?

(a): FISSION

(b): FUSION

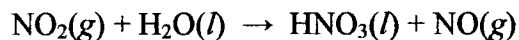
2

d) Which, if any, of the above reactions could form an uncontrolled chain reaction? Explain.

(a) CAN BECOME AN UNCONTROLLED CHAIN REACTION BECAUSE IT PRODUCES MORE NEUTRONS THAN IT CONSUMES.

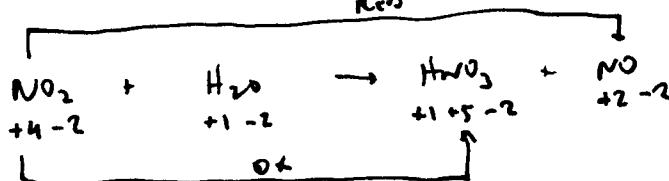
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4. The last step of the Ostwald process for nitric acid production is the reaction of nitrogen dioxide with water to form nitric acid and nitrogen oxide:



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

4

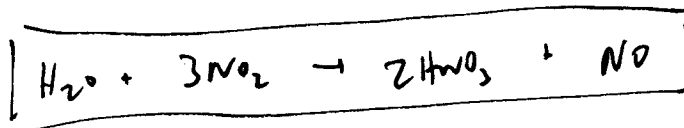
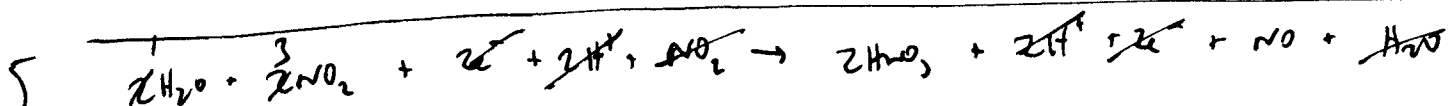
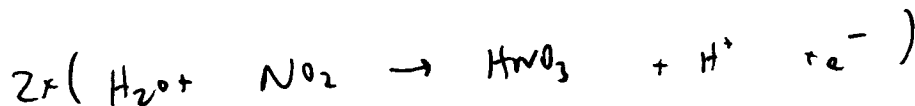


b) Identify which atom is being oxidized and which atom is being reduced.

1

N in NO_2 is both oxidized and reduced.

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



d) The pure nitric acid produced has a density of 1.51 g/mL. How many moles of $\text{NO}_2(\text{g})$ are necessary to produce 1.0 L of pure nitric acid?

$$m = 63.01 \text{ g/mol}$$

$$1000 \text{ mL HNO}_3 \cdot \frac{1.51 \text{ g HNO}_3}{1 \text{ mL HNO}_3} \cdot \frac{1 \text{ mol HNO}_3}{63.01 \text{ g HNO}_3} \cdot \frac{3 \text{ mol NO}_2}{2 \text{ mol HNO}_3} = \boxed{35.9 \text{ mol NO}_2}$$

5

5. Explain the following phenomena.

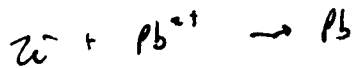
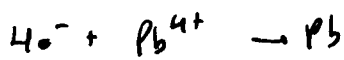
a) Gamma rays can penetrate much farther into matter than alpha particles.

5 ALPHA PARTICLES ARE LARGE, CHARGED PARTICLES, WHILE
 GAMMA RAYS ARE NEUTRAL, MASSLESS PHOTONS, SO
 THE α -PARTICLES INTERACT MORE STRONGLY WITH
 MATTER AND CANNOT PENETRATE AS FAR AS γ -RAYS.

b) Sodium hydride (NaH) is a very strong reducing agent, but none of the atoms in sodium hydride undergo reduction in its reactions.

5 A REDUCING AGENT FORCES OTHER COMPOUNDS TO
 UNDERGO REDUCTION, WHICH MEANS THAT IT LOSES
 ELECTRONS TO THEM AND MUST BE ITSELF
 OXIDIZED.

c) An electrolysis cell reducing $\text{Pb}(\text{SO}_4)_2$ to lead metal will produce half as much lead as an electrolysis cell reducing $\text{Pb}(\text{NO}_3)_2$ to lead metal per mol of electrons passed through the cell.



THE LEAD (IV) SULFATE REQUIRES

TWICE AS MANY ELECTRONS TO

5 REDUCE AS LEAD (II) NITRATE, SO IT WILL PRODUCE

HALF AS MUCH MOL Pb PER MOL e^- .

For problems 10 and 11, refer to the activity series at the right.

10. Which of the following reactions are spontaneous?

- I. ✓ $2 \text{Al}(s) + 3 \text{Ni}^{2+}(aq) \rightarrow 2 \text{Al}^{3+}(aq) + 3 \text{Ni}(s)$
II. ✗ $\text{Li}^{+}(aq) + \text{Ag}(s) \rightarrow \text{Li}(s) + \text{Ag}^{+}(aq)$
III. ✓ $\text{Pb}^{2+}(aq) + \text{Sn}(s) \rightarrow \text{Pb}(s) + \text{Sn}^{2+}(aq)$
IV. ✓ $3 \text{Na}(s) + \text{Au}^{3+}(aq) \rightarrow 3 \text{Na}^{+}(aq) + \text{Au}(s)$
V. ✗ $\text{Ca}^{2+}(aq) + \text{Cu}(s) \rightarrow \text{Ca}(s) + \text{Cu}^{2+}(aq)$

- (A) 2 I and III
(B) 2 I and IV
(C) II and IV
5 (D) I, III, and IV
(E) II, III, and V

11. Which of the following set of metals will dissolve in acid?

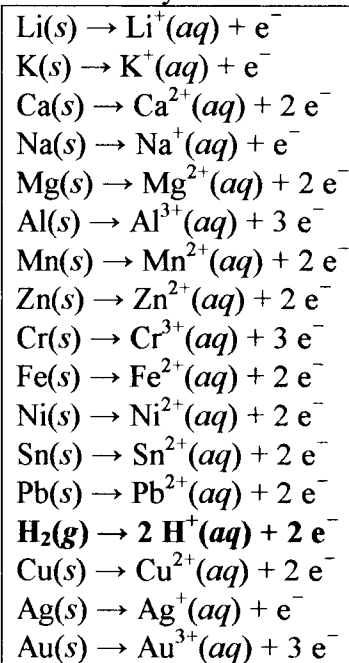
- (A) Ag, Au, and Cu
(B) Ag, Li, and Na
(C) Al, Au, and Cr
5 (D) Ca, Mg, and Zn
(E) Cu, Pb, and Zn

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

- I. ✓ $\text{SF}_4(g) + \text{F}_2(g) \rightarrow \text{SF}_6(g)$
II. ✗ $6 \text{H}_2\text{O}(l) + \text{P}_4\text{O}_{10}(s) \rightarrow 4 \text{H}_3\text{PO}_4(aq)$
III. ✓ $\text{K}(s) + \text{O}_2(g) \rightarrow \text{KO}_2(s)$
IV. ✓ $\text{Sn}(s) + 2 \text{AgNO}_3(aq) \rightarrow \text{Sn}(\text{NO}_3)_2(aq) + 2 \text{Ag}(s)$
V. ✗ $\text{Na}_2\text{O}(s) + \text{H}_2\text{O}(l) \rightarrow 2 \text{NaOH}(aq)$

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

The Activity Series



13. How many neutrons, protons, and electrons are in lead-206?

- (A) 82 neutrons, 82 protons, 124 electrons
 (B) 206 neutrons, 82 protons, 82 electrons
 (C) 124 neutrons, 82 protons, 124 electrons
 (D) 124 neutrons, 82 protons, 82 electrons
 (E) 82 neutrons, 206 protons, 206 electrons

206 Pb
82 p

5

14. Technetium-99 has a half-life of 2.12×10^5 years. If a sample originally contains 30.0 mg of ^{99}Tc , how much will be left after one million years?

- (A) 1.14 mg
 (B) 21.6 mg
 (C) 25.9 mg
 (D) 34.7 mg
 (E) 789 mg

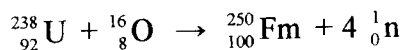
$$N = N_0 e^{-(\ln 2) \frac{t}{t_{1/2}}}$$

$$= 30.0 \text{ mg} e^{-(\ln 2) \frac{1 \times 10^6}{2.12 \times 10^5}}$$

$$= 1.14 \text{ mg}$$

5

15. One process that forms fermium-250 is the following reaction:



What is this process an example of?

- (A) nuclear fusion
 (B) nuclear fission
 (C) α particle emission
 (D) β particle emission
 (E) γ ray emission

5

Equations for radioactive decay

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

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