PLEASE SHOW ALL WORK AND CIRCLE FINAL ANSWERS

1. Balance the following reaction and identify the oxidizing and reducing agents.

\[
\text{Fe(OH)}_2 (s) + \text{MnO}_4^- (aq) \rightarrow \text{MnO}_2 (s) + \text{Fe(OH)}_3 (s) \quad \text{(basic)}
\]

oxidizing agent ______________________________
reducing agent ______________________________

2. Decide which phrase (a through d) best completes the sentence. A product-favored oxidation-reduction reaction has . . .
   a) a positive \(\Delta G^0\) and a positive \(E^0\)
   b) a negative \(\Delta G^0\) and a positive \(E^0\)
   c) a positive \(\Delta G^0\) and a negative \(E^0\)
   d) a negative \(\Delta G^0\) and a negative \(E^0\)

3. Circle all of the following statements which are True.
   a) The value of an electrode potential doubles when the half-reaction is multiplied by a factor of 2. That is, \(E^0\) for (2 Li\(^+\) + 2 e\(^-\) → 2 Li) is twice that for (Li\(^+\) + e\(^-\) → Li).
   b) Al is the strongest reducing agent listed in the reduction potential table.
   c) The equilibrium constant for an oxidation-reduction reaction can be calculated using the Nernst equation.
   d) Changing the concentrations of dissolved substances does not change the potential observed for an electrochemical cell.

4. Calculate \(\Delta G^0\) (in Joules) for the reaction 2 AlI\(_3\) (aq) \(\rightarrow\) 2 Al (s) + 3 I\(_2\) (s).

\[
\begin{align*}
\text{Al}^{3+} (aq) + 3 \text{e}^- & \rightarrow \text{Al} (s) \quad \text{E}^0 = -1.66 \text{ V} \\
\text{I}_2 (s) + 2 \text{e}^- & \rightarrow 2 \text{I}^- (aq) \quad \text{E}^0 = 0.54 \text{ V}
\end{align*}
\]

5. For the cell \(\text{Zn} (s) | \text{Zn}^{2+} (aq) \parallel \text{Ag}^+ (aq) | \text{Ag} (s)\), the standard cell potential is 1.56 V. A cell using these reagents was made, and the observed potential was 1.35 V. A possible explanation for the observed voltage is that
   a) there was 0.0100 mol of Zn\(^{2+}\) and 0.200 mol of Ag\(^+\).
   b) the zinc-ion concentration was larger than the silver-ion concentration.
   c) the Ag electrode was twice as large as the Zn electrode.
   d) the volume of the Zn\(^{2+}\) solution was larger than the volume of the Ag\(^+\) solution.
   e) the volume of the Ag\(^+\) solution was larger than the volume of the Zn\(^{2+}\) solution.
6. A current of 2.50 amp is passed through a solution of \( \text{Ni(NO}_3\text{)}_2 \) for 2.00 hours. What mass of nickel is deposited at the cathode?

7. Write a balanced nuclear equation for the electron capture by \(^{103}\text{Pd}\).

8. In the thorium (Th) decay series, thorium-232 loses a total of 6 \( \alpha \) particles and 4 \( \beta \) particles in a 10-stage process. What is the final isotope produced?

9. The most likely mode of decay for \(^{13}\text{N}\) is
   a) positron emission    b) beta emission    c) alpha emission    d) gamma radiation    e) a neutron emission

10. In 1984, cobalt-60 was involved in the worst accident with radioactive isotopes in North America (Science 84, December 1984, p. 28). The half-life of the isotope is 5.3 years. Starting with 10.0 mg of \(^{60}\text{Co}\), how much will remain after 21.2 years?

11. To synthesize the heavier transuranium elements, a lighter nucleus must be bombarded with a relatively large particle. If you know the products are Californium-246 (\(^{246}\text{Cf}\)) and 4 neutrons, with what particle would you bombard uranium-238 atoms.

12. Oxygen-16 is one of the most stable nuclides. Obtain the mass defect (in amu) and binding energy (in MeV) for the \(^{16}_8\text{O}\) nucleus. The mass of an \(^{16}_8\text{O}\) atom is 15.994915 amu.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>neutron</td>
<td>1.00867</td>
</tr>
<tr>
<td>proton</td>
<td>1.00728</td>
</tr>
</tbody>
</table>

**equalities**

1 amu = \(1.660 \times 10^{-27}\) kg

1 MeV = \(1.602 \times 10^{-13}\) J
13. All of the following are characteristic properties of metals except
   a) metals consist of metal ions and delocalized electrons.
   b) valence electrons make up what is known as a sea of electrons.
   c) metals are good oxidizing agents because of the delocalized electrons.
   d) thermal conductivity is due to the delocalized electrons.
   e) electrical conductivity is due to the delocalized electrons.

14. Which one of the following metals forms the most covalent-like molecules?
   a) Ca  b) Li  c) Na  d) Be  e) Mg

15. Complete and balance the following equations.
   a) \( Li_2CO_3(\text{aq}) + HNO_3(\text{aq}) \rightarrow \)
   b) \( K(s) + O_2(g) \rightarrow \)

16. Which element has the largest second ionization energy?
   a) Be  b) Al  c) Ba  d) Tl  e) Na

17. Calcium oxide is used to remove sulfur dioxide from power plant exhaust because the two react to give solid calcium sulfite. How many grams of sulfur dioxide can be removed using 1000.0 kg of calcium oxide?

18. "Aerated" concrete bricks are widely used building materials. They are obtained by mixing gas-forming additives with a moist mixture of lime, sand, and possibly cement. Industrially, the following reaction is important: \( 2 \text{Al} (s) + 3 \text{Ca(OH)}_2 (s) + 6 \text{H}_2\text{O} (l) \rightarrow [3 \text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 6 \text{H}_2\text{O}] (s) + 3 \text{H}_2 (g) \)  
Assume that the mixture of reactants contains 0.56 g of Al in each brick. What volume of hydrogen gas do you expect at 26 °C and atmospheric pressure of 745 mm Hg?
### Solubility Rules for Ionic Compounds

<table>
<thead>
<tr>
<th>Rule</th>
<th>Applies to</th>
<th>Statement</th>
<th>Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Li⁺, Na⁺, K⁺, NH₄⁺</td>
<td>Group IA and ammonium compounds are soluble.</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>C₂H₃O₂⁻, NO₃⁻</td>
<td>Acetates and nitrates are soluble</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>Cl⁻, Br⁻, I⁻</td>
<td>Most chlorides, bromides, and iodides are soluble</td>
<td>AgCl, Hg₂Cl₂, PbCl₂, AgBr, HgBr₂, Hg₂Br₂, PbBr₂, AgI, HgI₂, HgI₂, PbI₂</td>
</tr>
<tr>
<td>4</td>
<td>SO₄²⁻</td>
<td>Most sulfates are soluble.</td>
<td>CaSO₄, SrSO₄, BaSO₄, Ag₂SO₄, Hg₂SO₄, PbSO₄</td>
</tr>
<tr>
<td>5</td>
<td>CO₃²⁻</td>
<td>Most carbonates are insoluble.</td>
<td>Group IA carbonates, (NH₄)₂CO₃</td>
</tr>
<tr>
<td>6</td>
<td>PO₄³⁻</td>
<td>Most phosphates are insoluble</td>
<td>Group IA phosphates, (NH₄)₃PO₄</td>
</tr>
<tr>
<td>7</td>
<td>S₂⁻</td>
<td>Most sulfides are insoluble</td>
<td>Group IA sulfides, (NH₄)₂S</td>
</tr>
<tr>
<td>8</td>
<td>OH⁻</td>
<td>Most hydroxides are insoluble</td>
<td>Group IA hydroxides, Ba(OH)₂</td>
</tr>
</tbody>
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