PART 1

1&2. In Bronsted-Lowry Theory of acids and bases, an acid is defined as:
(a) a proton donor (d) a water-former
(b) a hydroxide donor (e) a proton acceptor
(c) an electron-pair acceptor

3&4. Determine the oxidation number of bromine in the perbromate ion, BrO₄⁻.
(a) +2 (b) +4 (c) +6 (d) +7 (e) +8

5&6. Assign oxidation numbers to each element in this unbalanced reaction. The oxidation agent is:
P₄ + NO → P₄O₆ + N₂
(a) P₄ (b) NO (c) P₄O₆ (d) N₂ (e) this is not a redox reaction

7&8. Which statement is FALSE?
(a) Energy is the capacity to do work.
(b) An exothermic reaction releases heat.
(e) When two objects come into contact, they will in time be at the same temperature.
(d) A joule is a unit of energy.
(c) Heat flows from a cold object to a hot one.
9&10. Here is a particle view of a substance in water. Pick the compound that is represented by this particle view.

<table>
<thead>
<tr>
<th>(a) NaCl</th>
<th>(b) NaOH</th>
<th>(c) AgOH</th>
<th>(d) HF</th>
<th>(e) LiCH₃COO</th>
</tr>
</thead>
</table>

11&12. Balance the equation with the SMALLEST WHOLE NUMBER COEFFICIENTS possible. Choose the number that is the SUM of the coefficients in the balanced equation. Don’t forget coefficients of one.

\[
\text{Na}_2\text{SO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{SO}_2
\]

<table>
<thead>
<tr>
<th>(a) 5</th>
<th>(b) 7</th>
<th>(c) 9</th>
<th>(d) 12</th>
<th>(e) 15</th>
</tr>
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</table>

13&14. Consider this acid-base net ionic equation: \( \text{CH}_3\text{COOH(aq)} + \text{OH}^-(aq) \rightarrow \text{CH}_3\text{COO}^-(aq) + \text{H}_2\text{O(l)} \)

Which of the following statements is TRUE?

(a) The acid is a strong acid.
(b) The base is insoluble.
(c) The spectator ion could have been a \text{NO}_3^- \text{ion}.
(d) The salt is a weak electrolyte.
(e) The spectator ion could have been a Na$^+$ \text{ion}.
15&16. Consider this graph representing $A \rightleftharpoons B$. Which is the FALSE statement?

(a) $A$ and $B$ reach equilibrium after 15 minutes.
(b) The reaction is reactant-favored.
(c) After about 15 minutes, the concentrations of $A$ and $B$ seem to be about constant.
(d) After about 15 minutes, $A$ is becoming $B$ just as fast as $B$ is converting to $A$.
(e) Even after 15 minutes, the system is very dynamic.

17&18. The pH of a 0.0177 M solution of $\text{HClO}_3$ is

(a) 4.03 (b) 1.04 (c) 1.75 (d) 1.00 (e) 2.15

19&20. How many moles of $\text{NH}_3$ will be produced when 8.94 moles of $\text{H}_2\text{O}$ are also produced according to the following equation?

$$\text{Ce}_2\text{O}_3 + 6 \text{NH}_4\text{Cl} \rightarrow 2 \text{CeCl}_2 + 3 \text{H}_2\text{O} + 6 \text{NH}_3$$

(a) 4.47 mol (b) 13.4 mol (c) 6.00 mol (d) 17.9 mol (e) 2.24 mol
21&22. How many grams of potassium chloride are in 775 mL of a solution which is 35.5% KCl by weight and has a density of 1.28 g/mL?

(a) 215 g  (b) 275 g  (c) 352 g  (d) 640 g  (e) 972 g

23&24. Carbon tetrachloride, a valuable commercial solvent, can be produced by the gas phase reaction of methane with chlorine gas.

\[
\text{CH}_4 + 4 \text{Cl}_2 \rightarrow \text{CCl}_4 + 4 \text{HCl}
\]

Assuming this process is 64% efficient, how many kilograms of chlorine are required for the production of 15 kg of CCl$_4$, assuming excess CH$_4$?

(a) 43 kg  (b) 18 kg  (c) 67 kg  (d) 83 kg  (e) 96 kg
25&26. Consider the reaction: \(2 \text{KCrO}_2 + 3 \text{H}_2\text{O}_2 + 2 \text{KOH} \rightarrow 2 \text{K}_2\text{CrO}_4 + 4 \text{H}_2\text{O}\)

If 20.0 g of each reactant were used for this reaction, the limiting reactant would be:

(a) KCrO\textsubscript{2}  
(b) H\textsubscript{2}O\textsubscript{2}  
(c) KOH  
(d) K\textsubscript{2}CrO\textsubscript{4}  
(e) H\textsubscript{2}O

27&28. How many milliliters of a 1.40 M NaOH solution are required to make 250. mL of 0.100 M NaOH solution?

(a) 14.7 mL  
(b) 3500 mL  
(c) 17.9 mL  
(d) 35.0 mL  
(e) 25.0 mL
29&30. If 6.00 g of HBr was dissolved in enough water to give a pH of 1.78, what was the volume of the solution?

(a) 4.47 L  (b) 1.30 L  (c) 2.59 L  (d) 5.95 L  (e) 3.22 L

31&32. A 2.00 g sample of calcite ore containing CaCO₃ reacted totally with 15.22 mL of 2.30 M hydrochloric acid until no more carbon dioxide gas was evolved according to:

\[
\text{CaCO}_3 + \text{HCl} \rightarrow \text{H}_2\text{O} + \text{CaCl}_2 + \text{CO}_2 \quad \text{(UNBALANCED)}
\]

What percentage of the sample was CaCO₃?

(a) 96.2%  (b) 71.9%  (c) 63.1%  (d) 87.6%  (e) 43.8%
PART 2

33. Consider the precipitation reaction between aqueous solutions of sodium phosphate and calcium nitrate. If you have problems with the nomenclature, make something up and go with that to get partial credit.

(4 pts) (a) What is the balanced formula unit equation? Include the phase for every compound.

(2 pts) (c) What is/are the spectator ion/s, if any?

(2 pts) (d) What is the net ionic equation? Include the charge for every ion.
34. Consider this reaction: \( S + O_2 \rightarrow SO_3 \).

(2 pts) (a) Balance the equation.

(3 pts) (b) If you had 6 moles of S and 3 moles of O\(_2\), draw the particle view that would represent the final situation. Let \( \bullet \) = S and \( \bigcirc \) = O

\[ \text{Initial system} \quad \text{Final system} \]

(2 pts) (c) What is the limiting reactant?

35. Given: benzene (C\(_6\)H\(_6\)): m.p. 5.5°C, b.p. 80.0°C

heat of fusion = 127 J/g at 5.5°C
heat of vaporization = 395 J/g at 80.0°C

specific heat (g) = 1.04 J/g°C
specific heat (l) = 1.74 J/g°C
specific heat (s) = 0.89 J/g°C

Calculate the amount of heat that must be absorbed to convert 425 g of solid benzene at 5.5°C to liquid benzene at 70.0°C (in kJ).