1. Pentaborane, B₅H₉, is known as the “green dragon” because it burns with a bright, green flame. What is the coefficient for O₂ when the combustion reaction below is balanced?

   \[ \text{B₅H₉(s)} + \text{O₂(g)} \rightarrow \text{B₂O₃(s)} + \text{H₂O(l)} \]

   A. 2          C. 12
   B. 10         D. 20

2. Which compound has the bromine with the most negative (lowest) oxidation state?

   A. BrO₅⁻          D. BrO⁻
   B. BrF₃          E. Br₂
   C. HBr

3. For a gaseous process, work is done on the system and the system releases heat. What is the correct relationship?

   A. expands  positive
   B. contracts  positive or negative
   C. expands  positive or negative
   D. contracts  negative

4. Use the bond energies in the Table 7.1 to estimate the enthalpy change (ΔH) associated with the hydration reaction of ethene (C₂H₄) to form ethanol (C₂H₅OH) shown in this reaction.

   \[ \text{C=H} + \text{H₂O} \rightarrow \text{C–H} + \text{H–C–O–H} \]

   A. −39 kJ/mol
   B. 39 kJ/mol
   C. −89 kJ/mol
   D. 89 kJ/mol

5. The fat tristearin, C₅₇H₁₁₀O₆ (891.5 g/mol) is stored in a camel’s hump. It’s a source of energy and water (18.0 g/mol) when metabolized, according the reaction shown.

   \[ 2 \text{C₅₇H₁₁₀O₆} + 163 \text{O₂} \rightarrow 114 \text{CO₂} + 110 \text{H₂O} \]

   What mass of H₂O is available from a pound (454 g) of fat?

   A. 166 g H₂O  C. 1008 g H₂O
   B. 9.17 g H₂O  D. 504 g H₂O

6. Classify each reaction. (Phases have been omitted.)

   I: \( \text{H₂SO₄} + 2\text{NaOH} \rightarrow 2\text{H₂O} + \text{Na₂SO₄} \)
   II: \( \text{SO₄}^{2–} + \text{Ca}^{2+} \rightarrow \text{CaSO₄} \)
   III: \( 3\text{H}^+ + \text{Ca} + \text{HSO₄}^- \rightarrow \text{H₂SO₃} + \text{Ca}^{2+} + \text{H₂O} \)

   A. neutralization  II redox  III precipitation
   B. redox  II precipitation  III neutralization
   C. neutralization  II precipitation  III redox
   D. redox  II neutralization  III precipitation

7. Calculate \( \Delta H^\circ \) for the reaction:

   \[ 2\text{Cu(s)} + \text{O₂(g)} \rightarrow 2\text{CuO(s)} \]

   From the following enthalpies of reaction:

   \[ 4\text{CuO(s)} \rightarrow 2\text{Cu₂O(s)} + \text{O₂(g)} \quad \Delta H^\circ = +300 \text{ kJ} \]
   \[ \text{Cu₂O(s)} \rightarrow \text{Cu(s)} + \text{CuO(s)} \quad \Delta H^\circ = +10 \text{ kJ} \]

   A. +310 kJ  D. −310 kJ
   B. +280 kJ  E. −320 kJ
   C. −280 kJ
8. 35.20 g of unknown compound contains 1.90 moles of carbon, what is the percent by mass of carbon in this compound?

A. 5.4 %  
B. 64.8 %  
C. 0.449 %  
D. 1.54 %  
E. 18.5 %

9. Solution 1 and 2 are aqueous solutions of the same solute. Which statement is true?

![Solution 1 and Solution 2]

A. Solution 1 is more concentrated with a higher molarity.  
B. Solution 1 is more concentrated with a lower molarity.  
C. The solutions have similar concentrations with identical molarities.  
D. Solution 2 is more concentrated with a higher molarity.  
E. Solution 2 is more concentrated with a lower molarity.

10. An endothermic reaction has…

A. a negative ΔH and feels cold to the touch. 
B. a positive ΔH and feels warm to the touch. 
C. a negative ΔH and feels warm to the touch. 
D. a positive ΔH and feels cold to the touch.

11. In an experiment in the lab, 4.00 g NH₄HCO₃ (79.06 g/mol) reacted per the reaction shown, only 0.59 g water (18.02 g/mol) was collected. What was the % yield for the reaction?

\[ \text{NH}_4\text{HCO}_3 \rightarrow \text{NH}_3 + \text{H}_2\text{O} + \text{CO}_2 \]

A. 15%  
B. 33%  
C. 22%  
D. 50%  
E. 65%

12. For which reaction does \( \Delta H^\circ_{\text{rxn}} \) represent the standard heat of formation?

\[
\begin{align*}
\text{rxn I: } & \text{N}_2(g) + \text{O}_2(g) \rightarrow 2 \text{NO}(g) \\
\text{rxn II: } & \frac{1}{2} \text{N}_2(g) + \text{O}_2(g) \rightarrow \text{NO}_2(g) \\
\text{rxn III: } & 2 \text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)
\end{align*}
\]

A. I only  
B. II only  
C. III only  
D. I and II only  
E. II and III only

13. Identify the spectator ion(s) in the following reaction:

\[ \text{H}_2\text{SO}_4(aq) + \text{CaCl}_2(aq) \rightarrow \text{CaSO}_4(s) + 2\text{HCl}(aq) \]

A. \text{H}^+ and \text{Cl}^-  
B. \text{Cl}^- only  
C. \text{H}^+ and \text{SO}_4^{2-}  
D. \text{Ca}^{2+} only  
E. There are no spectator ions.

14. 100.0 g each of three liquids at room temperature are subjected to the same amount of heat. Which statement is true?

![Toluene, Ethanol, Carbon Tetrachloride]

- toluene: \( C_p = 1.74 \text{ J/g } ^\circ\text{C} \)  
- ethanol: \( C_p = 2.46 \text{ J/g } ^\circ\text{C} \)  
- carbon tetrachloride: \( C_p = 0.861 \text{ J/g } ^\circ\text{C} \)

A. They will all reach 50 °C in the same amount of time.  
B. Toluene will reach 50 °C first, and carbon tetrachloride last.  
C. Ethanol will reach 50 °C first, and carbon tetrachloride last.  
D. Carbon tetrachloride will reach 50 °C first, and ethanol last.
15. Nitrogen, 45.0 moles, and oxygen, 145.0 moles, react according to the equation below, what remains assuming complete reaction?

\[ 2N_2(g) + 5O_2(g) \rightarrow 2N_2O_5(g) \]

A. 112 mol O_2  
D. 54 mol N_2  
B. 100 mol O_2  
E. 13 mol N_2  
C. 32 mol O_2

16. A solution is prepared by dissolving 47.3 g ZnI_2 (319.2 g/mol) in sufficient water to give 71.50 mL of solution. What is the iodide ion, I\(^{-}\), concentration of this solution?

A. 1.04 M  
D. 0.662 M  
B. 0.148 M  
E. 4.14 M  
C. 2.07 M

17. A nurse dilutes 1.0 L of 0.30 M C_6H_12O_6(aq) to a new volume of 5.0 L by the addition of water. The nurse then adds 100 mL of the new (diluted) solution to an IV bag. How many moles of glucose, C_6H_12O_6, are in the IV bag?

A. 6.0 \times 10^{-3} \text{ mol}  
D. 1.2 \times 10^{-2} \text{ mol}  
B. 9.0 \times 10^{-2} \text{ mol}  
E. 1.0 \times 10^{-2} \text{ mol}  
C. 1.0 \times 10^{-2} \text{ mol}

18. This heating curve is for a substance that is initially a solid. Which of the line segments correspond to melting and boiling of the substance?

![Heating Curve Graph]

A. I  
D. III  
B. II  
E. III  
C. II  

19. Which combination correctly matches the compound with its solute properties?

A. HCl is a weak electrolyte.  
D. NH_4F is a strong electrolyte.  
B. NaOH is weak electrolyte.  
E. CH_3OH is a strong electrolyte.  
C. NH_3 is a non-electrolyte.

20. What quantity of heat must be added to cause the decomposition of 25.0 g of phosphorus pentachloride (208.2 g/mol) to its elements according to the equation below?

\[ 4PCl_5(s) \rightarrow P_4(s) + 10Cl_2(g) \quad \Delta H_{rx} = 1774.0 \text{ kJ} \]

A. 1740 kJ  
D. 213 kJ  
B. 852 kJ  
E. 53.3 kJ  
C. 436 kJ

21. What reagent would distinguish between Ag\(^{+}\) and Fe\(^{3+}\) in aqueous solution?

A. NaClO_4  
D. NaOH  
B. NaI  
E. NaN_3  
C. NaNO_3

22. A reaction releases 15 kJ of heat and does 3 kJ of work on the surroundings at constant pressure. What are the values of \( \Delta E \) and \( \Delta H \) for this reaction?

\[ \begin{array}{cc} \Delta E & \Delta H \\ \hline A. & -18 \text{ kJ} \\ B. & -15 \text{ kJ} \\ C. & -12 \text{ kJ} \\ D. & -15 \text{ kJ} \\ E. & -18 \text{ kJ} \end{array} \]

23. Determine the empirical formula for a compound that contains carbon, hydrogen and oxygen. It contains 44.76% C and 47.71% O by mass.

A. C_5H_13O_4  
D. C_6H_6O_3  
B. CH_3O  
E. C_5H_{10}O_4  
C. C_2H_5O_2
24. The neutralization reaction of which acid has this net ionic equation? Assume the base is NaOH.

\[ \text{H}^+ (aq) + \text{OH}^- (aq) \rightarrow \text{H}_2\text{O}(l) \]

A. HClO₄  C. HNO₂
B. HF  D. HCN

25. Determine the standard enthalpy of formation for N₂O given the following information about the formation of NO₂ under standard conditions, and \( \Delta H^\circ \) (NO₂) = + 33.2 kJ/mol.

\[ 2 \text{N}_2\text{O}(g) + 3 \text{O}_2(g) \rightarrow 4 \text{NO}_2(g) \] \( \Delta H_{\text{rxn}} = -31.4 \text{kJ} \)

A. +82.1 kJ/mol  D. −164.2 kJ/mol
B. −82.1 kJ/mol  E. +50.7 kJ/mol
C. +164.2 kJ/mol

26. What mass of hydrogen bromide gas (80.9 g/mol) is produced when 35.0 g N₂H₄ (32.1 g/mol) is combined with 150.0 g Br₂ (159.8 g/mol) according to the following chemical equation?

\[ 2 \text{Br}_2(l) + \text{N}_2\text{H}_4(g) \rightarrow 4 \text{HBr}(g) + \text{N}_2(g) \]

A. 75.9 g  D. 304 g
B. 88.2 g  E. 353 g
C. 152 g

60. Mark A on your scantron.

Check your answers. When you are finished give your scantron to the proctor and show your calculator and picture ID. Be sure to sign the roster. You may keep the exam booklet. An answer key will be posted later tonight.
USEFUL INFORMATION:

Equations

\[ q = \text{specific heat capacity} \times \text{mass} \times \Delta T \]

\[ \Delta E = q + w \]

\[ w = -P\Delta V \]

\[ \Delta E = \Delta H - P\Delta V \]

\[ \Delta H^\circ_{rx} = \sum n\Delta H^\circ_{f} \text{ (products)} - \sum n\Delta H^\circ_{f} \text{ (reactants)} \]

Constants

\[ N_A = 6.0221 \times 10^{23} \]

Specific heat capacity of water 4.18 J/(g°C)

101.3 J = 1 L·atm

PERIODIC TABLE OF THE ELEMENTS

Clemson University
Department of Chemistry

Lanthanides

Actinides
### SOLUBILITY RULES

<table>
<thead>
<tr>
<th>Ion</th>
<th>Solubility</th>
<th>Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li⁺, Na⁺, K⁺, Rb⁺, Cs⁺</td>
<td>usually soluble</td>
<td>none</td>
</tr>
<tr>
<td>NH₄⁺</td>
<td>soluble</td>
<td>none</td>
</tr>
<tr>
<td>Cl⁻, Br⁻, I⁻</td>
<td>soluble</td>
<td>Ag⁺, Hg₂²⁺, Pb²⁺, Cu⁺</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>soluble</td>
<td>none</td>
</tr>
<tr>
<td>ClO₄⁻</td>
<td>soluble</td>
<td>none</td>
</tr>
<tr>
<td>C₂H₃O₂⁻ (CH₂CO₂⁻)</td>
<td>soluble</td>
<td>Ag⁺, Hg₂²⁺, Pb²⁺, Ca²⁺, Ba²⁺, Sr²⁺</td>
</tr>
<tr>
<td>SO₄²⁻</td>
<td>soluble</td>
<td>Ag⁺, Hg₂²⁺, Pb²⁺, Ca²⁺, Ba²⁺, Sr²⁺</td>
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</table>

<table>
<thead>
<tr>
<th>Ion</th>
<th>usually insoluble</th>
<th>Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>OH⁻</td>
<td>insoluble</td>
<td>Gp. IA, NH₄⁺, slightly soluble: Ca²⁺, Ba²⁺, Sr²⁺</td>
</tr>
<tr>
<td>S²⁻</td>
<td>insoluble</td>
<td>Gp. IA, NH₄⁺, Ca²⁺, Ba²⁺, Sr²⁺</td>
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<tr>
<td>CO₃²⁻</td>
<td>insoluble</td>
<td>Gp. IA, NH₄⁺</td>
</tr>
<tr>
<td>PO₄³⁻</td>
<td>insoluble</td>
<td>Gp. IA, NH₄⁺</td>
</tr>
</tbody>
</table>

### TABLE 7.1  Average Bond Dissociation Energies, D (kJ/mol)ᵃ

<table>
<thead>
<tr>
<th>Bond</th>
<th>Energy (kJ/mol)</th>
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<tr>
<td>H—H</td>
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<td>H—I</td>
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<td>H—O</td>
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<tr>
<td>H—S</td>
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<table>
<thead>
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<th>Bond</th>
<th>Energy (kJ/mol)</th>
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<tbody>
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<tr>
<td>C═O</td>
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<tr>
<td>O═O</td>
<td>498</td>
</tr>
<tr>
<td>N≡N</td>
<td>945</td>
</tr>
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</table>

—is exact value.

—we'll discuss multiple covalent bonds in Section 7.5.