MULTIPLE CHOICE. (3 points each)

1) Which one of the following substances is the product of this combination reaction?
   \[ \text{Al(s)} + \text{I}_2(s) \rightarrow \text{______} \]
   A) \text{AlI}_3 \quad \text{B) AlI} \quad \text{C) Al}_2\text{I}_3 \quad \text{D) Al}_3\text{I}_2

2) The formula weight of aluminum sulfate (\text{Al}_2(\text{SO}_4)_3) is ________ amu.
   A) 150.14 \quad \text{B) 59.04} \quad \text{C) 273.06} \quad \text{D) 342.14}

3) How many moles of pyridine (\text{C}_5\text{H}_5\text{N}) are contained in 3.13 g of pyridine?
   A) 25.3 \quad \text{B) 0.319} \quad \text{C) 0.0396} \quad \text{D) 0.00404}

4) Lead carbonate decomposes to give lead oxide and carbon dioxide:
   \[ \text{PbCO}_3(s) \rightarrow \text{PbO(s)} + \text{CO}_2(g) \]
   How many grams of lead oxide will be produced by the decomposition of 0.00935 mol of lead carbonate?
   A) 0.00936 \quad \text{B) 0.41} \quad \text{C) 2.09} \quad \text{D) 2.50}

5) Pentacarbonyliron (\text{Fe(CO)}_5) reacts with phosphorous trifluoride (\text{PF}_3) and hydrogen, releasing carbon monoxide:
   \[ \text{Fe(CO)}_5 + 2\text{PF}_3 + \text{H}_2 \rightarrow \text{Fe(CO)}_2(\text{PF}_3)_2(\text{H}_2) + 3\text{CO} \]
   The reaction of 5.0 mol of \text{Fe(CO)}_5, 8.0 mol of \text{PF}_3 and 6.0 mol of \text{H}_2 will release ________ mol of \text{CO}.
   A) 5.0 \quad \text{B) 12} \quad \text{C) 15} \quad \text{D) 24}

6) Sulfur and fluorine react in a combination reaction to produce sulfur hexafluoride:
   \[ \text{S(s)} + 3 \text{F}_2(g) \rightarrow \text{SF}_6(g) \]
   In a particular experiment, the percent yield is 79.0%. This means that a 7.90-g sample of fluorine yields ________ g of \text{SF}_6 in the presence of excess sulfur.
   A) 7.99 \quad \text{B) 10.1} \quad \text{C) 0.110} \quad \text{D) 24.0}

7) Of the species below, only ________ is not an electrolyte in water.
   A) \text{HCl} \quad \text{B) KOH} \quad \text{C) Ar} \quad \text{D) NaCl}

8) The balanced molecular equation for complete neutralization of \text{H}_2\text{SO}_4 by \text{KOH} in aqueous solution is ________.
   A) 2 \text{H}^+(aq) + 2 \text{KOH (aq)} \rightarrow 2 \text{H}_2\text{O (l)} + 2 \text{K}^+(aq)
   \text{B) } \text{H}_2\text{SO}_4(aq) + 2 \text{KOH (aq)} \rightarrow 2 \text{H}_2\text{O (l)} + \text{K}_2\text{SO}_4(aq)
   \text{C) } \text{H}_2\text{SO}_4(aq) + 2 \text{KOH (aq)} \rightarrow 2 \text{H}_2\text{O (l)} + \text{K}_2\text{SO}_4(s)
   \text{D) } \text{H}_2\text{SO}_4(aq) + 2 \text{OH}^-(aq) \rightarrow 2 \text{H}_2\text{O (l)} + \text{SO}_4^{2-}(aq)

9) Which one of the following compounds is insoluble in water?
   A) \text{NaCl} \quad \text{B) Fe(NO}_3)_3 \quad \text{C) NaC}_2\text{H}_3\text{O}_2 \quad \text{D) ZnS}
10) Which one of the following is a diprotic acid?
A) hydrofluoric acid  B) nitric acid  
**C) sulfuric acid**  D) phosphoric acid

11) Which one of the following is a weak acid?
A) HF  B) HClO₄  C) HCl  
D) HNO₃

12) Based on the activity series, which one of the reactions below will occur?
A) Zn(s) + MnI₂(aq) → ZnI₂(aq) + Mn(s)  
B) 3 FeBr₂(aq) + 2 Au (s) → 3 Fe(s) + 2 AuBr₃(aq)  
C) 3 Hg(l) + 2 Cr(NO₃)₃(aq) → 3 Hg(NO₃)₂(aq) + 2Cr(s)  
**D) 2 AgNO₃(aq) + Pb(s) → 2 Ag(s) + Pb(NO₃)₂(aq)**

13) Oxidation is the __________ and reduction is the __________.
A) loss of oxygen, gain of electrons  B) gain of electrons, loss of electrons  
**C) loss of electrons, gain of electrons**  D) gain of oxygen, loss of mass

14) Which one of the following is a correct expression for molarity?
A) mol solute/ L solution  B) mol solute/L solvent  
C) mmol solute/L solution  D) mol solute/mL solvent

15) How many grams of NaOH (MW = 40.0) are there in 500.0 mL of a 0.175 M NaOH solution?
A) 114g  B) 3.50g  C) 2.19 x 10⁻³g  
**D) 3.50 x 10⁻³g**

16) What is the molarity (M) of an aqueous solution containing 52.5 g of sucrose (C₁₂H₂₂O₁₁)in 35.5 mL of solution?
A) 5.46M  B) 1.85M  C) 0.104M  
**D) 4.32M**

17) Of the following, which one is a state function?
A) H  B) w  C) heat  
**D) q**

18) A __________ ΔH corresponds to an __________ process.
A) negative, endothermic  **B) negative, exothermic**  
C) positive, exothermic  D) zero, exothermic

19) Which one of the following statements is true?
A) **Enthalpy is a state function.**  
B) Enthalpy is an intensive property.  
C) The enthalpy change for a reaction is independent of the state of the reactants and products.  
D) H is the value of q measured under conditions of constant temperature.

20) The value of ΔH° for the reaction below is -790 kJ. The enthalpy change accompanying the reaction of 0.95 g of S is __________ kJ.

\[
2S(s) + 3O₂(g) \rightarrow 2SO₃(g)
\]
A) -790  B) -23  **C) -12**  D) 12
21) The value of $\Delta H^\circ$ for the reaction below is +128.1 kJ:
$$\text{CH}_3\text{OH}(l) \rightarrow \text{CO}(g) + 2\text{H}_2(g)$$
How many kJ of heat are released when 5.10 g of $\text{H}_2(g)$ is formed as shown in the equation?
A) 62.0kJ  B) 162kJ  C) 128kJ  D) 326kJ

22) The units of specific heat are _______.
A) J/g°C  B) g°C/J  C) J/°C  D) °C/J

23) Which of the following is a statement of Hess's law?
A) The $\Delta H$ for a process in the forward direction is equal to the $\Delta H$ for the process in the reverse direction.
B) The $\Delta H$ of a reaction depends on the physical states of the reactants and products.
C) If a reaction is carried out in a series of steps, the $\Delta H$ for the reaction will equal the sum of the enthalpy changes for the individual steps.
D) The $\Delta H$ for a process in the forward direction is equal in magnitude and opposite in sign to the $\Delta H$ for the process in the reverse direction.

24) The temperature of a 15-g sample of lead metal increases from 22°C to 37°C upon the addition of 29.0 J of heat. The specific heat capacity of the lead is _______ J/g°C.
A) 29  B) 0.13  C) -29  D) 1.9

25) A chemical reaction that absorbs heat from the surroundings is said to be _______ and has a _______ $\Delta H$ at constant pressure.
A) endothermic, positive  B) endothermic, negative
C) exothermic, negative  D) exothermic, positive

Problems (SHOW ALL WORK ON THIS PAPER)

(5 points) From the heats of reaction:

<table>
<thead>
<tr>
<th>Reaction</th>
<th>$\Delta H$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(g)$</td>
<td>-483.6 kJ</td>
</tr>
<tr>
<td>$3 \text{O}_2(g) \rightarrow 2 \text{O}_3(g)$</td>
<td>+284.6 kJ</td>
</tr>
</tbody>
</table>

calculate the heat of the reaction:
$$3\text{H}_2(g) + \text{O}_3(g) \rightarrow 3 \text{H}_2\text{O}(g)$$

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<td>$3/2 (2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(g))$</td>
<td>$3/2(-483.6 \text{kJ})$</td>
</tr>
<tr>
<td>$-1/2 (3\text{O}_2(g) \rightarrow 2 \text{O}_3(g))$</td>
<td>$-1/2(+284.6 \text{kJ})$</td>
</tr>
</tbody>
</table>

$$3 \text{H}_2(g) + 3/2\text{O}_2(g) \rightarrow 3\text{H}_2\text{O}(g)$$
-725.4 kJ

$$3/2 \text{O}_3(g) \rightarrow \text{O}_2(g)$$
-142.3 kJ

$$3\text{H}_2(g) + \text{O}_3(g) \rightarrow 3 \text{H}_2\text{O}(g)$$
-867.7 kJ
(10 points) The complete combustion of octane, \( \text{C}_8\text{H}_{18} \), proceeds in the following manner:

\[
\text{C}_8\text{H}_{18}(l) + 25 \text{O}_2(g) \rightarrow 16 \text{CO}_2(g) + 18 \text{H}_2\text{O}(l)
\]

How many grams of \( \text{O}_2 \) are needed to burn 7.50g of \( \text{C}_8\text{H}_{18} \)?

\[
\text{mol } \text{C}_8\text{H}_{18} = \frac{7.50 \text{g}}{114.18 \text{g/mol}} = 0.0657 \text{mol}
\]

\[
\frac{25 \text{O}_2}{\text{mol } \text{C}_8\text{H}_{18}} = \frac{x}{0.0657 \text{mol}}
\]

\[x = 1.64 \text{ mol } \text{O}_2\]

\[g \text{ O}_2 = 1.64 \text{ mol } \text{O}_2 \left( 32.0 \text{ g/mol} \right) = 52.5 \text{ g}\]

(10 points) A 2.200g sample of quinine (\( \text{C}_6\text{H}_4\text{O}_2 \)) is burned in a bomb calorimeter whose total heat capacity is 7.854kJ/°C. The temperature of the calorimeter increases from 23.44°C to 30.57°C. What is the heat of combustion per gram of quinine AND per mole of quinine?

\[
q = -C_{\text{cal}} \Delta t
\]

\[= -7.854 \text{kJ/°C} (30.57°C - 23.44°C) = -55.99 \text{kJ}
\]

per gram

\[
\Delta H = \frac{-55.99 \text{kJ}}{2.200 \text{ g}} = -25.45 \text{kJ/g}
\]

per mole

\[
\Delta H = \frac{-55.99 \text{kJ}}{\left( 2.200 \text{ g/108.04 g/mol} \right)} = -2750 \text{kJ/mol}
\]