Changes of State

**PART A – ACTIVATION CURVE GRAPH** Use the graph below to answer the following questions.

1. What does A represent? ______________ What is the actual number? ______________
2. What does B represent? ______________ What is the actual number? ______________
3. What does C represent? ______________ What is the actual number? ______________
4. What does D represent? ______________ What is the actual number? ______________
5. What does D represent? ______________ What is the actual number? ______________
6. What sign would $\Delta H$ be for this reaction? (circle one) + (positive) or - (negative)
7. What kind of reaction will this be? (circle one) Exothermic or Endothermic

**PART C – HEATING CURVES.** Use the heating curve below to answer the following questions.

8. What is the melting point of the substance? __________
9. What is the boiling point of the substance? __________
10. Which letter represents heating of the solid? __________
11. Which letter represents heating of the vapor? __________
12. Which letter represents melting of the solid? __________
13. Which letter represents boiling of the liquid? __________

14. For the chemical above (use the heating curve listed on the previous page) determine the amount of energy required to take 3.45 g of this substance from -2°C to 22°C?

\[
\Delta H_{\text{fus}} = 3.4 \text{ J/g} \quad \Delta H_{\text{vap}} = 675 \text{ J/g} \quad c_{\text{p solid}} = 0.43 \text{ J/(g°C)} \quad c_{\text{p liquid}} = 10.43 \text{ J/(g°C)} \quad c_{\text{p solid}} = 7.85 \text{ J/(g°C)}
\]
**PART D – PHASE DIAGRAMS.** Use the phase diagram for water below to answer the following questions.

15. What is the state of water at 2 atm and 50°C?

16. What phase change will occur if the temperature is lowered from 80°C to -5°C at 1 atm?

17. You have ice at -10°C and 1 atm. What could you do in order cause the ice to sublime?

18. What letter is the triple point? ________________
   
   What is the temperature? _____
   
   What is the pressure? _____

19. What letter is the critical point? __________

20. What letter is the normal melting point? ________________

21. What letter is the normal boiling point? ________________

22. What state is present at 70°C and 0.005 atm? ________________

23. What state is present at -5°C and 0.5 atm? ________________

**PART E – HESS’ LAW.**

24. Find \( \Delta H_{\text{rxn}} \) for the following reaction:

\[ \text{N}_2\text{O}_4 + 3 \text{CO} \rightarrow \text{N}_2\text{O} + 3\text{CO}_2 \]

<table>
<thead>
<tr>
<th>Reactants</th>
<th>( \Delta H^\circ )</th>
<th>Products</th>
<th>( \Delta H^\circ )</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{N}_2\text{O}_4</td>
<td>9.7 kJ/mol</td>
<td>\text{N}_2\text{O}</td>
<td>81 kJ/mol</td>
</tr>
<tr>
<td>\text{CO}</td>
<td>-110 kJ/mol</td>
<td>\text{CO}_2</td>
<td>-393 kJ/mol</td>
</tr>
</tbody>
</table>

\[ \Sigma \Delta H^\circ_{\text{products}} = \] ________________

\[ \Sigma \Delta H^\circ_{\text{reactants}} = \] ________________

\[ \Sigma \Delta H^\circ_{\text{products}} - \Sigma \Delta H^\circ_{\text{reactants}} = \] ________________

\( \Delta H_{\text{rxn}} = \) ___________________________ Exo/Endo? ________________
25. Challenge Practice: Using the following reaction, find the $\Delta H^\circ_f$ for $C_2H_6$

$$2C_2H_6 + 7O_2 \rightarrow 6H_2O + 4CO_2 \quad \Delta H = -3119 \text{ kJ}$$

<table>
<thead>
<tr>
<th>Reactants</th>
<th>$\Delta H^\circ_f$</th>
<th>Products</th>
<th>$\Delta H^\circ_f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_2H_6$</td>
<td>$? \quad \text{(reaction)}$</td>
<td>$H_2O$</td>
<td>$-286 \text{ kJ/mol}$</td>
</tr>
<tr>
<td>$O_2$</td>
<td>0</td>
<td>$CO_2$</td>
<td>$-393 \text{ kJ/mol}$</td>
</tr>
</tbody>
</table>

$$\Sigma \Delta H^\circ_f \text{products} = \text{_______________________________}$$

$$\Sigma \Delta H^\circ_f \text{reactants} = \text{_______________________________}$$

$$\Sigma \Delta H^\circ_f \text{products} - \Sigma \Delta H^\circ_f \text{reactants} = \text{_______________________________}$$

$\Delta H^\circ_f$ for $C_2H_6 = \text{_______________________________}$

$\Delta H_{rxn} = \text{_______________________________} \quad \text{Exo/Endo?}$

26. Calculate the enthalpy change for the following reaction:

$$\text{NiO} + 2\text{HCl} \rightarrow \text{NiCl}_2 + \text{H}_2\text{O(g)} \quad \Delta H^\circ = \text{_______________________________}$$

From the following enthalpy changes:

$$\text{SOCl}_2 + \text{NiO} \rightarrow \text{SO}_2 + \text{NiCl}_2 \quad \Delta H^\circ = 150 \text{ kJ}$$

$$\text{SOCl}_2 + \text{H}_2\text{O} \rightarrow \text{SO}_2 + 2\text{HCl} \quad \Delta H^\circ = -27 \text{ kJ}$$

27. Given the following information:

$$\Delta H_f \text{C}_2\text{H}_4(g)) = 52.3 \text{ kJ/mol}$$

$$\Delta H_f \text{CO}_2(g) = -393.5 \text{ kJ/mol}$$

$$\Delta H_f \text{H}_2\text{O(g)} = -241.8 \text{ kJ/mol}$$

(A) What is $\Delta H$ of the reaction?

(B) How much heat would be evolved when 220.56 g $\text{H}_2\text{O(g)}$ were produced?

(C) How many moles of $\text{C}_2\text{H}_4(g)$ would be required to produce 400.0 kJ of heat?

(D) If the molar volume of $\text{C}_2\text{H}_4(g)$ is 22.4 l/mol, how many liters of $\text{C}_2\text{H}_4$ are required in part (C)?