Exam Packet Instructions: Do your best and don’t be anxious. Read the question, re-read the question, write down all given or valuable information, and write down what you want to find.

1. A 27.0 g sample of NH₄NO₃ is dissolved in 200 g of water at 32.0°C in a coffee-cup calorimeter. If the enthalpy of dissolution of NH₄NO₃ is 25.7 kJ/mol, what is the final temperature of the solution in the calorimeter? Assume that the specific heat capacity of the solution is 4.184 J/g°C.

   (1) 12.81°C    (2) 41.12°C    (3) 32.0°C    (4) 44.84°C    (5) 51.12°C

2. If you dropped a 1 gram chunk of either iron (heat capacity = 0.450 J/gK) or gold (heat capacity = 0.129 J/gk) at 100°C into 1 gram of water at 25°C, which metal would change the water temperature most and is the water temperature change endothermic or exothermic?

   (1) Iron, water temperature change is exothermic
   (2) Iron, water temperature change is endothermic
   (3) Gold, water temperature change is exothermic
   (4) Gold, water temperature change is endothermic
   (5) Both are the same, water change is endothermic
3. Given the following data, what is the enthalpy of formation of HNO₃(aq)?

\[ \begin{align*}
3 \text{NO}_2(g) + \text{H}_2\text{O}(l) &\rightarrow 2 \text{HNO}_3(aq) + \text{NO}(g) \quad \Delta H = -136.7 \text{ kJ/mol} \\
\Delta H_f(\text{NO}_2) &\approx 33.2 \text{ kJ/mol}; \quad \Delta H_f(\text{H}_2\text{O}) = -285.8 \text{ kJ/mol}; \quad \Delta H_f(\text{NO}) = 90.3 \text{ kJ/mol}
\end{align*} \]

\[(1) \quad -69.9 \text{ kJ/mol} \quad (2) \quad -139.8 \text{ kJ/mol} \quad (3) \quad -206.6 \text{ kJ/mol} \]

\[(4) \quad -413.2 \text{ kJ/mol} \quad (5) \quad -479.6 \text{ kJ/mol} \]

4. Use the following information to find \( \Delta H_f^{\circ} \) of gaseous HCl:

\[ \begin{align*}
\text{N}_2(g) + 3 \text{H}_2(g) &\rightarrow 2 \text{NH}_3(g) \quad \Delta H_f^{\circ} \text{rxn} = - 91.8 \text{ kJ} \\
\text{N}_2(g) + 4 \text{H}_2(g) + \text{Cl}_2(g) &\rightarrow 2 \text{NH}_4\text{Cl}(s) \quad \Delta H_f^{\circ} \text{rxn} = - 628.8 \text{ kJ} \\
\text{NH}_3(g) + \text{HCl}(g) &\rightarrow \text{NH}_4\text{Cl}(s) \quad \Delta H_f^{\circ} \text{rxn} = - 176.2 \text{ kJ}
\end{align*} \]

\[1) \quad -92.3 \text{ kJ/mol} \quad 2) \quad +92.3 \text{ kJ/mol} \quad 3) \quad -46.15 \text{ kJ/mol} \quad 4) \quad -170.2 \text{ kJ/mol} \quad 5) \quad +170.2 \text{ kJ/mol} \]
5. To determine its caloric content, a 5 g piece of caramel (1 serving) was burned in a bomb calorimeter with a heat capacity of 6.0 kJ/°C. The calorimeter also contained 1.0 L of water and rose in temperature by 3.5°C. Determine the number of Calories in one serving of caramel.

1 Calorie = 1000 calories; 1 calorie = 4.18 J; C(H₂O) = 4.18 J/g°C, d(H₂O) = 1.00 g/mL

(1) 3.5 Calories  (2) 5.0 Calories  (3) 8.5 Calories  (4) 25 Calories  (5) 29 Calories

6. The ΔHrxn for dissolving a certain compound in water is 25.4 kJ. When 10.5 g of the compound dissolves in 500 mL of water, the reaction is ________ and the temperature of the solution ________. The correct terms to fill in the blanks are:

(1) endothermic, increases    (2) endothermic, decreases    (3) exothermic, decreases
(4) exothermic, increases     (5) endothermic, doesn’t change
7. A gaseous compound composed of carbon, hydrogen, and chlorine, effuses through a pinhole only 0.411 times as fast as neon. What is the correct molecular formula for the compound?

(1) CHCl₃          (2) CH₂Cl₂       (3) C₂H₂Cl₂       (4) C₂H₃Cl       (5) CCl₄

8. Based on ideal behavior, if a 2.5 L gas-filled balloon originally at 25°C and 1.00 atm is changed to conditions of 0.85 atm and 15°C, what is the resulting volume of the balloon?

(1) 1.5 L          (2) 2.1 L       (3) 2.6 L       (4) 2.8 L       (5) 3.0 L
9. Consider the preparation of ethanol, CH₃CH₂OH, by fermentation of glucose, C₆H₁₂O₆:

\[ \text{C}_6\text{H}_{12}\text{O}_6(aq) \rightarrow 2 \text{CH}_3\text{CH}_2\text{OH}(aq) + 2 \text{CO}_2(g) \]

At STP, what volume of CO₂ is produced by the fermentation of 125 g of glucose (180.16 g/mole) if the reaction has a yield of 97%?

(1) 15.1 L  (2) 30.2 L  (3) 31.2 L  (4) 34.6 L  (5) 41.4 L

10. A cylinder with a frictionless movable piston contains an ideal gas at 400K. After the temperature of the cylinder is increased to 800K at constant barometric pressure, which of the following will not be true?

(1) the volume of the gas in the cylinder at 800K will be twice the volume of the gas in the cylinder at 400K
(2) the average kinetic energy of the gas in the cylinder at 800K will be greater than it was at 400K
(3) the frequency and force of the gas particle collisions in the cylinder at 800K will be greater than at 400K
(4) the root-mean-square velocity (u_rms) of the gas in the cylinder at 800K will be greater than at 400K
(5) the pressure of the gas inside the cylinder at 800K will be twice the pressure of the gas at 400K
11. A certain gaseous oxide of sulfur has an effusion rate that is 0.707 times the effusion rate of oxygen gas.

What is the most likely molecular formula of this oxide?
(1) SO   (2) SO₂   (3) SO₃   (4) SO₄   (5) S₂O

12. A rigid vessel at constant temperature initially contains 0.500 atm of nitrogen gas and 0.500 atm of hydrogen gas. If these gases react to form ammonia, and the reaction is assumed to go to completion, what is the closest value to the final (total) pressure in the vessel after the reaction has gone to completion?
(1) 0.167 atm   (2) 0.66 atm   (3) 1.00 atm   (4) 1.50 atm   (5) 2.00 atm
13. Using the above table, determine the rate law.

(1) rate = k [A]^2[B] [C]
(2) rate = k [A] [B]^2[C]
(3) rate = k [A] [B][C]^2
(4) rate = k [A]^2 [B]2[C]
(5) rate = k [A] [B]2[C]^2

14. Using the table, determine the rate constant \( (L^3\text{mol}^{-3}\text{s}^{-1}) \).

(1) 2.0   (2) 3.0   (3) 4.0   (4) 8.0   (5) 16.0

15. In the above table, determine the missing number.

(1) 0.025   (2) 0.040   (3) 0.400   (4) 0.029   (5) 0.016
16. Using the data in the table below, determine the rate law for: \( N_2 + H_2 + F_2 \rightarrow N_2H_2F_2 \).

<table>
<thead>
<tr>
<th>Exp</th>
<th>([N_2])</th>
<th>([H_2])</th>
<th>([F_2])</th>
<th>Initial Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.10 M</td>
<td>0.10 M</td>
<td>0.20 M</td>
<td>0.040 M/s</td>
</tr>
<tr>
<td>2</td>
<td>0.20 M</td>
<td>0.20 M</td>
<td>0.20 M</td>
<td>0.080 M/s</td>
</tr>
<tr>
<td>3</td>
<td>0.10 M</td>
<td>0.20 M</td>
<td>0.20 M</td>
<td>0.040 M/s</td>
</tr>
<tr>
<td>4</td>
<td>0.10 M</td>
<td>0.10 M</td>
<td>0.40 M</td>
<td>0.080 M/s</td>
</tr>
</tbody>
</table>

(1) Rate = \( k[N_2][H_2] \)  
(2) Rate = \( k[N_2][H_2][F_2] \)  
(3) Rate = \( k[H_2][F_2] \)  
(4) Rate = \( k[N_2H_2F_2] \)  
(5) Rate = \( k[N_2][F_2] \)

17. Given the overall reaction, \( A + C \rightarrow D + F \), and the following mechanism, what is the rate law?

step 1: \( A \rightleftharpoons 2B \) (fast, equilibrium)  
step 2: \( B + C \rightarrow D + E \) (slow)  
step 3: \( B + E \rightarrow F \) (fast)  

(1) \( k[A][C] \)  
(2) \( k[A]^{1/2}[C] \)  
(3) \( k[B][C] \)  
(4) \( k[A][C]^2 \)  
(5) \( k[A]^{1/2} \)

GOOD LUCK ON THE EXAM, and remember to love your moles: all 6.022 x 10^{23} of them!

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