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CH1020

EXAM 3B (70 points)

November 30^{th}, 2018

There are a total of 11 pages in the exam (including this page).
There are a total of 13 questions.
Show your work to get full credit.
The required tables can be found on the last 4 pages

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1. (2 points) Which of the following statements correctly describes the signs of q and w for the following process at P = 1 atm and T = 25°C ?

$$N_2(l) \rightarrow N_2(g)$$

   a. q and w are negative

   b. q is positive, and w is negative

   c. q is negative and w is positive

   d. q and w are both positive

   e. q and w are both zero

2. (2 points) Indicate of each of the following processes is ***exothermic*** **or** ***endothermic***

   a. condensation of water vapor (water vapor is the system) exothermic

   b. When solid sodium hydroxide is dissolved in water, the solution gets warm (sodium hydroxide is the system) exothermic

3. (2 points) For each of the following reactions, indicate whether the absolute value ΔE is smaller, equal or larger than ΔH

   a. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ ΔE __<__ ΔH

   b. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ ΔE __=__ ΔH

4. (2 points) 10.0 g of a metal, initially at 25°C, is placed into 10.0 g of water, initially at 100°C. Which metal will have the highest final temperature? Shown after each metal is its specific heat (you don't need to do a calculation to solve this question).

   a. iron (0.450 J/(g·°C))

   b. copper (0.385 J/(g·°C))

   c. gold (0.128 J/(g·°C))

   d. silver (0.235 J/(g·°C))

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5. (5 points) To inflate a balloon pressure-volume work is done on the surroundings. If 210 J of work was used to inflate a balloon from an initial volume of 0.200 L against an external pressure of 1.00 atm, what is the final volume of the balloon?

$-210\,J \cdot \frac{1\,atm \cdot L}{101.3\,J} = -2.07\,atm \cdot L$ (1)

$-2.07\,atm \cdot L = -1.00\,atm \cdot (V_f - 0.2L)$ (1)

$2.07\,L = V_f - 0.2L$ (1)

$V_f = 2.27\,L$ (2)

6. (5 points) Use Hess's Law to calculate the enthalpy change for the reaction

$$C_2H_4(g) + 6F_2(g) \rightarrow 2CF_4(g) + 4HF(g)$$

from the following data:

$[H_2(g) + F_2(g) \rightarrow 2HF(g) \quad \Delta H = -537kJ] \times 2 = -1074\,kJ$ (1)

$[C(s) + 2F_2(g) \rightarrow CF_4(g) \quad \Delta H = -680kJ] \times 2 = -1360\,kJ$ (1)

$[2C(s) + 2H_2(g) \rightarrow C_2H_4(g) \quad \Delta H = +52.3kJ] \times (-1) = -52.3\,kJ$ (1)

(provide the appropriate chemical reactions to receive full credit)

$-2486.3\,kJ$ (2)

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7. (8 points) Use ΔH^{o}_{f} values to calculate ΔH^{o}_{rxn} for the reaction below (see table for ΔH^{o}_{f} values, provide the appropriate chemical reactions to receive full credit).

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$$

$[2C + 3H_2 + \frac{1}{2}O_2 \rightarrow C_2H_5OH] \times (-1) \Rightarrow +277.7$ kJ/mol (2)

$[C(s) + O_2(g) \rightarrow CO_2(g)] \times (2) \Rightarrow -393.5$ kJ/mol $\times 2 =$ (2)
-787 kJ/mol

$[H_2(g) + \frac{1}{2}O_2 \rightarrow H_2O(g)] \times (3) \Rightarrow -241.8 \times 3 =$ (2)
-725.4 kJ/mol

$\Delta H_{rxn} = -1235$ kJ/mol (2)

8. (8 points) A 45.0 g iron metal (specific heat capacity = 0.450 J/g °C) is heated to 90.0°C and dropped into 55.0 g of water at 23.2 °C (specific heat capacity = 4.184 J/g°C). What is the final temperature of the water/iron mixture?

$m_{Fe} \cdot C_s(Fe) \cdot \Delta T(Fe) = -(m_{H_2O} \cdot C_s(H_2O) \cdot \Delta T_{H_2O})$ (1)

$45.0g \cdot 0.450\ J/g°C \cdot \Delta T_{Fe} = -(55.0g \cdot 4.184\ J/g°C \cdot \Delta T_{H_2O})$ (1)

$20.25\ \Delta T_{Fe} = -230.12\ \Delta T_{H_2O}$ (1)

$\Delta T_{Fe} = -11.36\ \Delta T_{H_2O}$ (1)

$T_f - 90°C = -11.36(T_f - 23.2°C)$ (1)

$T_f + 11.36T_f = 263.6°C + 90°C = 353.6°C$ (1)

$T_f = \frac{353.6°C}{12.36} = 28.6°C$ (2)

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9. (8 points) Magnesium metal reacts with hydrochloric acid according to the balanced equation:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g) \qquad \Delta H_{rxn} = ?$$

When 2.00g Mg(s) metal is combined with enough 1.00M HCl to make 300 mL of the solution, it causes the temperature of the solution to increase from 22.4°C to 27.5°C. Find ΔH_{rxn} for this reaction as written ($d_{solution}$=1.00 g/ml; $C_{s,\ solution}$=4.18 J/g°C)

$q = 300g \cdot 4.18\,J/g°C \cdot \underbrace{(27.5°C - 22.4°C)}_{5.1°C}$ (2)

(2)

$q = 6395J \Rightarrow q_{rxn} = -6395J$ (1)

(2)

$\Delta H = \dfrac{-6395J \; (1)}{0.0823\,mol \; (1)} = -77731\,J/mol = -77.7\,kJ/mol$

10. (8 points) A bomb calorimeter has a heat capacity of 3.640 kJ/°C. When a 1.608 g sample of cymene ($C_{10}H_{14}$, found in several spices and fragrances including thyme, anise and coriander) was burned in this calorimeter, the temperature increased by 19.35°C. Calculate the energy of combustion for one mole of cymene.

$q = 3.640\,kJ/°C \cdot 19.35°C = 70.4\,kJ$ (2)

$q_{rxn} = -70.43\,kJ$ (2)

(1)

$\#\,moles = 1.608g \cdot \dfrac{1\,mol}{134.2} = 0.012\,mol$

(2)

$\Delta H_{rxn} = \dfrac{-70.43\,kJ \; (1)}{0.012\,mol} = -5878\,kJ/mol$

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11. (4 points) What mass of CH_4 must burn to emit 267 kJ of heat?

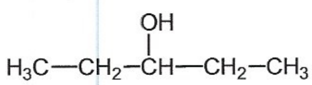
$$CH_4(g) + 2O_2(g) \rightarrow \cancel{3}CO_2(g) + 3H_2O(g) \quad \Delta H_{rxn} = -802.3\, kJ/mol$$

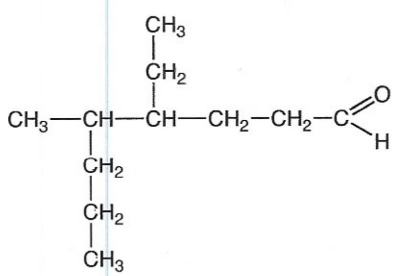
$\Delta H_{rxn} = \frac{q_{rxn}}{\#moles} \Rightarrow -802.3\, kJ/mol = \frac{-267\, kJ}{\#moles}$ (2)

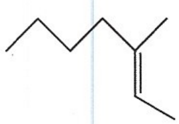
#moles = 0.333 mol (1)

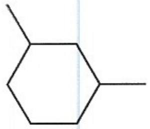
mass (CH_4) = 5.34g (1)

12. (8 points) Give the names for the following chemical compounds:

a).  3 - pentanol (2)

b)  4-ethyl-5-methyl octanal (2)

c)  3-methyl-2-heptene (2)

d)  1,3 dimethyl cyclo hexane (2)

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13. (8 points) Provide the condensed structural formula for the following compounds:

a) 2-pentene

$CH_3-CH=CH-CH_2-CH_3$ 2

b) 2-but~~a~~enoic acid

$CH_3-CH=CH-C\begin{matrix}{}^{\,=O}\\{}_{\,-OH}\end{matrix}$ 2

c) 2,3-dimethyl hexane

$$\begin{array}{cccccc} & CH_3 & CH_3 & & & \\ & | & | & & & \\ CH_3- & CH- & CH- & CH_2- & CH_2- & CH_3 \end{array}$$ 2

d) 2-butanol

$$\begin{array}{cccc} & OH & & \\ & | & & \\ CH_3- & CH- & CH_2- & CH_3 \end{array}$$ 2