Name _____ Block: _____

Thermochemistry worksheet – many different types of problems exist below. Be patient and work through them – pay attention to units and read the question ***twice***.

**1.** What is the specific heat, s, ($J \cdot g^{-1} \cdot K^{-1}$) of a substance if 51 J of heat are required to raise the temperature of 1.7 grams of this substance from 20.5 ºC to 25.5 ºC?

**2.** In a calorimetry experiment, the temperature of 500. mL of water rose from 19.78 ºC to 23.61 ºC when 1.0 g of sodium metal reacted according to the following balanced equation:

$$2\ Na\ (s) + H_2O\ (l) \rightarrow 2\ NaOH\ (aq) + H_2\ (g)$$

Using the assumption that the calorimeter's heat capacity is due only to the 500 gram of water (specific heat = 4.184 J/(g K)), calculate $q_{rxn}$ for the reaction. (How much heat is evolved?)

**3.** Consider that the following enthalpy changes are known for the stated reactions 1-3 below. Using Hess' Law, calculate the enthalpy change for reaction #4.

1. $N_2\ (g) + 2\ H_2\ (g) \rightarrow N_2H_4\ (l)$ $\Delta H1 = +\ 50.6$ kJ
2. $H_2\ (g) + O_2\ (g) \rightarrow H_2O_2\ (l)$ $\Delta H2 = -187.8$ kJ
3. $2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g)$ $\Delta H3 = -\ 483.6$ kJ

4. $N_2H_4\ (l) + 2\ H_2O_2\ (l) \rightarrow N_2\ (g) + 4\ H_2O\ (g)$

**4.** Calculate the specific heat of copper (J/g $^oC$), if 77.0 g of copper requires 16.14 kJ to raise its temperature from 22.5 $^oC$ to 567.0 $^oC$.

**5.** The specific heat of nickel is 0.444 J/g $^oC$. How many J and cal of heat are needed to raise the temperature of 300.0 g of of nickel by 78.0 $^oC$?

**6.** The specific heat of zinc is 0.388 J/g $^oC$. How many kJ and kcal of heat are needed to raise the temperature of 4.00 lb of zinc from 100.0 to 350.0 $^oC$? 1 lb = 453.59 g

**7.** A sheet of Au weighing 10.0 grams at a T of 18.0 $^oC$ is placed flat on a sheet of Fe weighing 20.0 grams and is at a T of 55.6 $^oC$. What is the final temperature of the combined metals? (hint – heat gained be gold must be equal to heat lost by iron, also you will need to find the s values for gold and iron from a book)

**8.** The reaction between hydrogen and nitrogen will produce ammonia with an overall enthalpy of -92.6 kJ. What amount of heat would be given off if $1.26 \times 10^4$ g of ammonia is produced?

**9.** Calculate the amount of hear in kJ required to convert 74.6 g of water to steam at 100 $^{o}$C. The molar heat of vaporization of water is 40.79 kJ/mol.

**10.** How much heat in kJ is needed to convert 866 grams of ice at -10 $^{o}$C to steam at 126 $^{o}$C? The specific heat of ice and steam are 2.03 J/g $^{o}$C and 1.99 J/g $^{o}$C; the heat of fusion of water is 6.01 kJ/mol, the heat of vaporization is given in question 9. You should know the specific heat for liquid water. Take a breath and write out the number of actual ***steps*** this will take. Go from there.

**11.** Use the table of enthalpy values to calculate the following $\Delta H_{rxn}$ for each reaction:

i. ethene (g) is combusted to form gaseous carbon dioxide and liquid water.
ii. $H_2S(g) + O_2(g) \rightarrow H_2O(l) + SO_2(g)$
iii. Gaseous Hydrogen and oxygen form liquid water

**12.** Pentaborane-9 ($B_5H_9$) is highly reactive with oxygen. The reaction is as follows:

$$2B_5H_9(l) + 12O_2(g) \rightarrow 5B_2O_3(s) + 9\,H_2O(l)$$

Calculate the heat released per gram of $B_5H_9$ when reacted with oxygen. The $\Delta H_f$ for petanborane-9 is 73.2 kJ/mol.

**13.** Write an elementary reaction that would allow you to determine the heat of formation ($\Delta H_f^o$) for silver oxide. No need to perform a calculation. This is simple; do not over think the problem.

**14.** Calculate the heat of decomposition at 1 atm and 298 K for solid calcium carbonate decomposing to solid calcium oxide and $CO_2$ gas. (use table)

Some values – more comprehensive list is on the site. You will need the longer list for exams.

| Compound | $\Delta H_f$/kJ mol$^{-1}$ | $\Delta H_f$/kcal mol$^{-1}$ | Compound | $\Delta H_f$/kJ mol$^{-1}$ | $\Delta H_f$/kcal mol$^{-1}$ |
|---|---|---|---|---|---|
| AgCl(*s*) | –127.068 | –30.35 | $H_2O$(*g*) | –241.818 | –57.79 |
| $AgN_3$(*s*) | +620.6 | +148.3 | $H_2O$(*l*) | –285.8 | –68.3 |
| $Ag_2O$(*s*) | –31.0 | –7.41 | $H_2O_2$(*l*) | –187.78 | –44.86 |
| $Al_2O_3$(*s*) | –1675.7 | –400.40 | $H_2S$(*g*) | –20.63 | –4.93 |
| $Br_2$(*l*) | 0.0 | 0.00 | HgO(*s*) | –90.83 | –21.70 |
| $Br_2$(*g*) | +30.907 | +7.385 | $I_2$(*s*) | 0.0 | 0.0 |
| C(*s*), graphite | 0.0 | 0.00 | $I_2$(*g*) | +62.438 | +14.92 |
| C(*s*), diamond | +1.895 | +0.453 | KCl(*s*) | –436.747 | –104.36 |
| $CH_4$(*g*) | –74.81 | –17.88 | KBr(*s*) | –393.798 | –94.097 |
| CO(*g*) | –110.525 | –26.41 | MgO(*s*) | –601.7 | –143.77 |
| $CO_2$(*g*) | –393.509 | –94.05 | $NH_3$(*g*) | –46.11 | –11.02 |
| $C_2H_2$(*g*) | +226.73 | +54.18 | NO(*g*) | +90.25 | +21.57 |
| $C_2H_4$(*g*) | +52.26 | +12.49 | $NO_2$(*g*) | +33.18 | +7.93 |
| $C_2H_6$(*g*) | –84.68 | –20.23 | $N_2O_4$(*g*) | +9.16 | +2.19 |
| $C_6H_6$(*l*) | +49.03 | +11.72 | $NF_3$(*g*) | –124.7 | –29.80 |
| CaO(*s*) | –635.09 | –151.75 | NaBr(*s*) | –361.062 | –86.28 |
| $CaCO_3$(*s*) | –1206.92 | –288.39 | NaCl(*s*) | –411.153 | –98.24 |
| CuO(*s*) | –157.3 | –37.59 | $O_3$(*g*) | +142.7 | +34.11 |
| $Fe_2O_3$(*s*) | –824.2 | –196.9 | $SO_2$(*g*) | –296.83 | –70.93 |
| HBr(*g*) | –36.4 | –8.70 | $SO_3$(*g*) | –395.72 | –94.56 |
| HCl(*g*) | –92.307 | –22.06 | ZnO(*s*) | –348.28 | –83.22 |
| HI(*g*) | +26.48 | +6.33 | | | |