These problems are intended to ***supplement*** the problems in the textbook, not ***replace*** them.

Questions

Use the following data to answer questions 2-6:

Specific Heats (J/g·K)					
Al_2O_3 *(s)*	0.775	Cu*(s)*	0.387	Hg*(l)*	0.14
C_2H_5OH*(l)*	2.45	H_2O*(l)*	4.184	Pyrex glass	0.78

1. A 1.62 gram sample of sodium chloride absorbs 27.78 J as it is heated from 16.4 °C to 36.2 °C. What is the specific heat of sodium chloride ?

2. If 3.50 grams of liquid mercury absorbs 1.97 calories, by how much will its temperature change, in °C ?

3. A 497 milligram sample of aluminum oxide is initially at 25.0 °C. If it absorbs 16.11 J of heat, then what will its final temperature be ?

4. A 1.00 pound sample of an unknown substance is heated from 12.66 °C to 98.71 °C by applying 15.0 kJ of energy. Which substance listed in the table is this ?

5. A Pyrex glass measuring cup has a mass of 561 grams. How much energy is needed to heat this measureing cup from 0.0 °C to 100.0 °C?

6. If 50.0 grams of copper initially at 145.0 °C is put into 150.0 mL of water initially at 25.00 °C, then what will the final temperature of the mixture be ? Hint: assume that all of the heat lost by the hot copper is absorbed by the cold water.

In the following questions, assume the mixture in the coffee cup has the same density and specific heat as pure water.

7. A coffee-cup calorimeter initially contains 125.0 grams of water at 24.20 °C. Potassium bromide (10.5 grams), also at 24.20 °C, is added to the water. After all of the potassium bromide dissolves, the final temperature is 21.10 °C. Calculate ΔH for this reaction:

$$KBr(s) \xrightarrow{water} K^{1+}(aq) + Br^{1-}(aq)$$

8. In a coffee-cup calorimeter, 100.0 mL of 1.76 M HNO_3 and 100.0 mL of 1.22 M $Ca(OH)_2$ are mixed. Both solutions were originally at 24.6 °C. The maximum temperature observed during the experiment is 36.4 °C. Calculate the enthalpy change for the neutralization reaction that occurs.

9. A 5.00 gram chunk of potassium is dropped into 1.000 kg of water initially at 24.00 °C in a coffee-cup calorimeter. The temperature at the end of the reaction is 30.00 °C. Find ΔH for the reaction which occurs, assuming the pressure remains constant:

$$2\,K(s) + 2\,H_2O(l) \rightarrow 2\,KOH(aq) + H_2(g)$$

For the next 4 questions, refer to the following thermochemical equation:

$$4\ NH_3\,(g) + 5\ O_2\,(g) \rightarrow 4\ NO(g) + 6\ H_2O(g) \qquad \Delta H° = -906\ kJ$$

10. How many moles of ammonia must react to produce 1234 kJ ?

11. How much heat is released when 62.4 grams of steam are produced ?

12. How many oxygen molecules must react to produce 1.00 calorie ?

13. If 88 grams of nitrogen monoxide are produced, how much heat is released ?

Calculate ΔH for the following reactions using this data:

Standard Enthalpies of Formation (kJ/mol)					
$Ag(s)$	0	$Cr_2O_3\,(s)$	−1139.7	$H_2S(g)$	−20.17
$Ag_2O(s)$	−31.05	$Fe(s)$	0	$O_2\,(g)$	0
$C_6H_{12}O_6\,(s)$	−1273.02	$Fe_2O_3\,(s)$	−822.16	$PbO(s)$	−217.3
$CO(g)$	−110.5	$H_2\,(g)$	0	$PbS(s)$	−100.0
$CO_2\,(g)$	−393.5	$H_2O(g)$	−241.82	$SO_2\,(g)$	−296.9
$Cr(s)$	0	$H_2O(l)$	−285.83		

14. $2\ H_2S(g) + 3\ O_2\,(g) \rightarrow 2\ H_2O(l) + 2\ SO_2\,(g)$

15. $2\ PbS(s) + 3\ O_2\,(g) \rightarrow 2\ SO_2\,(g) + 2\ PbO(s)$

16. $Fe_2O_3\,(s) + 3\ CO(g) \rightarrow 2\ Fe(s) + 3\ CO_2\,(g)$

17. $C_6H_{12}O_6\,(s) + 6\ O_2\,(g) \rightarrow 6\ H_2O(l) + 6\ CO_2\,(g)$

18. $2\ Ag_2O(s) \rightarrow 4\ Ag(s) + O_2\,(g)$

19. $Cr_2O_3\,(s) + 3\ H_2\,(g) \rightarrow 2\ Cr(s) + 3\ H_2O(l)$

Use Hess's Law to find the enthalpy changes for the following reactions:

20. reaction: $Hg_2Cl_2\,(s) \rightarrow 2\ Hg(l) + Cl_2\,(g)$

data:

$Hg(l) + Cl_2\,(g) \rightarrow HgCl_2\,(s)$ ΔH = −224 kJ

$Hg(l) + HgCl_2\,(s) \rightarrow Hg_2Cl_2\,(s)$ ΔH = −41.2 kJ

21. reaction: $NH_3\,(g) + CH_4\,(g) \rightarrow HCN(g) + 3\ H_2\,(g)$

data:

$N_2\,(g) + 3\ H_2\,(g) \rightarrow 2\ NH_3\,(g)$ ΔH = −92.2 kJ

$C(s) + 2\ H_2\,(g) \rightarrow CH_4\,(g)$ ΔH = −74.7 kJ

$2\ C(s) + H_2\,(g) + N_2\,(g) \rightarrow 2\ HCN(g)$ ΔH = +270.3 kJ

22. reaction: $C_6H_4(OH)_2(aq) + H_2O_2(aq) \rightarrow C_6H_4O_2(aq) + 2\ H_2O(l)$

data:

$C_6H_4(OH)_2(aq) \rightarrow C_6H_4O_2(aq) + H_2(g)$ ΔH = +177.4 kJ

$H_2(g) + O_2(g) \rightarrow H_2O_2(aq)$ ΔH = −191.2 kJ

$H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(g)$ ΔH = −241.8 kJ

$H_2O(g) \rightarrow H_2O(l)$ ΔH = −43.8 kJ

23. reaction: $2\ N_2(g) + 5\ O_2(g) \rightarrow 2\ N_2O_5(g)$

data:

$H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(l)$ ΔH = −285.9 kJ

$N_2O_5(g) + H_2O(l) \rightarrow 2\ HNO_3(l)$ ΔH = −76.6 kJ

$N_2(g) + 3\ O_2(g) + H_2(g) \rightarrow 2\ HNO_3(l)$ ΔH = −348.2 kJ

24. reaction: $KClO_3(s) + 3\ PCl_3(g) \rightarrow 3\ POCl_3(g) + KCl(s)$

data:

$2\ KCl(s) + 3\ O_2(g) \rightarrow 2\ KClO_3(s)$ ΔH = +78.0 kJ

$P_4(s) + 6\ Cl_2(g) \rightarrow 4\ PCl_3(g)$ ΔH = −1148.0 kJ

$P_4(s) + 2\ O_2(g) + 6\ Cl_2(g) \rightarrow 4\ POCl_3(g)$ ΔH = −2168.8 kJ

<u>Answers</u>

If you cannot figure out how to get the correct answer, go to your instructor, Science Tutoring Center, SI, etc.

NOTE: molar mass values were taken from the CHE 111 Lab Manual and used without rounding

1. 0.866 J/g·K
2. 17 °C
3. 66.8 °C or 340.0 K
4. copper
5. 4.4×10^4 J or 44 kJ
6. 28.59 °C or 301.7 K
7. +20.0 kJ
8. −112 kJ
9. −394 kJ
10. 5.45 mol NH_3
11. 523 kJ released
12. 1.39×10^{19} O_2 molecules
13. 6.6×10^2 kJ released
14. −1125.2 kJ
15. −828.4 kJ
16. −26.8 kJ
17. −2803.0 kJ
18. +62.10 kJ
19. +282.2 kJ
20. +265 kJ
21. +256.0 kJ
22. −202.6 kJ
23. +28.6 kJ
24. −804.6 kJ