UNIT 2

ENERGY

ANSWERS

Calorimetry Exercises Cont'd
Solutions

1. $m = 18.69g$
$\Delta T = 17K$
$Q = 41.8J$
$Q = mc\Delta t$
$c = \frac{q}{m\Delta t} = \frac{41.8}{(18.69)(17)} = 0.13J/g\cdot K$

2. Steel ball
$m = 25g$
$c = 427j/kg\cdot K$
$\Delta T = 73K$
$Q = mc\Delta t$
$Q = (0.025)(427)(73)$
$Q = 779.275J$ *Heat flows out of steel ball equals heat flows into water and calorimeter together.

Water
$m = 50g$
$c = 4.18J/g\cdot K$
$\Delta T = 2K$
$Q = (50)(4.18)(2)$
$Q = 418J$

Calorimeter
$Q = 779.275 - 418 = 361.2755J$
$m = 200g$
$c = ?$
$\Delta T = 2K$
$c = \frac{Q}{m\Delta t} = \frac{361.275}{(200)(2)}$
$c = 0.903J/g\cdot K$
$c = 903J/kg\cdot K$

3. Water
$Q = ?$
$m = 244g$
$\Delta T = 5.3°C$
$c = 4.18J/g\cdot °C$

$Q = mc\Delta t$
$Q = 5405.65J$

Molybdenum
$Q = 5405.65$
$m = 237g$
$\Delta T = 84.7$
$c = \frac{Q}{m\Delta t} = \frac{5405.65}{(237)(84.7)}$
$c = 0.269J/g\cdot K$ or $269J/kg\cdot K$

4. $95°C = 368.15K$ The heat flows from the zinc is equal and opposite to the heat flow into water and calorimeter.

$20°C = 293.15K$

$$\therefore \; -\left(\overset{zinc}{mc\Delta t}\right) = \overset{water}{mc\Delta t} + \overset{calorimeter}{mc\Delta t}$$

$$-[(0.1)(\cancel{372}\,377)(t_2-t_1)] = 0.06(4180)(t_2-t_1) + (0.1)(419)(t_2-t_1)$$

$$-37.7(t_2-368.15) = 250.8(t_2-293.15) + 41.9(t_2-293.15)$$

$$-37.7t_2 + 13879.255 = 250.8t_2 - 73522.02 + 41.9t_2 - 12282.985$$

$$13879.255 + 73522.02 + 12282.985 = 250.8t_2 + 41.9t_2 + 37.7t_2$$

$$99684.26 = 330.4t_2$$

$$t_2 = \cancel{301.7k} \quad 342K$$

5. Water

water	beaker
m=250g	m=100g
$c=4.18J/g\cdot k$	$c=0.67J/g\cdot k$
$\Delta T=80k$	$\Delta T=80k$
$Q=mc\Delta t$	$Q=mc\Delta t$
$=83600J$	$=5360J$

Total $= 83600 + 5360$

$= 88960J$

$\therefore$ in 8 mins the flame gives 88960J

$$88960x = 8(33180)$$

$$x = 2.98\,mins$$

Glycerine

glycerine	Beaker
m=200g	m=100g
$c=2.43J/g\cdot k$	$c=0.67J/g\cdot k$
$\Delta T=60k$	$\Delta T=60k$
$Q=mc\Delta t$	$Q=mc\Delta t$
$=29160J$	$=4020J$

Total $= 33180J$

$\therefore$ we need 33180J to heat the system to the required temperature

Calorimetry Exercises Cont'd

6.

	-10 Ice → 0°	melt	water 0° → 35°C
For 1 mole:	$m = 18g$	18g	$m = 18g$
	$c = 2.09\ J/g \cdot k$	melted	$c = 4.18J/k \cdot g$
	$\Delta T = 10k$	$Q = ?$	$\Delta T = 35k$
	$Q = mc\Delta t$		$Q = mc\Delta t$
	$= 376.2J$		$= 2633.4J$

Total energy required for whole process is 8772J

∴ The amount required for melting is 8772 - 376.2 - 2633.4

∴ melting requires 5762.4J

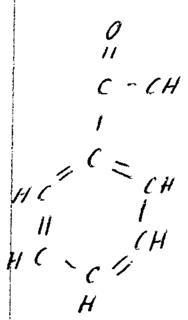
∴ 18g = 5762.4J

1g = x

$18x = 5762.4$

$x = 320.13$ ∴ It takes 320.13 J to melt 1g of ice at 0°C.

7. Benzoic Acid



1 mol → 7C's → 84g

2 O's → 32g

6 H's → 6g

Total → 122g

∴ $\frac{1.22g}{122g} = 0.01mol$ ∴ we burned 0.01mol of acid

Calorimeter $Q = mc\Delta t$

$= (8.364)(3.86)$

$= 32.28504kJ$

0.01mol → 32.28504kJ

1mol → x kJ

$x = 3228.504kJ$ ∴ Burning 1mole of acid gives off 3228.5kJ

8. Jet = 0.0001 mol/S

∴ 1 mol passes through jet every 10 000 seconds. In that 10 000 sec there has been 20000g of water pass through the coil (∴ 20g/s × 1000 sec)

Each gram is raised 3.44k

$Q = mc\Delta t$

$= (20000)(4.18)(3.44)$

$= 2875840 J$

$= 2875.84 kJ$ ∴ 1 mol of butane releases 2875.84 kJ when burned.

9. Ice $\Delta H^{\circ}fus = 5.76 kJ/mol$
Fake $\Delta H^{\circ}fus = 1.26 kJ/mol$ } The only difference between the two is the lack of hydrogen bonding in fake ice

∴ Hydrogen bonding accounts for 4.5 kJ/mol during breaking up.

If the ice were 100% hydrogen bonded there would be

$20 kJ/mol \times 2 mol = 40 kJ$

2H bonds possible for each molecule of water

But only 4.5kJ are needed to break H bonding

∴ $\frac{4.5}{40} = 11.25\%$ H bonding.

Hess's Law - Principle of Additivity of Reaction Heats

Solutions

a

a) 2×(1) $2HNO_2(aq) + \cancel{O_2(g)} \rightarrow \cancel{2HNO_3(aq)}$ $\Delta H = -104.6\ kJ$

rev (2) $\cancel{2HNO_3(aq)} + \overset{1NO_2}{\cancel{2NO_2(g)}} \rightarrow H_2O(l) + \frac{1}{2}O_2(g)$ $\Delta H = +97.45\ kJ$

rev (3) $\cancel{NO_2(g)} \rightarrow NO(g) + \cancel{\frac{1}{2}O_2(g)}$ $\Delta H = +56.6\ kJ$

$2HNO_2(aq) \rightarrow H_2O(l) + NO(g) + NO_2(g)$ $\Delta H = +49.45\ kJ$

b) 10×(1) $\cancel{10PCl_3(l)} + 5O_2(g) \rightarrow \cancel{10POCl_3(l)}$ $\Delta H = -5874\ kJ$

rev(2) $\cancel{10POCl_3(l)} \rightarrow P_4O_{10}(s) + \cancel{6PCl_5(s)}$ $\Delta H = +418\ kJ$

6×rev(4) $\cancel{6PCl_5(s)} \rightarrow \cancel{6P(s)} + 15\,\cancel{Cl_2(g)}$ $\Delta H = +5352\ kJ$

(3)×10 $\overset{4P(s)}{\cancel{10P(s)}} + \cancel{15Cl_2(g)} \rightarrow \cancel{10PCl_3(s)}$ $\Delta H = -6858\ kJ$

$4P(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$ $\Delta H = -6962\ kJ$

c) (1) $N_2H_4(l) + \cancel{3O_2(g)} \rightarrow \cancel{2NO_2(g)} + 2H_2O(g)$ $\Delta H = -466\ kJ$

2×rev(2) $2H_2O_2(l) \rightarrow \cancel{2H_2O(l)} + \cancel{O_2(g)}$ $\Delta H = -196\ kJ$

2×rev(3) $\cancel{2NO_2(g)} \rightarrow N_2(g) + \cancel{2O_2(g)}$ $\Delta H = -68\ kJ$

2×(4) $\cancel{2H_2O(l)} \rightarrow 2H_2O(g)$ $\Delta H = +88\ kJ$

$N_2H_4(l) + 2H_2O_2(l) \rightarrow N_2(g) + 4H_2O(g)$ $\Delta H = -642\ kJ$

d) rev(2) $K^+(g) + \cancel{e^-} \rightarrow K(g)$ $\Delta H = -419.1\ kJ$

(4) $F^-(g) \rightarrow \cancel{F(g)} + \cancel{e^-}$ $\Delta H = +333.3\ kJ$

(5) $\cancel{K(s)} + \frac{1}{2}\cancel{F_2(g)} \rightarrow KF(s)$ $\Delta H = -533\ kJ$

rev(1) $\cancel{K(g)} \rightarrow \cancel{K(s)}$ $\Delta H = -90\ kJ$

rev(3)/2 $\cancel{F(g)} \rightarrow \cancel{\frac{1}{2}F_2(g)}$ $\Delta H = -75.35\ kJ$

$K^+(g) + F^-(g) \rightarrow KF(s)$ $\Delta H = -784.15\ kJ$

SCH 4UI Chemistry- Energy and Kinetics
Heat of Rxn from Heat of Formation

Answers:

Calculate the ΔHr for each of the following:

a) $NO\ (g) + 1/2O_2\ (g) \Longrightarrow NO_2\ (g)$

$\Delta Hr = 34 - 90.4 = -56.4$KJ/mol of NO

but we have $\frac{30g}{20g/mol}$

=1 mol therefore $\Delta Hr = -56.4$KJ

b) $\Delta Hr = 2.5 \times [(-297-242.0) - (-814\ )]$

= 2.5x (   )

= 688.5KJ

c) $H_2\ (g) + CuO\ (s) \Longrightarrow H_2O\ (l) + Cu\ (s)$

$\Delta Hr = -285.5 + 155 = -130.5$KJ/mol of H_2O

but we have $\frac{54g}{18g/mol}$ = 3 mol

therefore $\Delta Hr = -391.5$KJ

d) $N_2\ (g) + 3\ H_2\ (g) \Longrightarrow 2\ NH_3\ (g)$

$\Delta Hr = 2x-46 = -92$ KJ/mol H_2

H_2 is the limiting reagent therefore, -30.7KJ/mol H_2

therefore for this reaction -30.7 KJ of energy will be released.

30.7KJ/ 20 KJ/K

=1.53K

e) $\frac{1.52g}{76012g/mol}$

=0.0200mol

therefore $-21.5 = 0.0200\ [\ 2(-297) + (-393.5) - (\ \Delta Hf\ CS_2)]$

$-107.5 = -594-393.5-\Delta Hf\ CS_2$

$\Delta Hf\ CS_2 = 87.5$ KJ/mol

f) $CaCl_2\ (s) \Longrightarrow Ca\ (aq) + 2\ Cl\ (aq)$

$\frac{11.11g}{11.1g/mol}$

0.10000mol

$\Delta Hr = 0.1\ [-543 + 2(-164) - (-795)]$

= 0.1*-76

=-7.6KJ

Calculating Mass Defect

Isotopic Mass (g-mol)	# of protons	# of neutrons	# of electrons	Total Mass (g/mol)	Mass Defect (g/mol)	Mass Defect (kg/mol)	Energy Equiv. (J/mol)
4.00260	2	2	2	4.03298	0.03038	$3.0*10^{-5}$	$2.7*10^{12}$
7.01600	3	4	3	7.05813	0.04214	$4.2*10^{-5}$	$3.8*10^{12}$
9.01218	4	5	4	9.07462	0.06245	$6.2*10^{-5}$	$5.6*10^{12}$
11.00931	5	6	5	11.0911	0.08189	$8.1*10^{-5}$	$7.4*10^{12}$
12.0000	6	6	6	12.0989	0.0989	$9.9*10^{-5}$	$8.9*10^{12}$
14.00307	7	7	7	14.1154	0.11236	$1.1*10^{-4}$	$1.0*10^{13}$
15.99491	8	8	8	16.1319	0.13701	$1.3*10^{-4}$	$1.2*10^{13}$
18.99840	9	10	9	19.1570	0.15868	$1.6*10^{-4}$	$1.4*10^{13}$
19.99244	10	10	10	20.1649	0.17247	$1.7*10^{-4}$	$1.5*10^{13}$

Radioactive Decay:

${}^{211}_{82}Pb \rightarrow {}^{0}_{-1}e + {}^{211}_{83}Bi$

${}^{220}_{86}Rn \rightarrow {}^{4}_{2}He + {}^{216}_{84}Po$

${}^{245}_{96}Cm \rightarrow {}^{4}_{2}He + {}^{241}_{94}Pu$

${}^{140}_{56}Ba \rightarrow {}^{0}_{-1}e + {}^{140}_{57}La$

Alpha and gamma emission from plutonium-242

${}^{242}_{94}Pu \rightarrow {}^{4}_{2}He + {}^{0}_{0}\gamma + {}^{238}_{92}U$

Beta emission from magnesium-28

${}^{28}_{12}Mg \rightarrow {}^{0}_{-1}e + {}^{28}_{13}Al$

Beta emission from potassium-42

${}^{42}_{19}K \rightarrow {}^{0}_{-1}e + {}^{42}_{20}Ca$

Alpha emission from californium-251

${}^{251}_{98}Cf \rightarrow {}^{4}_{2}He + {}^{247}_{96}Cm$

Beta emission by aluminum-30

${}^{30}_{13}Al \rightarrow {}^{0}_{-1}e + {}^{30}_{14}Si$

Alpha gamma emission by einsteinium-252

${}^{252}_{99}Es \rightarrow {}^{4}_{2}He + {}^{0}_{0}\gamma + {}^{248}_{97}Bk$