

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

$Q = 779.275 - 418J = 361.275J$

$m = 200g$

$c = ?$

$\Delta T = 2K$

$c = \frac{Q}{m\Delta T} = \frac{361.275}{(200)(2)}$

$c = 0.903J/g \cdot K$

$c = 903J/kg \cdot K$

3. Water

$Q = ?$

$m = 244g$

$\Delta T = 5.3^{\circ}C$

$c = 4.18J/g \cdot ^{\circ}C$

$Q = mc\Delta T$

$Q = 5405.65J$

Molybdenum

$Q = 5405.65J$

$m = 237g$

$\Delta T = 84.7^{\circ}C$

$c = \frac{Q}{m\Delta T} = \frac{5405.65}{(237)(84.7)}$

$c = 0.269J/g \cdot K$ or $269J/kg \cdot K$

4. $95^{\circ}\text{C} = 368.15\text{K}$ The heat flows from the zinc is equal and opposite to the
 $20^{\circ}\text{C} = 293.15\text{K}$ heat flow into water and calorimeter.

$$\therefore - (m_{\text{zinc}})_{\text{377}}^{\text{zinc}} = m_{\text{water}}^{\text{water}} \Delta t + m_{\text{calorimeter}}^{\text{calorimeter}} \Delta t$$

$$- [(0.1)(377)(t_2 - t_1)] = 0.06(4180)(t_2 - t_1) + (0.01)(419)(t_2 - t_1)$$

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

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

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

$$99684.26 = 330.4t_2$$

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

5. Water

water	beaker
$m = 150\text{g}$	$m = 100\text{g}$
$c = 4.18\text{J/g}\cdot\text{K}$	$c = 0.67\text{J/g}\cdot\text{K}$
$\Delta T = 80\text{K}$	$\Delta T = 80\text{K}$
$Q = mc\Delta t$	$Q = mc\Delta t$
$= 83600\text{J}$	$= 5360\text{J}$

$$\text{Total} = 83600 + 5360$$

$$= 88960\text{J}$$

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

$$88960x = 8(33180)$$

$$x = 2.98\text{mins}$$

Glycerine

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

$$\text{Total} = 33180\text{J}$$

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

Calorimetry Exercises Cont'd

6. -10

	Ice $\rightarrow 0^\circ$	melt	water $0^\circ \rightarrow 35^\circ\text{C}$
For 1 mole:	$m = 18\text{g}$	18g	$m = 18\text{g}$
	$c = 2.0\text{J/g}\cdot\text{K}$	melted	$c = 4.18\text{J/K}\cdot\text{g}$
	$\Delta T = 10\text{K}$	$q = ?$	$\Delta T = 35\text{K}$

$$Q = mc\Delta T$$

$$= 376.2\text{J}$$

$$Q = mc\Delta T$$

$$= 2633.4\text{J}$$

Total energy required for whole process is 8772J

$\therefore$ The amount required for melting is $8772 - 376.2 = 2633.4$

$\therefore$ melting requires 5762.4J

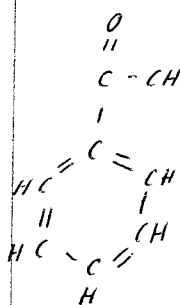
$$\therefore 18\text{g} = 5762.4\text{J}$$

$$1\text{g} = x$$

$$18x = 5762.4$$

$$x = 320.13$$

$\therefore$ It takes 320.13J to melt 1g of ice at 0°C .

7. Benzoic Acid

$$1\text{mol} \rightarrow 7\text{C's} \rightarrow 84\text{g}$$

$$2\text{O's} \rightarrow 32\text{g}$$

$$6\text{H's} \rightarrow 6\text{g}$$

$$\text{Total} \rightarrow 122\text{g}$$

$$\therefore \frac{1.22\text{g}}{122\text{g}} = 0.01\text{mol}$$

$\therefore$ we burned 0.01mol of acid

Calorimeter $Q = mc\Delta T$

$$= (8.564)(3.86)$$

$$= 32.28504\text{kJ}$$

$$0.01\text{mol} \rightarrow 32.28504\text{kJ}$$

$$1\text{mol} \rightarrow x\text{kJ}$$

$$x = 3228.504\text{kJ} \quad \therefore \text{Burning 1 mole of acid gives off } 3228.5\text{kJ}$$

8. Jet = 0.0001 mol/s

∴ 1 mol passes through jet every 10000 seconds. In that 10000 sec

there has been 20000g of water pass through the coil (∴ 20g/s × 1000 sec)

Each grain is raised 3.44K

$$Q = m(\Delta t)$$

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

$$= 2875840 \text{ J}$$

$$= 2875.84 \text{ kJ} \quad \therefore 1 \text{ mol of butane releases } 2875.84 \text{ kJ when burned.}$$

9. Ice $\Delta H^\circ_{\text{fus}} = 5.76 \text{ kJ/mol}$ } The only difference between the two is the
 Fake $\Delta H^\circ_{\text{fus}} = 1.26 \text{ kJ/mol}$ } 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

$$20 \text{ kJ/mol} \times 2 \text{ mol} = 40 \text{ kJ}$$



2H bonds possible for each molecule of water

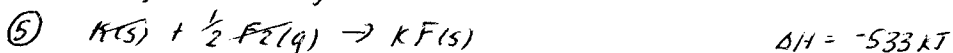
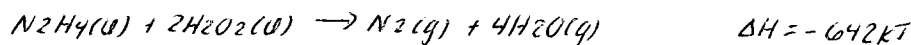
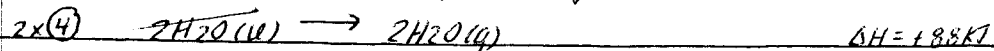
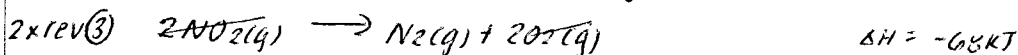
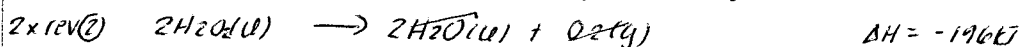
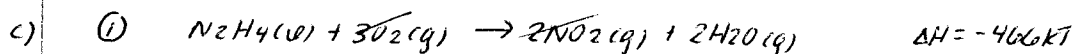
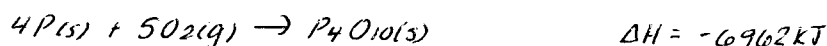
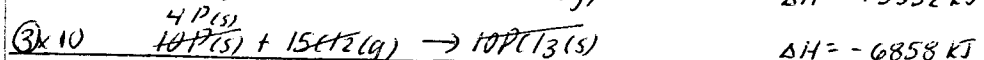
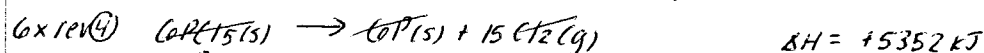
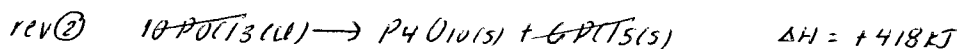
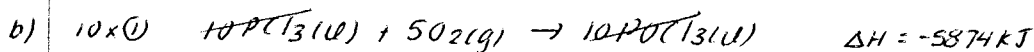
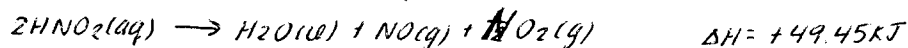
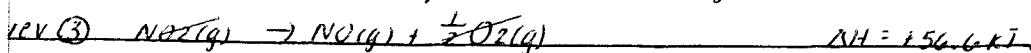
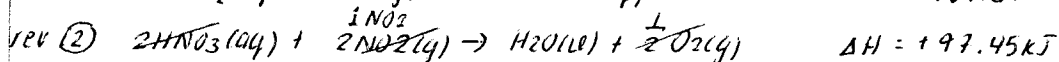
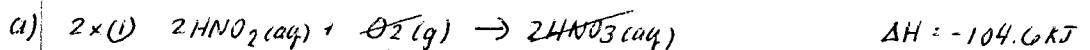
But only 4.5 kJ are needed to break H bonding

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

Hess's Law - Principle of Additivity of Reaction Heats

Solutions

a

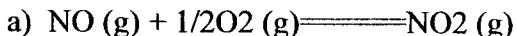


SCH 4UI Chemistry- Energy and Kinetics

Heat of Rxn from Heat of Formation

Answers:

Calculate the ΔH_r for each of the following:

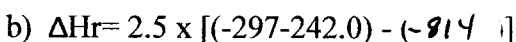


$$\Delta H_r = 34 - 90.4 = -56.4 \text{ KJ/mol of NO}$$

but we have 30g

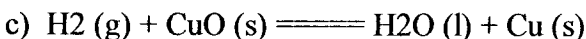
$$20 \text{ g/mol}$$

$$= 1 \text{ mol therefore } \Delta H_r = -56.4 \text{ KJ}$$



$$= 2.5 \times (-528.6)$$

$$= -1321.5 \text{ KJ}$$

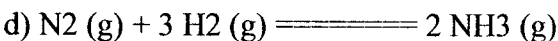


$$\Delta H_r = -285.5 + 155 = -130.5 \text{ KJ/mol of H}_2\text{O}$$

but we have 54g

$$18 \text{ g/mol} = 3 \text{ mol}$$

$$\text{therefore } \Delta H_r = -391.5 \text{ KJ}$$



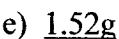
$$\Delta H_r = 2 \times -46 = -92 \text{ KJ/mol H}_2$$

H₂ is the limiting reagent therefore, -30.7 KJ/mol H₂

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

$$30.7 \text{ KJ} / 20 \text{ KJ/K}$$

$$= 1.53 \text{ K}$$



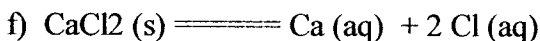
$$76012 \text{ g/mol}$$

$$= 0.0200 \text{ mol}$$

$$\text{therefore } -21.5 = 0.0200 [2(-297) + (-393.5) - (\Delta H_f \text{ CS}_2)]$$

$$-107.5 = -594 - 393.5 - \Delta H_f \text{ CS}_2$$

$$\Delta H_f \text{ CS}_2 = 87.5 \text{ KJ/mol}$$



$$11.1 \text{ g}$$

$$11.1 \text{ g/mol}$$

$$0.10000 \text{ mol}$$

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

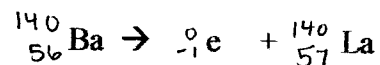
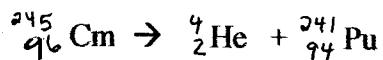
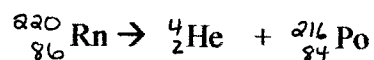
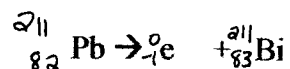
$$= 0.1 \times -76$$

$$= -7.6 \text{ KJ}$$

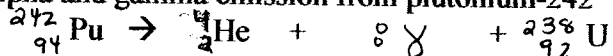
Calculating Mass Defect

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	$3.0 \cdot 10^{-5}$	$2.7 \cdot 10^{12}$
7.01600	3	4	3	7.05813	0.04214	$4.2 \cdot 10^{-5}$	$3.8 \cdot 10^{12}$
9.01218	4	5	4	9.07462	0.06245	$6.2 \cdot 10^{-5}$	$5.6 \cdot 10^{12}$
11.00931	5	6	5	11.0911	0.08189	$8.1 \cdot 10^{-5}$	$7.4 \cdot 10^{12}$
12.0000	6	6	6	12.0989	0.0989	$9.9 \cdot 10^{-5}$	$8.9 \cdot 10^{12}$
14.00307	7	7	7	14.1154	0.11236	$1.1 \cdot 10^{-4}$	$1.0 \cdot 10^{13}$
15.99491	8	8	8	16.1319	0.13701	$1.3 \cdot 10^{-4}$	$1.2 \cdot 10^{13}$
18.99840	9	10	9	19.1570	0.15868	$1.6 \cdot 10^{-4}$	$1.4 \cdot 10^{13}$
19.99244	10	10	10	20.1649	0.17247	$1.7 \cdot 10^{-4}$	$1.5 \cdot 10^{13}$

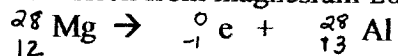
Radioactive Decay:



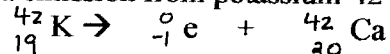
Alpha and gamma emission from plutonium-242



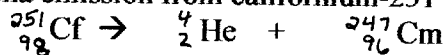
Beta emission from magnesium-28



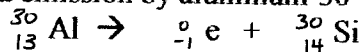
Beta emission from potassium-42



Alpha emission from californium-251



Beta emission by aluminum-30



Alpha gamma emission by einsteinium-252

