Suggested Answers to Tutorial 5a Chemical Energetics 1: Self–Check Questions

1 Refer to lecture notes.
Please give specific definition when asked for the enthalpy change for a specific substance.

Example:
(a) Standard enthalpy change of formation of **$CH_3OH(l)$** is the energy change when **1 mole of $CH_3OH(l)$** is formed from its constituents elements, **C(s), $O_2(g)$ and $H_2(g)$** at 298 K and 1 bar.

$$\mathbf{C(s) + \tfrac{1}{2}\, O_2(g) + 2H_2(g) \rightarrow CH_3OH(l)} \qquad \mathbf{\Delta H_f^{\theta}\,[CH_3OH(l)]}$$

2 No. of moles of butane = 1.2/24.0 = **0.0500 mol**
Heat produced by combustion = $-\Delta H_c$(butane) x n_{butane} = $-(-3000 \times 10^3) \times 0.0500$
= **$+1.50 \times 10^5$ J**
Given 80% efficiency, heat absorbed by water = 80/100 x 1.50 x 10^5 = **$+1.20 \times 10^5$ J**

Applying $q = mc\Delta T$
$+120000 = m \times 4.18 \times$ **(100 – 20)**
Mass of water heated, m = **359 g**

3 $\frac{1}{2}N_2(g) + \frac{3}{2}H_2O(g) \rightarrow NH_3(g) + \frac{3}{4}O_2(g)$

$\Delta H_r = [\frac{1}{2}BE(N{\equiv}N) + 3BE(O\text{-}H)] - [3BE(N\text{-}H) + \frac{3}{4}BE(O{=}O)]$

$= [\frac{1}{2}(944) + 3(460)] - [3(390) + \frac{3}{4}(496)] =$ **$+310$ kJ mol^{-1}**

[Note: whenever only bond energies are used, the species must be in the gaseous states.]

4 *Note: This question is different from example in Section 3.7 of lecture notes. The heat absorbed by the copper calorimeter was not ignored here since the specific heat capacity of copper was given in the question.*

Method 1:
Heat capacity of apparatus, C = 120 x 0.387 + 150 x 4.18 = 673.44 J K^{-1}
Heat absorbed by the apparatus = $C\Delta T$ = 673.44 x (85–20) = +43774 J

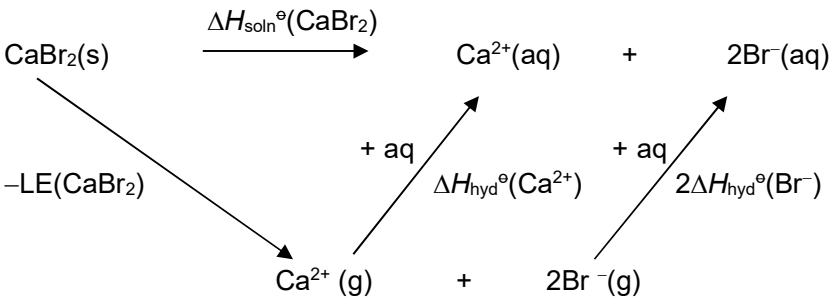
Note: ΔT in K is the same as ΔT in °C

Method 2:
Total heat absorbed = q(calorimeter) + q(water) = 120 x 0.387 x (85–20) + 150 x 4.18 x (85–20)
= +43774 J

Given that efficiency is 75%, heat producted by combustion = +43774/0.75
= +58365 J
Mass of ethanol burnt = 43.56 – 41.36 = 2.20 g
Amount of ethanol burnt = 2.20 / 46.1 = 0.047722 mol

Enthalpy change of combustion of ethanol = –58365 / 0.047722 = **–1220 kJ mol^{-1}**

5



$\Delta H_{soln}^{\ominus}(CaBr_2) = \Delta H_{hyd}^{\ominus}(Ca^{2+}) + 2\Delta H_{hyd}^{\ominus}(Br^-) - LE(CaBr_2)$

$= -1591 + 2(-284) - (-2132)$

$= \mathbf{-27\ kJ\ mol^{-1}}$

6 C Recall: Enthalpy change of formation of carbon monoxide is the energy change when <u>one mole</u> of gaseous carbon monoxide is formed from its constituent <u>elements, C(s) and O_2(g), in their standard states</u>.

- Option A is incorrect.
  C(g) should be C(s). C in its standard state is C(s).
  O(g) should be ½O_2(g). C in its standard state is O_2(g).
- Option B is incorrect.
  C(g) should be C(s). C in its standard state is C(s).
- Option C is correct. C(s) and O_2(g) are elements in their correct standard states. Also, 1 mole of CO(g) is formed.
- Option D is incorrect.
  CO_2(g) is not an element. Also, 2 moles of CO(g) is formed instead of 1 mole.

7 B $H_2S(g) + ½O_2(g) \rightarrow H_2O(g) + S(s)$ ΔH_{rxn}

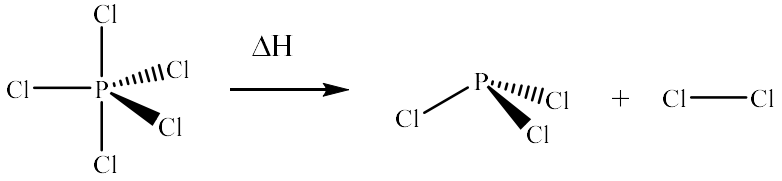
Since enthalpy changes of formation are given, we use

$\mathbf{\Delta H_{rxn} = \Sigma n\Delta H_f(pdts) - \Sigma m\Delta H_f(rxts)}$

$\Delta H_{rxn} = -243 - (-20.5) = -222.5\ kJ\ mol^{-1}$

Recall: $\Delta H_f^{\ominus}[O_2(g)] = 0\ kJ\ mol^{-1}$;
$\Delta H_f^{\ominus}[S(s)] = 0\ kJ\ mol^{-1}$

8 D $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$ ΔH



ΔH = ΣBE of bonds broken in reactants – ΣBE of bonds formed in products

= 2BE(P–Cl) – BE(Cl–Cl)

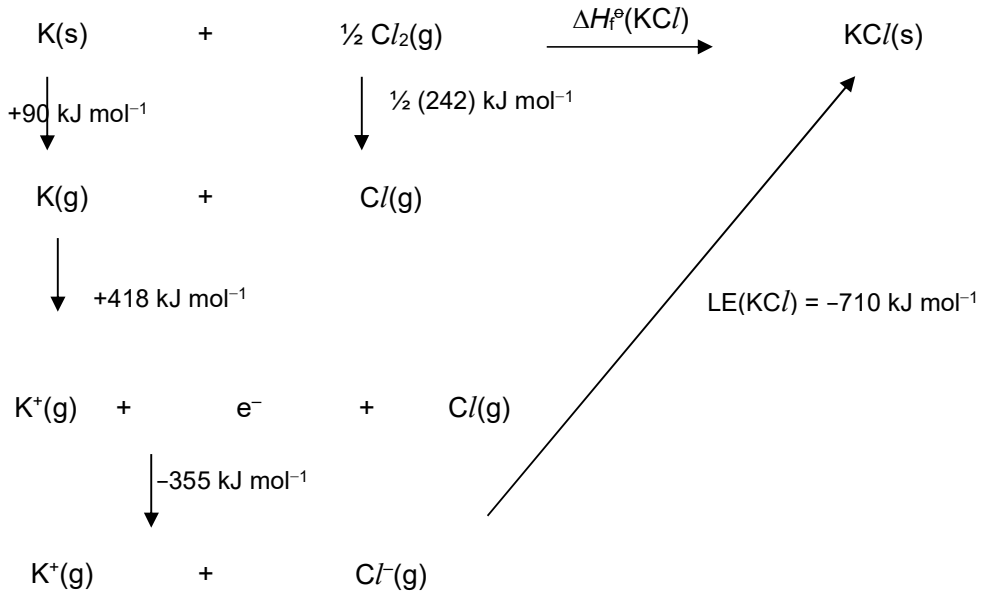
= 2 x 330 – 240

= +420 kJ mol^{-1}

9 C $|LE| \propto \left|\frac{q_+q_-}{r_+ + r_-}\right|$

The magnitude of lattice energy is proportional to product of ionic charges and inversely proportional to the sum of ionic radii (or interionic distance).

10 B



Applying Hess' Law

ΔH_f of KC*l* = 90 + ½(242) + 418 + (–355) + (–710) = **–436 kJ mol^{-1}**