

SUGGESTION ANSWER SCHEME
CHAPTER 8: THERMOCHEMISTRY

ANSWER SCHEME UPS 2004/2005 SK027

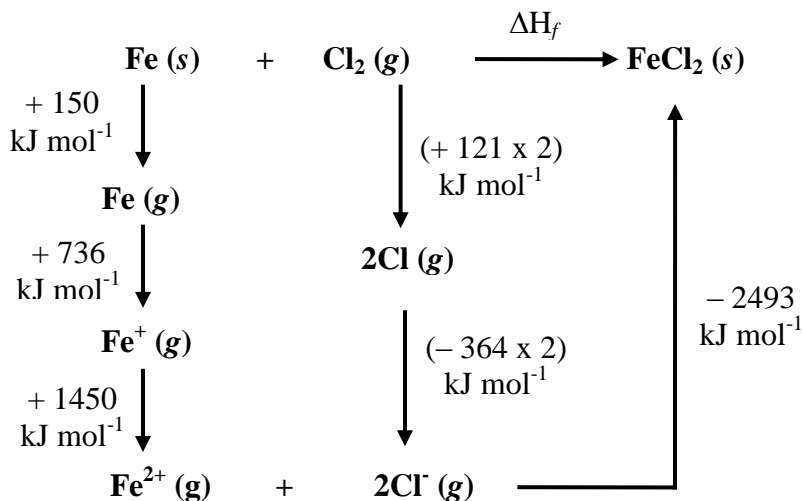
1 (a) Use the data in the table below to answer the following questions:

Enthalpy change	ΔH (kJ/mol)
Atomization energy of iron	+ 150
First ionization energy of iron	+ 736
Second ionization energy of iron	+1450
Atomization energy of chlorine	+ 121
Electron affinity of chlorine	- 364
Lattice energy of iron (II) chloride	- 2493

i. Define enthalpy of formation.

Heat change when 1 mole of a compound is formed from its elements in their stable states at standard condition (25 °C and 1 atm).

ii. Sketch the Born-Haber cycle for iron (II) chloride.



iii. Hence, calculate the enthalpy of formation for iron (II) chloride.

$$\begin{aligned}
 \Delta H_f &= (+ 150) + (+ 736) + (+ 1450) + (+ 121 \times 2) + (- 364 \times 2) + (- 2493) \\
 &= - 643 \text{ kJ mol}^{-1}
 \end{aligned}$$

[8 marks]

ANSWER SCHEME UPS 2005/2006 SK027

- 2 (a) Define the enthalpy of combustion.

Heat released when 1 mole of substance/compound is completely combusted in excess oxygen at standard condition (25 °C and 1 atm).

[1 mark]

- (b) A bomb calorimeter experiment is performed with powdered xylose, C
- ₅
- H
- ₁₀
- O
- ₅
- as the combustible substance. The data obtained are:

Mass of xylose burned	= 1.183 g
Heat capacity of calorimeter	= 4.728 kJ °C ⁻¹
Initial calorimeter temperature	= 23.29 °C
Final calorimeter temperature	= 27.19 °C

- i. Calculate the heat of combustion of xylose, in kilojoule per mole?

Heat given off by xylose = heat absorbed by the calorimeter

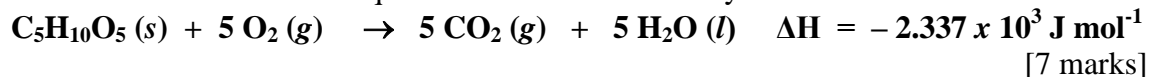
$$\begin{aligned} Q &= C\Delta T \\ &= 4.728 \text{ kJ } ^\circ\text{C}^{-1} (27.19 - 23.29) ^\circ\text{C} \\ &= 18.44 \text{ kJ} \end{aligned}$$

$$\begin{aligned} \text{Mole of xylose} &= 1.183 / 150 \\ &= 7.89 \times 10^{-3} \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{Heat of combustion} &= 18.44 \text{ kJ} / 7.89 \times 10^{-3} \\ &= 2337.14 \text{ kJ/mol} \\ &= 2337 \text{ kJ/mol @ } 2.337 \times 10^3 \text{ kJ/mol} \end{aligned}$$

$$\Delta H_c \text{ xylose} = -2.337 \times 10^3 \text{ kJ mol}^{-1}$$

- ii. Write the thermochemical equation for combustion of xylose.



[7 marks]

- (c) Which substance in the following pairs has larger lattice energy? Explain.

KCl or RbCl

KCl. The size of K⁺ is smaller than Rb⁺.

[2 marks]

ANSWER SCHEME UPS 2006/2007 SK027

- 3 (a) A 0.1375 g of magnesium is burned in a constant volume bomb calorimeter that has a heat capacity of $1769 \text{ J } ^\circ\text{C}^{-1}$. If the calorimeter contains 300.0 g of water and the temperature increases by $1.126 \text{ }^\circ\text{C}$, calculate the heat of combustion of magnesium in kJ mol^{-1} .

[5 marks]

Heat released by combustion = heat absorbed by calorimeter + heat absorbed by water

$$\begin{aligned} q &= C_c\Delta T + m_w c_w \Delta T \\ &= [1769 \text{ J } ^\circ\text{C}^{-1} \times 1.126 \text{ }^\circ\text{C}] + [300 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1} \times 1.126 \text{ }^\circ\text{C}] \\ &= 3.403 \times 10^3 \text{ J} \end{aligned}$$

$$\begin{aligned} \text{Mole of Mg} &= 0.1375 \text{ g} / 24.3 \text{ g mol}^{-1} \\ &= 5.658 \times 10^{-3} \text{ mol} \end{aligned}$$

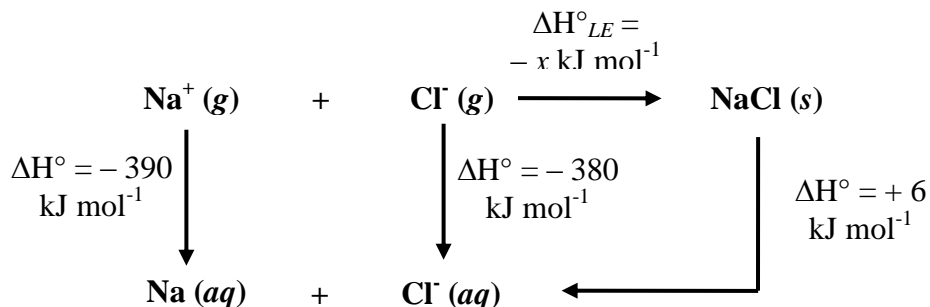
$$\begin{aligned} 5.658 \times 10^{-3} &\approx 3.403 \times 10^3 \text{ J} \\ 1.0 \text{ mol} &= 601.0 \text{ kJ mol}^{-1} \end{aligned}$$

$$\Delta H_c \text{ Mg} = -601.0 \text{ kJ mol}^{-1} @ -6.010 \times 10^2 \text{ kJ mol}^{-1}$$

- (b) Based on the data given below:

$$\begin{aligned} \Delta H^\circ_{\text{hydration}} \text{ Na}^+ &= -390 \text{ kJ mol}^{-1} \\ \Delta H^\circ_{\text{hydration}} \text{ Cl}^- &= -380 \text{ kJ mol}^{-1} \\ \Delta H^\circ_{\text{solution}} \text{ NaCl} &= +6 \text{ kJ mol}^{-1} \end{aligned}$$

- i. Construct an energy cycle diagram to represent the dissolution of NaCl.



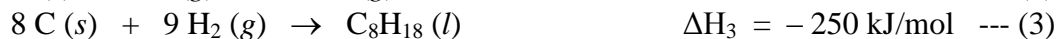
- ii. Calculate the lattice energy of NaCl.

$$\begin{aligned} \text{Lattice energy} &= \Delta^\circ H_{\text{hydration}} \text{ Na}^+ + \Delta^\circ H_{\text{hydration}} \text{ Cl}^- + \Delta H^\circ_{\text{solution}} \text{ NaCl} \\ &= [-390 + (-380) + (-6)] \text{ kJ mol}^{-1} \\ &= -776 \text{ kJ mol}^{-1} \end{aligned}$$

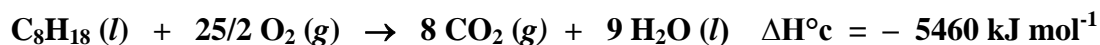
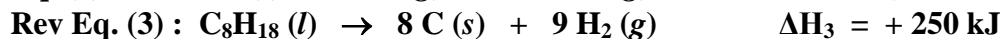
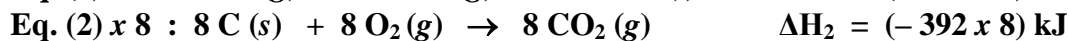
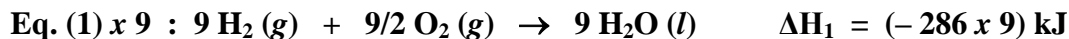
[5 marks]

ANSWER SCHEME UPS2007/2008 SK027

- 4 (a) Combustion of $C_8H_{18} (l)$ forms water and carbon dioxide. Using the data given, calculate the amount of heat released if 100.0 g of $C_8H_{18} (l)$ is completely burnt.



[5 marks]

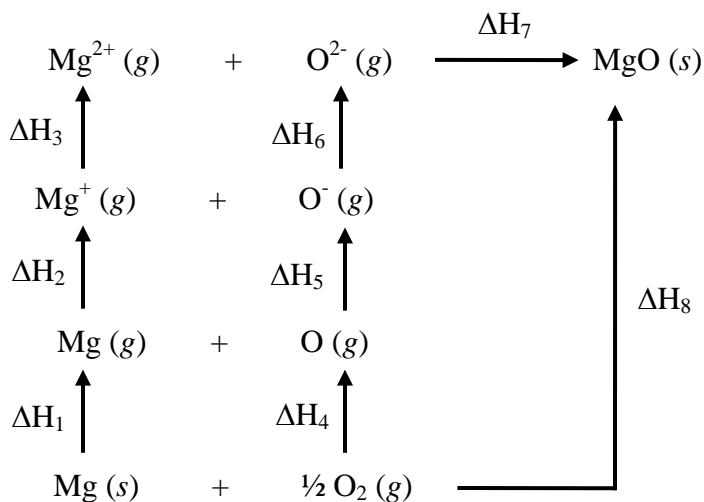


$$\begin{aligned} \Delta H^\circ c &= \Delta H_1 + \Delta H_2 + \Delta H_3 \\ &= -2574 + (-3136) + (+250) \\ &= -5460 \text{ kJ/mol} \end{aligned}$$

$$\text{No of mole of } C_8H_{18} = 100 \text{ g} / 114 \text{ g mol}^{-1} = 0.8772 \text{ mol}$$

$$\begin{aligned} \text{The amount of heat released} \\ &= -5460 \text{ kJ/mol} \times 0.8772 \text{ mol} \\ &= -4789.51 \text{ kJ} \\ &= -4790 \text{ kJ} @ 4.790 \times 10^3 \text{ kJ} \end{aligned}$$

- (b) The Born-Haber cycle for magnesium oxide is shown below:



- i. Name the enthalpy change for ΔH_1 , ΔH_3 and ΔH_7 .
 ΔH_1 – enthalpy of atomisation @ sublimation of magnesium
 ΔH_3 – second ionisation energy of magnesium
 ΔH_7 – lattice energy of magnesium oxide [3 marks]
- ii. Compare the lattice energy of magnesium oxide, MgO and barium oxide, BaO. Give reason.
The lattice energy of MgO is higher/more electronegative than that of BaO.
The size of Mg^{2+} is smaller than Ba^{2+} . @ attractive forces between Mg^{2+} and O^{2-} are stronger than those between Ba^{2+} and O^{2-} . [2 marks]

ANSWER SCHEME UPS 2008/2009 SK027

- 5 (a) A calorimeter contains 400.0 mL of water at 25°C. If 600.0 mL of water at 60 °C is added to it, determine the final temperature. Assume that the heat absorbed by the calorimeter is negligible.

Heat released by adding water = heat absorbed by adding water
 $m_1 C_1 \Delta T_1 = m_2 C_2 \Delta T_2$

$$\Delta T_1 = 60^\circ\text{C} - Y$$

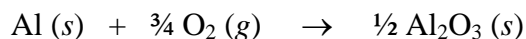
$$\Delta T_2 = Y - 25^\circ\text{C}$$

$$\therefore 600 \times 4.18 \times (60^\circ\text{C} - Y) = 400 \times 4.18 \times (Y - 25^\circ\text{C})$$

$$Y = 46^\circ\text{C} @ 46.0^\circ\text{C}$$

[4 marks]

- (b) The combustion of a sample of aluminium produces 0.25 mol of aluminium oxide and releases 419.0 kJ of heat at standard conditions.



- i. Define the standard enthalpy of combustion.
The amount of heat released when 1 mole of substance is completely burnt in excess of oxygen at standard conditions (25 °C and 1 atm).
- ii. Calculate the standard enthalpy of combustion of aluminium.

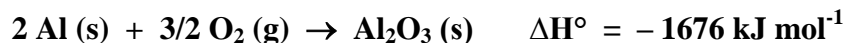
$$0.25 \text{ mol } Al_2O_3 \approx 416 \text{ kJ}$$

$$0.5 \text{ mol } Al_2O_3 \approx ? \text{ kJ}$$

$$\Delta H_c^\circ Al = 0.5 \times 419 / 0.25 = -838 \text{ kJ mol}^{-1} @ -838.0 \text{ kJ mol}^{-1}$$

- iii. Determine the enthalpy of formation of Al_2O_3 and write its thermochemical equation.

$$\begin{aligned}\Delta H_f^\circ \text{Al}_2\text{O}_3 &= \Delta H_c^\circ \text{Al} \\ &= 2 \times (-838) \\ &= -1676 \text{ kJ mol}^{-1}\end{aligned}$$



[6 marks]

UPS 2009/2010 SK027

- 6 (a) Define standard enthalpy of combustion.

Heat released when 1 mole of substance/compound is completely combusted in excess oxygen at standard condition (25 °C and 1 atm).

[1 marks]

- (b) Propane, C_3H_8 , is a hydrocarbon gas that is commonly used as a fuel for cooking. The standard enthalpy of combustion is $-220.1 \text{ kJ mol}^{-1}$.

Write a balanced equation for the complete combustion of propane gas. Assuming all of the heat evolved in burning 10.0 g of propane is transferred to 8.0 kg of water, calculate the increase in temperature of the water.



$$\text{Mr C}_3\text{H}_8 = 44 \text{ g mol}^{-1}$$

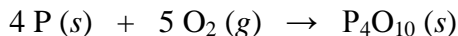
44 of C_3H_8 releases 220.1 kJ

10 g @ 0.227 mol of C_3H_8 releases 50.02 kJ

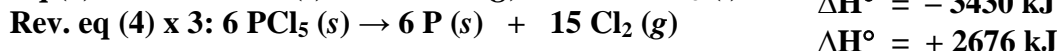
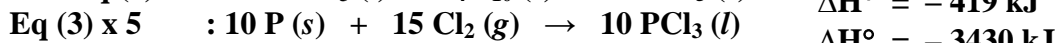
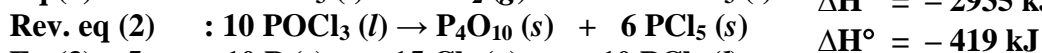
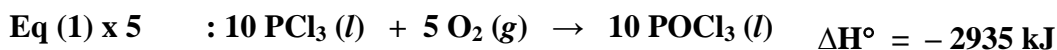
$$\begin{aligned}\text{Heat released} &= mc\Delta T \\ -50.02 \times 10^3 \text{ J} &= 8000 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1} \times \Delta T \\ \Delta T &= 1.5 \text{ }^\circ\text{C} @ 1.50 \text{ }^\circ\text{C}\end{aligned}$$

[5 marks]

- (c) When phosphorus is reacted with an excess of oxygen, tetraphosphorus decaoxide, P_4O_{10} , is formed as shown in the following reaction:

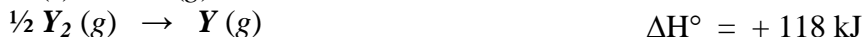


Using the information below, calculate the heat of formation, ΔH°_f , of P_4O_{10} .

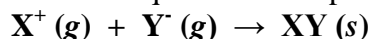


ANSWER SCHEME UPS 2009/2010 TS027

- 7 (a) Define standard enthalpy of formation.
Heat change (absorbed or released) when 1 mole of compound is formed from its elements under standard conditions (25 °C and 1 atm).
- [1 mark]
- (b) Elements X and Y form an ionic compound XY . The enthalpy changes involved in the formation of this compound under standard conditions are as follows:

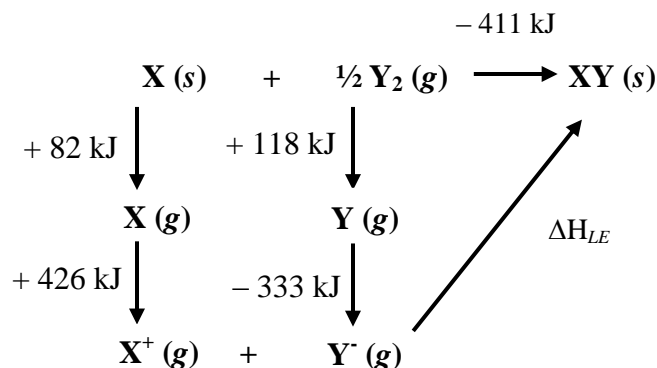


- i. Write an equation that represents the lattice energy of compound XY .



- ii. Calculate the value of the lattice energy by using energy cycle method.

[6 marks]



$$\begin{aligned}
 (+82) + (+426) + (+118) + (-333) + \Delta H_{LE} &= -411 \text{ kJ} \\
 \Delta H_{LE} &= -734 \text{ kJ mol}^{-1}
 \end{aligned}$$

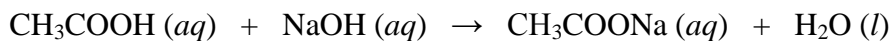
- (c) An amount of 1.23 kJ of heat is supplied to 70.0 g of water at a temperature of 28.0 °C. Calculate the final temperature of the water.

$$\begin{aligned}
 Q &= mc\Delta T \\
 1.23 \text{ kJ} &= 70.0 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1} \times (T_{final} - T_{initial}) \text{ }^\circ\text{C} \\
 1.23 \text{ kJ} &= 70.0 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1} \times (T_{final} - 28) \text{ }^\circ\text{C} \\
 T_{final} &= 32.2 \text{ }^\circ\text{C}
 \end{aligned}$$

[3 marks]

ANSWER SCHEME UPS 2010/2011 SK027

- 8 (a) A matriculation student carried out an experiment involving a reaction between an acid and a base as shown in the following reaction:



In this experiment, 20.0 cm³ of 2.0 M of NaOH solution was added to 30.0 cm³ of 1.0 M of CH₃COOH solution in a plastic cup. A maximum rise of 5.8°C in temperature was recorded.

[Heat capacity of the plastic cup = 37.30 J °C⁻¹. Assume density of solution = density of water]

- i. Name the enthalpy for this reaction.
Enthalpy of neutralization

- ii. Calculate the standard enthalpy for this reaction.

$$\begin{aligned}\text{Mol NaOH} &= 2.0 \times 20.0 / 1000 = 0.04 \text{ mol} \\ \text{Mol CH}_3\text{COOH} &= 1.0 \times 30.0 / 1000 = 0.03 \text{ mol} \\ \text{Limiting reactant is CH}_3\text{COOH}\end{aligned}$$

$$\text{Mol H}_2\text{O} = \text{mol CH}_3\text{COOH} = 0.03 \text{ mol}$$

$$\begin{aligned}\text{Assume volume of water} &= \text{volume of solution} \\ \text{Total volume} &= 20.0 \text{ cm}^3 + 30.0 \text{ cm}^3 = 50.0 \text{ cm}^3\end{aligned}$$

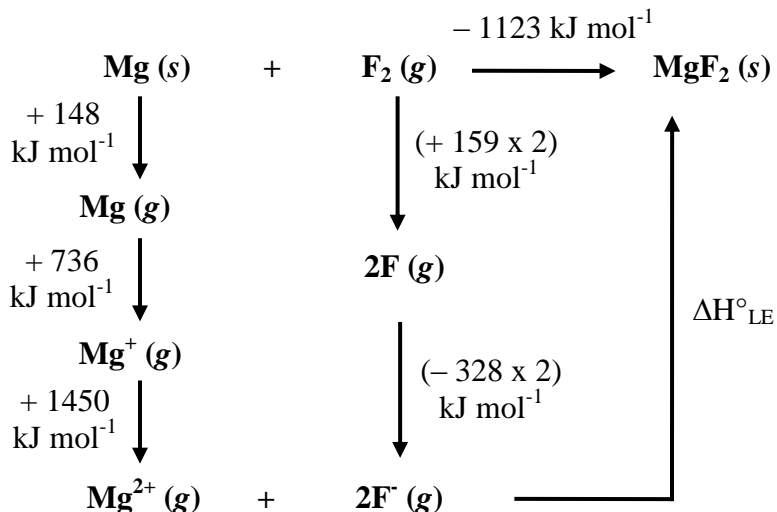
$$\begin{aligned}\text{Heat released} &= mc\Delta T + C\Delta T \\ &= (50.0 \times 4.18 \times 5.8) + (37.3 \times 5.8) \\ &= 1428.54 \text{ J @ } 1.4285 \text{ kJ}\end{aligned}$$

$$\begin{aligned}\Delta H^\circ_{\text{neutralisation}} &= 1.4285 / 0.03 \\ &= -47.62 \text{ kJ mol}^{-1}\end{aligned}$$

[6 marks]

- (b) i. Construct a Born-Haber cycle for the formation of magnesium fluoride, MgF_2 , by using the data below:

Enthalpy of atomisation of magnesium	+ 148 kJ mol ⁻¹
Enthalpy of atomisation of fluorine	+ 159 kJ mol ⁻¹
First ionisation energy of magnesium	+ 738 kJ mol ⁻¹
Second ionisation energy of magnesium	+ 1450 kJ mol ⁻¹
Electron affinity of fluorine	- 328 kJ mol ⁻¹
Standard enthalpy of formation of magnesium fluoride	- 1123 kJ mol ⁻¹



- ii. Based on the Born-Haber cycle, determine the lattice energy of magnesium fluoride.

$$\begin{aligned}\Delta H^{\circ}_{LE} &= -1123 - [148 + (159 \times 2) + 738 + 1450 + (-328 \times 2)] \\ &= -3121 \text{ kJ mol}^{-1}\end{aligned}$$

[4 marks]

ANSWER SCHEME UPS 2010/2011 TK025

- 9 (a) Use the data in the table below to answer the following questions:

Enthalpy change	ΔH (kJ/mol)
Atomisation energy of iron	+ 150
First ionisation energy of iron	+ 736
Second ionisation energy of iron	+ 1450
Atomisation energy of chlorine	+ 121
Electron affinity of chlorine	- 364
Lattice energy of iron (II) chloride	- 2493

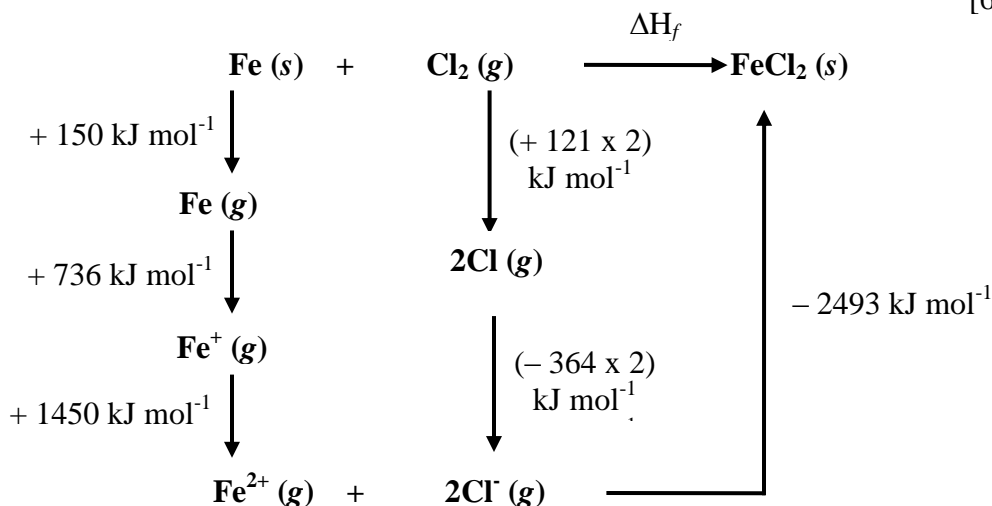
- (i) Define enthalpy of formation.

Heat change when 1 mole of a compound is formed from its elements in their stable states at standard conditions.

[1 mark]

- (ii) Sketch the Born-Haber cycle with appropriate enthalpy values for iron (II) chloride.

[6 marks]



[6 marks]

(iii) Calculate the enthalpy of formation for iron (II) chloride.

$$\begin{aligned}\Delta H_f &= 150 + 736 + 1450 + (121 \times 2) + (-364 \times 2) + (-2493) \\ &= -643 \text{ kJ mol}^{-1} @ -643.0 \text{ kJ mol}^{-1}\end{aligned}$$

[1 mark]

(b) Which compound between KCl or RbCl has larger lattice energy? Explain.

KCl. The size of K^+ is smaller than Rb^+ . The electrostatic attraction between K^+ and Cl^- is stronger than that of Rb^+ and Cl^- .

[2 marks]

10. (a) Define Hess's Law.

The total enthalpy change for a reaction is the same whether it occurs in one step or in many steps.

[1 mark]

(b) Lattice energy of potassium chloride, KCl is $+4 \text{ kJ mol}^{-1}$ and its enthalpy of hydration is -686 kJ mol^{-1} .

i. Write the thermochemical equation for the hydration process of potassium chloride.

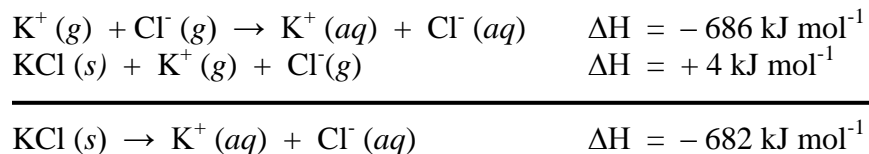


[2 marks]

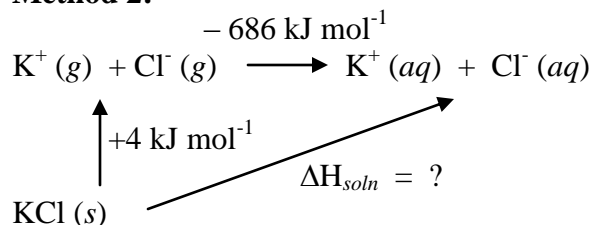
ii. Calculate the enthalpy of solution for the salt.

[3 marks]

Method 1:

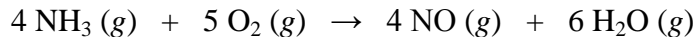


Method 2:

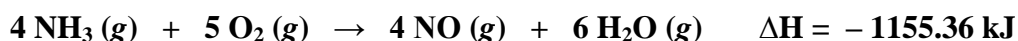
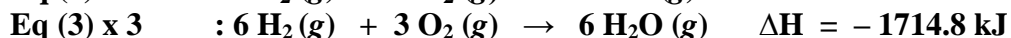
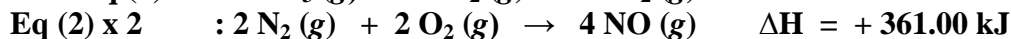
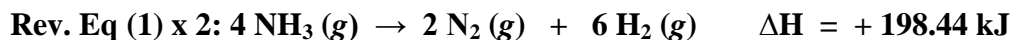
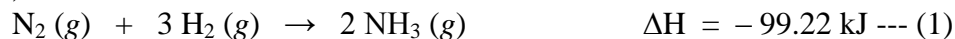


$$\begin{aligned}\Delta H_{soln} &= \Delta H_{hyd} + \Delta H_{LE} \\ &= (-686 + 4) \text{ kJ mol}^{-1} \\ &= -682 \text{ kJ mol}^{-1}\end{aligned}$$

- (c) Determine the enthalpy change for the oxidation of ammonia.



Given;



[4 marks]

ANSWER SCHEME UPS 2011/2012 TK025

- 11 (a) i. What is calorimetry?

Calorimetry is the measurement of a quantity of heat

[1 marks]

- ii. What is the basic principle of the simple calorimeter?

**All the heat lost by a system is gained by its surrounding (or vice versa) @
heat released = heat absorbed.**

[1 marks]

- iii. A 1.50 g sample of an alloy is heated to 99.0 °C. It is then dropped into 28.0 g water in a calorimeter. The water temperature rises from 20.00 °C to 22.25°C. Calculate the specific heat capacity of the alloy.

heat released = heat absorbed

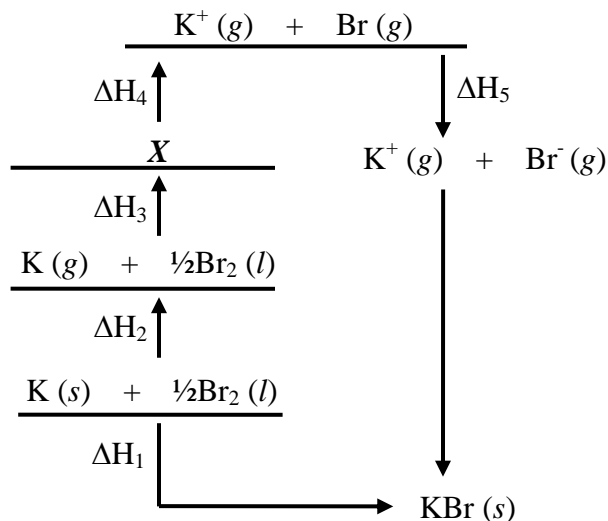
$$(\text{mc}\Delta T)_{\text{alloy}} = (\text{mc}\Delta T)_{\text{water}}$$

$$1.5 \text{ g} \times c \times 76.75 \text{ }^\circ\text{C} = 28.0 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1} \times 2.25 \text{ }^\circ\text{C}$$

$$c = 2.29 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$$

[3 marks]

- (b) FIGURE below is the Born-Haber cycle diagram for the formation of potassium bromide, KBr crystals.

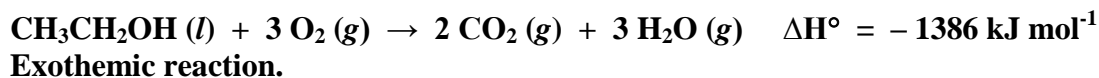


- (i) Name ΔH_2 and ΔH_5 .
 $\Delta H_2 =$ **enthalpy of atomization of potassium**
 $\Delta H_5 =$ **electron affinity of bromine** [2 marks]
- (ii) Write the appropriate products for X.
 $X = K^+(g) + \frac{1}{2} Br_2(l)$ [1 marks]
- (iii) What will happen to value of ΔH_3 if potassium (K) metal in the above cycle is replaced by sodium (Na) metal? Explain.
 ΔH_3 for Na is larger.
 Na is a smaller atom with the valence shell closer to the nucleus and hence bound more tightly. [2 marks]

12 (a) Define

- (i) Standard enthalpy of formation.
Heat change when 1 mole of compound is formed from its elements under standard condition (25 °C and 1 atm).
- (ii) Standard enthalpy of combustion.
Heat released when 1 mole of a substance is burnt in oxygen under standard condition (25 °C and 1 atm). [2 mark]

- (b) Standard enthalpy of combustion of ethanol, $\text{CH}_3\text{CH}_2\text{OH}$ is 1386 kJ mol^{-1} . Write the thermochemical equation to represent the statement. State whether the reaction is exothermic or endothermic.



[2 marks]

- (c) Standard enthalpy of combustion for propane, $\text{CH}_3\text{CH}_2\text{CH}_3$ is $-2220 \text{ kJ mol}^{-1}$.
- (i) How much energy is released when 1.0 g of propene undergoes complete combustion?

$$\text{Mr propane, C}_3\text{H}_8 = 44.0 \text{ g mol}^{-1}$$

$$\begin{aligned} \Delta H &= 1.0 \times 2220 / 44.0 \\ &= 50.45 \text{ kJ} \end{aligned}$$

[2 marks]

- (ii) How much energy is released when 33.6 dm^3 of propane at STP is completely burnt?

At STP:
 22.4 dm^3 is equivalent to 1 mol
 33.6 dm^3 equal to 1.5 mol

$$\begin{aligned} \Delta H &= 1.5 \times 2220 \\ &= 3330 \text{ kJ} \end{aligned}$$

[2 marks]

- (iii) How many grams of propane must be completely burnt in order to produce 100 kJ of heat?

$$\begin{aligned} 2220 \text{ kJ} &\rightarrow 1 \text{ mol} \\ 100 \text{ kJ} &\rightarrow (100/2220) \times 1.0 \text{ mol} \\ &= 0.045 \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{Mass of propane} &= 0.045 \times 44 \\ &= 1.98 \text{ g} \end{aligned}$$

[2 marks]

ANSWER SCHEME UPS 2011/2012 SK026

- 13 (a) Combustion of 1 mole of butane gas, C_4H_{10} involves 2874 kJ of heat.
- i. Write a thermochemical equation for the combustion of butane.
- $$\text{C}_4\text{H}_{10} (g) + 13/2 \text{O}_2 (g) \rightarrow 4 \text{CO}_2 (g) + 5 \text{H}_2\text{O} (l) \quad \Delta H^\circ = -2874 \text{ kJ mol}^{-1}$$

- ii. Calculate the mass of butane that must be burnt in order to increase $1.56\text{ }^{\circ}\text{C}$ of 1000 g water in a bomb calorimeter with a heat capacity of $958\text{ J }^{\circ}\text{C}^{-1}$.

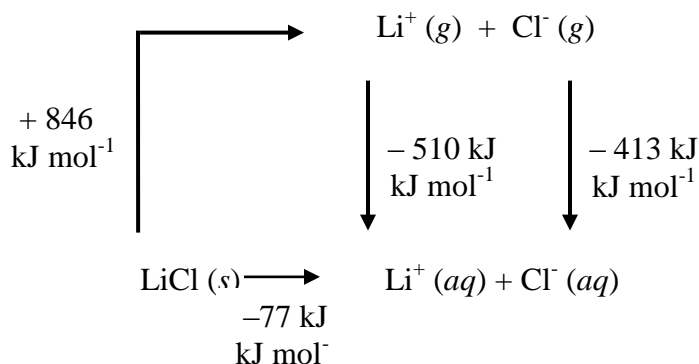
$$\begin{aligned} Q_{\text{rxn}} &= C_c\Delta T + m_w c_w \Delta T \\ &= 958\text{ J }^{\circ}\text{C} (1.56\text{ }^{\circ}\text{C}) + (1000\text{ g})(4.18\text{ J g}^{-1}\text{ }^{\circ}\text{C}^{-1})(1.56\text{ }^{\circ}\text{C}) \\ &= 8015.25\text{ J} \\ &= 8.02\text{ kJ} \end{aligned}$$

[5 marks]

- (b) i. Based on the data given in **TABLE 1**, construct an energy cycle diagram for dissolution of lithium chloride, LiCl.

TABLE 1

Process	Enthalpy of reaction (kJ mol^{-1})
Lattice energy of LiCl	$\Delta H = -846$
Dissolution of LiCl	$\Delta H = -77$
Hydration of Li^+	$\Delta H = -510$
Hydration of Cl^-	$\Delta H = -413$



- ii. Which of these salts, LiCl or KCl, would have larger lattice energy? Explain.
LiCl because Li^+ has smaller ionic radius than K^+

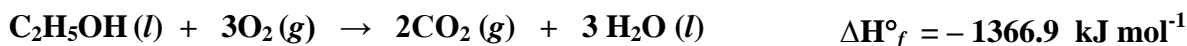
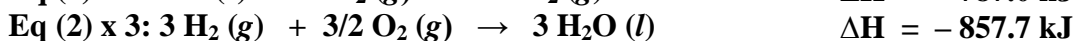
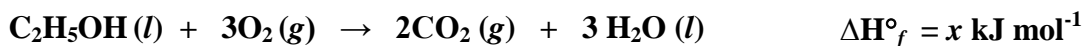
[5 marks]

ANSWER SCHEME UPS 2012/2013 TK025

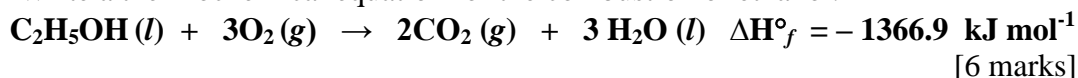
- 14 (a) i. Define the standard enthalpy of combustion of ethanol, $\text{C}_2\text{H}_5\text{OH}$.
The heat released when 1 mol of ethanol is burned in excess oxygen under standard condition.

- ii. Using the following standard enthalpies of formation, calculate the standard enthalpy of combustion for ethanol.

Compound	ΔH_f° (kJ mol ⁻¹)
C ₂ H ₅ OH	-277.8
H ₂ O (l)	-285.9
CO ₂ (g)	-393.5



- iii. Write a thermochemical equation for the combustion of ethanol.



- (b) The following data is obtained from an experiment using ethanol as fuel to heat a sample of water.

Mass of spirit lamp (g)	185.7
Mass of spirit lamp + ethanol	187.6
Volume of water heated (cm ³)	250.0

By using the enthalpy of combustion of ethanol obtained in (a) (ii), calculate the increase in temperature of the water.

[4 marks]

$$\text{Mass of ethanol} = 187.6 \text{ g} - 185.7 \text{ g} = 1.9 \text{ g}$$

$$\text{Moles of ethanol used} = \frac{1.9}{46} = 0.0413 \text{ mol}$$

$$\text{Quantity of heat released} = 0.0413 \times 1366.9 = 56.45 \text{ kJ}$$

$$q = mc\Delta T$$

$$\Delta T = \frac{56.45 \times 1000}{250 \times 4.18}$$

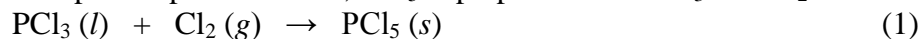
$$= 54.02 \text{ }^{\circ}\text{C}$$

- 15 (a) State Hess's Law.

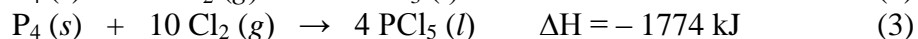
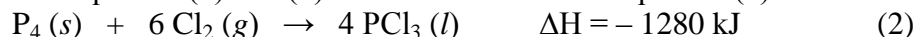
[1 mark]

Hess's Law states that when reactants are converted to products, the overall change in enthalpy is the same whether the reaction takes place in a single step or in a series of steps.

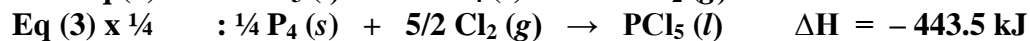
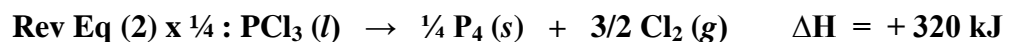
- (b) Phosphorus pentachloride, PCl_5 is prepared from PCl_3 and Cl_2 :



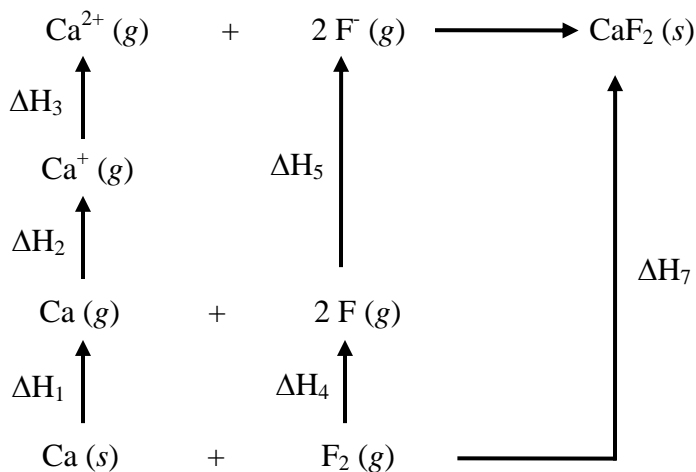
Use equation (2) and (3) to calculate ΔH_{rxn} of equation (1):



[4 marks]



- (c) The Born-Haber cycle for calcium fluoride is shown below:



- i. Name the enthalpy change for ΔH_1 , ΔH_3 and ΔH_5 .

ΔH_1 = enthalpy of atomization of calcium

ΔH_3 = second ionization energy of calcium

ΔH_5 = electron affinity of fluorine

- ii. Compare the lattice energy of calcium chloride and calcium fluoride. Give your reason.

Lattice energy of CaF_2 is larger than lattice energy of CaCl_2 because the ionic radius of F^- is smaller than Cl^- , so interionic distance of CaF_2 is smaller.

[5 marks]