5.2 Hess's Law

Question Paper

Course	DP IB Chemistry
Section	5. Energetics / Thermochemistry
Topic	5.2 Hess's Law
Difficulty	Hard

Time allowed: 20

Score: /10

Percentage: /100

Question 1

The equations below show the formation of sulfur oxides from sulfur and oxygen.

$S(s) + O_2(g) \rightarrow SO_2(g)$ $\quad \Delta H_f^{\ominus} = -297\ kJ\ mol^{-1}$

$S(s) + 1½O_2(g) \rightarrow SO_3(g)$ $\quad \Delta H_f^{\ominus} = -395\ kJ\ mol^{-1}$

What is the enthalpy change of reaction, $\Delta H^{\ominus}$, of $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ in $kJ\ mol^{-1}$?

A. (794 – 594)

B. (296 + 395)

C. (– 395 + 297)

D. (–790 + 594)

[1 mark]

Question 2

Some bond energy values are listed below.

bond	bond energy / $kJ\ mol^{-1}$
Br–Br	193
Cl–Cl	242
C–H	414
C–Cl	324

These bond energy values relate to the following four reactions.

W $\quad Br_2 \rightarrow 2Br$

X $\quad 2Cl \rightarrow Cl_2$

Y $\quad CH_3 + Cl \rightarrow CH_3Cl$

Z $\quad CH_4 \rightarrow CH_3 + H$

What is the correct order of enthalpy changes of the above reactions from most negative to most positive?

A. Y → Z → W → X

B. Z → W → X → Y

C. Y → X → W → Z

D. X → Y → Z → W

[1 mark]

Question 3

A student calculated the standard enthalpy change of formation of propane, C_3H_8, using a method based on standard enthalpy changes of combustion.

He used correct values for the standard enthalpy change of combustion of propane

(-2220 kJ mol^{-1}) and hydrogen (-286 kJ mol^{-1}) but he used an incorrect value for the standard enthalpy change of combustion of carbon. He then performed his calculation correctly. His final answer was -158 kJ mol^{-1}.

What did he use for the standard enthalpy change of combustion of carbon?

A. $-2220 + (286 \times 4) + 158$

B. $\frac{-2220 + [286 \times 4] + 158}{3}$

C. $\frac{+2220 - [286 \times 4] - 158}{3}$

D. $\frac{3}{-2220 + [286 \times 4] + 158}$

[1 mark]

Question 4

Given the following enthalpy changes,

$$I_2(s) \rightarrow I_2(g) \qquad \Delta H^{\ominus} = +38 \text{ kJ mol}^{-1}$$

$$I_2(g) + 3Cl_2(g) \rightarrow 2ICl_3(s) \qquad \Delta H^{\ominus} = -214 \text{ kJ mol}^{-1}$$

What is the correct value for $\Delta H_f^{\ominus}$ of iodine trichloride, $ICl_3(s)$?

A. $2\,(38 - 214)$

B. $2\,(214 - 38)$

C. $\frac{1}{2}\,(38 - 214)$

D. $\frac{1}{2}\,(214 - 38)$

[1 mark]

Question 5

Using the following information:

$CO(g) + ½O_2(g) \rightarrow CO_2(g)$ $\Delta H^{\ominus} = -283\ kJ\ mol^{-1}$

$H_2(g) + ½O_2(g) \rightarrow H_2O(l)$ $\Delta H^{\ominus} = -286\ kJ\ mol^{-1}$

$H_2O(g) \rightarrow H_2O(l)$ $\Delta H^{\ominus} = -44\ kJ\ mol^{-1}$

What is the enthalpy change, $\Delta H^{\ominus}$, for the following reaction?

$$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$$

A. $-286 - 44 - 283$

B. $-286 + 44 + 283$

C. $-286 - 44 + 283$

D. $-286 + 44 - 283$

[1 mark]

Question 6

Iodine trichloride, ICl_3, is made by reacting iodine with chlorine.

$I_2(s) + Cl_2(g) \rightarrow 2ICl(s)$ $\Delta H^{\ominus} = +14\ kJ\ mol^{-1}$

$ICl(s) + Cl_2(g) \rightarrow ICl_3(s)$ $\Delta H^{\ominus} = -88\ kJ\ mol^{-1}$

By using the data above, what is the enthalpy change of the formation for solid iodine trichloride?

A. $-162\ kJ\ mol^{-1}$

B. $-81\ kJ\ mol^{-1}$

C. $-74\ kJ\ mol^{-1}$

D. $-60\ kJ\ mol^{-1}$

[1 mark]

Question 7

Shown below are three enthalpy changes:

$CH_4(g) + O_2(g) \rightarrow HCHO(l) + H_2O(l)$ $\Delta H = x$

$HCHO(l) + ½O_2(g) \rightarrow HCOOH(l)$ $\Delta H = y$

$2HCOOH(l) + ½O_2(g) \rightarrow (COOH)_2(l) + H_2O(l)$ $\Delta H = z$

Use the information given to deduce the correct expression for the enthalpy change of the following reaction:

$$2CH_4(g) + 3½\,O_2(g) \rightarrow (COOH)_2(l) + 3H_2O(l)$$

A. $x + y + z$

B. $2x + y + z$

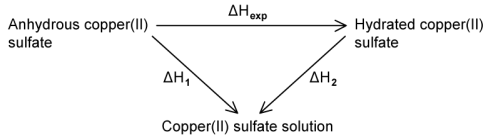
C. $2x + 2y + z$

D. $2x + 2y + 2z$

[1 mark]

Question 8

The hydration enthalpy of anhydrous copper(II) sulfate, labelled as ΔH_{exp}, cannot be measured directly. It can be found indirectly by determining the solution enthalpies of anhydrous and hydrated copper(II) sulfate.



Which of the following statements correctly explains why the value for ΔH_{exp} for this reaction cannot be measured directly?

I. Hydrated copper(II) sulfate is not produced in a controlled manner
II. Dissolving of the solid is difficult to avoid
III. Heat energy is trapped inside the solid copper(II) sulfate

A. I and II only

B. I and III only

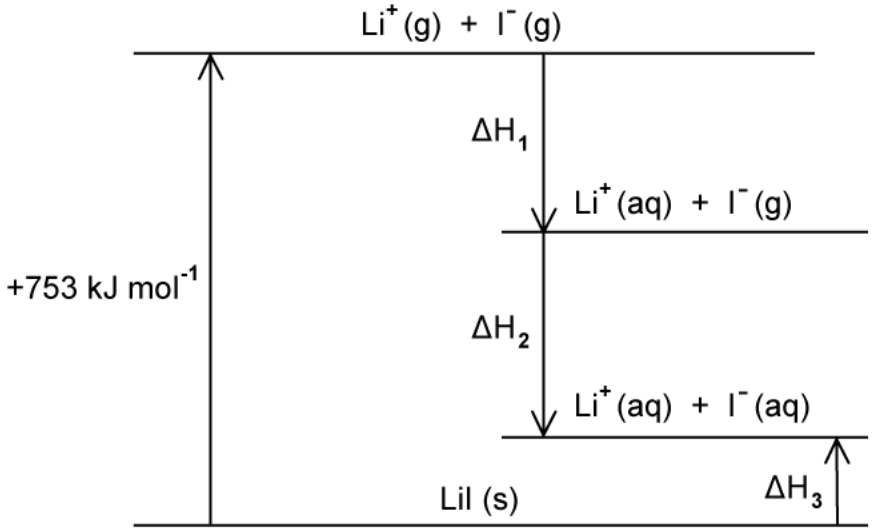
C. II and III only

D. I, II and III

[1 mark]

Question 9

Lithium iodide solution can be produced by two different reaction paths, according to the following diagram:



Which labels could be added to complete the diagram

	ΔH_1	ΔH_2	ΔH_3
A	+364 kJ mol^{-1}	ΔH_{hyd}	+82 kJ mol^{-1}
B	ΔH_{hyd}	ΔH_{sol}	+82 kJ mol^{-1}
C	ΔH_{hyd}	-307 kJ mol^{-1}	ΔH_{sol}
D	-364 kJ mol^{-1}	ΔH_{sol}	ΔH_{hyd}

[1 mark]

Question 10

Bond energy calculations show the enthalpy of combustion for propene to be -1572.0 kJ mol^{-1}.

Compound	C_3H_6 (g)	CO_2 (g)	H_2O (l)	H_2O (g)
$\Delta H^{\ominus}_f$ / kJ mol^{-1}	+20.0	-393.5	-285.8	-241.8

Using the enthalpy of formation data, which calculation correctly shows the percentage error between propene's enthalpy of combustion values obtained from bond energy calculations and Hess's Law calculations, assuming the bond energy calculation value is correct?

A. $\frac{-1572.0}{((3 \times -393.5) + (3 \times -241.8) - (20)) - 1572.0} x\ 100$

B. $\frac{(3 \times -393.5) + (3 \times -241.8) - (20)}{-1572.0} x\ 100$

C. $\frac{(3 \times -393.5) + (3 \times -241.8) + (20)}{-1572.0} \times 100$

D. $\frac{((3 \times -393.5) + (3 \times -241.8) - (20)) - (-1572.0)}{-1572.0} \times 100$

[1 mark]