5.2 Hess's Law

Question Paper

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

To be used by all students preparing for DP IB Chemistry HL
Students of other boards may also find this useful

Question 1

The first stage in the industrial production of nitric acid from ammonia can be represented by the following equation.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

Using the following standard enthalpy change of formation data, what is the value of the standard enthalpy change $\Delta H^{\ominus}$ for this reaction?

Compound	$\Delta H_f^{\ominus}$ /kJ mol^{-1}
$NH_3(g)$	-46.1
NO(g)	+90.3
$H_2O(g)$	-241.8

A. $(4 \times (-46.1)) + ((4 \times 90.3) + (6 \times (-241.8))$

B. $((4 \times 90.3) + (6 \times (-241.8)) - (4 \times (-46.1))$

C. $(4 \times (-46.1)) - ((4 \times 90.3) + (6 \times (-241.8)))$

D. $(-46.1) - (90.3) + (-241.8)$

[1 mark]

Question 2

Titanium occurs naturally as the mineral rutile, TiO_2. One possible method of extraction of titanium is to reduce the rutile by heating with carbon.

$$TiO_2(s) + 2C(s) \rightarrow Ti(s) + 2CO(g)$$

The standard enthalpy changes of formation of $TiO_2(s)$ and CO(g) are –890 kJ mol^{-1} and –110.5 kJ mol^{-1} respectively.

What is the standard enthalpy change of the extraction of titanium?

A. + 669 kJ mol^{-1}

B. + 779.5 kJ mol^{-1}

C. – 779.5 kJ mol^{-1}

D. – 669 kJ mol^{-1}

[1 mark]

Question 3

The combustion of ethanol (C_2H_5OH) is increasingly being used to fuel cars. The combustion reaction is shown below

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

The standard enthalpy change of formation of carbon dioxide is **a** kJ mol^{-1}.

The standard enthalpy change of formation of water is **b** kJ mol^{-1}.

The standard enthalpy change of formation of ethanol is **c** kJ mol^{-1}.

What is the standard enthalpy change of combustion for ethanol?

A. $2a + 3b + c$

B. $2a + 3b - c$

C. $-2a - 3b + c$

D. $-2a - 3b - c$

[1 mark]

Question 4

Propanone has the molecular formula C_3H_6O. Use the following information to calculate the enthalpy change for the formation of propanone?

The enthalpy change of combustion of carbon is ***x*** kJ mol^{-1}

The enthalpy change of combustion of hydrogen is ***y*** kJ mol^{-1}

The enthalpy change of combustion of propanone is ***z*** kJ mol^{-1}

A. $x + y - z$

B. $3x + 3y - z$

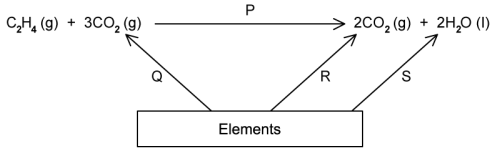
C. $z - 3x + 3y$

D. $3x + 3y + z$

[1 mark]

Question 5

Combustion of ethene proceeds via the reaction shown in the Hess cycle diagram.



What are the correct elements missing from the Hess cycle?

A. $2C(g) + 2H_2(g) + 3O_2(g)$

B. $C(s) + H_2(g) + O_2(g)$

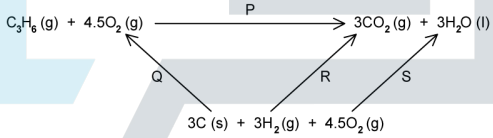
C. $2C(s) + 2H_2(g) + 3O_2(g)$

D. $C_2(s) + 2H_2(g) + 3O_2(g)$

[1 mark]

Question 6

Combustion of propene proceeds via the reaction shown in the Hess cycle diagram.



Which are the correct labels for the enthalpies shown in the Hess cycle?

	P	*Q*	*R*	*S*
A	ΔH^{Θ}_{c}	ΔH^{Θ}_{r}	ΔH^{Θ}_{c}	ΔH^{Θ}_{c}
B	ΔH^{Θ}_{c}	ΔH^{Θ}_{f}	ΔH^{Θ}_{r}	ΔH^{Θ}_{r}
C	ΔH^{Θ}_{c}	ΔH^{Θ}_{f}	ΔH^{Θ}_{c}	ΔH^{Θ}_{f}
D	ΔH^{Θ}_{r}	ΔH^{Θ}_{r}	ΔH^{Θ}_{f}	ΔH^{Θ}_{f}

[1 mark]

Question 7

Hess's Law can be used to calculate the enthalpy change for reactions that are difficult to measure experimentally, such as the conversion of graphite to diamond.

Which enthalpy data could be used to calculate the enthalpy change for the conversion of graphite to diamond?

I. Enthalpy of reaction
II. Enthalpy of combustion
III. Enthalpy of formation

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

[1 mark]

Question 8

A basic definition of Hess's Law states that the overall enthalpy change for a reaction is the same independent of the route taken.

The addition of which of the following statements makes the definition of Hess's Law more complete?

I. Providing that the reactants are the same
II. Providing that the products are the same
III. Providing that the conditions at the start and the end of the reaction are the same

A. I and II only

B. I and III only

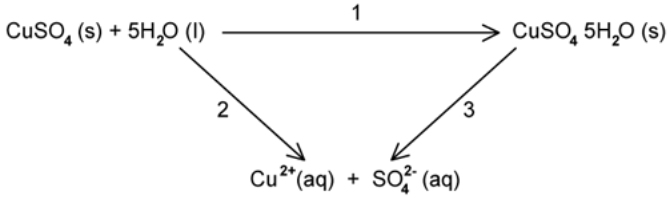
C. II and III only

D. I, II and III

[1 mark]

Question 9

The hydration enthalpy of anhydrous copper(II) sulfate cannot be measured directly. It can be found indirectly by determining the solution enthalpies of anhydrous and hydrated copper(II) sulfate.



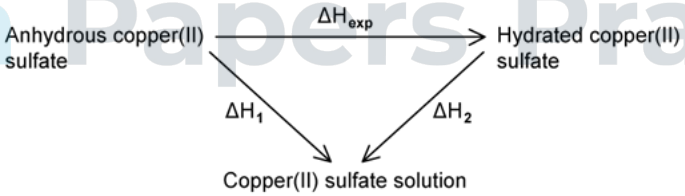
Which are the correct labels for the enthalpies shown in the Hess cycle?

	1	2	3
A	ΔH^{Θ}_{sol}	ΔH^{Θ}_{hyd}	ΔH^{Θ}_{hyd}
B	ΔH^{Θ}_{r}	ΔH^{Θ}_{hyd}	ΔH^{Θ}_{hyd}
C	ΔH^{Θ}_{hyd}	ΔH^{Θ}_{sol}	ΔH^{Θ}_{hyd}
D	ΔH^{Θ}_{r}	ΔH^{Θ}_{sol}	ΔH^{Θ}_{sol}

[1 mark]

Question 10

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?

A. Measuring the temperature change in a solid is difficult

B. The reaction is very slow

C. The reaction has high energy requirements

D. The reaction is endothermic

[1 mark]