

Define Enthalpy Change of a Reaction

$$\Delta H^\circ [ABC]$$

It is the amount of Energy change that takes place in a given stoichiometric equation. Its unit is kJ/mol . Symbol is ΔH .

Standard Define Enthalpy Change of Atomisation ($\Delta H_{\text{at}}^\circ$)

→ Signify that it is under standard conditions

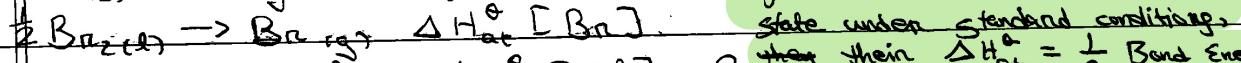
→ 298K

1 atm pressure

(if present) 1 mol/dm³ soln

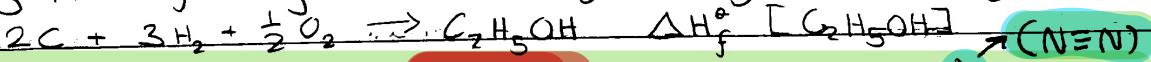
always endothermic

It is the amount of Energy change when 1 mol of a gaseous atom is formed from its element, under standard conditions.



Define Standard Enthalpy change of formation (ΔH_f°) # ALWAYS mention either exothermic or endothermic under standard conditions

It is the amount of energy change when 1 mol of a compound is formed from its constituent elements, under standard conditions.

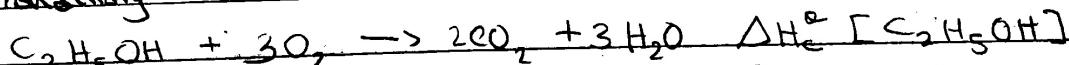


Most of the time ΔH_f° is exothermic. In most cases when N_2 will act as a reactant, there is a high possibility for ΔH_f° to be endothermic. (and vice versa).

Define Standard Enthalpy change of Combustion (ΔH_c°)

$\text{N}=\text{N}$ prob
means $99\% - \Delta H$

It is the amount of Energy Change when 1 mol of substance a compound is completely burned in excess oxygen under standard conditions



Strong base weak acid neutralisation will be less exothermic than
 Strong base Strong acid " as some of the energy will be used in
 ionising the weak acid.
 Weak base and weak acid neutralisation will be even less exothermic

Define Standard Enthalpy Change of Neutralisation (ΔH°)
 always exothermic ↪

- It is the amount of energy change when 1 mol of H_2O is formed from an acid-base reaction, under standard conditions.
- $$HCl + NaOH \rightarrow NaCl + H_2O \quad \Delta H_n^\circ$$
- $$NaOH + \frac{1}{3} H_3PO_4 \rightarrow \frac{1}{3} Na_3PO_4 + H_2O \quad \Delta H_n^\circ$$

Define Standard Enthalpy Change of Solution (ΔH_{sol}°):
 either exothermic or endothermic ↪

- It is the amount of energy change when 1 mol of an ionic solid (compound) is dissolved in H_2O to form an infinitely dilute solution, under standard conditions.

By infinitely dilute solution we mean there will be no further change in the temperature of the solution when more solvent is added to it.

Salts whose charge ΔH_{sol}° are exothermic or slightly endothermic are always soluble in water:

$$NaCl(s) \rightarrow NaCl(aq) \quad \Delta H_{sol}^\circ [NaCl]$$

$$Na_2O(s) \rightarrow 2 Na^+(aq) + O^{2-}(aq) \quad \Delta H_{sol}^\circ [Na_2O]$$

Define Standard Enthalpy change of Hydration (ΔH_{hydr}°)
 always exothermic ↪

- It is the amount of energy change when 1 mol of a hydrated salt is formed from its anhydrous form, under standard conditions.

This definition is only applicable for A'G Chemistry

$$CuSO_4(s) + 6 H_2O \rightarrow CuSO_4 \cdot 6 H_2O(s) \quad \Delta H_{hydr}^\circ [CuSO_4]$$

Calculating Enthalpy Change of Solution Experimentally

↳ Specific Heat Capacity of Water : $4.18 \text{ J/g} \times 10^3 \text{ J}^{-1} \text{ K}^{-1}$

Assumption: Heat loss to the surroundings is negligible

Use the equation $Q = -mc\Delta\theta$

Q) Mass of PolyStyrene Cup = 23g

Mass of PolyStyrene Cup + NaOH = ~~101.75~~ 24.95g

Volume of water added = 100cm³

Initial temperature of water before adding = 18 °C

Final temperature = 21.6 °C

Use all this information to form ΔH_{sol} of NaOH

$$\frac{\partial Q}{\partial t} = \frac{mc}{23} \Delta\theta$$
$$= \cancel{0.418} \times 100 \times 4.18 \times 3.6$$
$$= 1504.8 \text{ J}$$

$$1504.8 \div 0.04875$$

$$Q = -mc\Delta\theta$$

$$= -100 \times 4.18 \times 3.6$$

$$= -1504.8 \text{ J}$$

$$= -1.5048 \text{ kJ}$$

$$\text{mol of NaOH} = \frac{\text{mass}}{\text{molar mass}} = \frac{1.95}{40} = 0.04875 \text{ mol/g}$$

$$\Delta H_{sol} [\text{NaOH}] = \frac{-1504.8}{0.04875} = -30.9 \text{ kJ (Ag)}$$

Calculating ΔH_{rxn} Experimentally

30 cm³ of 0.5 mol/dm³ NaOH is reacted with 50 cm³ of 0.5 mol/dm³ of HCl. Temperature rise = 7.3 °C.

Find ΔH_{rxn} .

$$Q = mc\Delta\theta$$

$$= -80 \text{ g} \times 4.18 \times 7.3$$

$$= -2.44112 \text{ kJ}$$

$$\text{mol} = \frac{0.5}{1000} \times 30 = 0.015 \text{ mol}$$

$$\Delta H_{\text{rxn}} = \frac{-2.44112}{0.015} = -162.741333 \text{ kJ/mol}$$

$$= -163 \text{ kJ/mol}$$

70g of Water

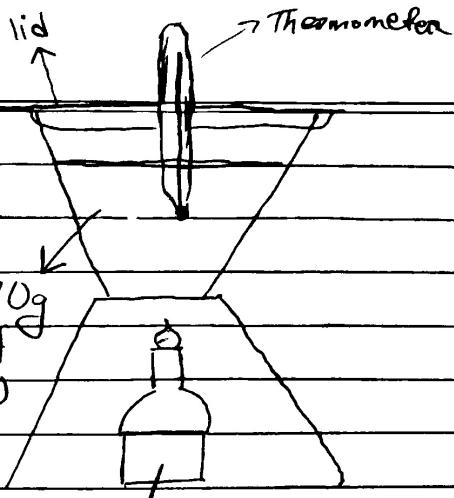
(initial)

$$\text{mass of spirit lamp + propanol} = 113.2 \text{ g}$$

$$(\text{final}) \text{ mass of } " " " " = 106.8 \text{ g}$$

$$\text{Initial temperature of Water} = 28^\circ\text{C}$$

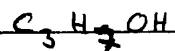
$$\text{Final } " " " " = 63.4^\circ\text{C}$$



$$\Delta Q = -mc\Delta\theta$$

$$= -70 \times 4.18 \times 35.4$$

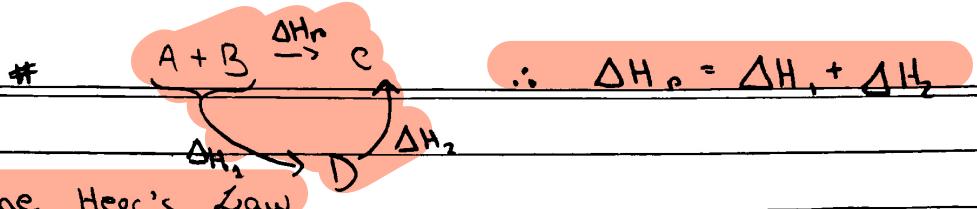
$$= -10.35804 \text{ kJ}$$



$$\frac{6.4 \text{ g}}{60} = \frac{8}{7.5} \text{ mols of propanol}$$

$$= 97 \text{ kJ/mol}$$

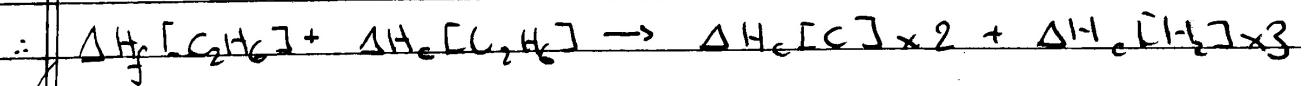
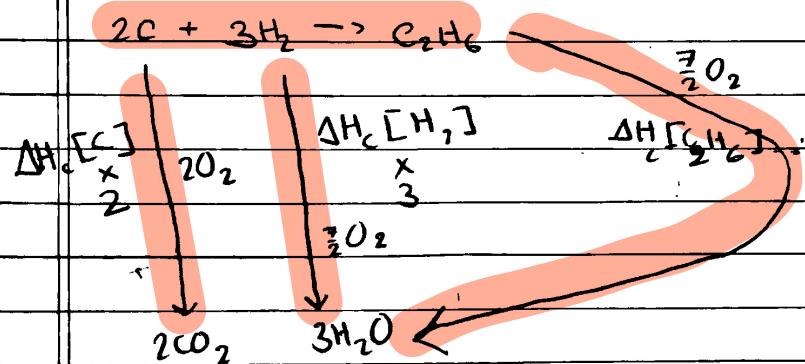
$$-97.1 \text{ kJ/mol}$$



Define Hess's Law

↳ It states that Enthalpy Change of a Reaction is Independent of the route by which the reaction is taking place, given that the conditions remain same.

Central Equation



This is called Hess's Cycle.

If there is ΔH_f involved in the construction of a Hess's cycle, it will ALWAYS be a part of the Central Equation.

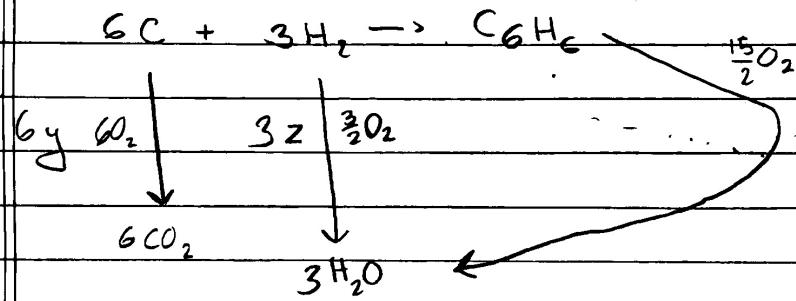
$$\Delta H_f [C_6H_6] = ?$$

$$\Delta H_c [C_6H_6] = x$$

$$\Delta H_c [C] = y$$

$$\Delta H_c [H_2] = z$$

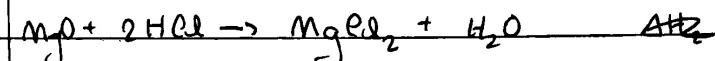
Use the above information to construct a Hess's Cycle to evaluate $\Delta H_f [C_6H_6]$



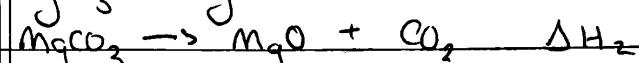
$$6y + 3z = ? + x$$

$$\Delta H_f [C_6H_6] = 6y + 3z - x$$

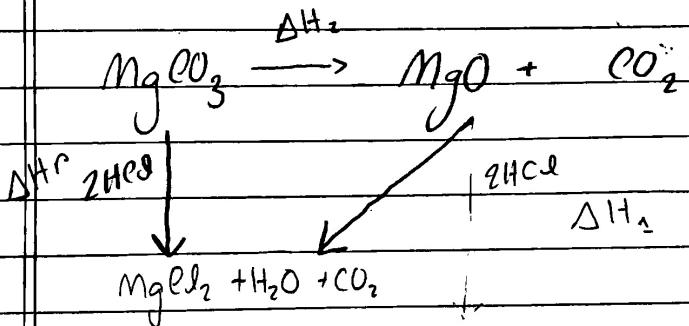
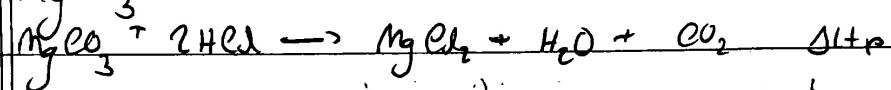
* The reactant and product of the central equation will be the main reactant of all the other equations.



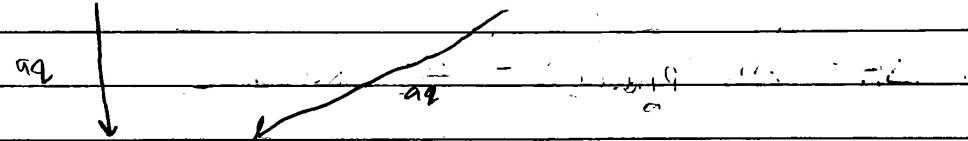
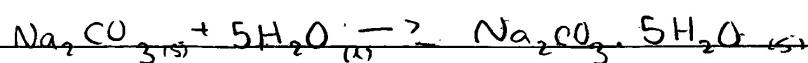
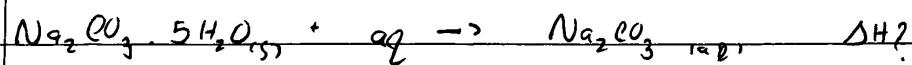
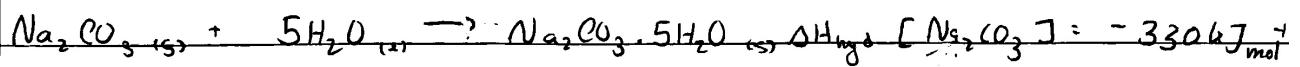
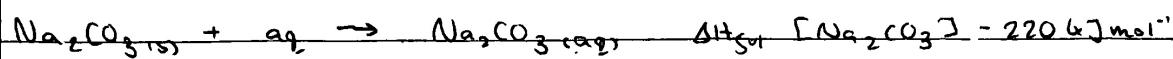
~~MgCO₃ → MgO~~



~~MgCO₃ →~~



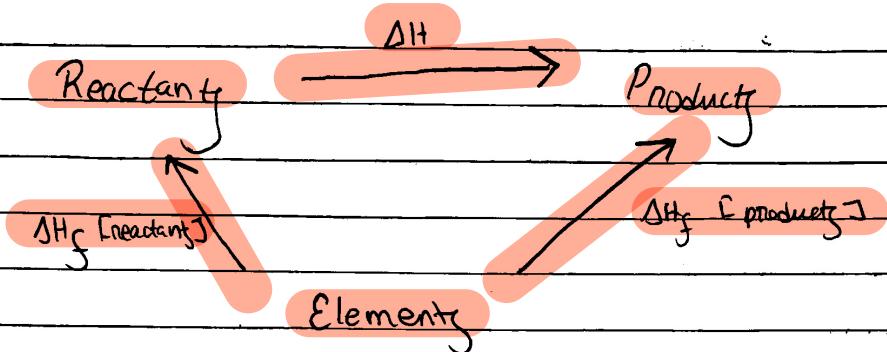
$$\Delta H_2 + \Delta H_1 = \Delta H_p$$



$$\Delta H_{\text{sol}} [\text{Na}_2\text{CO}_3] = \Delta H? + \Delta H_{\text{hyd}} [\text{Na}_2\text{CO}_3]$$

$$-220 = -330 + \Delta H$$

$$\Delta H = 110 \text{ kJ mol}^{-1}$$

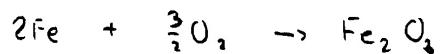


$$\Delta H_f [\text{Reactants}] + \Delta H = \Delta H_f [\text{products}]$$

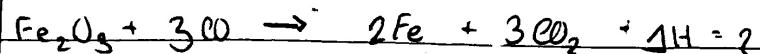
$$\therefore \Delta H = \Delta H_f [\text{Products}] - \Delta H_f [\text{Reactants}]$$

If there is an element in the product or reactant, the ΔH_f of that element is 0.

The ΔH_f of oxides are equal to the sum of the ΔH_c of that element



Remaining an element.



$$\Delta H_f [\text{Fe}_2\text{O}_3] = -300 \text{ kJ mol}^{-1}$$

$$\Delta H_f [\text{CO}] = -200 \text{ kJ mol}^{-1}$$

$$\Delta H_f [\text{C}] = -400 \text{ kJ mol}^{-1}$$

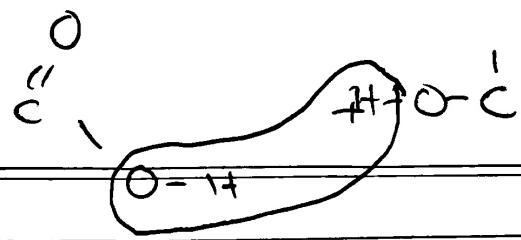
$$-900 \xrightarrow{\Delta H?}$$

$$\Delta H = \Delta H_f [\text{product}] - \Delta H_f [\text{reactant}] : \quad \uparrow \quad \uparrow \quad -400, -1200$$

$$= -1200 - (-900) \quad -1300$$

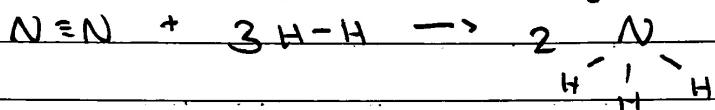
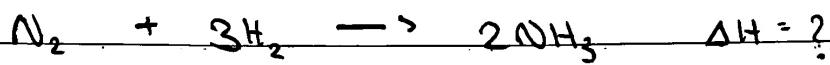
$$= -300 \text{ kJ mol}^{-1} \quad -700 \text{ kJ mol}^{-1}$$

$$-300 \text{ kJ mol}^{-1}$$

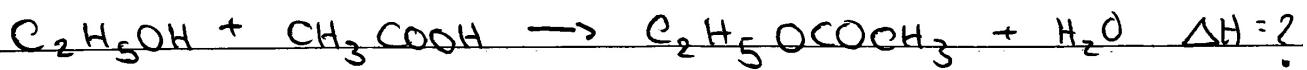


$$\Delta H = \text{Bond breaking Energy} + \text{Bond Forming Energy}$$

Bond breaking Energy → Endothermic (+ve)
 Bond Forming Energy → Exothermic (-ve)



$$\begin{aligned}
 \Delta H &= \{(N \equiv N) + 3(H-H)\} + \{G(-N-H)\} \\
 &= \{(944) + 3(436)\} + \{G(-390)\} \\
 &= 88 \text{ kJ mol}^{-1}
 \end{aligned}$$



C-O (form) $\Delta H \approx 6$

C-O (break)

O-H (break)

O-H (form)

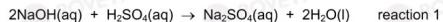
Mise. Notes

ΔH_n always remains constant for the reaction between any strong acid and strong base (As none // no portion of the energy released is needed // trying to ionize / dissociate the acid or base).

Enthalpy Change & Hess's Law

24

The enthalpy change of reaction 1 is -114 kJ mol^{-1} .



By using this information, what is the most likely value for the enthalpy change of reaction 2?



- A -57 kJ mol^{-1} B -76 kJ mol^{-1} C -114 kJ mol^{-1} D -228 kJ mol^{-1}

Paper 1 Variant 2 Summer 2018 | Q7

Answer:

C

#

Elimination Reactions are always endothermic

#

Substitution Reactions are almost always exothermic (exception: free radical substitution reactions are endothermic)

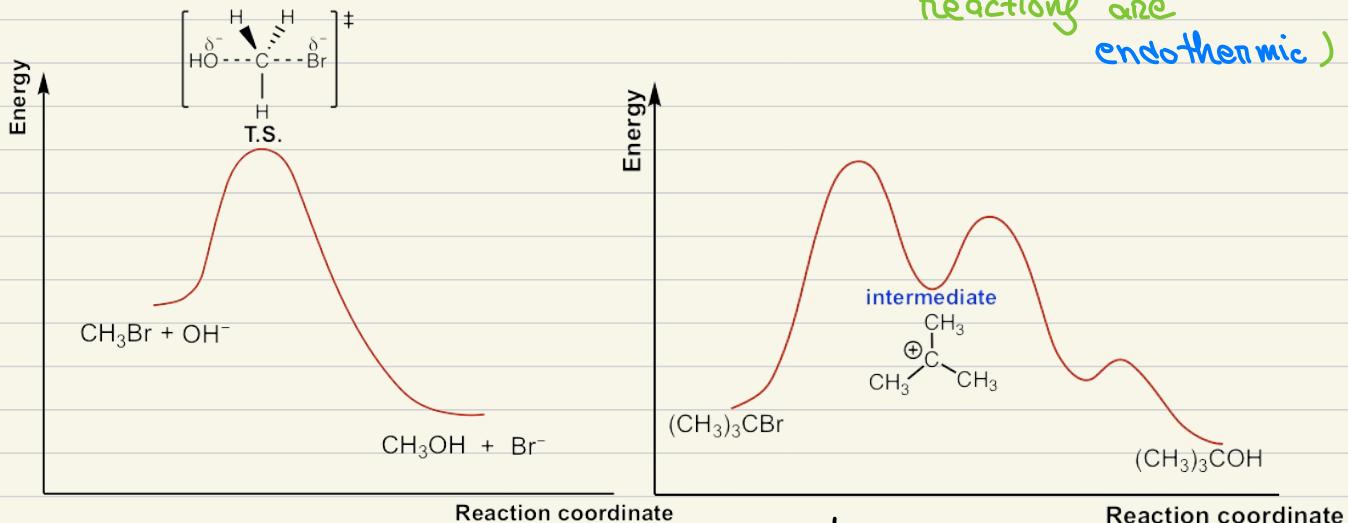


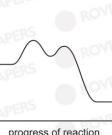
Fig. 7.1 Energy Diagram for S_N2 reaction between CH₃Br and OH⁻

↳ Energy Diagram for S_N1 reaction

Reaction Kinetics

16

A reaction pathway diagram is shown.



Which reactions would have this reaction pathway diagram?

- 1 (CH₃)₃CBr + NaOH → (CH₃)₂COH + NaBr
- 2 CH₃CH₂CH₂Br + NaOH → CH₃CH₂CH₂OH + NaBr
- 3 (CH₃)₂CCH₂Cl + 2NH₃ → (CH₃)₂CCH₂NH₂ + NH₄Cl

Paper 1 Variant 3 Winter 2017 | Q38

Answer:

D

Reaction Kinetics

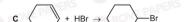
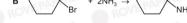
24

A reaction pathway diagram is shown.



The four reactions that follow are all exothermic.

Which reaction would not have such a pathway?



All the options except 'A' have an intermediate product

Electrophilic addition will ALWAYS have an intermediate product

Paper 1 Variant 3 Summer 2016 | Q25

Answer:

A

Hide Answer

Hide Answer

ΔH_c^\ominus :-

Propane : $-2220 \text{ kJ mol}^{-1}$

Propene : $-2058 \text{ kJ mol}^{-1}$

Propanol : $-2021 \text{ kJ mol}^{-1}$

Propanal : $-2005.8 \text{ kJ mol}^{-1}$

Propanone : $-1816.5 \text{ kJ mol}^{-1}$

Propanoic acid : $-1527.2 \text{ kJ mol}^{-1}$

In calculating the enthalpy change, ΔH , of an experiment involving solutions, the mass of the solution, m , specific heat capacity of the solution, c , and the temperature change, ΔT , are needed.

$$\Delta T = T_{\text{final}} - T_{\text{initial}}$$

Which expression for ΔH is correct?

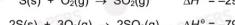
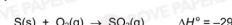
- A $\Delta H = \frac{mc}{\Delta T}$ B $\Delta H = \frac{-mc}{\Delta T}$ C $\Delta H = mc\Delta T$ D $\Delta H = -mc\Delta T$

Paper 1 Variant 2 Winter 2017 | Q6

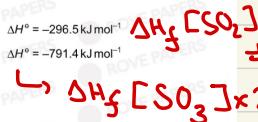
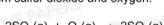
Answer:

D

Sulfur can be oxidised in two ways.



Sulfur trioxide can be made from sulfur dioxide and oxygen.



What is the standard enthalpy change for this reaction?

- A $-1384.4 \text{ kJ mol}^{-1}$
 B $-989.8 \text{ kJ mol}^{-1}$
 C $-494.9 \text{ kJ mol}^{-1}$
 D $-198.4 \text{ kJ mol}^{-1}$

There's no need to draw a Hess's Cycle. You can see that the ΔH_f^\ominus of reactants and products is given in the question.

Paper 1 Variant 3 Winter 2017 | Q8

Answer:

D

Contact Process : Exothermic, 450°C , 2 atm, V_2O_5 catalyst
 Haber Process : Exothermic, 450°C , 200 atm, Fe catalyst

$\Delta H_f^\ominus [SO_2] = \Delta H_c^\ominus [S]$

- 3 Enthalpy changes that are difficult to measure directly can often be determined using Hess' Law to construct an enthalpy cycle.

Which enthalpy change is indicated by X in the enthalpy cycle shown?

