SL Paper 1

The enthalpy of combustion of ethanol is determined by heating a known mass of tap water in a glass beaker with a flame of burning ethanol.

Which will lead to the greatest error in the final result?

A. Assuming the density of tap water is 1.0 g cm^{-3}

B. Assuming all the energy from the combustion will heat the water

C. Assuming the specific heat capacity of the tap water is 4.18 J g^{-1} K^{-1}

D. Assuming the specific heat capacity of the beaker is negligible

---

What is the enthalpy of combustion of butane in **kJ mol^{-1}**?

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$

$$\begin{array}{ll} \mathrm{C(s) + O_2(g) \rightarrow CO_2(g)} & \Delta H = x\,\mathrm{kJ} \\ \mathrm{H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)} & \Delta H = y\,\mathrm{kJ} \\ \mathrm{4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)} & \Delta H = z\,\mathrm{kJ} \end{array}$$

A. $4x + 5y - z$

B. $4x + 5y + z$

C. $8x + 10y - 2z$

D. $8x + 5y + 2z$

A 5.00 g sample of a substance was heated from 25.0 °C to 35.0 °C using 2.00×10^2 J of energy. What is the specific heat capacity of the substance in $\mathrm{J\,g^{-1}K^{-1}}$?

A. 4.00×10^{-3}

B. 2.50×10^{-1}

C. 2.00

D. 4.00

Which statement is correct for this reaction?

Fe_2O_3 (s) + 3CO (g) → 2Fe (s) + $3CO_2$ (g)   *ΔH* = −26.6 kJ

A. 13.3 kJ are released for every mole of Fe produced.

B. 26.6 kJ are absorbed for every mole of Fe produced.

C. 53.2 kJ are released for every mole of Fe produced.

D. 26.6 kJ are released for every mole of Fe produced.

The enthalpy changes for two reactions are given.

$Br_2 (l) + F_2 (g) \rightarrow 2BrF (g) \qquad \Delta H = x \text{ kJ}$
$Br_2 (l) + 3F_2 (g) \rightarrow 2BrF_3 (g) \qquad \Delta H = y \text{ kJ}$

What is the enthalpy change for the following reaction?

$BrF (g) + F_2 (g) \rightarrow BrF_3 (g)$

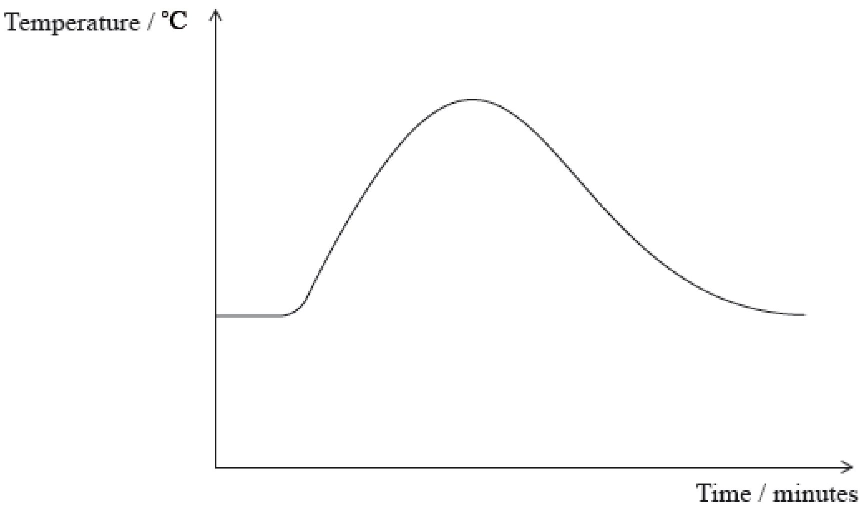
A. $x - y$

B. $-x + y$

C. $\frac{1}{2}(-x + y)$

D. $\frac{1}{2}(x - y)$

A student measured the temperature of a reaction mixture over time using a temperature probe. By considering the graph, which of the following deductions can be made?



I. The reaction is exothermic.

II. The products are more stable than the reactants.

III. The reactant bonds are stronger than the product bonds.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

What is the enthalpy change, in kJ, of the following reaction?

$$3H_2\,(g) + N_2\,(g) \rightleftharpoons 2NH_3\,(g)$$

Bond	Bond enthalpy / kJ mol^{-1}
N≡N	945
H–H	436
N–H	391

A. (6 × 391) – [(3 × 436) + 945]

B. (3 × 391) – (436 + 945)

C. –[(3 × 436) + 945] + (3 × 391)

D. –(6 × 391) + [(3 × 436) + 945]

Which process is endothermic?

A. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

B. $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

C. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

D. $H_2O(g) \rightarrow H_2O(l)$

Why is the value of the enthalpy change of this reaction calculated from bond enthalpy data less accurate than that calculated from standard enthalpies of formation?

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$$

A. All the reactants and products are gases.

B. Bond enthalpy data are average values for many compounds.

C. Elements do not have standard enthalpy of formation.

D. Standard enthalpies of formation are per mole.

5.35g of solid ammonium chloride, $NH_4Cl(s)$, was added to water to form 25.0g of solution. The maximum decrease in temperature was 14 K. What is the enthalpy change, in kJmol^{-1}, for this reaction? (Molar mass of NH_4Cl = 53.5gmol^{-1}; the specific heat capacity of the solution is 4.18 Jg^{-1}K^{-1})

A. $\Delta H = +\frac{25.0\times4.18\times(14+273)}{0.1\times1000}$

B. $\Delta H = -\frac{25.0\times4.18\times14}{0.1\times1000}$

C. $\Delta H = +\frac{25.0\times4.18\times14}{0.1\times1000}$

D. $\Delta H = +\frac{25.0\times4.18\times14}{1000}$

A simple calorimeter was set up to determine the enthalpy change occurring when one mole of ethanol is combusted. The experimental value was found to be $-867\ \mathrm{kJ\,mol^{-1}}$. The Data Booklet value is $-1367\ \mathrm{kJ\,mol^{-1}}$ (at 298 K and $1.01 \times 10^5\ \mathrm{Pa}$).

During the experiment some black soot formed.

Which statements are correct?

I. The percentage error for the experiment can be calculated as follows:

$$(1367 - 867) \times 100\%$$

II. The difference between the two values may be due to heat loss to the surroundings.

III. The black soot suggests that incomplete combustion occurred.

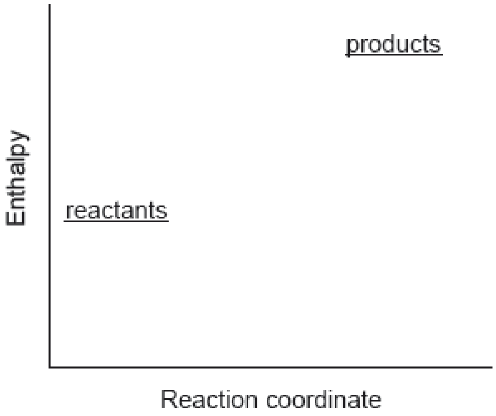
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Which describes the reaction shown in the potential energy profile?



A. The reaction is endothermic and the products have greater enthalpy than the reactants.

B. The reaction is endothermic and the reactants have greater enthalpy than the products.

C. The reaction is exothermic and the products have greater enthalpy than the reactants.

D. The reaction is exothermic and the reactants have greater enthalpy than the products.

Which statement is correct?

A. In an exothermic reaction, the products have more energy than the reactants.

B. In an exothermic reversible reaction, the activation energy of the forward reaction is greater than that of the reverse reaction.

C. In an endothermic reaction, the products are more stable than the reactants.

D. In an endothermic reversible reaction, the activation energy of the forward reaction is greater than that of the reverse reaction.

Consider the following reactions.

$$\begin{aligned} &\mathrm{Cu_2O(s)} + \tfrac{1}{2}\mathrm{O_2(g)} \rightarrow \mathrm{2CuO(s)} \quad && \Delta H^{\ominus} = -144\ \mathrm{kJ} \\ &\mathrm{Cu_2O(s)} \rightarrow \mathrm{Cu(s)} + \mathrm{CuO(s)} && \Delta H^{\ominus} = +11\ \mathrm{kJ} \end{aligned}$$

What is the value of $\Delta H^{\ominus}$, in kJ, for this reaction?

$$\mathrm{Cu(s)} + \frac{1}{2}\mathrm{O_2(g)} \rightarrow \mathrm{CuO(s)}$$

A. $-144 + 11$

B. $+144 - 11$

C. $-144 - 11$

D. $+144 + 11$

Consider the following reactions.

$$\begin{aligned} &\mathrm{N_2(g)} + \mathrm{O_2(g)} \rightarrow \mathrm{2NO(g)} && \Delta H^{\ominus} = +180\ \mathrm{kJ} \\ &\mathrm{2NO_2(g)} \rightarrow \mathrm{2NO(g)} + \mathrm{O_2(g)} \quad && \Delta H^{\ominus} = +112\ \mathrm{kJ} \end{aligned}$$

What is the $\Delta H^{\ominus}$ value, in kJ, for the following reaction?

$$\mathrm{N_2(g)} + \mathrm{2O_2(g)} \rightarrow \mathrm{2NO_2(g)}$$

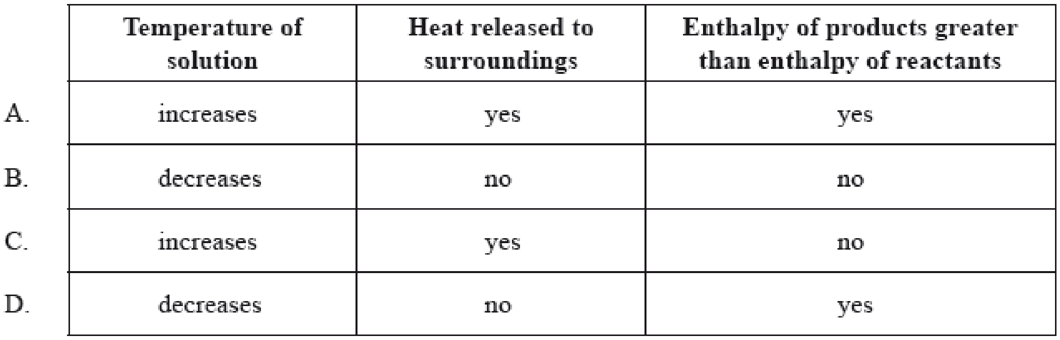
A. $-1 \times (+180) + -1 \times (+112)$

B. $-1 \times (+180) + 1 \times (+112)$

C. $1 \times (+180) + -1 \times (+112)$

D. $1 \times (+180) + 1 \times (+112)$

Which combination is correct for the exothermic reaction that occurs between zinc and copper sulfate solution.



	Temperature of solution	Heat released to surroundings	Enthalpy of products greater than enthalpy of reactants
A.	increases	yes	yes
B.	decreases	no	no
C.	increases	yes	no
D.	decreases	no	yes

Some water is heated using the heat produced by the combustion of magnesium metal. Which values are needed to calculate the enthalpy change of reaction?

I. The mass of magnesium

II. The mass of the water

III. The change in temperature of the water

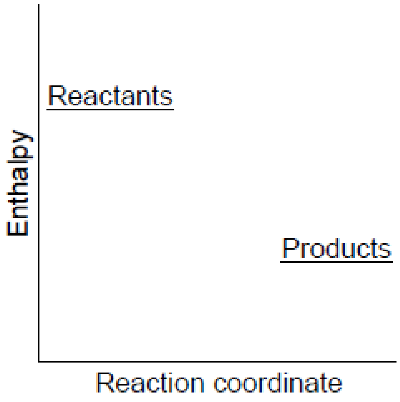
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

What can be deduced from this reaction profile?



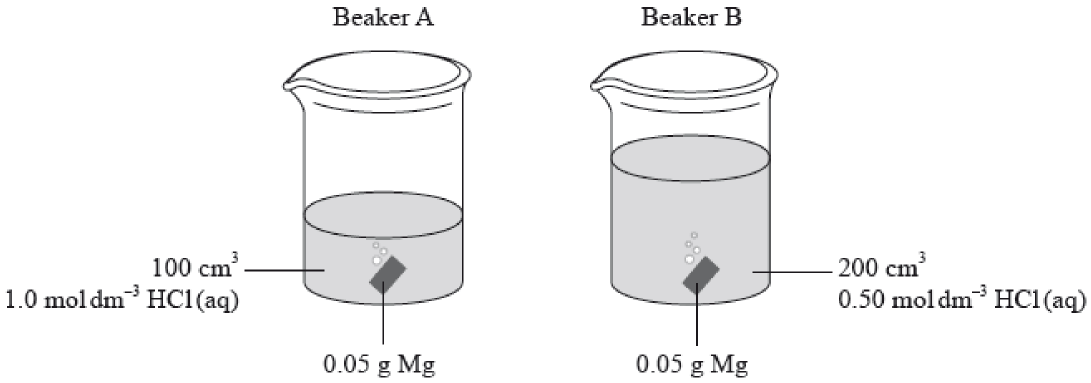
A. The reactants are less stable than the products and the reaction is exothermic.

B. The reactants are less stable than the products and the reaction is endothermic.

C. The reactants are more stable than the products and the reaction is exothermic.

D. The reactants are more stable than the products and the reaction is endothermic.

Identical pieces of magnesium are added to two beakers, A and B, containing hydrochloric acid. Both acids have the same initial temperature but their volumes and concentrations differ.



Which statement is correct?

A. The maximum temperature in A will be higher than in B.

B. The maximum temperature in A and B will be equal.

C. It is not possible to predict whether A or B will have the higher maximum temperature.

D. The temperature in A and B will increase at the same rate.

Hydrazine reacts with oxygen.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(l) \qquad \Delta H^\theta = -623 \text{ kJ}$$

What is the standard enthalpy of formation of $N_2H_4(l)$ in kJ? The standard enthalpy of formation of $H_2O(l)$ is -286 kJ.

A. -623 - 286
B. -623 + 572
C. -572 + 623
D. -286 + 623

Two 100 cm^3 aqueous solutions, one containing 0.010 mol NaOH and the other 0.010 mol HCl, are at the same temperature.

When the two solutions are mixed the temperature rises by *y* °C.

Assume the density of the final solution is 1.00 g cm^{-3}.

Specific heat capacity of water = 4.18 J g^{-1} K^{-1}

What is the enthalpy change of neutralization in kJ mol^{-1}?

A. $\frac{200\times4.18\times y}{1000\times0.020}$

B. $\frac{200\times4.18\times y}{1000\times0.010}$

C. $\frac{100\times4.18\times y}{1000\times0.010}$

D. $\frac{200\times4.18\times(y+273)}{1000\times0.010}$

Which processes are exothermic?

I. Ice melting

II. Neutralization

III. Combustion

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

What can be deduced from the facts that ozone absorbs UV radiation in the region of 340 nm and molecular oxygen in the region of 242 nm?

A. The bond between atoms in molecular oxygen is a double bond.

B. The bonds in ozone are delocalized.

C. The bonds between atoms in ozone are stronger than those in molecular oxygen.

D. The bonds between atoms in molecular oxygen need more energy to break.

The reaction between methane and oxygen is exothermic.

$$\mathrm{CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)}$$

Which statement is correct?

A. The total bond enthalpies of the reactants are less than the total bond enthalpies of the products.

B. The total bond enthalpies of the reactants are greater than the total bond enthalpies of the products.

C. The total energy released during bond formation is less than the total energy absorbed during bond breaking.

D. The activation energy is the difference between the total bond enthalpies of the products and the total bond enthalpies of the reactants.

Which statement about bonding is correct?

A. Bond breaking is endothermic and requires energy.

B. Bond breaking is endothermic and releases energy.

C. Bond making is exothermic and requires energy.

D. Bond making is endothermic and releases energy.

The specific heat of iron is $0.450\ \mathrm{J\,g^{-1}K^{-1}}$. What is the energy, in J, needed to increase the temperature of 50.0 g of iron by 20.0 K?

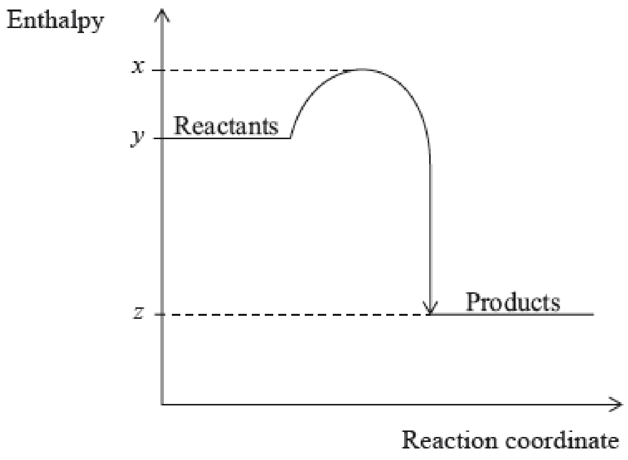
A. 9.00

B. 22.5

C. 45.0

D. 450

What is the value of ΔH for the exothermic reaction represented by the diagram below?



A. $y - z$

B. $z - y$

C. $x - z$

D. $z - x$

In a reaction that occurs in 50 g of aqueous solution, the temperature of the reaction mixture increases by 20 °C. If 0.10 mol of the limiting reagent is consumed, what is the enthalpy change (in $\mathrm{kJ\,mol^{-1}}$) for the reaction? Assume the specific heat capacity of the solution $= 4.2\mathrm{kJ^{-1}K^{-1}}$.

A. $-0.10 \times 50 \times 4.2 \times 20$

B. $-0.10 \times 0.050 \times 4.2 \times 20$

C. $\frac{-50\times4.2\times20}{0.10}$

D. $\frac{-0.050\times4.2\times20}{0.10}$

What is the temperature rise when 2100 J of energy is supplied to 100 g of water? (Specific heat capacity of water $= 4.2\ \mathrm{J\,g^{-1}K^{-1}}$.)

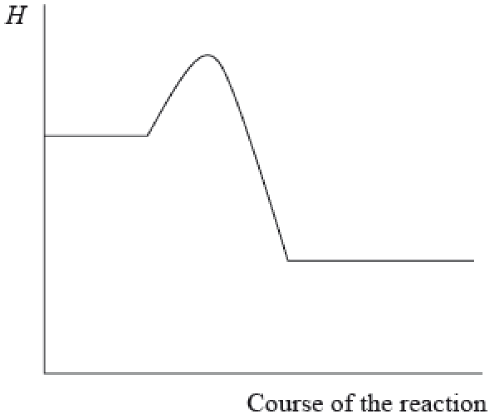
A. 5 °C

B. 278 K

C. 0.2 °C

D. 20 °C

Which statement is correct given the enthalpy level diagram below?



A. The reaction is endothermic and the products are more thermodynamically stable than the reactants.

B. The reaction is exothermic and the products are more thermodynamically stable than the reactants.

C. The reaction is endothermic and the reactants are more thermodynamically stable than the products.

D. The reaction is exothermic and the reactants are more thermodynamically stable than the products.

Which of the following reactions are exothermic?

I. $\mathrm{CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O}$

II. $\mathrm{NaOH + HCl \rightarrow NaCl + H_2O}$

III. $\mathrm{Br_2 \rightarrow 2Br}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

. The specific heat capacities of two substances are given in the table below. [1]

Substance	Specific heat capacity / J g^{-1} K^{-1}
Ethanol	2.43
Water	4.18

Which statement is correct?

A. More heat is needed to increase the temperature of 50 g of water by 50 °C than 50 g of ethanol by 50 °C.

B. If the same heat is supplied to equal masses of ethanol and water, the temperature of the water increases more.

C. If equal masses of water at 20 °C and ethanol at 50 °C are mixed, the final temperature is 35 °C .

D. If equal masses of water and ethanol at 50 °C cool down to room temperature, ethanol liberates more heat.

. The enthalpy changes of three reactions are given below. [1]

$$\mathrm{2HCOOH(l) + O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)} \quad \Delta H = a$$

$$\mathrm{C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)} \quad \Delta H = b$$

$$\mathrm{2HCOOC_2H_5(l) + 7O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)} \quad \Delta H = c$$

What is the enthalpy change for the following reaction?

$$\mathrm{HCOOH(l) + C_2H_5OH(l) \rightarrow HCOOC_2H_5(l) + H_2O(l)}$$

A. $a + b + c$

B. $a + 2b - c$

C. $\frac{1}{2}a + b + \frac{1}{2}c$

D. $\frac{1}{2}a + b - \frac{1}{2}c$

What is the enthalpy change of combustion of urea, $(NH_2)_2CO$, in kJ mol^{-1}?

$$2(NH_2)_2CO(s) + 3O_2(g) \rightarrow 2CO_2(g) + 2N_2(g) + 4H_2O(l)$$

	ΔH_f / kJ mol^{-1}
$(NH_2)_2CO$ (s)	−333
CO_2 (g)	−394
H_2O (l)	−286

A. 2 × (−333) −2 × (−394) −4 × (−286)

B. $\frac{1}{2}$[2 × (−394) + 4 × (−286) −2 × (−333)]

C. 2 × (−394) + 4 × (−286) −2 × (−333)

D. $\frac{1}{2}$[2 × (−333) −2 × (−394) −4 × (−286)]

Which is correct about energy changes during bond breaking and bond formation?

	Bond breaking	**Bond formation**
A.	exothermic and ΔH positive	endothermic and ΔH negative
B.	exothermic and ΔH negative	endothermic and ΔH positive
C.	endothermic and ΔH positive	exothermic and ΔH negative
D.	endothermic and ΔH negative	exothermic and ΔH positive

In which order does the oxygen–oxygen bond enthalpy increase?

A. $H_2O_2 < O_2 < O_3$

B. $H_2O_2 < O_3 < O_2$

C. $O_2 < O_3 < H_2O_2$

D. $O_3 < H_2O_2 < O_2$

Which change of state is exothermic?

A. $CO_2(s) \rightarrow CO_2(g)$
B. $H_2O(l) \rightarrow H_2O(g)$
C. $NH_3(g) \rightarrow NH_3(l)$
D. $Fe(s) \rightarrow Fe(l)$

Which process represents the C–Cl bond enthalpy in tetrachloromethane?

A. $\mathrm{CCl_4(g) \rightarrow C(g) + 4Cl(g)}$

B. $\mathrm{CCl_4(g) \rightarrow CCl_3(g) + Cl(g)}$

C. $\mathrm{CCl_4(l) \rightarrow C(g) + 4Cl(g)}$

D. $\mathrm{CCl_4(l) \rightarrow C(s) + 2Cl_2(g)}$

When $25.0 cm^3$ $0.100 mol dm^{-3}$ NaOH(aq) is mixed with $25.0 cm^3$ $0.100 mol dm^{-3}$ HCl(aq) at the same temperature, a temperature rise, *ΔT*, is recorded.

What is the expression, in $kJ mol^{-1}$, for the enthalpy of neutralisation? (Assume the density of the mixture = $1.00 g cm^{-3}$ and its specific heat capacity=$4.18 kJ kg^{-1} K^{-1} = 4.18 J g^{-1} K^{-1}$)

A. $-\frac{25.0\times4.18\times\Delta T}{50.0\times0.100}$

B. $-\frac{25.0\times4.18\times\Delta T}{25.0\times0.100}$

C. $-\frac{50.0\times4.18\times\Delta T}{50.0\times0.100}$

D. $-\frac{50.0\times4.18\times\Delta T}{25.0\times0.100}$

Which expression gives the mass, in g, of ethanol required to produce 683.5 kJ of heat upon complete combustion?

(M_r for ethanol = 46.0, $\Delta H_c^\theta = -1367\ \mathrm{kJ\,mol^{-1}}$)

A. $\frac{683.5}{1367\times46.0}$

B. $\frac{1367}{683.5\times46.0}$

C. $\frac{683.5\times46.0}{1367}$

D. $\frac{1367\times46.0}{683.5}$

Using the equations below:

$$\begin{array}{ll} C(s) + O_2(g) \rightarrow CO_2(g) & \Delta H^\ominus = -390\ \text{kJ} \\ H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) & \Delta H^\ominus = -286\ \text{kJ} \\ CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) & \Delta H^\ominus = -890\ \text{kJ} \end{array}$$

what is $\Delta H^\ominus$, in kJ, for the following reaction?

$$C(s) + 2H_2(g) \rightarrow CH_4(g)$$

A. –214

B. –72

C. +72

D. +214

Consider the following enthalpy of combustion data.

$$\begin{array}{ll} C(s) + O_2(g) \rightarrow CO_2(g) & \Delta H^\ominus = -x\ \text{kJ mol}^{-1} \\ H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) & \Delta H^\ominus = -y\ \text{kJ mol}^{-1} \\ C_2H_6(g) + 3\frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) & \Delta H^\ominus = -z\ \text{kJ mol}^{-1} \end{array}$$

What is the enthalpy of formation of ethane in kJ mol^{-1}?

$$2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$$

A. $[(-x) + (-y)] - (-z)$

B. $(-z) - [(-x) + (-y)]$

C. $[(-2x) + (-3y)] - (-z)$

D. $(-z) - [(-2x) + (-3y)]$

Which equation represents the average bond enthalpy of the Si–H bond in SiH_4?

A. $SiH_4(g) \rightarrow SiH_3(g) + H(g)$
B. $\frac{1}{4}$ SiH_4 (g) → $\frac{1}{4}$ Si(g) + H(g)
C. $SiH_4(g) \rightarrow SiH_3(g) + \frac{1}{2} H_2(g)$
D. SiH_4 (g) → Si(g) + 4H(g)

In which reaction do the reactants have a lower potential energy than the products?

A. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
B. HBr(g) → H(g) + Br(g)
C. $Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$
D. NaOH(aq) + HCl(aq) → NaCl(aq) + $H_2O(l)$

What is the energy, in kJ, released when 1.00 mol of carbon monoxide is burned according to the following equation?

$$2\text{CO(g)} + \text{O}_2\text{(g)} \rightarrow 2\text{CO}_2\text{(g)} \quad \Delta H^{\ominus} = -564\ \text{kJ}$$

A. 141

B. 282

C. 564

D. 1128

Which statements are correct for an exothermic reaction?

I. The products are more stable than the reactants.

II. The enthalpy change, ΔH, is negative.

III. The temperature of the surroundings increases.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

When $100\ \text{cm}^3$ of $1.0\ \text{mol dm}^{-3}$ HCl is mixed with $100\ \text{cm}^3$ of $1.0\ \text{mol dm}^{-3}$ NaOH, the temperature of the resulting solution increases by 5.0 °C.

What will be the temperature change, in °C, when $50\ \text{cm}^3$ of these two solutions are mixed?

A. 2.5

B. 5.0

C. 10

D. 20

Consider the following two equations.

$2\text{Ca(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{CaO(s)} \quad \Delta H^{\ominus} = +x\ \text{kJ}$

$\text{Ca(s)} + 0.5\text{O}_2\text{(g)} + \text{CO}_2\text{(g)} \rightarrow \text{CaCO}_3\text{(s)} \quad \Delta H^{\ominus} = +y\ \text{kJ}$

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

$$\text{CaO(s)} + \text{CO}_2\text{(g)} \rightarrow \text{CaCO}_3\text{(s)}$$

A. $y - 0.5x$

B. $y - x$

C. $0.5 - y$

D. $x - y$

Which processes have a negative enthalpy change?

I. $2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$

II. $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

III. $H_2O(g) \rightarrow H_2O(l)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

When some solid barium hydroxide and solid ammonium thiosulfate were reacted together, the temperature of the surroundings was observed to decrease from 15 °C to –4 °C. What can be deduced from this observation?

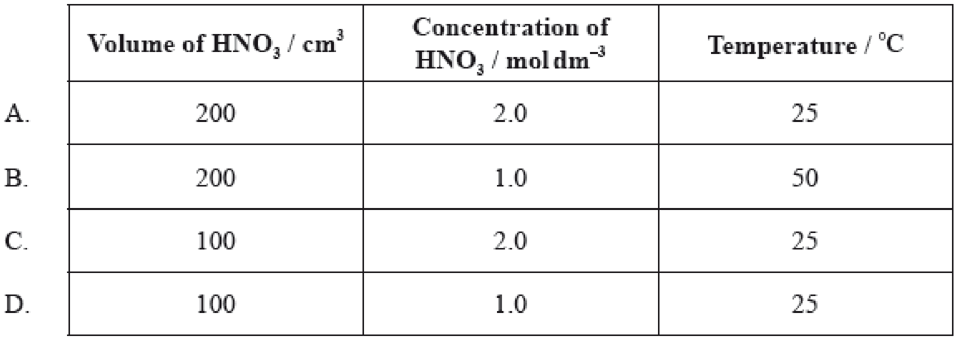
A. The reaction is exothermic and ΔH is negative.

B. The reaction is exothermic and ΔH is positive.

C. The reaction is endothermic and ΔH is negative.

D. The reaction is endothermic and ΔH is positive.

At 25 °C, $200\ cm^3$ of $1.0\ mol\,dm^{-3}$ nitric acid is added to 5.0 g of magnesium powder. If the experiment is repeated using the same mass of magnesium powder, which conditions will result in the same initial reaction rate?



	Volume of HNO_3 / cm^3	Concentration of HNO_3 / $mol\,dm^{-3}$	Temperature / °C
A.	200	2.0	25
B.	200	1.0	50
C.	100	2.0	25
D.	100	1.0	25

When four moles of aluminium and four moles of iron combine with oxygen to form their oxides, the enthalpy changes are –3338 kJ and –1644 kJ respectively.

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s) \quad \Delta H = -3338\ kJ$$
$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s) \quad \Delta H = -1644\ kJ$$

What is the enthalpy change, in kJ, for the reduction of one mole of iron(III) oxide by aluminium?

$$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(s) + Al_2O_3(s)$$

A. $+1694$

B. $+847$

C. -847

D. -1694

Which processes are exothermic?

I. $CH_3CH_2CH_3(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

II. $Cl_2(g) \rightarrow 2Cl(g)$

III. $CH_3CH_2COOH(aq) + NaOH(aq) \rightarrow CH_3CH_2COONa(aq) + H_2O(l)$

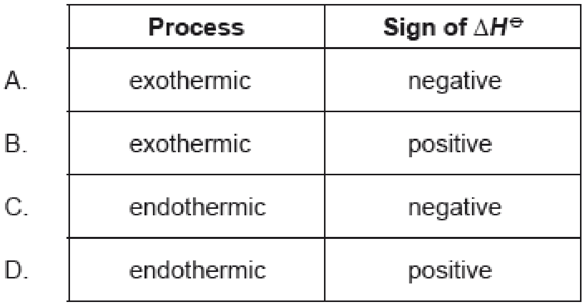
A. I and II only

B. I and III only

C. II and III only

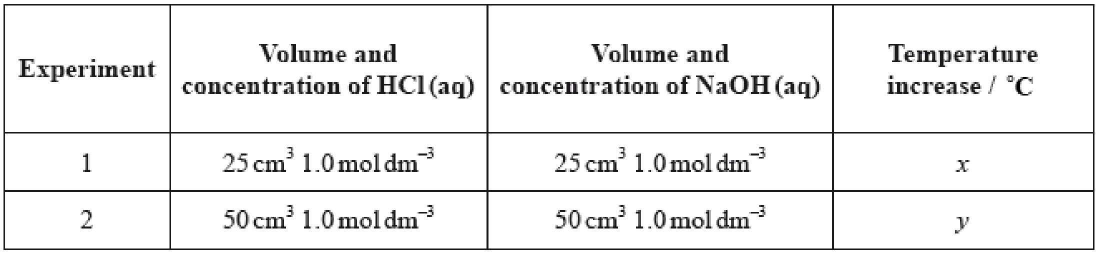
D. I, II and III

Which combination is correct for the standard enthalpy change of neutralization?



	Process	Sign of $\Delta H^\ominus$
A.	exothermic	negative
B.	exothermic	positive
C.	endothermic	negative
D.	endothermic	positive

The table shows information about temperature increases when an acid and an alkali are mixed.



Experiment	Volume and concentration of HCl (aq)	Volume and concentration of NaOH (aq)	Temperature increase / °C
1	$25\,cm^3$ $1.0\,mol\,dm^{-3}$	$25\,cm^3$ $1.0\,mol\,dm^{-3}$	x
2	$50\,cm^3$ $1.0\,mol\,dm^{-3}$	$50\,cm^3$ $1.0\,mol\,dm^{-3}$	y

What is the value of y?

A. $\frac{1}{2}x$

B. x

C. $2x$

D. $4x$

Which processes are exothermic?

I. $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$

II. $2C(s) + O_2(g) \rightarrow 2CO(g)$

III. $C(s) + O_2(g) \rightarrow CO_2(g)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Which equation best represents the bond enthalpy of HCl?

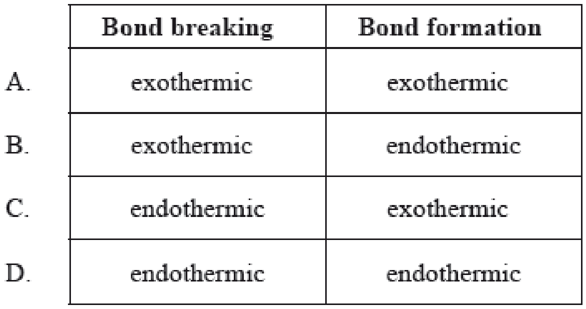
A. $HCl(g) \rightarrow H^+(g) + Cl^-(g)$

B. $HCl(g) \rightarrow H(g) + Cl(g)$

C. $HCl(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g)$

D. $2HCl(g) \rightarrow H_2(g) + Cl_2(g)$

Which combination is correct about the energy changes during bond breaking and bond formation?



	Bond breaking	Bond formation
A.	exothermic	exothermic
B.	exothermic	endothermic
C.	endothermic	exothermic
D.	endothermic	endothermic

The specific heat capacity of aluminium is $0.900\ J\,g^{-1}K^{-1}$. What is the heat energy change, in J, when 10.0 g of aluminium is heated and its temperature increases from 15.0 °C to 35.0 °C?

A. +180

B. +315

C. +1800

D. +2637

The standard enthalpy changes for the combustion of carbon and carbon monoxide are shown below.

$$\begin{array}{ll} \mathrm{C(s)} + \mathrm{O_2(g)} \rightarrow \mathrm{CO_2(g)} & \Delta H_c^\ominus = -394\ \mathrm{kJ\ mol^{-1}} \\ \mathrm{CO(g)} + \frac{1}{2}\mathrm{O_2(g)} \rightarrow \mathrm{CO_2(g)} & \Delta H_c^\ominus = -283\ \mathrm{kJ\ mol^{-1}} \end{array}$$

What is the standard enthalpy change, in kJ, for the following reaction?

$$\mathrm{C(s)} + \frac{1}{2}\mathrm{O_2(g)} \rightarrow \mathrm{CO(g)}$$

A. –677

B. –111

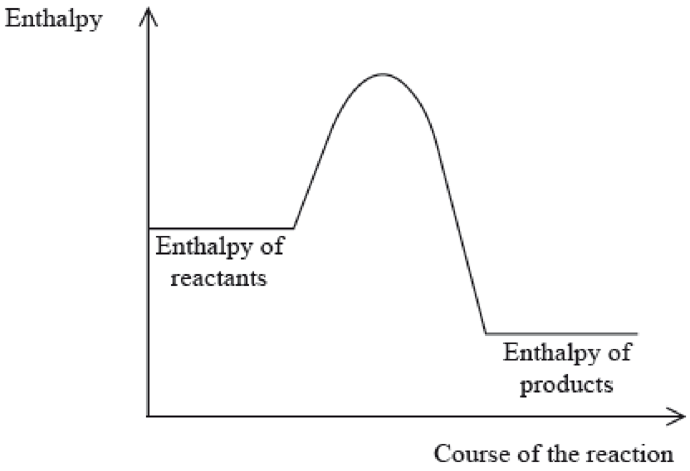
C. +111

D. +677

Which is true for a chemical reaction in which the products have a higher enthalpy than the reactants?

	Reaction	ΔH
A.	endothermic	positive
B.	endothermic	negative
C.	exothermic	positive
D.	exothermic	negative

Which statement is correct for the enthalpy level diagram shown?



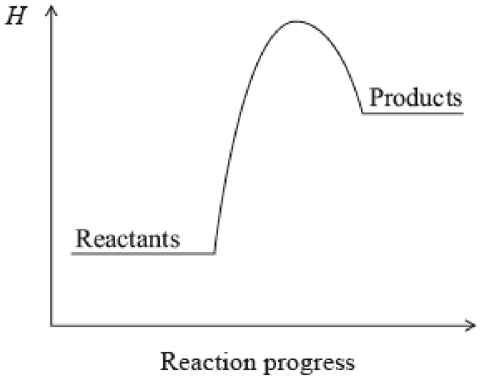
A. The reaction is exothermic and the products are more stable than the reactants.

B. The reaction is exothermic and the sign of the enthalpy change is positive.

C. The reaction is endothermic and the sign of the enthalpy change is negative.

D. The reaction is endothermic and the products are more stable than the reactants.

Which statement is correct for the reaction with this enthalpy level diagram?



A. Heat energy is released during the reaction and the reactants are more stable than the products.

B. Heat energy is absorbed during the reaction and the reactants are more stable than the products.

C. Heat energy is released during the reaction and the products are more stable than the reactants.

D. Heat energy is absorbed during the reaction and the products are more stable than the reactants.

Which equation corresponds to the bond enthalpy of the H–I bond?

A. $\mathrm{HI(g)} \rightarrow \frac{1}{2}\mathrm{H_2(g)} + \frac{1}{2}\mathrm{I_2(g)}$

B. $\mathrm{HI(g)} \rightarrow \frac{1}{2}\mathrm{H_2(g)} + \frac{1}{2}\mathrm{I_2(s)}$

C. $\mathrm{HI(g)} \rightarrow \mathrm{H^+(g)} + \mathrm{I^-(g)}$

D. $\mathrm{HI(g)} \rightarrow \mathrm{H(g)} + \mathrm{I(g)}$

Consider the following equations.

$$\mathrm{2Fe(s)} + 1\tfrac{1}{2}\mathrm{O_2(g)} \rightarrow \mathrm{Fe_2O_3(s)} \qquad \Delta\mathrm{H}^{\Theta} = x$$

$$\mathrm{CO(g)} + \tfrac{1}{2}\mathrm{O_2(g)} \rightarrow \mathrm{CO_2(g)} \qquad \Delta\mathrm{H}^{\Theta} = y$$

What is the enthalpy change of the reaction below?

$$\mathrm{Fe_2O_3(s)} + \mathrm{3CO(g)} \rightarrow \mathrm{3CO_2(g)} + \mathrm{2Fe(s)}$$

A. $3y - x$

B. $3y + x$

C. $-3y - x$

D. $-3y + x$

Use the average bond enthalpies below to calculate the enthalpy change, in kJ, for the following reaction.

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

Bond	**Bond energy / kJ mol^{-1}**
H–H	440
I–I	150
H–I	300

A. +290

B. +10

C. –10

D. –290

The enthalpy change for the reaction between zinc metal and copper(II) sulfate solution is $-217\ \mathrm{kJ\,mol^{-1}}$. Which statement about this reaction is correct?

A. The reaction is endothermic and the temperature of the reaction mixture initially rises.

B. The reaction is endothermic and the temperature of the reaction mixture initially drops.

C. The reaction is exothermic and the temperature of the reaction mixture initially rises.

D. The reaction is exothermic and the temperature of the reaction mixture initially drops.

Consider the equations:

$$\begin{array}{ll} N_2(g) + 2H_2(g) \rightarrow N_2H_4(l) & \Delta H^\ominus = +50.6\ \mathrm{kJ\,mol^{-1}} \\ N_2H_4(l) \rightarrow N_2H_4(g) & \Delta H^\ominus = +44.8\ \mathrm{kJ\,mol^{-1}} \end{array}$$

What is $\Delta H^\ominus$, in kJ, for the following reaction?

$$N_2(g) + 2H_2(g) \rightarrow N_2H_4(g)$$

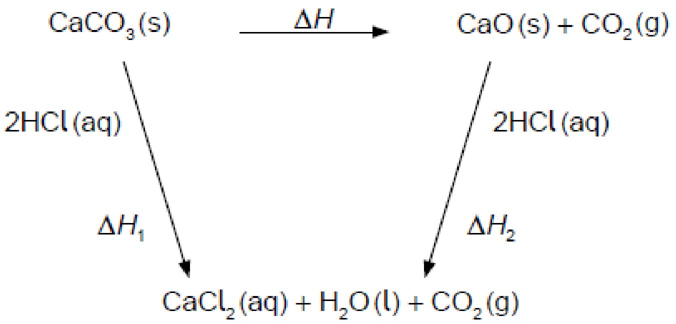
A. -95.4

B. -5.80

C. $+5.80$

D. $+95.4$

Which expression gives the enthalpy change, *ΔH*, for the thermal decomposition of calcium carbonate?



A. $\Delta H = \Delta H_1 - \Delta H_2$

B. $\Delta H = 2\Delta H_1 - \Delta H_2$

C. $\Delta H = \Delta H_1 - 2\Delta H_2$

D. $\Delta H = \Delta H_1 + \Delta H_2$

Which enthalpy changes can be calculated using **only** bond enthalpy data?

I. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

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

III. $CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$

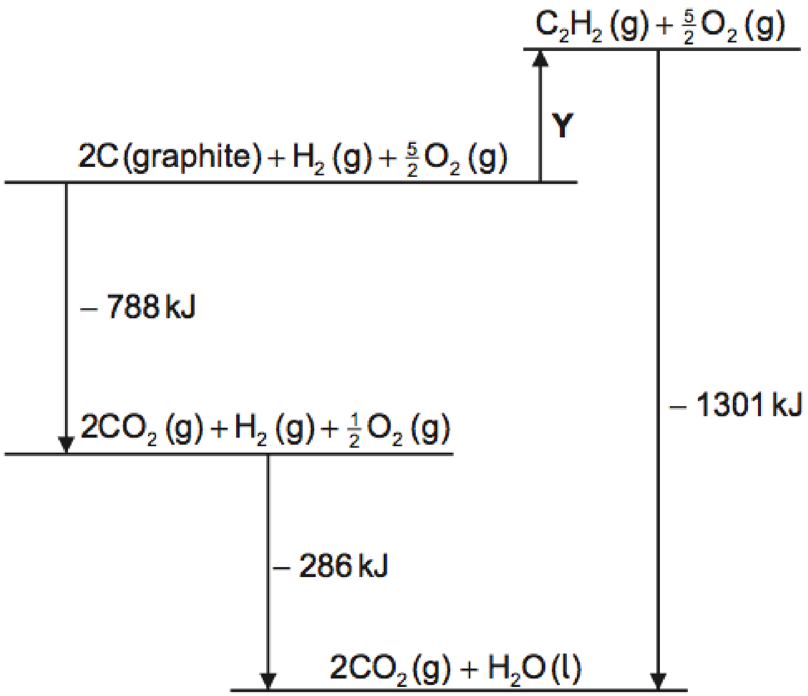
A. I and II only

B. I and III only

C. II and III only

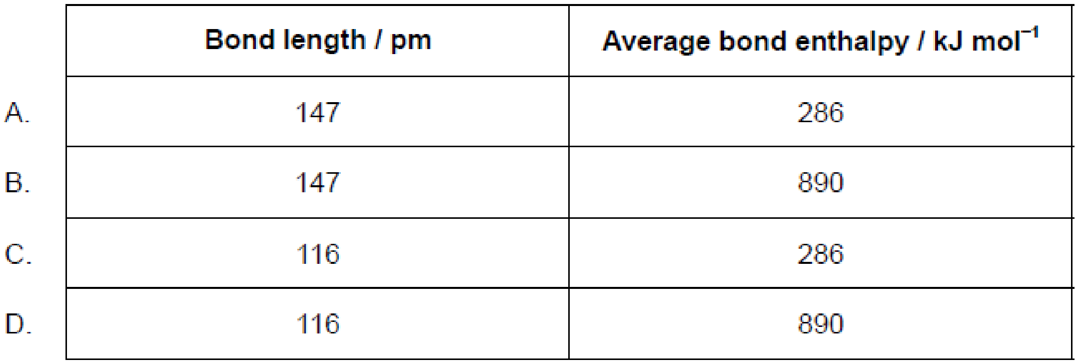
D. I, II and III

What is the enthalpy of formation of ethyne, in kJmol^{-1}, represented by the arrow **Y** on the diagram?



A. −788−286+1301
B. −788−286−1301
C. +788+286−1301
D. +788+286+1301

The C=N bond has a bond length of 130 pm and an average bond enthalpy of 615kJmol^{-1}. Which values would be most likely for the C-N bond?



	Bond length / pm	**Average bond enthalpy / kJ mol^{-1}**
A.	147	286
B.	147	890
C.	116	286
D.	116	890